The British Columbia Field Sampling Manual

Part E1

Surface Water

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1 Introduction

Surface water is one of British Columbia's (B.C.) most valuable natural resources. Managing the quality and quantity of surface water is essential for ecosystem health, human health, wildlife, and economic development. Surface water provides a number of services for our communities including crop irrigation, livestock production, energy generation, human consumption, recreation, and industrial use (ENV 2016). With the continuing growth of the province's population and the risks posed by pollution and climate change, the challenges and demands on B.C.'s surface water resources will continue to increase. Decisions regarding this vital resource must be based on reliable and consistent data that meets a commensurate level of quality.

Part E1 of the B.C. Field Sampling Manual (BCFSM) provides effective guidance for persons required to develop and conduct surface water quality monitoring programs. The information and guidance presented in this section of the BCFSM is compiled from a wide variety of sources including industry best practices, provincial and federal guidelines, sampling technology manuals and peer-reviewed literature. The protocols and methods provided herein are designed to produce surface water data at a level of quality that satisfies the province's resource protection and management objectives.

The primary objective of a sampling plan is to collect representative, minimally disturbed samples that meet the requirements of the sampling program, and to deliver those samples to a qualified laboratory without deterioration or contamination. The procedures outlined in this manual standardize sampling protocols and methods which may be required by permit, approval, regulation, or bylaw. They also serve as a guideline for regulatory staff, permittees, and consultants.

This *part* of the BCFSM takes into account B.C. acts, regulations, protocols, and guidelines that pertain to surface water quality, and watercourse-specific water quality objectives. The primary acts and regulations that apply to the information contained in this *part* are described in more detail below. This list is not exhaustive however, and other acts, regulations or permit requirements may necessitate monitoring of surface water quality.

The Water Sustainability Act (WSA), is the principal law for managing the diversion and use of water resources and provides a strategy for protecting, managing, and using water efficiently.

- Under the WSA, the **Water Sustainability Regulation (WSR[1])** addresses the requirements to allocate both ground and surface water and identifies the requirements for using water or making changes to a stream, including the protection of water quality.

The Environmental Management Act (EMA) regulates industrial and municipal waste discharge, pollution, hazardous waste, and contaminated site remediation. The EMA provides the authority for introducing wastes into the environment, while protecting public health and the environment. The Act enables the use of permits, regulations, and codes of practice to authorize discharges to the environment and enforcement options, such as administrative penalties, orders, and fines to facilitate compliance. Section 14 of the Act enables the Province to issue a permit authorizing the introduction of waste into the environment subject to requirements for the protection of the environment. Permittees may be required to conduct studies and to report information specified by the Province including, but not necessarily limited to, water quality data.

- Under the EMA, the **Contaminated Sites Regulation (CSR[2])** provides numerical and risk-based standards for soil, sediment, surface water, groundwater and vapour. These standards are used to

[1] *Water Sustainability Regulation (WSR)*, B.C. Reg. 36/2016, including amendments up to B.C. Reg. 187/2020, July 20, 2020.
[2] *Contaminated Sites Regulation (CSR)*, B.C. Reg. 375/96, including amendments up to B.C. Reg. 196/2017, November 1, 2017.

determine whether surface water quality is acceptable for applicable current and future surface water uses at a site and adjacent sites.

- Under the EMA, the **Hazardous Waste Regulation (HWR[3])** addresses the proper handling and disposal of hazardous wastes, which could represent a risk to surface water.
- Under the EMA, the **Environmental Data Quality Assurance Regulation (EDQR[4])** outlines the requirements for the collection and analysis of environmental samples and the environmental data produced from those samples.
- Under the EMA, the **Environmental Impact Assessment Regulation (EIAR[5])** addresses which components are required for an environmental impact assessment conducted under the EMA, including an assessment for impacts to water quality.

The **Drinking Water Protection Act** outlines the requirements for drinking water operators and suppliers to ensure the provision of safe drinking water within B.C. Section 11 of the Act requires water suppliers to monitor their source of drinking water and submit samples to a laboratory for analysis.

The **Environmental Assessment Act** provides a mechanism for reviewing major projects to assess their potential impacts to the environment, which could include impacts to surface water quality. Under the Act, a proponent may be required to develop a surface water quality monitoring program as a condition of their permit.

The **Oil and Gas Activities Act** regulates oil and gas related activities in B.C. Permit holders must comply with all environmental measures outlined in the permit, which may include monitoring surface water quality.

1.1 Purpose and Scope

This part of the BCFSM provides guidance, instruction and technical protocols that are required for surface water sampling and for the development of competent surface water quality monitoring programs (SWQMP). The primary goals of surface water sampling should be identified and addressed in an SWQMP. At a minimum those primary goals include the collection of samples from accurately identified locations, at a strategic frequency with consistent deployment of sampling protocols. The primary objective of surface water sampling is to provide to the testing laboratory a sample that is representative of the source water at the time of sampling. This requires that the sample be collected, preserved, and delivered to the laboratory free of contamination and deterioration. The following sections outline the steps necessary to achieve the primary objective of an SWQMP including field preparation, quality assurance and quality control (QA/QC), sample collection and handling methods, field measurements, and storage and transport of samples to the laboratory. The protocols outlined in this section will aid field staff in collecting consistent and reliable, representative water samples.

[3] *Hazardous Waste Regulation (HWR)*, B.C. Reg. 63/88, including amendments up to B.C. Reg. 243/2016, November 1, 2017.
[4] *Environmental Data Quality Assurance Regulation (EDQAR),* B.C. Reg 301/90, including ammendments up to B.C. Reg. 19/2017, January 31, 2017.
[5] *Environmental Impact Assessment Regulation,* B.C. Reg 330/81, including ammendments up to B.C. Reg. 321/2004.

2 Monitoring Plans

The quality of surface water in both lakes and rivers change in response to short-term and long-term changes in climate, resource extraction, industrial discharges, and land use activities. A well developed surface water quality monitoring program (SWQMP) will establish a point-in-time assessment of the quality of a water body and or provide an understanding of the effects of these stresses on the quality, composition, and quantity of this resource.

Federal, provincial, territorial, municipal and community agencies implement surface water quality monitoring programs individually and jointly to establish ambient or baseline characteristics for effective resource management. The data produced through these monitoring programs are used to assist government agencies and communities in assessing risks to the environment and human health. Monitoring data are also used in the development of strategies regarding protection, remedial measures, and plans designed to address emerging concerns and adaptation measures (ENV, 2000).

Water quality monitoring is essential to understanding current conditions, as well as changes in natural processes and the influences of human activity over time. Examples of water quality monitoring in B.C. include provincial lake monitoring and river monitoring. Provincial lake monitoring programs in B.C. involve over 50 lakes that are sampled each year (ENV, 2020). The quality of river water in B.C. is monitored through a cooperative Federal-Provincial water quality monitoring program which involves sampling on 31 rivers within B.C. (ENV, 2020). These two programs were designed to achieve similar goals which include the assessment of current conditions, influences by human activity, responses to climate change, and ultimately the provision of scientifically defensible water quality data for use in resource protection and management decisions.

The development of an SWQMP should begin with an identified goal and a set of objectives designed to achieve that goal. Although the goal of a lake monitoring project or plan may differ from a project or plan developed for a river, each may have common objectives such as establishing long-term trends, understanding seasonal effects, effects from anthropogenic inputs, and monitoring water quality relative to quantity.

2.1 Planning and Design

The planning and design of a surface water quality monitoring program initially requires a careful understanding of objectives, so that the program may be designed to meet these objectives in the most efficient manner possible. Objectives may vary from establishing baseline conditions, to monitoring the long-term effects of climate change, or monitoring a specific chemical parameter or constituent which may be from natural or anthropogenic inputs or influences. Once the program's objectives are understood, the planning and design of the monitoring program, including the development of a sampling plan, can start to take shape.

Monitoring plans can include the collection of water, sediment or tissue samples to provide data regarding chemical and physical parameters; benthic macroinvertebrates, plankton and periphyton to provide aquatic health indicators and assess ecosystem balance. The collection of biological samples are covered in Part C – Biological, of this manual.

Data from the sampling plan should adequately characterize the source water and parameters of interest. The following key aspects should be considered in the development of a SWQMP:

- Seasonal changes,
- Accessibility and seasonal barriers to accessibility,

- Lake size, bathymetry and depth for sampling sites, river size and flow, timing and volume,
- Potential influences of connecting and or nearby water bodies (i.e., groundwater-surface water interactions, sea water intrusion and tidal influences, losing vs. gaining riverbeds),
- Surrounding land uses such as urban and rural development, logging and agriculture,
- Indicator parameters to identify land use or climate change impacts; and,
- Logistics including equipment, access, safety, and transport to laboratory services.

2.1.1 Data Quality Objectives

Data quality objectives (DQOs) are integral components of quality assurance/quality control (QA/QC) and as such are presented here as they must be considered, developed, and included in the SWQMP. DQOs are formal data quality specifications, that are developed to address the specific needs of the SWQMP. These objectives determine the maximum amount of uncertainty (or error) that is considered acceptable for a specific plan or project. Total uncertainty includes the variability attributable to the natural heterogeneity of the parent material and bias introduced during sample collection and handling, and the variability and bias introduced during the analytical process. DQOs include the degree of confidence required for analytical data, numbers and types of QC samples required for any given project, plan or sampling event and quantitative thresholds.

Examples of Data Quality Objectives:

1. A confidence interval (i.e. 95% confidence).
2. Equipment blank for each sample station.
3. Maximum acceptable concentration of reportable analytes in any equipment blank (i.e. 5 x the Reportable Detection Limit (RDL) for a given analyte.
4. A duplicate sample for each sample station or sampling event.
5. A specified acceptable relative percent difference (RPD) value (i.e. 50%) for duplicate samples of a target analyte.

DQOs are highly specific to the intended use of the data. DQOs must be established and presented in the SWQMP and understood by field staff prior to the collection of regular and QC samples. When DQOs have been established and sampling has commenced, there must be regular performance checks to determine whether or not the DQOs are being met. Corrective action must be taken when DQOs fail. The SWQMP should include specific instructions or actions to be taken when DQOs have not been achieved. Out-of-control events, responses, and corrective actions must be recorded.

2.1.2 Establishing Sampling Stations

The location from which samples will be collected, also referred to as ‘sample stations’, must be identified in the SWQMP with efficient traceability. The selection of sampling stations should be based on the objectives of the SWQMP which may require two or more locations in a lake, marine area or river. SWQMPs that involve multiple and multi-seasonal sampling events should consider accessibility constraints imposed by seasonal conditions, topography, and land ownership. Sampling stations are typically located by coordinates but may also be characterized by site information features and distances to permanent structures. Global positioning systems (GPS) are effective tools that can be used to locate sampling stations independent of naturally changing site features. GPS units are capable of high accuracy which make them an ideal tool for field staff returning to a sampling station. SWQMPs that operate over a number

of years, especially those that include an objective of establishing long-term trends, should include sampling stations with dependable and accurate location features such as GPS coordinates to ensure that each data set is collected at the same sampling station. Regardless of the method of locating a sampling station or stations, the location information should be accurately recorded to facilitate repeat visits and to ensure that new field crew members have the ability to accurately locate each station.

2.1.3 Sample Scope

The primary objective of surface water sampling within a SWQMP is to obtain samples that are representative of in situ physical and chemical conditions at the time, location, and depth from which they are collected. The choice of samples to be collected will depend on a multitude of factors which must be considered to ensure they meet the objectives of the SWQMP.

In addition to regular samples, quality control (QC) samples are collected to support the defensibility of the data produced through the program. Field measurements are often taken to document the value of specific parameters, such as dissolved oxygen, pH and temperature, at the time of sample collection. Detailed information regarding QC samples is provided in Section 3.3, and detailed information on field measurements is provided in Section 5.

2.1.3.1 Water Quality Parameters

The goal and objectives of a SWQMP will define the parameters to be analyzed and ultimately the number and types of samples to be collected during each sampling event. Most monitoring plans will include standard or common water quality parameters. These common parameters typically include temperature, pH, turbidity, dissolved oxygen, and specific conductance. Common parameters (see Table 2.1 below) are used to better understand and interpret parameters such as metals and nutrients.

A monitoring plan developed to monitor long-term trends will include a selection of parameters relevant to broader water quality trends and perhaps include additional parameters to capture specific aspects of interest. Long-term monitoring can be conducted indefinitely and in doing so amass a significant amount of water quality data. Water quality monitoring including long-term monitoring, should be designed to answer specific questions. For example long term monitoring of water quality is often designed to observe the effects of cumulative inputs including discharges from industry along with non-point source runoff from surrounding land use. A monitoring plan designed to establish and observe the impacts of discharges into a water body or land use impacts such as agriculture, will monitor indicator parameters but also include parameters associated with the discharge or land use.

Ultimately the list of parameters will be chosen to achieve the objectives of the SWQMP which may be influenced by regulatory requirements, known site conditions, proximal land uses, and regional characteristics. The following table provides a brief description of the role of various water quality parameters in fresh water.

Table 2.1 Water Quality Parameters and What They Mean

Parameter Type	Parameter Name	Role or Effect
Physical	pH	pH is the measure of the hydrogen ion activity in a solution; and is a measure of how acidic or basic the water is. The geology of the watershed typically has the greatest influence on the pH of a waterbody. pH affects the solubility and bioavailability of other chemical constituents in water such as metals or nutrients. For

Parameter Type	Parameter Name	Role or Effect
		example, many metals become more toxic at lower pH (acidic) while ammonia is more toxic at higher pH (basic) (CCME, 2003).
Physical	Alkalinity	Alkalinity is a measure of water's ability to neutralize acids. Water with high alkalinity will experience less of a change in pH when subjected to an acidic input (CCME, 2003).
Physical	Specific Conductivity and Conductance	Specific Conductivity is the measure of water's ability to conduct electricity at a specific temperature (25°C). Conductance is the measure of water's ability to conduct electricity without adjustment for temperature. Water conducts electricity because of the salts dissolved in it. Conductance is affected by seasonal changes in turbidity, water temperature, quantity of groundwater present and rainfall. Human activity can increase the amount of dissolved salts in the water resulting in decreased health of aquatic ecosystems (USEPA, 2016).
Physical	Dissolved Oxygen	Most aquatic organisms need dissolved oxygen for respiration. Oxygen enters water from the atmosphere and from photosynthesis in aquatic plants. Flowing water often contains higher dissolved oxygen concentrations than standing water. Dissolved oxygen is also affected by temperature. Cold water can hold more oxygen than warm water. Microbes typically use dissolved oxygen to decompose organic matter; therefore high levels of organic matter can lead to low oxygen in waterbodies such as wetlands. Low dissolved oxygen levels can lead to increased mortality of fish eggs and severely stress or kill aquatic life (BC ENV, 1997). A decreasing trend in dissolved oxygen can also lead to deteriorating water quality conditions as anoxic environments may release metals or nutrients previously bound to sediment.
Physical	Hardness	Hardness is a measure of ions in water - primarily calcium and magnesium. Natural sources of hardness in waterbodies are groundwater and runoff from soils. Hardness influences the toxicity of many metals and some ions. Certain metals and ions such as lead, zinc, copper, cadmium, nickel and sulphate become more toxic at lower concentrations of water hardness. (CCME, 2003)
Physical	Non-filterable Residue (aka Total Suspended Solids or TSS)	Non-filterable residue or total suspended solids are a measure of the suspended particulate matter in water. Fine sediments can clog gill structures in aquatic organisms, cause injury to eye and gill membranes by abrasion and inhibit egg development. Soil erosion from agricultural and urban run-off, removal of riparian vegetation, channelization and dredging can cause high levels of suspended sediments (BC ENV, 1997). Total suspended solids may also affect the availability of metals to aquatic organisms as metals can be liberated from their dissolved phase as they adhere to fine sediments.

Parameter Type	Parameter Name	Role or Effect
Physical	Turbidity	Turbidity is a measure of clarity in water. Turbidity is an indicator of TSS and is typically measured in the field. Clay, silt, organic and inorganic matter, plankton, and microorganisms can all cause water to be turbid. In aquatic ecosystems, high turbidity can affect light penetration through the water, reducing plant growth, and smothering benthic habitats (BC ENV, 1997).
Anions & Nutrients	Chloride	Chloride is widely distributed in nature, mostly in the form of sodium and potassium salts. The greatest amount of chloride is found in oceans. Chloride is an essential element for aquatic life; however, it is detrimental to aquatic organisms at high concentrations.
Organic Carbon	Dissolved Organic Carbon and Total Organic Carbon	Organic carbon is a measure of the dissolved or particulate organic matter in water. Natural organic matter is typically from plant litter, microbial biomass, and soil humus. Human sources of organic carbon include municipal wastewater, septic systems, agricultural runoff, and industrial discharges (Health Canada, 2019). Organic carbon has the ability to bind to some fractions of metals thereby reducing their toxicity (CCME, 2003).
Anions & Nutrients	Sulphate	Sulphate is the oxidized form of sulphur, which is essential for many biological processes in plants and animals. However, at high concentrations sulphate is harmful to aquatic organisms. Sulphur occurs naturally in rocks as sulphides. In the presence of water, the sulphide is oxidized to form sulphate. Human sources include waste from industries that produce or use sulphates or sulphuric acid such as mining and smelting operations, kraft pulp and paper mills, textile mills, tanneries, and agricultural run-off and sewage (Meays, 2013).
Anions & Nutrients	Phosphorous	Phosphorus is naturally occurring in rocks, animal waste, plant material and in the atmosphere. High levels of phosphorus can increase vegetation and algae growth to such an extent as to result in a bloom or population explosion. The continued input of nutrients is called eutrophication which can cause a decrease of dissolved oxygen. Human activities such as the discharge of sewage effluent and run-off from residential and agricultural lands can increase phosphorous levels in water bodies (CCME, 2004).
Anions & Nutrients	Nitrogen	Nitrogen is essential for many biological processes in plants and bacteria but is often toxic to other aquatic organisms. Nitrate, nitrite, and ammonia are the major biologically available compounds occurring in surface water. Nitrogen pollution is typically from municipal wastewater, agricultural run-off, and groundwater. Excessive nitrogen can be used by some algae and rooted plants but is directly toxic to fish by reducing their ability to expel ammonia (Nordin, 1986).
Metals	Metals	Metals occur naturally in the environment, leaching into water from rocks and soil. Many organisms need small amounts of some

Parameter Type	Parameter Name	Role or Effect
		essential metals such as iron, copper, manganese, molybdenum, selenium, and zinc. However, these and other non-essential metals become toxic to aquatic organisms at higher concentrations. Other sources of metals in water include wastewater, mining, and industrial activity. The toxicity and bioavailability of many metals depends on their oxidation state and form. Generally, dissolved metals are more bioavailable than metals bound to sediment or in complexes with other molecules (CCME, 2003).

In addition to the water quality parameters described in Table 2.1, a monitoring plan may also include sampling for benthic macroinvertebrates, zooplankton, phytoplankton, and periphyton as these organisms provide a good indication of aquatic ecosystem health. For more information on these organisms, sampling protocols, and what they can tell us about the quality of surface water, see Part C – Biological, of this manual.

2.1.3.2 Inter-Relationship of Water Quality Parameters

In addition to the role of established water quality parameters and what they tell us about the quality or condition of the water, it is important to note that some of these parameters have an affect on other parameters. The following table provides a brief description of some inter-relationships between water quality parameters.

Table 2.2: Inter-Relationship of Water Quality Parameters

1st Parameter	2nd Parameter	Relationship
Specific Conductivity	**TDS**	**Specific Conductivity** and **Total Dissolved Solids (TDS)** are related, and each provides a measure of the dissolved salts in a waterbody. TDS is the sum of constituents such as chloride, sulphate, etc.
Turbidity	**TSS**	**Turbidity** is typically relative to the concentration of **Total Suspended Solids (TSS)** in a waterbody. In situations where there is high colour, this relationship may be less straight forward.
Temperature	**DO**	The amount of **Dissolved Oxygen (DO)** in water increases with cooler water **temperatures**.
pH and Temperature	**Ammonia**	The toxicity of **Ammonia** in water increases with higher **pH** and **temperature**.
Secchi Disc Reading	**Turbidity, Colour, Algae**	The **Secchi Disc** measures light penetration in water. Light penetration is reduced by these three parameters.
Chloride	**Nitrite**	The toxicity of **Nitrite** in water decreases with increased **Chloride**.

1st Parameter	2nd Parameter	Relationship
Hardness	**Alkalinity**	**Alkalinity** and **Hardness** concentrations are often very similar as both are measures of the concentration of alkaline compounds such as calcium and magnesium.
Hardness, DOC	**Metals**	The toxicity of **metals** such as copper and zinc decreases with increasing **Hardness** and **DOC**.

Adapted from the Protocols Manual for Water Quality Sampling in Canada (CCME, 2011)

Surface water sampling methodologies are discussed in sections 5 and 6. Detailed sampling instructions are provided in Standard Operating Procedures (SOP) which are provided in Appendix 2 of this *part* of the BCFSM.

2.1.4 Monitoring and Sampling Frequency

A key factor in planning a monitoring program is the frequency of monitoring and sampling which should be established to meet the program's objectives. Water quality data collected over one or more decades may be required to obtain sufficient data to observe and interpret trends. Monitoring data collected over a long term increases the possibility that variations caused by climate change, changes in land use or water management practices will be observed (Taylor, et al., 2001).

Monitoring may be conducted manually using meters and sondes as part of a monitoring event or in conjunction with sampling. Sampling may be conducted annually, bi-annually, monthly, weekly or a frequency required for comparison to water quality standards such as the B.C. Water Quality Guidelines.

A guiding principle for determining the most appropriate frequency for sampling will depend in part on the following considerations and potential program objectives:

- short-term and long-term objectives,
- comparison to chronic or acute water quality guidelines,
- a requirement to identify and or track seasonal effects,
- establishing trends,
- identification of land use or industrial impacts,
- seasonal sampling station accessibility; and,
- budgetary constraints.

3 Quality Assurance / Quality Control

A thorough program of quality assurance/quality control (QA/QC) will enable the collection of meaningful and scientifically credible samples. Monitoring programs should include a quality assurance (QA) and quality control (QC) component in their design and in the plans produced through that design. Competent QA/QC protocols will help ensure that samples are free of contamination, properly preserved, unbiased, and representative of the parent material from which they are sourced. Samples that are collected under these controls and analyzed by a laboratory with strong QA/QC protocols such as those required for accreditation to ISO/IEC 17025 provide reliable and robust information regarding the quality of the surface water being monitored. The reliability of analytical results is crucial when the objectives of the monitoring plan include the detection of small changes in surface water quality parameters. A comprehensive presentation of QA/QC requirements pertaining to all environmental matrices is provided in Part A - Quality Control and Quality Assurance of this manual. Detailed information regarding QA/QC aspects and requirements specific to surface water quality monitoring is provided in the following sub-sections.

3.1 Controlling Variability and Bias in Sampling

The analytical results of a SWQMP will always include a component of random variability and bias, collectively referred to as 'error' (EPA 2002; Table 1). Error can be introduced during field sampling and unlike analytical errors, which are usually well understood and controlled by laboratory QA/QC procedures, errors introduced in the field are more difficult to identify, quantify and control (EPA 2002). Random variability can arise from the inherent heterogeneity of the media being sampled, or from inconsistent sampling methods. Bias can arise from any sampling device, sampling method or transport procedure that could create a systematic shift from the true value (EPA 2002). It is important that field staff identify and understand the potential sources of error within a SWQMP prior to heading out to the field. The following sections describe certain protocols and QA/QC measures that should be implemented as part of each SWQMP to reduce variability and bias that may occur in the field.

Table 3.1. Types of Sampling Error (Adapted from EPA 2002)

Type of Sampling Error	Description	Strategy to Minimize
Fundamental Error	Inherent error that exists due to the natural heterogeneity within the material to be sampled.	▪ This type of error remains even when sampling methods are properly deployed. ▪ This type of error can be minimized by increasing the volume of the sample collected.
Grouping and Segregation Error	Results from the local heterogeneity around the area from which a sample is collected. Particles may either group together or segregate naturally.	▪ Grouping Error – Take many samples. ▪ Segregation Error – Homogenize the sample.
Increment Delimitation / Extraction Error	Occurs when the sampling device excludes certain portions of the material to be sampled, or when parts of the sample are lost during sampling	▪ Select sampling devices that can properly capture and retain all of the flow in an undisturbed cross-section.

Type of Sampling Error	Description	Strategy to Minimize
Preparation Error	Results from incorrect sampling methodology including handling, preservation and contamination.	▪ Implement standardized sampling protocols that will prevent contamination during handling and shipping. ▪ Use QA/QC tools such as replicate sampling to identify sources of preparation error. ▪ Properly store samples during transport.

3.2 Field Quality Assurance Program

The quality of data generated in a laboratory depends, to a large degree, on the integrity of the samples that arrive at the laboratory. To ensure that analytical data are robust and fit for purpose, the field investigator must be appropriately trained in surface water sampling, follow established sample collection protocols, and take the necessary precautions to protect samples from contamination and deterioration. Standard Operating Procedures (SOPs) located in Appendix 2 of this part of the BCFSM, provide detailed instruction for surface water quality sampling. These SOPs should be reviewed during the design phase of the SWQMP and incorporated into the SWQMP where relevant.

A competent Field Quality Assurance program includes a series of steps, procedures, and practices:

Sampling Materials and Equipment

› Sample bottles, including bottle caps, must be provided by the issuing laboratory, and certified as 'contaminant free'. Bottles must be supplied with caps in place. Upon receipt ensure the caps are fully closed to isolate and protect the inner portion of the bottle from contamination during preparation and transport.

› Use analyte specific bottle types as recommended by the issuing laboratory.

› Keep sample bottles in a clean environment, away from dust, dirt, fumes, and grime. Bottles must be capped at all times and stored in clean containers such as hard-bodied coolers, prior to and after the collection of the sample. Vehicle cleanliness is an important factor in eliminating sources of contamination.

› Reagents and preservatives must be analytical grade and certified by the issuing laboratory as contaminant free. Containers holding chemical reagents and preservatives should be clearly labeled to identify their contents and the expiry date of those contents. Expired reagents or preservatives should **not** be used. Return expired reagents to the laboratory for proper disposal.

› Sampling equipment, instrumentation, and coolers must be cleaned prior to deployment, following competent protocols. Adequate cleaning is more efficiently completed in the controlled environment of a laboratory-type setting (support facility). For sampling events that include ultra low level analyses, cleaning should only be carried out in a clean and controlled indoor facility. Store cleaned equipment in labelled, sealed plastic bags.

› Ensure that equipment is properly maintained and calibrated before each sampling event (Alberta Environment 2006).

› De-ionized water used for QC purposes should be provided by the testing laboratory, clearly labeled with both the filling date and expiry date and should not be used after 6 months (shelf-life period).

Sample Collection and Field Measurements

- To ensure data are produced to a consistent and established standard, field staff should be properly trained and provided with a sampling plan that outlines where and when water samples and field measurements are to be collected, the type of sampling equipment and methods that will be required, how the samples should be preserved, the type of analyses that need to be conducted and which laboratory the samples should be sent to (CCME 2011).
- Field staff must keep their hands clean, wear nitrile gloves, and refrain from eating or smoking while working with water samples.
- The inner portion of sample and preservative bottles and caps must never come in contact with bare hands, gloved hands, thermometers, probes, preservative dispensers, or equipment parts.
- Remove caps immediately prior to sampling and re-cap immediately following sample collection or filling. During sample collection, store bottle caps in a clean, resealable plastic bag, not in pockets, etc.
- Sample bottles provided by the laboratory must **not** be rinsed with the sample water being collected.
- For low and ultra-low level analyses, filtration should be carried out using individually wrapped syringes and single use individually wrapped disc filters.
- Petroleum products such as gasoline, oil, and exhaust fumes are prime sources of contamination. Fuel spills or drips (which often occur in boats) must be cleaned up immediately. Exhaust fumes and cigarette smoke can contaminate samples with lead and other heavy metals. Air conditioning units are also a source of trace metal contamination (CCME, 2011).
- Field measurements should always be taken in-situ when possible. Ex-situ measurements can be taken from dedicated sub-samples which are discarded when the measurements are complete. Field measurement instrumentation probes should never be inserted into a water sample that is subsequently sent to the testing laboratory for analyses.
- Ex-situ field measurements should be taken individually in dedicated sample containers to avoid contamination. In particular specific conductance should never be measured in sample water that was first used for pH measurements as potassium chloride diffusing from the pH probe alters the conductivity of the sample. **Dissolved oxygen measurements (by DO probe) should be made *in-situ* rather than in a separate container.**
- If conditions dictate that samples from multiple sites be preserved at the same time (such as when returning to shore after sampling several deep stations), the possibility of adding the wrong preservative to a sample or cross contaminating the preservative stocks should be minimized by preserving all the samples for a particular group of variables together. Colour-coded bottles and matching preservatives will help prevent mix-ups.

Sample Storage and Transport

- Samples must be placed in a chilled container immediately after collection. Samples must never be permitted to get warm; they should be stored in a cool, dark place. Hard-bodied coolers packed with double-bagged ice, or plastic bottles filled with water and frozen, are recommended. Samples collected for most types of analyses must be cooled to 10°C and maintained at or below that temperature until they are received by the laboratory. Conversely, samples must not be permitted to freeze unless freezing is part of the preservation protocol.
- Samples must be shipped to the laboratory without delay to ensure they arrive within 24 hours of sampling. Certain analyses must be conducted within 48 hours of collection.

3.3 Quality Control Samples

Quality control samples are used to verify the integrity of regular samples and subsequently to demonstrate the reliability of analytical data produced during a sampling event or program. Quality control samples can be used to measure the precision of analysis, detect contamination incurred during the sampling process, contamination of equipment or the environment and detect contamination within sample bottles and preservatives. The number of QC samples, the type of QC samples collected, and the parameters tested for any given sampling event will depend on the project type, Data Quality Objectives (DQO), and where applicable, based on historic sampling.

The following table provides ENVs recommendation for the frequency of QC samples.

Table 3.2. ENV Recommended Frequency for Quality Control Samples

QA Sample Type	Purpose	Recommended Frequency	Applicable Parameters
Replicates	Precision as an aggregate of sampling process, natural heterogeneity, and laboratory process	1 for every 10 samples	monitoring program parameters
Equipment/ Filtration Blank	Bias and imprecision resulting from contaminated equipment	1 per day, 1 for each type of sampling equipment used (for non-dedicated equipment), or 1 per sampling station	contaminants of concern
Trip Blank	Bias and imprecision resulting from cross-contamination between sample containers	1 per shipment/cooler	volatiles only
Ambient Blank	Bias and imprecision resulting from ambient contaminants	1 per day or 1 per geographical area	contaminants of concern

3.3.1 Quality Control Blanks

Blanks are samples of de-ionized or distilled water that is free of the target parameters to be analyzed. Blanks such as bottle blanks and preservative blanks are prepared by laboratories (Laboratory Blanks) to ensure those products are contaminant free prior to use or distribution for use by field staff. Blanks, including bottle blanks and equipment blanks can be prepared by field staff (Field Blanks) in a controlled indoor setting or in the field to detect the presence of or demonstrate the absence of contaminants that may have entered a bottle or equipment during transport to a sampling station or during sampling activities.

3.3.1.1 Laboratory Blanks

Quality control blanks such as trip blanks and bottle blanks are prepared by laboratories for a number of end uses. Trip blanks are used by field staff to detect contamination by volatile substances during a sampling event. In-house uses of laboratory blanks include batch-proofing field supplies such as preservatives, deionized water, and sample bottles. The analytical results of laboratory/control blanks provide supporting evidence that analytes detected and measured in regular samples are solely attributable to their source material.

3.3.1.1.1 Trip Blanks

Upon request, trip blanks are provided to samplers by the testing laboratory that will be analyzing a monitoring program's regular samples. A trip blank is used to determine if cross-contamination has or may

have occurred during the handling, storage, and shipment of regular samples. The trip blank is a laboratory-prepared water sample (typically distilled or deionized water) whose quality is known and documented. The trip blank is labelled by the lab and shipped along with requested sampling supplies to the sampler. The trip blank must remain closed for the entire duration of the sampling event and transport to the laboratory. One trip blank should be included in each cooler used to store and transport samples collected for the analysis of volatile substances. For most SWQMPs, trip blanks may be of limited value however, they may be useful in a sampling program where previous contamination was detected from an unknown source, where the validity of the analytical data may be challenged or require support, or if there is high potential of cross-contamination.

3.3.1.1.2 Bottle Blanks

As a measure of due diligence, most laboratories segregate the sample bottles they receive from a supplier until they are able to ensure they are contaminant free (batch proofing). To ensure the bottles are free of contamination, bottle blanks are prepared for each batch of bottles received. Bottle blanks prepared by a laboratory typically involve filling the bottle with deionized water which itself has been tested to ensure it is contaminant free. The bottle blanks are submitted for testing and reported back. The results of the analytical tests performed on the bottle blanks provide evidence that the bottles are contaminant free at which point they are released for distribution to their clients. For most monitoring programs this level of quality assurance is sufficient.

3.3.1.1.3 Preservative Blanks

Preservatives supplied to laboratories are typically provided in ‘lots’. Prior to use within the laboratory or distribution to clients, the lots are tested to ensure they are contaminant free. To ensure the preservatives are free of contamination, preservative blanks are prepared for each batch of bottles received. Preservative blanks prepared by a laboratory typically involve mixing an aliquot of the preservative with deionized water which itself has been tested to ensure it is contaminant free. The preservative blank is submitted for testing and reported back. The results of the analytical tests performed on the preservative blank provide evidence that the preservative is contaminant free at which point it is released for use within the laboratory and for distribution to their clients. For most monitoring programs this level of quality assurance is sufficient.

3.3.1.2 Field Blanks

Field blanks are samples prepared by field staff in a controlled indoor setting or in the field. Field blanks are prepared using laboratory supplied analyte-free deionized or distilled water whose quality is known and documented. Field blanks can be prepared to identify the presence and magnitude of contaminants in the sampling environment, contaminants in or on sampling equipment, or a combination thereof. Field blanks can be submitted as blind blanks or identified to indicate their purpose (e.g. Equipment Blank XX-XX, Filter Blank XX-XX). Regardless of the objective of the field blank, details of the full process of preparing the blank must be recorded in order to realize the full potential of its analytical results. Field blanks provide a versatile and powerful QA tool that can be customized to suit a sampling station or sampling plan.

Field blanks can be prepared to address a single aspect of exposure to potential contaminants or prepared to capture more than one aspect or all aspects of exposure. Field blanks prepared to capture a single aspect of exposure include ambient blanks and filter blanks. Field blanks prepared to address multiple aspects of exposure are subjected to or processed through a piece of sample equipment or the full sample collection and preservation process.

Detectable concentrations of analytes in field blanks should be investigated to determine the source of contamination, and to determine the potential impact of this contamination upon the sample data produced

during the sampling event. This evaluation may require the analyses of additional field blanks, laboratory blanks, and equipment blanks. Analytical results for regular samples may require rejection or qualification based upon the degree and source of contamination. Note that detectable concentrations of analytes in field blanks can not be subtracted from the reported results of regular samples.

The following field blanks can be used as described and titled or used as a template to prepare field blanks for specific objectives in which case the method and perhaps the title of the blank should be changed accordingly.

3.3.1.2.1 Bottle Blanks

Sample bottles received from most laboratories have been batch tested to ensure they are contaminant free. When sample bottles are received from a laboratory, they should be checked to ensure that damage has not occurred during transport, and that bottle caps are firmly in place. As a measure of added due diligence there may be value in preparing and submitting a bottle blank for one or each type of bottle that will be used in the sampling event. These blanks are best prepared in a controlled environment in which case the detection of contamination can reasonably be attributed to the bottle itself. Bottle blanks can also be prepared in the field in which case contaminant detection may be attributed to the bottle or an ambient source. In either case laboratory supplied deionized or distilled water is poured directly into the bottle or bottles which are subsequently handled as regular samples and submitted for analysis/analyses of target analytes.

3.3.1.2.2 Preservative Blanks

As with laboratory supplied sample bottles, preservatives received from most laboratories have been batch tested to ensure they are contaminant free. When preservatives are received from a laboratory, they should be checked to ensure that preservative container is intact, caps are firmly in place, and there are no visible signs of seepage. As a measure of added due diligence there may be value in preparing and submitting a preservative blank for one or each type of preservative that will be used in the sampling event. These blanks are best prepared in a controlled environment in which case the detection of contamination can reasonably be attributed to the bottle itself. Preservative blanks can also be prepared in the field in which case contaminant detection may be attributed to the bottle or an ambient source. In either case laboratory supplied deionized or distilled water is decanted into a sample bottle along with an aliquot of preservative. The preservative blank is subsequently handled as regular sample and submitted for analysis/analyses of target analytes.

3.3.1.2.3 Ambient Blanks

Ambient blanks measure contaminants in the sampling environment. Ambient contamination may stem from airborne particles, sampling surfaces or gloves. Ambient blanks are useful for projects where sampling is required in high-traffic corridors, industrial settings impacted by emissions, and projects aimed at identifying analytes at trace concentrations. Ambient blanks are prepared by filling a laboratory supplied sample bottle or bottles with deionized water in the same location as regular samples. The sampling bottle should remain open for the same period of time it takes to collect and process a regular sample. If the sole purpose of the ambient blank is to identify potential ambient contaminants, a wide-mouth jar is recommended and the amount of time the bottle is exposed to the ambient environment can be adjusted to achieve the purpose of the blank.

3.3.1.2.4 Equipment Blanks

Equipment blanks are used to assess whether the sampling equipment that will subsequently be used to collect or process regular samples has contributed contaminants to those samples. With the exception of single-use items such as syringes, field equipment should be decontaminated prior to sampling. Equipment decontamination should be repeated at each sampling station.

To prepare an equipment blank laboratory-prepared deionized or distilled water is processed through the same equipment that will be used to collect and process regular samples. This can include pumps and pump tubing, syringes, filters, and any other equipment that will or may come into contact with the sample material. Equipment blanks can be obtained from individual pieces of equipment to isolate and report on a specific piece of equipment, or it can be obtained from the complete assembly of equipment through which the sample material will travel. One equipment blank should be taken per day, per sampling station, or one per each type of sampling equipment used.

Equipment blanks can be submitted to the lab for analysis of contaminants of concern such as known or suspected airborne contaminants that may land on or in the sampling equipment after decontamination. More commonly, equipment blanks are analyzed for contaminants detected in previous investigations that may still exist after decontamination. Equipment banks can also be analyzed for any parameters included in the SWQMP to ensure that any detectable levels of a reported analyte in a regular sample is solely attributable to the surface water being sampled and not present or elevated by an artifact of previous sampling events or contaminated equipment.

3.3.1.2.5 Filtration Blanks

Filtration blanks are meant to detect contamination that may have been introduced from contact with filters or any type of filtering apparatus used in the sampling protocol (CCME 2011). In addition, filtration blanks can be used as a check for potential cross-contamination through inadequate field cleaning techniques (i.e., rinsing of the apparatus with de-ionized water between samples). To collect a filtration blank, de-ionized water is passed through the filtration apparatus in the same manner as the regular sample and collected for analysis. Each filtration blank collected should be preserved in the same fashion as the field samples. Filtration blanks for single use filters such as disc filters are only required once per sampling event. Filtration blanks for multi-use filtration devices should be collected before the first field sample is collected and again at some point between samples (after the apparatus has been cleaned and immediately before the next field sample is filtered).

3.3.2 Replicate Samples

Replicate samples are two (duplicate) or more independent samples that are collected as close as possible to the same point in space and time (i.e., in quick succession, or side-by-side) and are intended to be near-identical. Duplicate samples are commonly referred to as ‘blind duplicate samples’ because they are identified and labelled in a manner that conceals their purpose from the receiving laboratory to mitigate the potential for bias. Duplicate samples are submitted to the laboratory to assess precision as an aggregate of the sampling process, natural heterogeneity, and the laboratory process. Three or more replicate samples can be collected to determine mean values and standard deviations which allow a parameter to be reported within a confidence interval.

For non-volatile samples, blind duplicate samples are prepared by alternately filling two identical sample containers until both are full. For VOCs two sets of laboratory supplied pre-charged 40 mL sample vials used. In preparation, two sets of vials are laid out; one set for the regular sample and the second set for the duplicate sample. The vials are alternately filled up, going back and forth from the regular sample vials

to the duplicate sample vials. It is important to ensure that each vial is completely full. The information recorded on the label of a blind duplicate sample bottle/s should not in any way indicate that it is a duplicate of a regular sample. The identification of duplicates and their parent (regular) sample should be recorded in field notes. Note that the time of sampling should not be altered to hide the fact that it is a duplicate as there could be legal issues related to tampering with data (Nielsen, 2006).

3.3.2.1 Relative Percent Difference

The analytical results of duplicate samples are required to calculate relative percent difference (RPD). Duplicate samples are prepared by alternately decanting sample water into two identical sample containers until both are full or by collecting two samples side by side simultaneously. The information recorded on the label of a blind duplicate sample should not in any way indicate that it is a duplicate of a regular sample. The identification of duplicates and their parent (regular) sample should be recorded in field notes. Note that the time of sampling should not be altered to hide the fact that it is a duplicate as there could be legal issues related to tampering with data (Nielsen, 2006).

Analytical results for the regular sample and it's corresponding duplicate sample are compared using the calculated variability of the results expressed as Relative Percent Difference (RPD_{DUP}) which is calculated as:

$$\%RPD = \frac{(\text{sample result} - \text{duplicate result})}{((\text{sample result} + \text{duplicate result})/2)} * 100$$

RPD is defined as the absolute value of the difference between the results for the original and duplicate samples, divided by the average of the results. Because precision decreases as parameter concentrations near a laboratory's method detection limit, RPD_{DUP} values are only calculated where the analytical results of the original or the duplicate sample is greater than five times the laboratory's method detection limit. As such, it is important when possible to collect blind duplicate samples from waterbodies that have known impacts and or detectable concentrations of the target analyte rather than from waterbodies known to have non-detectable or very low concentrations of the target analyte.

RPD values should be reviewed to indicate if there is a problem with precision. Acceptable RPD values should be established as Data Quality Objectives (DQOs) as described in section 2.2.1. Acceptable RPD values differ by parameter type and analytical method and as such DQOs should be established with consideration of the inherent variablity of the source water and in consultation with the analytical laboratory to ensure that reasonable but robust objectives are used. Quality assurance plans should include actions to be taken in the event that DQOs are not achieved.

3.3.2.2 Standard Deviation

Replicate samples are also used to determine mean values and standard deviations where the mean value is the average of the samples and the standard deviation is a quantifiable representation of the imprecision. These calculations will determine a confidence interval which is an important tool in quality assurance.

The following example uses the analytical results of total phosphorous for triplicate samples reported at concentrations of 21.4 ug/L, 21.9 ug/L and 22.8 ug/L. The **mean concentration** of total phosphorous in these samples, calculated as (21.4 + 21.9 + 22.8)/3, is **21.03 ug/L**.

Using the equation: $SD = \sqrt{\frac{\Sigma|\chi - \mu|^2}{N}}$ where x is the data point and μ is the mean, we derive a **standard deviation** of **0.60 ug/L**.

Using the standard deviation of 0.60 ug/L produces a **66% confidence interval** of 21.03 ug/L ± 0.60 ug/L which tells us that at one standard deviation we can be 66% confident that the concentration of total phosporous is between **20.43 ug/L and 21.63 ug/L**. For greater confidence increase the number of replicates and use two standard deviations. Adding two more analytical results, reported at concentrations of 21.5 ug/L and 22.5 ug/L, produces a SD of 0.55 and a mean of 22.02 ug/L. At a **95% confidence level** the concentration of total phosporous is reported as a **confidence interval of 20.92 ug/L to 21.12 ug/L**.

Acceptable confidence levels and intervals should be established for each parameter during the development of the SWQMP. If confidence intervals calculated from reported analytical data are unacceptable, the source of the imprecision should be investigated. A sample splitter can be used to produce highly homogenous sample material for use as replicates. If the standard deviation of these replicates is significantly lower, it may mean that the sample material is inherently heterogenious or more control is required in the collection, processing and handling of samples in the field.

Alternately replicate samples prepared from a reference material can be submitted. In this case, if the standard deviation produces an acceptable confidence interval, a comensurate portion of the source of the imprecision can be assigned to sample collection, processing and handling. If the standard deviation remains high or unacceptable the testing laboratory will have to be engaged to determine the root cause.

3.3.3 Split Samples

Split samples are two or more aliquots that are taken from the same sample (i.e., split) and analyzed independently by one or more laboratories. Samples can be split in the field or in the laboratory, or both. Split samples are assumed to be identical and since they are not influenced by environmental heterogeneity like duplicate samples are, they can be used to measure just the field and laboratory precision of the sampling program (CCME 2011). When preparing split samples in the field (to measure field precision), care are must be taken to ensure that the initial sample is split in a way that ensures the greatest degree of homogeneity. Ideally, a sample splitter is used to homogenize and split the sample in the field following the methods outlined in SOP E1-01; however, in some circumstances it may be necessary to conduct side-by-side sampling instead (ENV 2019). If the sample is split in the lab instead of the field, it can be used to estimate analytical precision, and to identify contamination, random and systematic errors, or any other variability, which could be introduced after the time of sampling through analysis at the laboratory. Split samples are commonly used to compare two or more laboratories (i.e., inter-laboratory variability) or the consistency and precision of a single laboratory (CCME 2011).

Permit holders in British Columbia may be required to collect and submit split samples as part of ENV's Split Sample Audit Program.

Information on the program and criteria for collecting split samples can be found in ENV's 2019 publication titled *Split Sample Audit Program, Guidance Document for Permit Holders* which is available at: https://www2.gov.bc.ca/gov/content?id=A9BE9DDAB0674DD29D1308C4BEE7FBB4.

3.3.4 Spiked Samples

Spiked samples are used to assess a laboratories analytical accuracy. Spiked samples are prepared by spiking aliquots of a randomly selected water sample with a known, measured amount of a target analyte.

The spiked solution is prepared by an analytical laboratory (preferably), or it can be prepared by field staff (far less desirable) prior to a sampling trip. After adding an aliquot of spiked solution to the water sample, recap the bottle, mix, and then treat the sample as if it were a regular sample (i.e., preserve and filter if required). Additional aliquots of the un-spiked material are used to prepare regular samples, and both are submitted for analysis of the target analyte. The information gained from spiked samples is used to reveal any systematic errors (or bias) in the analytical procedure that may arise from matrix interference or analyte degradation. Accuracy of the analysis process can be estimated by determining the concentration of the target analyte in the spiked sample and subtracting the concentration reported for the un-spiked sample. Recovery can be estimated by determining how much of the target analyte is detected during analysis (Alberta Environment 2006). Alberta Environment (2006) recommends that one spiked sample be prepared for every 20 field samples, and that it is only used for variables of concern.

3.3.5 Reference Samples

Reference samples are used to document the bias and precision of the analytical (laboratory) process and serve as a performance test for the laboratory before a sampling program begins (Alberta Environment 2006). There are two types of reference samples. The first, and simplest type, can be prepared and provided by an independent laboratory (i.e., a laboratory that is not involved in the analysis of project samples) by adding a known quantity of the variable of interest to a known amount of pure water. The independent laboratory then sends the reference sample to the analyzing laboratory (i.e., the laboratory that will be analyzing the project samples) for analysis. The independent laboratory would provide the field staff with information on the variable amount and concentration that was added to the reference sample. This information can then be compared to the results produced by the analyzing laboratory to identify bias and precision of the analytical process.

The second type of reference sample is a certified reference sample (CRS). CRSs are used to measure analytical accuracy. CRSs are obtained from a recognized national scientific body such as the National Research Council. The sample itself is an aliquot of a very large stabilized (may be preserved) batch sample that was collected from one place at one time. The concentrations of target analytes for each CSR are established through a large number of analyses performed by independent laboratories. Consequently, the distributing agency can provide a mean value and confidence interval for the variable of concern based on the data from the multiple independent analyses. These samples are submitted blind (i.e., labeled as a regular sample) to the analyzing laboratory along with the regular samples collected during a field trip. There is the option of submitting them blind or non-blind with labeling that identifies the sample as a certified reference material. The former is a more desirable QA tool.

3.4 Field Equipment – Introduction

A comprehensive maintenance protocol for field equipment is an essential component of QA/QC which should be included in a SWQMP. The maintenance protocol should stipulate a requirement for equipment maintenance which must include any routine maintenance and calibration requirements specified by the manufacturer. Protocols should also include field-prep checks to ensure the equipment is functioning properly, battery checks to ensure there is capacity to operate for the duration of a sampling event, cleaning/decontamination, and storage procedures.

Thorough decontamination of field equipment is required to minimize the potential for cross-contamination between samples or sampling events. The primary objective of equipment decontamination is the prevention of sampling equipment from being a source of contamination that could affect the concentrations of target analytes in the collected samples (USGS 2004). Equipment should be properly cleaned before sampling to remove residue from new equipment, to remove dust / contaminants from stored equipment,

during sampling (i.e., between samples), and again immediately after use (CCME 2011). The effectiveness of the cleaning protocol can be monitored by analyzing equipment blanks taken after decontamination (see Section 3.3.1.2.2).

3.4.1 Cleaning and Decontamination of Sampling Equipment

Decontamination protocols vary based on the type of analysis required (i.e., organic vs inorganic analysis). The following cleaning and decontamination protocols are adapted from CCME 2011 and USGS 2004.

Trace Inorganic Analysis – Decontamination Protocol

- To remove particulate matter, residual oils and grease, scrub equipment with brushes and non-phosphate detergent (e.g., Liquinox, Contrad, Extran). A 0.1 – 2.0 % (v/v) detergent solution can be used to clean between field trips. Field cleaning solutions should not exceed 0.2% (v/v) detergent.
- To remove detergent residues rinse with tap water, followed by a distilled water rinse.
- Non-metallic equipment can undergo an acid rinse or 30 minute soak with a 5% (v/v) solution of hydrochloric acid (HCl) or a 10% (v/v) solution of nitric acid (HNO_3). Do not use nitric acid, if the samples collected will undergo nitrogen analysis.
    - Special care should be taken during this step including (1) conducting the acid rinses/soaks within a fume hood (or wear a respirator if fume hood is not available), (2) wear safety glasses and gloves, (3) consult the applicable Safety Data Sheet (SDS) for all chemicals used and (4) always add acid to water as opposed to adding water to acid.
    - Leftover acid should be stored in a labelled hazardous waste container, and properly disposed of.
    - Do not store acids next to solvents.
- To remove acid residues, three to five distilled water rinses should be performed. The last rinse should be done with de-ionized water.
- Air dry clean equipment. When the equipment is dry, store in clean containers or new re-sealable plastic bags. Equipment openings can be covered with Parafilm.

Trace Organic Analysis – Decontamination Protocol

- Containers must be stainless steel, glass or Teflon.
- To remove particulate matter, residual oils and grease, scrub equipment with brushes and non-phosphate detergent. For organic analysis, this should be done in the fume hood.
- To remove detergent residues rinse with tap water, followed by a distilled water rinse.
- Rinse with organic solvents (e.g., acetone, hexane or methanol). CCME (2011) recommends rinsing with hexane, allow the equipment to air dry, then rinse with acetone.
    - Special care should be taken during this step including (1) conducting the solvent rinses/soaks within a fume hood (or wear a respirator if fume hood is not available), (2) wear safety glasses and gloves, (3) consult the SDS for all chemicals used.
    - Discard solvent waste into a labelled container for organic solvents, and store in hazardous waste area for disposal.
    - Do not store acids next to solvents.
- To remove solvent residues, three to five distilled water rinses should be performed. The last rinse should be done with de-ionized water.

- Air dry clean equipment on a surface covered in new aluminum foil. When the equipment is dry store in clean containers or new re-sealable plastic bags. Equipment openings can be covered with Parafilm.

Stainless Steel – Decontamination Protocol

- Wash stainless steel equipment with a non-phosphate detergent.
- Rinse thoroughly with deionized water.
- Air dry and when dry, store in clean containers or new re-sealable plastic bags.

Peristaltic Pump Tubes and Other Specific Equipment – Decontamination Protocol

- Rinse with water (de-ionized, distilled or tap) inside and out. Remove all metal components and valves from the tubing.
- Soak or fill sampling tubing with 5% HCl and leave for 6-12 hours. Do not soak metal components of the sampling apparatus in acid.
- To remove acid residues, three to five distilled water rinses should be performed. The last rinse should be done with de-ionized water.
- Store tubing in clean containers or new re-sealable plastic bags. Tubing should be replaced annually.

3.4.2 Preventing the Spread of Invasive and Toxic Species

Sampling equipment and activities have the potential to spread aquatic invasive species or toxic algae (Cyanobacteria) between waterbodies if proper decontamination protocols are not followed. Aquatic invasive species of concern in B.C. include largemouth and smallmouth bass, New Zealand Mud Snails, and Eurasian milfoil. In addition, monitoring programs have been established for zebra and quagga mussels (IMISWG 2015). The spread of *Didymosphenia geminata* (Didymo), an aggressive native algae species, is also a major concern within B.C. (ENV 2019).

The following precautions were developed to prevent the spread of invasive aquatic and toxic algal species and are derived from CCME 2011 and B.C.'s "Clean, Drain and Dry" initiative (Gov. of BC 2021).

- Clean any sampling equipment, personal gear, watercraft, and trailers that have or may have come in contact with the waterbody. Mud, plant material and organisms should be removed, and the equipment should be pressure washed, or thoroughly rinsed with hot tap water (50ºC).
- Excess water should be drained from all sampling equipment and watercraft (bilge, engine, water pumps, etc.) either within the waterbody, or on land in the vicinity of the waterbody.
- If pressure washing is not available, watercraft and trailers should be dried in the hot sun for five days.
- If rinsing is not sufficient, additional options for equipment decontamination include:
    - Freeze for two or more days; or,
    - Soak equipment in a saltwater solution (2/3 cup of salt per 1L of water) for 24 hrs; or,
    - Soak equipment in white vinegar for 20 minutes; or,
    - Soak equipment in a solution of diluted household bleach (100 ml bleach per 20L of water) for 60 minutes.
- Dispose of unwanted aquatic organisms at the source to avoid spread of or release into another waterbody.

- If possible, avoid launching watercraft into more than one waterbody per day to allow time for the boat and gear to dry.
- Avoid using felt-soled waders, as these are difficult to disinfect and can easily disperse aquatic invasive species.

3.4.3 Preventing the Spread of Whirling Disease

Whirling Disease is an infectious disease caused by *Myxobolus cerebralis,* a protozoan parasite. *M. cerebralis* infects two hosts as part of its life cycle: Finfish, such as trout, salmon and whitefish, and the freshwater worm, *Tubifex tubifex*. After contracting the disease from an infected worm, affected finfish experience skeletal deformities and often adopt a 'whirling swimming pattern'. Whirling disease is fatal for up to 90% of infected fry and fingerlings (CFIA 2016). Whirling Disease was first detected in Alberta's Banff National Park and has since been detected in four watersheds within Alberta (Alberta 2017) and subsequently in eastern British Columbia in 2023.

In addition to the general protocols provided in Section 3.4.2, Alberta's *Decontamination Protocol for Work In or Near Water* provides additional guidance on decontamination techniques specific to controlling the spread of Whirling Disease (Alberta 2017).

4 Field Preparations

4.1 Preparing to Go to the Field

Sampling preparations include a variety of tasks which should be identified during the development of a SWQMP. Preparations should begin well in advance of each sampling event to ensure that all of the plan's objectives are achieved. Checklists aid greatly in avoiding oversights which are usually discovered when the field crew arrives at their first sampling location. It is strongly recommended that field staff prepare for a sampling trip with a checklist designed to meet the specific sampling requirements of each project. A generic checklist, provided in Appendix 1, can be used as a template, or starting point.

Before going to the field (USGS 2018, EC & ENV 2005):

- Prepare or review the project's work plan and design objectives. This should include a sampling schedule, a checklist of equipment and materials required, a list of planned environmental and quality-control samples that need to be collected, protocols (SOPs) for those sample types, and what analyses need to be conducted by the laboratory,
- Contact a qualified laboratory to arrange for the required analyses, pre-order bottles, preservatives (if required), trip blanks (if required), and chain-of-custody forms. Inspect all materials upon receipt from the lab for missing or damaged materials and ensure that bottle caps are secure,
- Prepare a bottle set for each sample station and store each set in a clean resealable plastic bag. To save time in the field, sample bottles should be pre-labelled at this stage,
- If filtration or preservatives are required, ensure appropriate supplies are included in your sample set and stored in designated containers,
- Place chain of custody forms, cooler labels and shipping waybills in a sealable plastic bag to protect them from moisture. Store this bag with sample bottle sets,
- Calibrate field meters, ensure batteries are fully charged and allow time for maintenance or repairs should they be required,
- Prepare a safety plan and provide your travel plans and details to a safety contact,
- If the sampling location is on private property, or if access to the sampling location requires crossing private property, contact the property owner before visiting the site to request access and inform them when the sampling will occur. Ask about access issues (i.e., key required, watch dogs, etc.); and,
- Carefully store sampling materials and equipment in a clean, secure location within your vehicle. Ensure the sampling materials are secure and will not move or become contaminated during transport. Key equipment should be packed in a dedicated travel box or plastic tote.

Ensure you have the following items:

- A site list with directions for access, sample location sketch, geo-referenced map (preloaded into a handheld field tablet), or Global Positioning System (GPS) and co-ordinates indicating the locations of the surface water sampling stations,
- Field notebook with all-weather/water resistant paper, writing utensils, permanent markers for labelling sample bottles, and a camera or video equipment as required,

- Standard Operating Procedure/s (SOP) for the type/s of sampling included in the SWQMP. SOPs are included in Appendix 2 of this *part* of the BCFSM,
- Ensure that coolers and sufficient quantities of ice are available to keep samples chilled throughout the sampling event and their transport to the laboratory,
- Assemble the sampling materials including pre-labelled sample bottles and extra (spare) bottles, preservatives, filters, and syringes all as required, nitrile gloves, and requisition forms (i.e., chain of custody),
- Assemble field equipment and tools required for sampling. Ensure instrumentation (e.g., water quality meters) has been calibrated, is in good working condition, batteries are fully charged and have adequate capacity for the duration of the sampling trip, and a toolkit for small repairs,
- Assemble and pack first aid kits, blankets, drinking water, radios and/or a satellite communication device; and,
- Personal gear for all possible weather conditions (e.g., survival suits, raincoats, protective footwear, waders, gloves, etc.).

4.1.1 Locating the Site in the Field

It is the responsibility of field staff to locate all sampling stations accurately. Only if the same location is consistently sampled can spatial and temporal changes in the quality of the subject water be interpreted with confidence. GPS coordinates are routinely used to locate the position of sampling sites and generally provide the most accurate method of assuring location. For lake sampling, a combination GPS/depth sounder unit can be used to locate the sample station, as well as confirm station depth prior to sampling.

If a GPS is not being used or GPS coordinates are not available, it is important to record accurate and well written descriptions of the site including key landmarks, cardinal points, and distances and features that can be used to locate each sampling station during subsequent sampling events. This information can be used to generate a site map which should be accompanied with informative photographic records.

4.1.2 Field Notes / Observations

Legible and detailed field notes are an important component of good sampling practice. A field notebook (3-ring binder with water-proof paper) is recommended for this purpose, but a laptop or handheld device such as a field tablet can be used. Field measurements and observations should be entered directly into the field notebook, and then scanned and entered into the project's database (if applicable) immediately upon return from the field. Field notes are important documents that are used in the interpretation of analytical data, to support project outcomes and defend findings. For these reasons considerable effort should be afforded to ensure they competently articulate relevant details and are properly archived.

Field notes should be written in a consistent format which in turn will prompt the recorder to include all pertinent information. At a minimum field notes should include the date, time of arrival and departure, site name and GPS coordinates, program or project name, purpose of the site visit, the names of the field crew, weather conditions, and general observations for each site. Specific information about seemingly unimportant facts such as the time of day or weather conditions are often important when interpreting data (CCME 2011).

Field parameters such as pH, temperature, Secchi (extinction) depth, conductivity, dissolved oxygen (DO), oxidation-reduction potential (ORP) and turbidity should be measured in the field and recorded in field notes. Field parameter measurements must also be recorded on requisition or chain of custody (COC)

forms to ensure they are included in laboratory reports, and where applicable, uploaded into databases. In addition, field staff are responsible for recording notable or unusual occurrences and observations. It is important to record any deviation from standard sampling protocols and the reason the deviation was taken (e.g., samples taken from a different location due to safety concerns or access limitations). If an alternate sampling location is required, the coordinates must be recorded along with a physical description of the location. In addition to recording these details in field notes, this information may also be included into the project database.

Observations of anomalies such as atypical flow conditions, unusual colour or odour, excessive algal growth, foreign substances (oil slicks, surface films, etc.), fish kills, or potential point or non-point sources of contamination must be recorded in field notes. These observations, along with the location's co-ordinates, should be reported immediately to the project manager as additional samples for analysis may be warranted to identify potential water quality impacts. In the case of observed anomalies, it may be prudent to collect and submit extra samples to be held by the laboratory for subsequent testing should the results of planned sample analyses indicate the need for further testing. The analytical results regardless of outcome will prove useful during the interpretive process of the study.

An example of a field data sheet is provided in Appendix 1. The template can be used to record site information and field parameters when sampling lakes/reservoirs or rivers.

5 Field Measurements

5.1 Introduction

Field measurements aid in the interpretation of analytical data, describe water quality conditions at the time of sampling and support the analytical data generated during a sampling event. Field measurements are taken prior to the collection of routine and QC samples to establish water quality parameters that are subject to rapid change upon exposure to the atmosphere. Most field parameters are taken at the sample station either in-situ by placing a probe or sonde directly into the water or taken ex-situ from a sample that is collected exclusively for that purpose. Field measurements for all parameters should be recorded in field notes or templates including those recorded by a datalogger. Field measurements must also be recorded in the appropriate fields of the requisition or COC form.

Physiochemical parameters monitored with field instruments in surface water include temperature, specific conductance, pH, Oxidation-Reduction Potential (ORP), dissolved oxygen (DO), stream flow, clarity, and turbidity. Most field measurements are taken using a physical device such as a Secchi disc, which is used to measure clarity, flow meter, parameter-specific meters or a multi-parameter instrument/sonde. Ideally, all field measurements should be taken directly within the waterbody, however depending on the type of equipment selected for the SWQMP, this may not always be possible. Parameters such as temperature, DO and ORP should **always** be measured directly within the waterbody. Other parameters such as pH, conductivity and turbidity can be measured in a sample drawn from the source and placed within an open container or cuvette in the case of turbidity (USGS 2008).

Specific conductance, pH, and turbidity should subsequently be measured in the laboratory as part of the General Chemistry analysis in order to identify and assess any change in chemistry during transport. A change in these parameters between the field and the lab may indicate that a secondary reaction may have occurred in the sample bottle, for example the loss of carbon dioxide or the presence of biological activity. A significant change in pH between the field and laboratory may affect concentrations of bicarbonate, ammonium, sulphate, hydrogen, and calcium. If a significant change between field and laboratory measured parameters exists, a review of sampling procedures and preservation measures should be completed.

Where applicable, field data are to be entered into the database (e.g., EMS for B.C. ENV) as soon as possible upon return from the field.

Detailed information regarding the collection of field measurements is provided in SOP E1-10 which can be found in Appendix 2 of this *part* of the BCFSM.

5.2 Field Measurement Instruments

Since numerous brands and models of field measurement instruments are available, this section will discuss their use from a general perspective only. Field staff are directed to, and should be familiar with, the reference documentation (i.e. user manual) provided by equipment manufacturers. It is good practice to prepare and include a simplified but complete set of instructions for the operation and calibration of each instrument, preferably laminated in plastic, in the instrument case. Most field instruments required for surface water quality are available for sale or rent from environmental/scientific equipment providers.

To ensure that field measurements are reliable, field instrumentation must be maintained and calibrated. Field staff must review and understand the instructions provided in the instrument's operations manual. A competent understanding of an instrument's functionality will enable the operator to properly deploy the instrument and detect any signs that the instrument may not be functioning properly. An equipment logbook

or spreadsheet that documents an instruments hours of operation, calibration results, calibration dates, and maintenance records is recommended for owned equipment. Hours of operation between calibration should also be recorded. Spare parts, including batteries where applicable, and specialized tools should be brought to the field with each instrument.

While individual instruments / meters exist for most field parameters (e.g. pH pen, turbidity meter, etc.), using multiple instruments in the field can be time consuming and difficult to pack into the field. Multi-parameter instruments, which deploy a sonde equipped with multiple sensors, have gained in popularity, and are regularly used as part of a SWQMP. Multi-parameter instruments are often capable of measuring temperature, DO, conductivity, pH, ORP, and turbidity at the same time. These devices include automated internal calibration mechanisms that must be checked during routine maintenance, and sondes that must be calibrated for each parameter. The required frequency of calibration may vary by instrument/manufacturer, but calibration should typically be conducted prior to and as close as possible to the field sampling event or season.

When taking surface water field measurements, the probe of the field measurement instrument should be held at approximately 0.2 m below the surface of the water. If using a multiparameter meter in a deep body of water, the sonde can be weighted and lowered down incrementally to record field parameters at multiple depths. Field measurements can then be recorded on the Field Data Sheet (Lake/Reservoir) provided in Appendix 1.

5.3 Field Measurements

5.3.1 Temperature

Temperature can be measured with a liquid-in-glass thermometer or with an electronic thermometer / multi-parameter instrument that has been calibrated against a lab-certified thermometer. Always record air temperature in addition to water temperature whenever samples are collected.

If using a liquid-in-glass thermometer, total immersion thermometers filled with alcohol are recommended for the field. Mercury-filled thermometers should never be used in the field. Measure surface water temperatures directly in the water, allowing the thermometer to come to equilibrium (one to two minutes) before recording the value to the nearest 0.5ºC. For deep waters, collect a grab sample (e.g., with a Van Dorn - Section 6) and decant some water into a 1 litre “field bottle”. **Never** measure the temperature in a sample bottle that is being submitted to the laboratory for other analyses. Measure the temperature as soon as the reading has reached equilibrium and record this value in the field notebook. Ensure that the corresponding depth is identified for each temperature recorded in the field notebook.

Temperature meters and multi-parameter instruments (recommended method) deploy a resistance device called a thermistor. The resistance of a thermistor changes with temperature and it is this relationship that is used to convert the value of its resistance to a temperature readout (USGS 2006). It is important to keep these devices calibrated, as the determination of other parameters measured by the device is based in part on this temperature and as such the accuracy of the temperature measurement is critical. Temperature data from meters are typically recorded to the nearest 0.2ºC (USGS 2006). For depth profiles, record temperature readings at increments of 1 - 2 metres. As a quality control measure, record the readings twice, once as the probe descends, and then again as it ascends. The sonde must be held at each desired depth until the sensor reaches equilibrium; for at least 60 seconds, or according to the manufacturer’s guidelines (USGS 2006).

Over time, thermometers and meters can become damaged and out of calibration (e.g., from thermal shock, or extended sunlight exposure). As such, all thermometers and meters must be checked against a reference

thermometer by a laboratory before use and, at a minimum, annually thereafter. Some meters may require calibration more frequently (check manufacturer's instruction), especially if they are heavily used (USGS 2006). Thermometers and meters that do not meet a data quality objective (i.e., accuracy) of the project should not be used.

Meters should be calibrated as per the operating instructions issued for each model. The field crew should carry an extra thermometer in the event that the accuracy of the primary field thermometer is in question. Meter temperature readings, both in air and in water, can be checked against this extra thermometer of known accuracy as an additional quality control measure. If the measures do not agree, the meter can be adjusted to the thermometer reading. This check should be repeated throughout the day to determine if the meter is "wandering". All adjustments must be recorded in the field notebook.

5.3.2 Dissolved Oxygen (DO)

Dissolved Oxygen (DO) meters provide a convenient and inexpensive method of measurement. DO meters can display DO concentration as milligrams per litre (mg/L) or as percent saturation (%). Luminescence-based (optical) DO sensors are the most widely used type of DO sensor, and they are available in single parameter meters or as part of a multi-parameter sonde (USGS 2020). Optical DO sensors include a luminophore-containing cap that needs to be replaced regularly according to manufacturer's instructions. Most sensor caps have a one to two-year lifespan (USGS 2020).

DO meters do not directly measure oxygen concentration; instead, the DO meter collects temperature and conductivity measurements along with the percent saturation of dissolved oxygen. These three values are then used to calculate the DO concentration which is provided in mg/L (USGS 2020). Most multi-parameter instruments are designed to automatically convert DO readings into concentrations. As such, it is important that the sensors for temperature and conductivity are maintained, functioning properly, and calibrated to ensure accurate readings of DO.

Obtain DO readings at increments of 1 - 2 metres both during the descent and the ascent of the probe. Allow the probe to equilibrate (a steady reading on the meter) at each depth before recording the value. When passing through a zone of rapid temperature or DO change (a lake thermocline for instance), additional time may be required for equilibration.

The Winkler method for the determination of DO concentrations (included in previous versions of this manual) is no longer used in the field but is still used as a method of calibration for DO sensors under laboratory conditions (USGS 2020).

5.3.3 Conductivity / Salinity

Conductivity is a numerical expression of the ability of matter to convey an electric current. If the matter is an aqueous solution, the term conductance is synonymous with conductivity. Either term is correct. Conductivity and salinity can be measured with a specific conductance meter or a multi-parameter instrument (e.g., a YSI multimeter) equipped with a conductivity sensor. Conductivity is often reported in micro siemens per centimeter (µS/cm).

Specific conductance (SPC) is a measure of a solution's ability to conduct electricity at 25ºC. Given that the conductivity of a solution changes with temperature, a correction is made (usually an internal automatic correction by the instrument) to estimate conductivity at 25ºC. The vast majority of instrumentation include automatic temperature compensation which report specific conductance. Meters with temperature compensation capabilities can be damaged such that the temperature compensation is not working. Therefore, instrument maintenance checks should include an evaluation of the instrument's temperature compensation. Routine maintenance protocols should include steps to follow the manufacturer's

instructions for storage, calibration, transportation, and use. The accuracy of the instrument should be verified against a conductivity standard.

During deployment, obtain readings at increments of 1 - 2 metres both during the descent and the ascent of the probe. Allow the sensor's readings to equilibrate at each depth increment before recording the corresponding value. The conductivity measured during descent should be averaged with that recorded during ascent. For quality control purposes collect a water sample from one or more depths and submit the sample/s to the laboratory for testing. Compare the instruments report with the laboratories report and ensure it achieves the SWQMP's DQO for that parameter. When measuring conductivity, keep in mind that high concentrations of suspended sediment, pH values lower than 4 or higher than 11, and temperatures lower than 5ºC and higher than 45ºC can be sources of measurement error, and alternative methods may need to be implemented (USGS 2019).

5.3.4 pH

pH is a unitless measurement of the hydrogen ion concentration in water ($pH = -\log_{10}[H+]$) which represents the acidity (<7) or alkalinity (>7) of a solution on a logarithmic scale from 0 to 14. Most natural surface waters have a pH between 6.5 and 8.5 (Hem, 1989). Either an electronic pH meter or a multi-parameter instrument is used to measure pH. The pH sensors inside of these instruments use ion-selective electrodes to measure hydrogen ion activity (USGS 2021). Generally, pH electrodes last 12 to 18 months before they need replacement (USGS 2021).

Most single-parameter pH meters require that the sample be brought to the surface, while the multi-parameter instruments can be lowered through the water column. pH measurements using samples brought to the surface are only accurate for the current conditions in a fresh sample. Rapid pH changes that occur as a result of gas diffusion, biological activity, and chemical reactions dictate that the measurements be performed as soon as possible following sample retrieval (i.e., within 15 minutes).

pH electrodes are available for specific measurement of pH in waters of low ionic strength and high ionic strength. It is imperative when measuring pH in water of low ionic strength that an electrode designed for measurement in solutions of low conductivity or dissolved solids be used.

Follow instructions as per the manufacturer's directions for calibration, storage, transportation, and use. The pH meter should be calibrated before heading into the field using buffer solutions provided by the manufacturer which will bracket the pH range of the samples [one neutral buffer at pH 7, one at acidic pH (4.0), and one at alkaline pH (10.0)]. If the reading does not correspond to the value of the buffer solution, adjust the meter, and record the discrepancy in the field notebook. Repeat this process before the end of the sampling day to verify the accuracy of the readings.

If using a single parameter meter, immerse the electrode directly into the surface water or into the field bottle (for samples collected from depth). Allow it to equilibrate before recording the value. If using a multi-parameter instrument, obtain pH readings at depth increments of 1 - 2 metres both during the descent and the ascent of the probe. Allow probe to equilibrate at each depth before recording the pH value. pH values are typically recorded to the nearest 0.1 pH unit.

5.3.5 Clarity

Water clarity in lakes and reservoirs is most commonly measured with a Secchi disc. The Secchi disc is a weighted disc, 20 cm in diameter, that is divided into black and white quadrants. The measurement is called the 'extinction depth'.

Lower the Secchi disc over the shaded side of the boat. Record the depth at which the pattern of the disc is no longer discernable. The disc should then be lowered beyond this depth and then retrieved. During the disc's ascent record the depth at which the pattern of the disc becomes discernable again. The average of the two depth readings is the extinction depth. Record these values in the field notebook along with the weather and water surface conditions (e.g., cloudy, sunny, windy, surface chop, etc.). Measurements should be to the nearest 0.1 meter.

Secchi disc readings should only be taken from 2 hours after dawn to 2 hours before dusk. During winter months, readings should only be taken between 10 A.M. and 2 P.M. Sunglasses should not be worn while taking the measurement.

5.3.6 ORP

Oxidation-Reduction potential (ORP) is a measure of the ability of an aqueous solution to gain (reduction) or lose (oxidation) electrons, therefore mediating chemical reactions within biological systems (EPA 2017). ORP is often reported in millivolts (mV), and a positive value indicates the substance tested is an oxidizing agent, and a negative value indicates the substance is a reducing agent. ORP measurements should always be taken *in situ* and because ORP is a temperature and pH sensitive parameter, these variables should always be recorded concurrent with ORP (EPA 2017).

ORP is most commonly measured with a multi-parameter instrument. Follow instructions as per the manufacturer's directions for storage, transportation, calibration, and use. Obtain readings for increments of 1 - 2 metres both during the descent and the ascent of the probe. Allow the probe to equilibrate at each depth before recording the measured value. As the meter approaches the lake bottom (use bathymetric maps or a depth sounder to assess depth), the readings may drop rapidly. At this point, take care that the probe does not contact the sediment.

5.3.7 Turbidity

Turbidity is a relative, qualitative measurement of the amount of light that is scattered or absorbed by suspended particles in a water sample. The suspended particles can be comprised of clay, silt, finely divided organic and inorganic matter, soluble coloured organic compounds, plankton, and other microscopic organisms (Connecticut DEEP, 2012). Water samples with higher turbidity will scatter more light and generate a higher numerical reading on the turbidity meter.

Turbidity is often measured using a turbidity meter however this parameter has also been incorporated into certain models of multi-parameter instruments and can be conveniently collected along with other field measurements. A multitude of turbidity probes are available and different probes use different wavelengths of light and angles of measurement to detect the scattered light (USGS 2005). As a result, different probes, based on their specific method of measuring turbidity, may utilize different units of measurement, some of which include Nephelometric Turbidity Units (NTU), Formazin Attenuation Units (FAU) or Formazin Nephelometric Units (FNU). For example, NTU and FNU both detect light scattered at 90º, but NTU probes use a white light source, whereas FNU probes use an infrared light source (USGS 2005).

Care should be taken when choosing a turbidity meter for a SWQMP, and only a single type of turbidity probe (and units) should be used throughout the monitoring program. Generally, NTU probes should be sufficient for most SWQMPs; however, based on the study objectives and water conditions, some monitoring programs may benefit from using probes that utilize a different measuring method / unit of measurement (e.g., when measuring turbidity > 1000 NTU, or if color compensation is desired). If that is the case, more information on choosing a turbidity meter can be found in Chapter 6.7 of the USGS National Field Manual for the Collection of Water Quality Data (USGS 2005).

5.3.8 Stream Flow

The concurrent measurement of stream flow alongside water quality can be valuable to many sampling programs. Not only do water quality parameter measurements often correlate with flow rate due to dilution or other processes, but pairing water quality data with flow rate allows total chemical loadings for the entire stream flow to be calculated.

Measuring flow in a stream or device requires strict adherence to established provincial protocols and as such the methods presented here are included to provide a conceptual understanding of common stream flow measurement methods. Detailed instruction for all appropriate methods of flow measurement are provided in the Manual of British Columbia Hydrometric Standards[6].Stream flow measurement methods vary in complexity with the main methods commonly used being the point velocity and depth measurement method (Area-Velocity Method) or through Dilution Gauging.

The **Area-Velocity Method** utilizes a current meter and involves the collection of liquid depth and velocity measurements at selected intervals across a channels cross section to determine the flow. The flow is equal to mean cross-sectional velocity multiplied by the cross-sectional flow area. A detailed methodology for performing this type of measurement is provided in the Manual of British Columbia Hydrometric Standards.

The **Velocity Head Rod Method** can be used in shallow streams if the appropriate field equipment is not available and flow estimates need only be approximate. A metre stick is used for this method which provides relatively accurate measurements in small or shallow streams. The metre stick is first placed on a stable streambed feature with the narrow edge of the stick in line with the flow of the stream. While holding the metre stick steady, an average water depth is recorded. The metre stick is then turned 180 degrees so the flat edge is now facing the stream flow causing the water to pile up. In this position, the elevated water depth is recorded. This process is repeated at three to six equidistant locations across the stream. The difference between the two measurements is then used to calculate velocity using the following equation:

Velocity (m/s) = $\sqrt{(2(\Delta D/100)*g)}$

Where

ΔD is the difference between the two depths (measured in centimetres), and g is acceleration due to gravity, or 9.81 m/s_2

Detailed steps for this method are provided in the Environment and Climate Change Canada document titled Canadian Aquatic Biomonitoring Network (CABIN) / Field Manual for Wadeable streams.

Dilution Gauging measures the flow rate by determining the dilution of a tracer solution, typically dissolved sodium chloride (salt). The tracer is injected either continuously (constant-rate) or instantaneously (slug injection) from a distance far enough upstream to ensure the trace is uniformly concentrated through the cross section at the point of measurement. The tracer concentration change is proportional to the change in flow rate (Moore, 2004). This method introduces chloride to the watercourse which may not be appropriate for watercourses that are already near or exceeding guidelines or those with sensitive species present. A local Environmental Protection representative should be contacted for more information prior to commencing salt-dilution measurements on those watercourses (RISC, 2018). A detailed methodology for performing this type of measurement is provided Manual of British Columbia Hydrometric Standards.

[6] Resources Information Standards Committee (RISC). 2018. *Manual of British Columbia Hydrometric Standards*, Version 2.0, December 2018.

6 Sample Collection

Water samples are often obtained by filling a container held just beneath the surface of the water, commonly referred to as a dip or grab sample. Through the use of special depth samplers, such as a Kemmerer or Van Dorn Sampler, grab samples can also be obtained from a specified depth or in the case of vertical profiles, a series of specified depths. Depth discrete samples are more common in SWQMPs for lakes and reservoirs where they provide data that can be used to characterize the water quality at a specific depth or a series of depths such as those collected to characterize the epilimnetic and hypolimnetic portions of a water body.

If a SWQMP requires an estimate of average water quality conditions, a composite sample can be produced by mixing equal volumes of discrete grab samples, collected from one point at regular time intervals, or collected from multiple points such as varying depths. For example, the monitoring of deep lakes (> 10m) commonly involves a composite sample to characterize the epilimnion and a composite sample to characterize the hypolimnion.

The following sections describe various sampling methods that can be used to collect water from lentic (lakes and reservoirs) or lotic (rivers and streams) systems. Standard Operating Procedures located in Appendix 2 of this *part* of the BCFSM provide detailed instructions for each of the sampling methods.

6.1 Lakes and Reservoirs – Introduction

Sample stations located within lakes and reservoirs can be established along the shore, near the shore, or in open water. At shore and near-shore stations are typically chosen to collect samples that provide short-term and or continuing trend data such as discharges into a water body as runoff, seepages from landfills and groundwater. Sample stations located in open water allow the sampler to collect samples from various depths and are generally chosen to provide long-term data and data that better represents the water body as a whole.

6.1.1 Sampling from Shore

Sampling from shore is not a recommended practice for the assessment of water quality within a lake or reservoir. This is because samples taken close to shore will not be representative of the entire lake system (CCME 2011). However, sampling programs designed to detect at shore or near-shore discharges such as those emanating from landfills or surface runoff may require that samples be collected from shoreline or near-shore stations.

Samples collected to detect or measure a constituent of a surface or near-surface discharge into a water body are typically collected at or very near the shore. Samples are also collected at or very near the shore when a boat is unavailable and in conditions where strong currents or thin ice are present and the data from these samples provides value to a project. Sample collection from a shoreline or near-shore station generally consists of taking surface water grab samples at specified locations. Grab samples are collected by plunging or lowering an inverted sample bottle into the water and in one fluid motion, pushing the bottle through the water and against any current until the bottle is full. Once full, the bottle is oriented upright and pulled up to the surface. For all other samples a sampler must wade out past the point where wave action affects the lake bottom. Samples collected using this method may still experience contamination from suspended sediments stirred up by the sampler and for this reason water samples are preferably collected from a boat or a dock or with the use of a telescopic swing sampler.

When sampling from shore, the sampler should not exceed a depth where there exists a reasonable possibility that water might enter the gumboot or hip-wader. This is particularly important during colder periods of the year when getting wet poses health risks such as hypothermia.

Sampling stations including those located at or near shore should be established with GPS coordinates to ensure that repeat samples are collected from the same location. In some situations, and, depending on the location and duration of the sampling program, sampling stations located at or near shore may be referenced with a semi-permanent marker, such as flagging tape or stakes. If this type of physical reference is used, photos, cardinal points and distances to reasonably permanent objects must be recorded as semi-permanent markers may be removed or degraded beyond recognition by weather or vandalism. It is critical that there be no deviation in location unless conditions at the site (e.g., severe weather, physical changes of the site, etc.) pose a threat to the sampler's safety. If safety is a concern, then search for an alternative location nearby, or simply do not attempt to take the sample. If an alternative location is used, then all details regarding the new site and the reasons why the alternative was necessary must be recorded in the field notebook. This information should be entered into the project database as soon as possible after returning from the field.

6.1.1.1 Use of a Swing Sampler

A **Swing Sampler** can be used when sampling from shore to extend the sampler's reach into the waterbody, and to minimize the potential that the water samples collected will be contaminated with suspended sediment. Swing samplers generally consist of a metal or fiberglass pole (minimum 2 m in length) with a free-swinging head on the collection end that a sample bottle is affixed to (Figure 6.1). The sample bottle can then be filled by lowering the sample bottle, with the mouth (opening) facing down, into the water and in one fluid motion, pushing the bottle through the water and against any current until the bottle is full. When the bottle is full, orient the swing sampler so the bottle is upright and pull it up out of the water. Please note that re-usable sampling bottles are discouraged due to the significant probability of contamination.

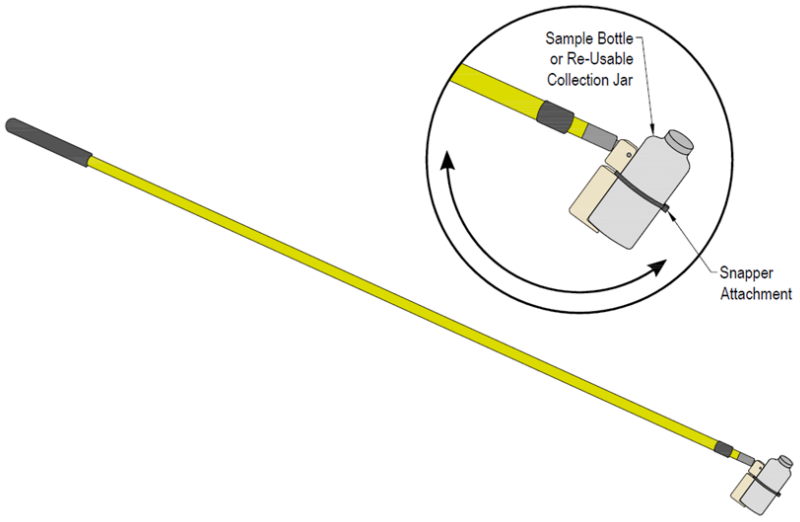

Figure 6.1. Swing Sampler

6.1.2 Sampling from a Boat

Water quality sampling on lakes and reservoirs is often conducted from a boat. Not only is a boat necessary to collect the deep samples, but it allows for surface water samples to be collected away from the shore which allows for a more representative sample. When collecting water quality samples from a boat, the following safety considerations and sampling protocols should be in place (CCME 2011):

1. At least one member of the field crew needs to be properly trained and experienced with boat operation and safety. At a minimum, one or more members of the field crew should have a valid Pleasure Craft Operator Card (PCOC). Additional certification such as the Small Vessel Operator Proficiency (SVOP) certification may be required when operating a commercially registered vessel.
2. Each member of the field crew should wear a Work Safe BC approved personal floatation device (PFD) at all times. Boating safety equipment required by Transport Canada should be on board at all times (extra paddles, bailer, flares etc.)
3. Weather forecast / marine conditions should be obtained prior to departure to the field. If conditions are poor, then the sampling event should be postponed until conditions improve.
4. If there are no safety concerns and circumstances allow, anchor the boat, and turn off the engine (to minimize the chance of hydrocarbon contamination) prior to taking the sample.
5. For deep stations where samples will be collected near the lake bottom (within 1m), it is recommended that anchoring be avoided to prevent disturbing benthic sediments and potentially contaminating samples. In these circumstances, keep the motor running and use the engine and GPS unit to keep the boat as stationary as possible. In less than perfectly calm conditions, one crew member will be designated to navigate while the other collects samples. If anchoring is unavoidable, ensure that a sufficient length of rope is used to allow the boat to drift well way from the location of the anchor and potentially disturbed sediments. This could require gauging the wind direction and traveling into the wind before anchoring, to allow the boat to drift towards and come to rest over the sample location.

6.1.2.1 Site Identification

Lake and reservoir sample station coordinates should be loaded on to a GPS prior to leaving for the field to allow the field crew to accurately navigate their way to the sample station. Deep water sampling sites monitored over long periods may be marked with a buoy. If GPS coordinates are not available, the sampling site can be referenced by easily and uniquely identifiable features (preferably two) on shore. Reference points should be described, both in writing and with photographs, in the field notebook. It is critical that there be no deviation in the location of a sample station unless there are access issues, or immediate safety concerns. In the event that an alternative location is utilized, then all details regarding the new site and the reasons why the alternative was necessary must be recorded in the field notebook.

Once at the site, and if it is not too deep, anchor the boat, or tie it to the buoy, and wait until it settles with the bow (front) facing into the current before collecting the sample. If the water is too deep to anchor, then one person will have to maintain the boats position, using either the motor or paddles, while the other person collects the samples and takes the field measurements. Photos in all four cardinal directions should be taken during each sample station visit to document any changes at the station throughout the duration of the sampling program.

6.1.2.2 Surface Water

When sampling lakes or reservoirs from a boat, surface water should ideally be collected after the engine is turned off, and as far away from the motor as possible to minimize hydrocarbon contamination. When

conducting water quality sampling, it is preferrable to use a boat with a four-stroke motor as opposed to a two-stroke motor. Two-stroke motors tend to discharge a larger component of unburned gas and oil mixture into the water which can increase the potential of hydrocarbon contamination.

Generally surface water can be collected by hand (i.e., grab samples) from smaller boats or by using a Swing Sampler (see Section 6.1.1.1) if the boat is too large to safely sample by hand. In some instances, a small water pump with a long intake hose that is kept afloat 0.2 m below the water surface with a small buoy, may be helpful when sampling from a boat (See section 6.1.2.3.3 for a description of a peristaltic pump). This type of set up would allow water samples to be taken at a further distance from the boat, which may be helpful in instances where the boat's engine can not be turned off during sampling and contamination from exhaust/boat fumes is of concern.

If lake sampling involves the collection of both surface and deep-water samples, all samples (including surface or near-surface) should be obtained using the depth sampling instrument to maintain consistency.

The person at the bow (front) should always collect the samples. This is because the bow is the anchor point and, even in slow moving water, the boat will drift so that the bow is upstream. In quiescent water, the samples should be collected after turning off the engine, but prior to anchoring, while the boat is slowly moving forward. These precautions reduce the potential of contamination from the boat or motor. In smaller boats, ensure that the person in the stern (rear) is providing counterbalance by working or leaning over the opposite side of the boat from which the samples are being collected. The person in the stern can be responsible for holding the boat's position when not anchored, taking the field measurements (see Section 5) and field notes. Contamination is not as much of a concern for field measurements and can be taken from the stern if necessary.

6.1.2.3 Deep Water

Parameters such as DO, temperature, and clarity vary with depth in lakes or reservoirs. For this reason, field measurements and water samples must be collected in increments throughout the water column. This process is sometimes referred to as Discrete Profile Sampling which provides information on how water quality changes with depth and how it is affected by stratification, sediment release or mass balance (CCME 2011). Discrete profile sampling is generally conducted at a sampling station positioned at the deepest point of the water body.

The recommended sequence of field activities is to obtain profile measurements prior to the collection of water samples. Instruments commonly deployed for this task include a hand-held interface device with datalogging capabilities with a multi-sensor sonde that is lowered into the water on a long cable. These measurements are often a necessary prerequisite for locating the depths from which the water samples should be taken. For example, temperature measurements are used to identify the stratification of the water body (Figure 6.2) which is then used to determine the depths at which discrete samples will be collected. Water quality in deep lakes is typically characterized using composite sampling. The composites are made up of equal aliquots of depth-discrete samples collected from within the stratified zones; the epilimnion and hypolimnion.

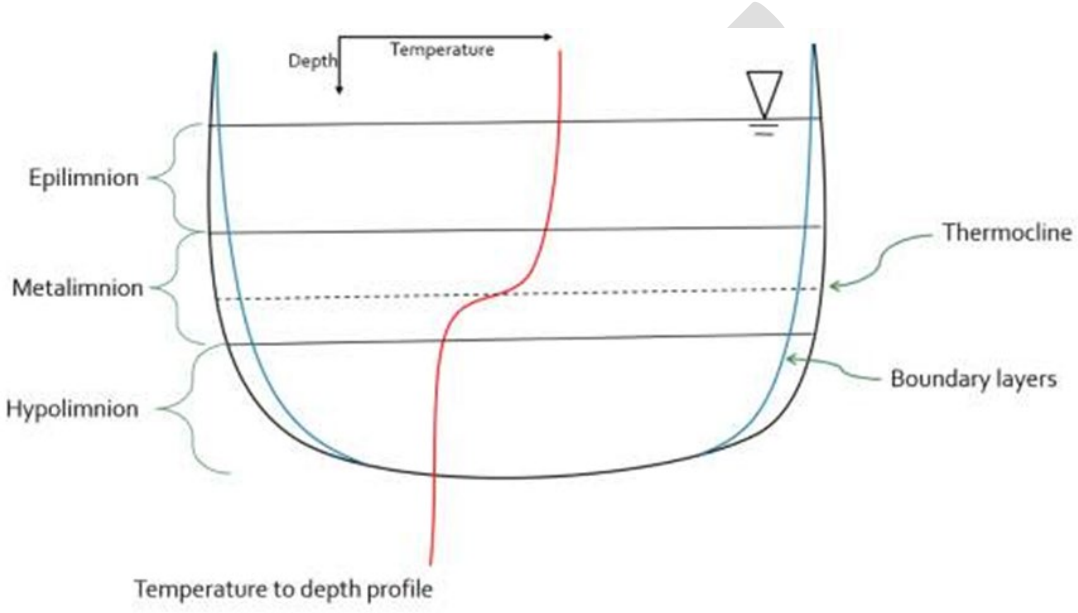

Figure 6.2. Schematic of Thermocline (UKDiss.com)

Water column grab samples may be collected from any desired depth through the use of a **Van Dorn** or **Kemmerer** depth sampler. Alternatively, a **peristaltic pump**, such as a GeoPump, Peristaltic, or a Fieldpro Peristaltic, can be used to pump water from depth to the surface (CCME 2011).

6.1.2.3.1 The Van Dorn Sampler

The Van Dorn Sampler is designed for sampling at a depth of two metres or greater. Note that Van Dorn samplers are available in both horizontal and vertical configurations. The advantage of the vertical configuration is that the water within the open bottle is flushed out as the bottle is lowered, so one can be confident that the water collected within it, was collected from the target depth. The advantage of the horizontal configuration is that a very narrow depth range is sampled. Vertical configurations are most commonly used.

The horizontal configuration should be used when samples are taken near bottom at the sediment-water interface, or when samples are required from a narrow band of the depth profile (i.e., chemocline, thermocline). Although operation of the Van Dorn bottle varies slightly depending on its size and style, the basic procedure is the same.

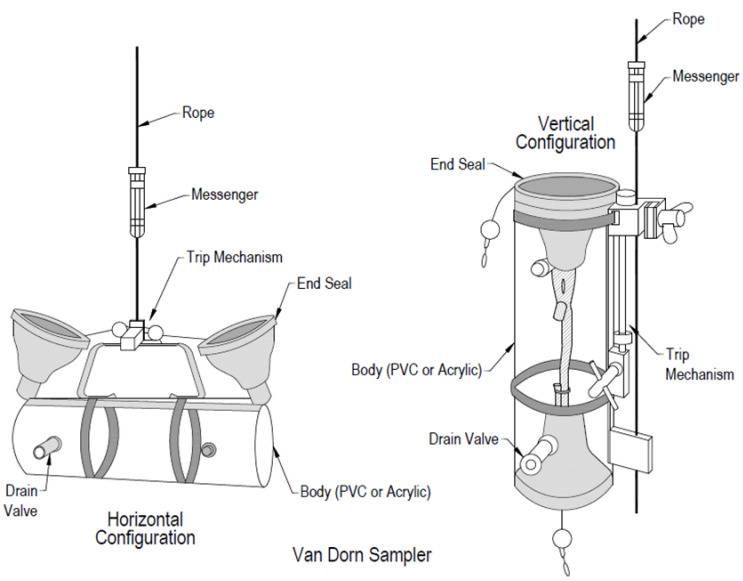

Figure 6.3. Van Dorn Sampler – Horizontal and Vertical Configurations

Prior to deployment it is important to ensure the sampler is clean and free of contamination, the drain valve or valves are in the closed position and that the sampler's line is demarcated at the desired depth increments beginning at the middle of the sampler. Alternatively, a depth counter can be used if a davit is deployed to raise and lower the sampler. Once in position, the Van Dorn sampler is lowered, with both ends open to the target depth. When the target depth has been reached a messenger weight is released, allowing it to slide down the rope to trigger the trip mechanism that will close both ends of the sampler, trapping the water inside. To ensure that the sample is collected at the desired depth, it is important to keep the rope as vertical as possible prior to triggering the trip mechanism. After each deployment the Van Dorn sampler should be thoroughly cleaned to ensure it is free of potential contamination. Cleaning is also required to remove any plants, animals, or mud before it is deployed in another body of water. Sampler cleaning ensures that aquatic invasive species are not transferred to new water bodies (CCME 2011). Detailed deployment instructions are provided in SOP E1-04 which is provided in Appendix 2.

6.1.2.3.2 Kemmerer Depth Sampler

The Kemmerer Sampler is designed for collecting grab samples at a depth of one metre or greater. Prior to deployment it is important to ensure the sampler is clean and free of contamination and that the sampler's line is demarcated at the desired depth increments beginning at the middle of the sampler. The two ends of the sampler are pulled apart to open the collection tube (Figure 6.4 right). Then, similar to the Van Dorn sampler, the Kemmerer is lowered into the water to the desired depth. With the line taut, a messenger weight is released to trigger the sampler to close and collect a 1.2 L water sample (Wildco 2005). After each deployment the Kemmerer sampler should be thoroughly cleaned to ensure it is free of potential contamination. Cleaning is also required to remove any plants, animals, or mud before it is deployed in another body of water. Sampler cleaning ensures that aquatic invasive species are not transferred to new water bodies (CCME 2011). SOP E1-04 provides detailed deployment instructions for a Kemmerer Depth Sampler. SOP E1-04 is provided in Appendix 2.

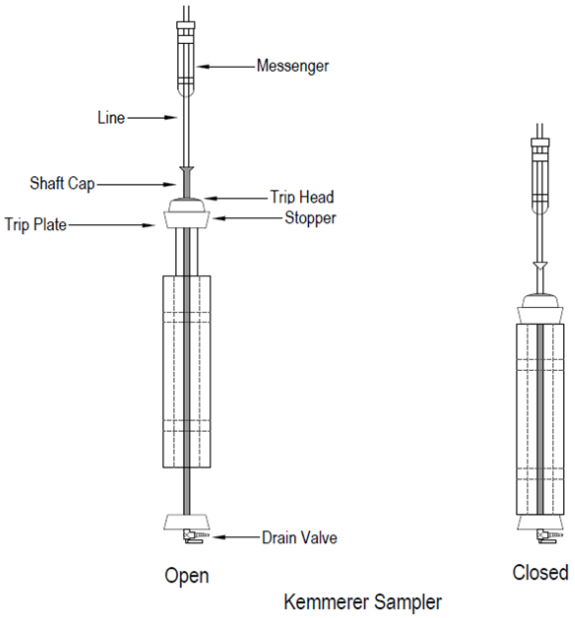

Figure 6.4: Kemmerer Depth Sampler (adapted from Wildco 2005).

6.1.2.3.3 Peristaltic Pump

A peristaltic pump (e.g., GeoPump Peristaltic, Fieldpro Peristaltic) can be used to pump water from depth, up to the surface for collection (Figure 6.5). After attaching the silicone intake and output hose, and connecting the pump to the power source, lower the weighted intake hose into the water to the desired depth (CCME 2011). Ensure that the length of silicone tubing used for the intake hose is long enough to reach the maximum desired depth.

At the first sampling depth, the pump should be run for five minutes to flush the system prior to collecting samples from the output hose. Subsequent sampling depths should be flushed for one minute per each 10 meters of tubing although most peristaltic pumps are limited to a depth of 10 meters. During sample collection do not let the output hose come in contact with the sample bottle (CCME 2011). Detailed instructions for the use of a Peristaltic Pump are provided in SOP E1-04.

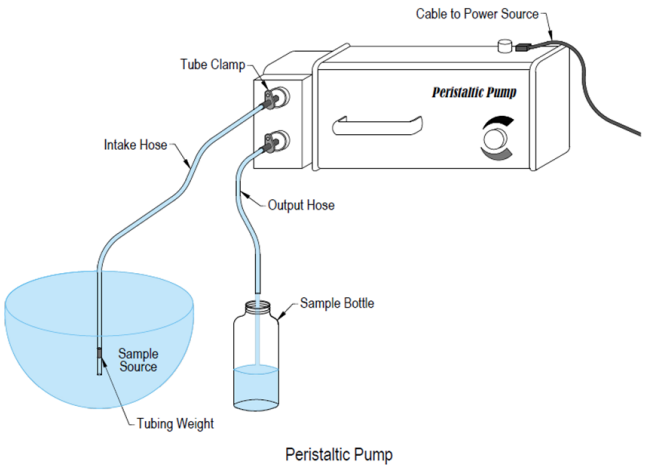

Figure 6.5: Peristaltic Pump Setup for Surface Water

6.1.3 Sampling in Winter

6.1.3.1 Safety Considerations

Sampling events conducted in winter conditions require additional planning to address challenges such as road conditions, site access, and elements of danger including hypothermia, icy and slippery ground, and working on ice. If a sampling or monitoring plan includes sample events scheduled to take place in the winter months or on an ice covered water course the sampling plan must include these additional considerations and preparations:

- Vehicle preparedness for winter conditions,
- Weather forecast and an assessment of 'day-of' weather and road conditions,
- Equipment required to access the site and station such as snowshoes, quad/ATV, boat,
- Winter appropriate clothing, PPE, and first aid supplies,
- Knowledge of the water course/body and surrounding area,
- Access to emergency and medical services,
- Knowledge of the different types of ice and their conditions,
- Safety plans, rescue procedures, and guidelines,
- Steps to measure the thickness of the ice; and,
- Appropriate equipment for working on ice.

Always proceed with caution over ice and never jeopardize your safety.

In preparation for the sampling event, review the weather conditions of the previous two to three weeks. Warm weather and rain events preceding the scheduled sampling event may weaken the ice cover. Remember that water can be thinner and weaker around islands, shoals, and shorelines.

Be aware that ice downstream from bridge supports and other structures may be thin as a result of modified flow patterns and de-icing agents (CCME 2011).

In preparation for your work on the ice, carefully move out onto the ice in pairs to measure the thickness of the ice with a rod or ice chisel, continuing every few steps to take a measurement until you have reached the sampling station. Both individuals should wear high visibility floatation suits, carry a length of buoyant polypropylene rope (tied around your waist) to use as a lifeline, carry an ice pick, remain at least 10 m apart, and be trained in rescue and self-rescue techniques (Alberta 2009). For an individual walking, the ice should be a minimum of 10 cm thick (Figure 6.6). Because the stress on the ice will increase the longer a weight stays in place, if you plan to be at the sampling station for more than two hours, the ice should be a minimum of 15 cm thick (Alberta 2009). Keep in mind that ice over moving water can be of varying thickness, and the strength of the ice cannot be estimated from its apparent thickness near the shore. **If the ice is unsafe, do not proceed. Never take unnecessary risks.**

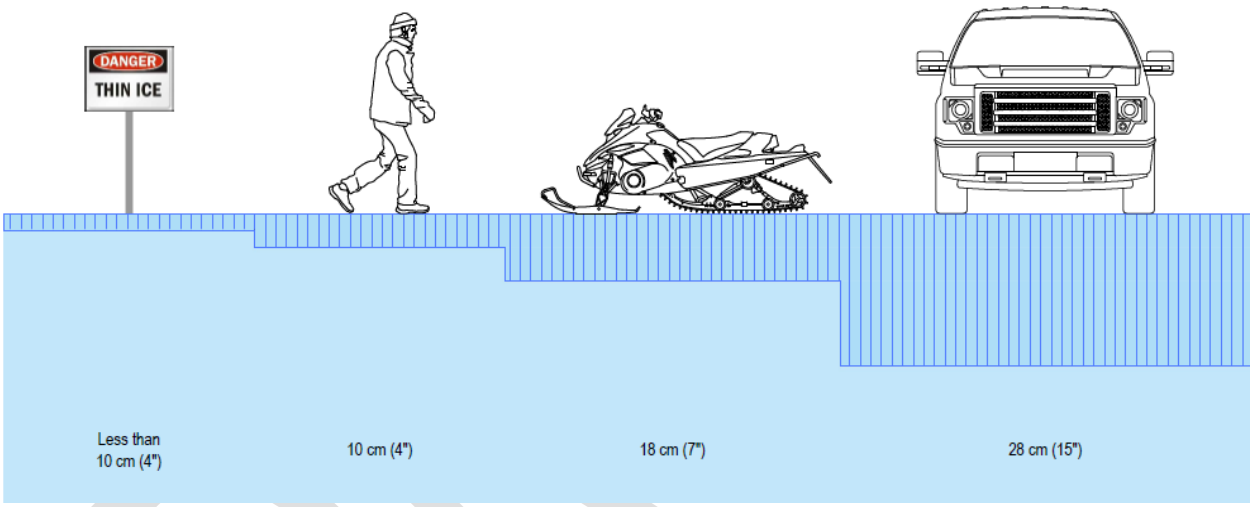

Figure 6.6. Ice thickness Guidelines (Adapted from Government of Alberta, 2009

Note: The ice near outflow and inflow areas of a lake is often thin, therefore, caution should be used when traversing or sampling in this area of an ice covered lake. Additionally, ice thickness on reservoirs, where water levels fluctuate, can be variable.

6.1.3.2 Sampling Through Ice

With safety considerations in mind, winter sampling stations should be as close as possible to the locations of the sampling stations established for summer sampling events. The stations should be chosen where the water is known to be deep enough to avoid stirring up bottom sediments and to ensure that there is water movement under the ice at your selected sampling site.

Prepare the sampling area by clearing loose ice and snow. Drill through the ice with a hand or motorized auger. At least one member of the sampling team should be familiar with the operation and safety of both motorized and hand operated augers. If using a motorized auger, ensure it is clean and free of contaminants prior to deployment and during drilling. Keep the area around the hole clear of potential contamination (e.g., dirt, fuel, oil, etc.). Ice chips and slush can be removed from the hole using a plastic sieve. A swing sampler can be inserted through the hole to collect grab samples from depths of up to 6 metres.

For deep water sampling, or Discrete Profile sampling, use a Van Dorn sampler, Kemmerer sampler, or peristaltic pump to collect the samples at the desired depths (see section 6.1.2). Be sure to include ice depth and total water depth with the field measurements in your field notebook.

When sampling in the winter, care should be taken to ensure that the samples do not freeze, as this could cause the sample containers to rupture. If at the time of sample collection, it is below freezing, add jugs of warm water to the sample storage coolers, as needed, to prevent the samples from freezing. Maintain the samples within a temperature range of between 4 and 10°C (CCME 2011).

6.2 Rivers and Streams – Introduction

The majority of samples collected from streams and rivers in British Columbia are grab samples taken near the surface at one point in the cross section of the flow. Grab samples can be collected by submerging the sample bottle by hand, or swing sampler, into the rivers flow or by lowering a multi-sampler from a bridge deck. Occasionally, more sophisticated multi-point sampling techniques, known as equal-discharge-increment (EDI) or equal-width-increment (EWI) methods, are used. Since these techniques are infrequently used, they will not be discussed here, but further information about the protocols can be obtained from Clark and Shera (1985).

6.2.1 Site Identification

River and stream sample station coordinates should be loaded on to a GPS prior to leaving for the field to allow the field crew to accurately navigate to the sample station (either by boat or on foot). Photos in all four cardinal directions should be taken during each sampling event to document changes of the natural environment in which the sampling station is located. Photos should be taken throughout the duration of the sampling program. It is critical that there be no deviation in location unless there are access issues, or immediate safety concerns. In the event that an alternative location is required, all details regarding the new or alternate station and the reasons why the alternate station was necessary must be recorded in the field notebook.

Wherever practical and when water quality is the only objective, samples should be collected at mid-stream and mid-depth, rather than near-shore and/or at surface. Samples collected from mid-stream reduce the probability of contamination from shore effects, back eddies, seepage from near shore soils, and atmospheric components such as pollen concentrating in slow moving water. Samples should not be taken in back eddies or brackish waters unless required by the monitoring program's objectives. Keep in mind that the most important issue to consider when deciding where the sample should be collected from is SAFETY.

6.2.2 Sampling Options

Rivers and streams can be sampled from shore either by wading into the flow, by lowering a multi-sampler into the centre of the flow from a bridge, or by sampling from the stream bank. Samples can also be collected from a boat using a variety of devices. Which technique is most appropriate will largely depend on the size of the watercourse, accessibility to the watercourse, and the velocity of stream flow.

6.2.2.1 Sampling Within a Stream

If the flow is sufficiently slow and allows the field crew to safely wade into the stream without risk, then the sample can be collected at a depth that does not pose a threat (discretion is key - **never wade into water that appears deep or fast flowing**). Always wear a PFD when wading, if wearing waders ensure the

wading belt is in place, have a second person nearby, and attach a safety line if conditions pose a potential risk. Samplers must be wary of uneven, slippery, or non-visible stream bottoms, especially under turbid conditions. It is very easy to lose your footing and balance in fast flowing waters. In addition, if the river bottom is soft, samplers may sink into the substrate. It is recommended that individuals who sample by wading, take swift-water training, carry appropriate safety gear (e.g., throw bag), and adhere to all water safety precautions (CCME 2011).

The sampler should always enter the river at a position that is downstream from the sample station, then wade upstream to the sample station. This ensures that sediments will not be disturbed and suspended into the water column from which the sample will be collected. The sample should always be collected while the sampler is oriented in an upstream direction. The sample should be collected by plunging the open sample bottle (open end down) into the water then scooping in an upstream motion, through the middle of the water column, up and away from the sampler. When the conditions of flow dictate that the sample be taken from or near to the stream bank, such as under fast flowing / high water conditions, deviations from the standard protocol should be accurately documented in the field notebook and transferred to the project database as soon as possible.

6.2.2.2 Sampling from a Stream Bank

Sampling from the stream bank is often used when sampling small, shallow streams. If the stream is narrow enough, a grab sample can be collected from the middle of the stream or deepest point of the channel (thalweg) by hand. In this case, care should be taken not to step into the stream to avoid disturbing the sediments. If the stream is too wide to collect the samples by hand, but deep enough that a sample tool will not stir up sediment, a Swing Sampler (Figure 6.1) can be used to extend the sampler's reach into the middle of the channel. In both cases, the samples must always be collected facing upstream and away from the stream bank. This will prevent contaminants from the sampler's hand or Swing Sampler from entering the sample and will prevent slower moving water from the streambank from entering the sample (CCME 2011).

Sampling from the stream bank may also be necessary for large rivers in cases where (1) the current is too strong, or the water is too deep to safely wade into the flow or (2) the ice is to thin to safely sample through the ice. In these cases, secure yourself to a solid object on shore with a safety harness and line if necessary. As a safety precaution, a second person must remain nearby while the first person is collecting the samples.

6.2.2.3 Sampling from a Bridge

Some sample stations are located at the mid-way crossing of a bridge, or the deepest point of the channel (thalweg). Sampling from a bridge allows samples to be collected from the central flow of rivers where wading or boating is not an option. If the bridge is located over navigable waters, sample equipment and ropes may need to be flagged so that the equipment is visible to boat operators. On navigable waters sample events should be scheduled so they do not interfere with boat traffic (CCME 2011). In addition, samplers must take special care when working around traffic (e.g., always wear high visibility vests, position traffic cones as needed and use sidewalks whenever possible etc.).

Samples can be collected using an apparatus called a **multiple sampler** (Figure 6.7) that is lowered over the side of the bridge. Since the multiple sampler holds more than one bottle, it has the advantage of allowing all containers (therefore, all variables) to be sampled at the same time and at the same place. This allows for more precise cross-referencing among the variables. Alternately sampling equipment such as a Van Dorn sampler can be deployed from a bridge to collect sample water that is then decanted into appropriate bottles. It is good practice to secure the free end of the multiple sampler's rope to the bridge structure to avoid losing the sampling equipment in the event that the sampler loses control of the rope.

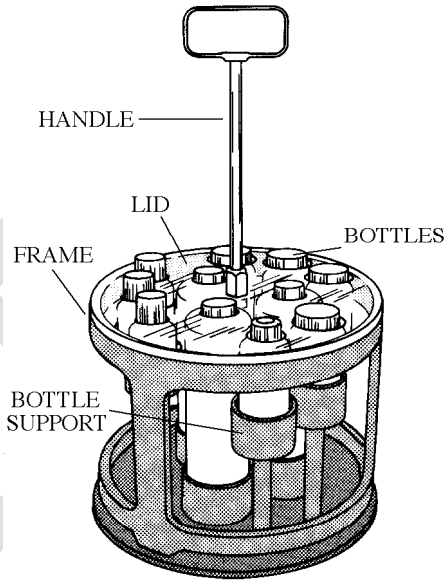

Figure 6.7. Generalized Multiple Sampler

The precise location at which the sampling device is lowered from the bridge should be marked with a GPS waypoint to ensure that the same section of the river is sampled each time. Whenever possible, lower the multiple sampler over the upstream side of the bridge, being careful not to disturb bridge surfaces with the rope or sampler. This avoids contamination of the sample from the bridge itself or substances falling into the water or into the open bottles from the bridge (e.g., fuel, oil, dust, paint chips, wood chips, etc.). The multi-sampler may also be fitted with a debris shield to prevent foreign matter from entering the bottles as it is being lowered from the bridge.

To deploy, the multi-sampler is lowered to the water where it is allowed to submerge and drift slightly downstream with the current. The multi-sampler is then lifted and swung back upstream where it is allowed to submerge once again. This process is repeated until all of the bottles have been filled. During this process, tension of the rope must be slack enough to allow the multi-sampler to submerge but taut enough to prevent it from hitting the stream bed.

6.2.2.4 Sampling from a Boat

When using a boat to conduct water quality sampling on a river, all safety considerations outlined in section 6.1.2 should be incorporated into the sampling plan. Because fast-flowing waters pose a serious threat, it is essential that the person operating the boat be very experienced with river boating. On a river, jet boats are preferred over propeller boats because they maneuver better in shallow water where propellors can hinder both operation and safety. In addition, it is preferrable to use a boat with a four-stroke motor as opposed to a two-stroke motor. Two-stroke motors tend to discharge an unburned gas and oil mixture into the water. In addition to negatively impacting water quality any such discharge may result in sample contamination.

Ideally, there should be three people along on the sampling trip when it involves boating on a river. Two people are responsible for collecting water samples at the bow, taking field measurements and recording field notes. The third person is responsible for boat operation only.

Sampling trips should start at the most downstream sample station and proceed working upstream. If mechanical problems should arise, the current will work to your advantage and assist you in returning to or near the boat launch. When a sample station is reached, the engine remains on and the boat operator idles into the current to maintain the boats position and orientation, using a reference point on shore to do this. When the boat is properly positioned, surface water samples and samples at depth (if the river is deep enough) can be collected following the protocols outlined in section 6.1.2 and accompanying SOPs.

6.2.3 Sampling in Winter

6.2.3.1 Safety Considerations

Generally, winter sampling on rivers follows similar safety protocols as for sampling lakes in winter (see section 6.1.3.1). However, because flow patterns in rivers and streams are generally more complex than in lakes, there are additional safety factors to consider. Honeycombed ice and areas over rapids should always be avoided. Be aware that ice downstream from bridge supports may be thin because of modified flow patterns and de-icing agents. At least two people must proceed onto the ice, one ahead of the other. The person in the rear should carry a rope and each must wear a life jacket/PFD. When the ice is unsafe, sample stations that are accessible from a bridge may be the only option.

6.2.3.2 Sampling Through Ice

With safety considerations in mind, winter sampling stations should be the same as or as close as possible to the summer sampling stations. Sample stations should be located where the water is known to be deep enough to avoid stirring up bottom sediments and to ensure that there is water movement under the ice at your selected spot.

Clear loose ice and snow from the sampling location, and drill through the ice with a hand or motorized auger. Keep the area around the hole clear of potential contamination (e.g., dirt, fuel, oil, etc.). Ice chips and slush can be removed from the hole using a plastic sieve. After the access hole has been drilled and cleared of debris, wait a few minutes before collecting the sample, to allow the natural flow of the river to flush any contaminants from the area.

Surface water samples and samples at depth (if the river is deep enough) can then be taken through the ice using a variety of equipment, including swing samplers, Van Dorn/Kemmerer Samplers, or a peristaltic pump. Each piece of equipment and their use are described in section 6.1.2 and SOP E1-04. In shallow streams, grab samples should be collected 20 cm below the bottom of the ice. If the river depth is sufficient, and deeper samples can be taken, the sample device (e.g., Van Dorn or intake hose of pump) may need to be weighted to counteract downstream movement caused by stream flow (CCME 2011). To overcome cross-flow, when collecting samples at depth with a peristaltic pump, the intake hose can be attached to a long pole marked with depth increments and lowered to the desired depth. Record the ice thickness, depth, and total water depth in your field notebook.

When river ice is thin, and working on the ice is not safe, sampling from a bridge may provide an alternative option. From the safety of the bridge, a hole of sufficient size to collect a sample may be produced by dropping a weight attached to a hand line. Once the current has cleared the hole of debris, the protocol for sampling from a bridge (see section 6.2.2.3) should be followed.

Extra care must be taken to avoid contamination in winter. De-icing agents such as salt can be easily transferred to the sample, particularly when working from a bridge. In addition, care should be taken to ensure that the samples do not freeze, as this could cause sample containers to rupture. If at the time of sample collection, it is below freezing, jugs of warm water can be added as needed to the sample storage coolers to prevent freezing. It is important to remember that regardless of ambient temperatures, samples must be maintained within a temperature range of between 4 and 10°C (CCME 2011).

7 Sample Handling and Processing

7.1 Introduction

Careful handling and processing of surface water samples is an important component of a field quality assurance plan. Samples collected for analyses such as metals and or dissolved phase parameters require additional handling and processing. Samples such as chlorophyll-α, or parameters requiring clean and ultra-clean sampling methodologies require very specific handling procedures.

7.2 Sample Integrity

A primary objective of water sample collection is to obtain a sample that is representative of its parent material. Subsequently, the integrity of a sample collected in the field must be maintained until it is received by the testing laboratory. Analytical results reported for deteriorated samples cannot be relied upon and consequently negate all the effort and cost expended in obtaining them. One of the key measures in maintaining sample integrity is time; in general, the shorter the elapsed time between collection and analysis, the more reliable the analytical results will be. Sample plans must consider and include transportation plans to accommodate samples with short hold times (sample hold times are discussed in Section 8.1). The second key measure in maintaining sample integrity is temperature. Samples collected for most analyses should be placed in a chilled cooler as soon as they are collected and maintained at a temperature of ≤ 10º C until their reception by the testing laboratory. Sample integrity for some analytes is further maintained by filtration and preservation, and/or by implementing clean and ultra-clean sampling methodologies. Procedures for these sample handling and processing methods are provided in the following sub-sections.

7.2.1 Field Filtration

Samples collected for parameters such as dissolved metals require filtration and chemical preservation. Whenever a sample type requires both filtration and chemical preservation, filtration must be conducted prior to adding a chemical preservative. In all cases, filtration should be conducted in the field. If the filtered sample is preserved in the field its holding time is extended from 14 days to 6 months. If the filtered sample will arrive at the testing laboratory within 14 days, the sample can be preserved at the laboratory. Under these conditions both field and laboratory preservation are considered equal and acceptable.

In order to field filter a sample, the sampled water is passed through a filter medium with a specific filter pore size (typically 0.45 µm) either under a vacuum or under positive pressure which is generally preferred. Filtering must be completed as quickly as possible, although care should be taken to minimize aeration, pressure, and temperature changes, and contact with ambient air (ASTM D6564-00 (2012) e1, 2012).

It is important to note that filtration can cause degradation in sample quality. Degradation can result from adsorption/desorption between sample constituents and the filter medium, removal of particulates smaller than the filter pore size because of filter clogging, and removal of solids (i.e., metal oxides/hydroxides) that may have precipitated during sample collection. Regardless of filter type, filters cannot be re-used, and a new filter must be used for each sample. If there is a concern regarding the potential of sample bias due to filtration, a filtration blank (Section 3.3.1.2.3) should be collected by passing distilled water through the filter and collecting the discharge into a sample bottle for analysis.

7.2.1.1 Filtration Devices and Techniques

Various methods are available for field filtering. The two most common types of filters are capsule filters and disc filters. ENV recommends that filters be individually wrapped, opened just prior to filtration, that they be pre-conditioned and that any water standing on the outside of the filtration apparatus be removed prior to decanting the filtered sample water into a sample bottle. These practices will mitigate the potential for contamination, minimize sample bias by removing any residues remaining on the filter following the manufacturing process, and create a uniform wetted surface to increase filter efficiency.

Collecting and preparing samples for chlorophyll-α analysis requires a specialized filtration apparatus and sampling methodology that is described below in Section 7.3.3.

7.2.1.2 Disc Filters

Disc filters are single-use filter cartridges that are attached to a syringe (Figure 7.1). The disc filter is attached to the syringe by inserting and rotating the flanged end of the filter into the threaded tip of the syringe. Ensure that only the outer rim of the filter is touched during this process; never touch the threaded end or dispensing end. After assembly remove the plunger from the syringe and decant sample water into the syringe. Insert the plunger and apply pressure to the assembly by pushing on the plunger until sample water begins discharging from the filter. Pre-condition the filter by passing approximately 10 mL of sample water through the filter. Properly discard the pre-conditioning water. Shake the filter assembly or use a paper towel to remove any water that may have gathered on the outside of the filtration assembly during filling or pre-conditioning. Water that collects on the outside of the assembly may not be filtered and may be contaminated and for these reasons it is important to ensure it does not enter the sample bottle. Apply pressure to the plunger and decant the remaining sample water into a laboratory supplied bottle. Depending on the volumetric size of the syringe, these steps may have to be repeated twice or more to provide the sample volume required by the testing laboratory. It is important to avoid contact with the inside of the syringe, the filter or the plunger. Pre-conditioning is only required once per filter however each time the syringe is refilled and prior to decanting, ensure the outside of the filtration assembly is dry.

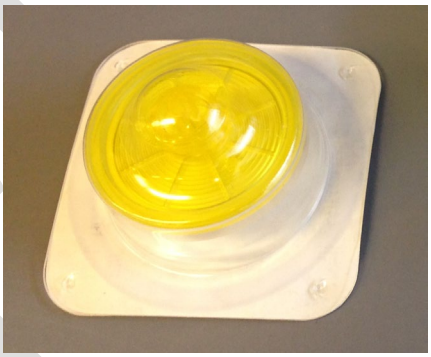

Figure 7.1. Example of an individually wrapped disc filter.

Sample water containing a high concentration of suspended solids may quickly clog the filter. If this occurs, replace the filter, precondition the filter, ensure there is no water on the outside of the filtration assembly, and continue decanting into the sample bottle. In these situations, multiple filters may be required for a single sample. ENV recommends limiting the amount of pressure applied to a filtration assembly and instead replace the filter as many times as required to produce the required volume of sample material. Samplers should watch for break through conditions and discard the sample in the event a break-through occurs.

7.2.1.3 Capsule Filters

A capsule filter (Figure 7) is a disposable polyethylene capsule with polyethersulphone filter media, which is capable of filtering samples of high volume, or of medium to high turbidity. Capsule filters can be connected in-line at the discharge end (i.e., output hose) of a peristaltic pump (USGS 2002). The peristaltic pump uses negative pressure to draw the sample water through the capsule filter.

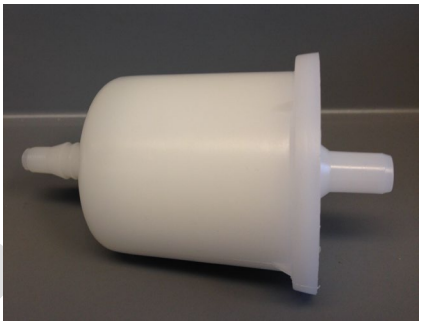

Figure 7.2. Example of a polyethersulfone capsule filter.

Filters should be individually wrapped, opened just prior to use in the field and be pre-conditioned prior to decanting the filtered sample water into its bottle.

Pre-conditioning for capsule filters requires a stated volume of sample water (usually two filter volumes or 0.5 L) be passed through the filter prior to sample filtration and collection (ASTM D6564-00 (2012) e1, 2012). After pre-conditioning, ensure that the outside of the filter is dry to mitigate the potential for unfiltered and potentially contaminated water from running off the filter and into the sample bottle. When ready turn on the pump or apply pressure and decant into a laboratory supplied bottle.

Capsule filters are available in a number of pore sizes. Field staff should verify that the capsule filters they are using have a pore size of 0.45 µm, which is generally recommended for surface water quality filtration.

7.2.2 Sample Preservation

The purpose of sample preservation is to minimize the chemical, physical and biological changes that can occur in a sample due to exposure to ambient conditions. Sample preservation can reduce the potential for microbial activity, volatilization, precipitation, or other physical or chemical processes that result in a change in chemical composition. Preservation also includes measures to protect the physical integrity of the sample container. Preservation requirements are determined on a parameter specific basis. It is important to note that preservation requirements are subject to change and for this reason, should be confirmed with the testing laboratory as a pre-trip activity and detailed as such in the sampling or monitoring plan. In general, surface water sample preservation methods can be categorized as physical preservation or chemical preservation (ASTM D6517-00 e1, 2012).

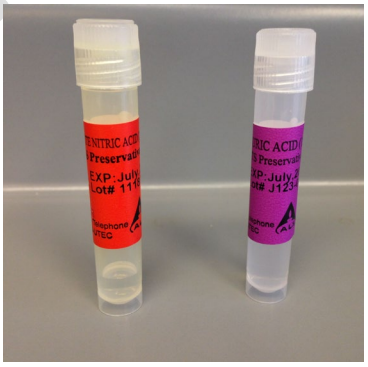

Figure 7.3. Example of pre-measured chemical preservatives.

Physical preservation methods include cooling, filtration, physical protection, contaminant-free sample containers made of materials that will not react with the analyte being sampled or the chemical preservatives added, if any, and light-blocking sample containers such as amber glass jars. Chemical preservatives stabilize the samples chemical constituents in solution and or inhibit microbial activity. Chemical preservatives include products such as nitric acid, sodium thiosulphate and sodium hydroxide.

Requirements for chemical preservation are based on the parameter/s a sample will be analyzed for. Samples collected for specific parameters, such as dissolved metals, require field filtration which must be conducted prior to preservation. In accordance with the B.C. Environmental Laboratory Manual, field filtration must occur as close as possible to the time of sample collection. If a filtered sample collected for dissolved metals analysis is preserved in the field, its holding time is extended from 14 days to 6 months. If the filtered sample will arrive at the testing laboratory within 14 days, the sample can be preserved at the

laboratory. Under these conditions both field and laboratory preservation are considered equal and acceptable.

For 'parameter specific' preservation requirements ENV strongly recommends following the guidance provided in their 'Sample Preservation & Holding Time Requirements' table which is available at: https://www2.gov.bc.ca/gov/content?id=A9BE9DDAB0674DD29D1308C4BEE7FBB4.

Some sample containers supplied by a laboratory are pre-charged with a chemical preservative. Samples collected into pre-charged sample containers do not require additional chemical preservation and in most cases, adding additional chemical preservatives will render the sample invalid for testing. For this reason it is important to identify which sample bottles if any, are pre-charged.

The most common forms of chemical preservation in the field are:

- addition of a pre-measured, fixed volume of liquid preservative (e.g., nitric acid) to the sample,
- addition of a pelletized preservative (e.g., sodium hydroxide) to the sample; or,
- use of sample containers that have been pre-charged with a preservative (ASTM D6517-00 (2012) e1, 2012).

Certain preservatives such as methanol are considered hazardous materials and, therefore, the Transportation of Dangerous Goods (TDG) Act and regulations outlined by WHMIS (Workplace Hazardous Materials Information System) must be adhered to. Read safety instructions and safety data sheets supplied for each preservative. Each vial or ampoule of preservative should be labeled to identify their contents and expiry date. Expired preservatives should be returned to the issuing laboratory for proper disposal.

Physical preservation begins with the use of appropriate sample containers which are specified for each parameter, the use of appropriate packing materials and an adequate shipping container to prevent breakage and cross-contamination. Most laboratories will supply the appropriate sample containers along with caps for each particular parameter, or suite of parameters (e.g., metals) to be tested. Sample containers and cap liner materials must be non-reactive with the sample (ASTM D6517-00(2012) e1, 2012). The choice of shipping container must also accommodate the need for cooling which is a required method of preservation for the vast majority of samples collected for analytical testing.

Sample containers should be filled and capped as quickly as possible to reduce the sample materials exposure to the atmosphere. Samples collected for some tests require that sample containers be filled fully to eliminate head space which creates and maintains an anaerobic condition. This can be accomplished by ensuring there is a meniscus protruding above the lip of the sample bottle prior to placing and securing the cap. When the cap has been secured the sample container should be rotated upside down to ensure that there are no bubbles. This is especially important for the collection of samples for the analyses of Volatile Organic Compounds (VOC).

Sample hold times must be strictly adhered to. A 'hold time' is defined as the time elapsed from sample collection to sample preparations by the laboratory. Samples can be stored in a clean refrigerator where necessary or desired to avoid weekend delivery, providing this does not result in an exceedance of a hold time.

The ENV maintains a table of required sample containers, storage temperatures, preservation requirements and holding times on their website at:

https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/laboratory-standards-quality-assurance/bc-environmental-laboratory-manual.

It is important to note that storage temperatures listed in the table are laboratory storage requirements. The B.C. Environmental Laboratory Manual (ENV, 2016b) states that for all tests where storage temperatures of ≤ 6°C is required at the laboratory, samples should be maintained at a temperature of ≤10°C during transport to the laboratory. However, microbiological samples should be stored at 4±3°C (or as per reference method) during transport to the laboratory.

7.3 Analyses Specific Considerations

Generally, samples to be analyzed for parameters that are most sensitive to handling are collected and handled first (USEPA, 1991). The typical sampling order by parameter is as follows:

1. Ultra-low concentration parameters,
2. Samples requiring field filtration (e.g., Dissolved Metals),
3. Semi-Volatile Organics,
4. Non-Volatile Organics,
5. Total Coliforms and *E.Coli,*
6. Total Metals,
7. Nutrients,
8. Other General Chemistry Parameters; and,
9. Chlorophyll-α.

Table 7.1 provides a quick reference guide for common surface water quality parameters that may be included in a SWQMP. Specific instructions for the collection and handling of samples for the analysis of chlorophyll-α are provided in SOP E1-08.

Table 7.1. Preservation Requirements for Common Surface Water Quality Parameters.

Parameter	Field Filtration	Chemical Preservation	Additional Considerations
General Chemistry	No	No	None
Dissolved Metals	Yes 0.45 micron filter	HNO_3 Preserve immediately after filtration to adjust the sample to a pH < 2	If testing for low-level / trace metals, ultra-clean sampling methods may be required. Samples not preserved in the field must be analyzed within 14 days.
Total Metals	No	HNO_3 Preserve to adjust the sample to a pH < 2	If testing for low-level / trace metals, ultra-clean sampling methods may be required. Samples not preserved in the field must be analyzed within 14 days.
Dissolved Organic Carbon	Yes 0.45 micron filter	H_2SO_4 or HCl Preserve to adjust the sample to a pH < 2	Collect samples in amber bottles. Samples not preserved in the field must be analyzed witin 72 hrs.

Parameter	Field Filtration	Chemical Preservation	Additional Considerations
Total Organic Carbon	No	H_2SO_4 or HCl Preserve to adjust the sample to a pH < 2	Collect samples in amber bottles. Samples not preserved in the field must be analyzed witin 72 hrs.
Chlorophyll-α	Yes 0.45 micron filter	No	After collection, the filter containing the Chlorophyll-α sample must be stored in an opaque vial to prevent degration from light.
Nitrogen (Ammonia, Kjeldahl, and Unionized)	No	H_2SO_4 Preserve to adjust the sample to a pH < 2	Samples not preserved in the field must be analyzed witin 3 days.
Total Coliforms and E.Coli	No	No	None
Total Phosphorus	No	H_2SO_4 Preserve to adjust the sample to a pH < 2	Samples not preserved in the field must be analyzed witin 3 days.
Total Suspended Solids	No	No	None

7.3.1 Total and Dissolved Parameters

Certain parameters, such as metals and organic carbon, can be analyzed for both dissolved and total components. Sample bottles should be labelled properly to indicate if the sample has been field filtered, and or preserved, and whether or not the contents will be analyzed for total or dissolved components.

Sampling for total components requires that the entire sample collected, including all suspended and settled solids, is transferred directly into the sample container. For those sample types requiring chemical preservation, do not fill the sample container all the way to the top; fill the container to the base of the container's neck leaving enough room to add preservative if required. If required, and if preserving in the field, add the appropriate preservative immediately after sample collection. Many sample types requiring chemical preservation are preserved to adjust the sample to a pH of < 2. Pre-measured volumes of preservative are supplied by the testing laboratory in ampules which provide a reliable means of achieving the required pH adjustment. If the pH of a sample must be confirmed in the filed, this can be accomplished by pouring a small volume of the preserved sample onto litmus paper (the paper should never be submerged in the sample bottle). Pre-charged sample bottles provided by the laboratory do not require additional preservative. Once an unfiltered sample is acidified in the field, the sample can only be analyzed for total components; it is not possible to determine dissolved concentrations from the preserved sample.

Sampling for dissolved components, requires that the water samples to be field filtered through a 0.45 µm filter. Once filtered, the sample can only be analysed for dissolved components. In the case of dissolved metals, if reducing conditions are present, certain dissolved metals may rapidly oxidize once the sample is collected, and precipitation of metal oxides or hydroxides will occur. In reducing conditions it is critical that samples intended for dissolved metals analyses be rapidly field filtered and preserved as soon as possible after the samples are retrieved. If a precipitate appears upon acidification, record the observation in field notes and report the observation to the testing laboratory. Consultation with ENV and the testing laboratory should be pursued to determine if the sample should be analyzed. Analytical results from such a sample should be flagged to denote the quality of the analytical results. Under normal conditions chemical preservation can occur at the testing laboratory, although hold times will be shorter.

7.3.2 Clean and Ultra Clean Sampling Methods

Special sampling and handling techniques known as “clean” and “ultra clean” methods are needed to collect samples analyzed for trace levels of target analytes in surface water samples. Clean methods are needed to quantify trace metals accurately when the concentrations are expected to be less than 20 mg/L and above 0.1 mg/L. Ultra clean methods are needed when the metal concentrations are expected to be less than 0.1 mg/L or within the ug/L range, as might be required for trace metals such as methylmercury and mercury (Hunt et al., 1995).

Ultra-clean sample collection methods are derived from the EPA Method 1669 which details specific sample collection procedures aimed at minimizing sample contamination (EPA 1996). Ultra-clean methods require two people be involved in the sample collection; one individual is designated as the “Clean Hands” and the second person is the “Dirty Hands”. “Dirty Hands” is responsible for operating sampling equipment, filtration units, and any additional activities that could potentially contaminate the sample. “Clean Hands” must only touch the sample and sample container (EPA 1996). If filtration is required when ultra-clean sampling methods are being used, the filters should be individually wrapped.

Empty sample bottles intended for ultra-clean sampling methods, will often arrive from the laboratory double bagged, with a pair of disposable gloves in the outermost bag. Wearing gloves, “Dirty Hands” will open the outer bag, and “Clean Hands” will reach in and put on the pair of gloves inside, in addition to the gloves they already have on. “Clean Hands” will then open the inner bag, remove the sample bottles, fill the sample bottle with water and then place the bottle back into the inner bag. The ultra-clean sample is then double bagged to prevent contamination during transport. Complete and detailed instructions for ultra-clean sampling are provided in SOP E1-09.

7.3.3 Chlorophyll-α

Chlorophyll-α is the phyotosynthetic pigment that is used by green plants and algae to generate energy. Measuring chlorophyll-a is an indicator of the algae biomass present within a waterbody and can provide information about the waterbodies trophic condition (EPA 2016).

Water samples to be analyzed for chlorophyll-a are collected using one of the methods described in Section 6.1 (i.e. swing sampler, Van Dorn, or peristaltic pump). Samples can be submitted to a laboratory filtered or unfiltered. Unfiltered samples are collected in opaque plastic or amber glass containers and must be received by the testing laboratory within 48 hours of collection. To prepare a filtered sample, a measured quantity of sample water is poured into a filtration device and passed through a 0.45 um filter membrane (cellulose acetate, or glass fibre GF/C membranes may be used). Any chlorophyll-containing organisms within the water sample will not be able to pass through the filter membrane and will instead remain on the surface of the filter. The filter membrane is then carefully removed from the filtration apparatus, folded, and placed into an opaque vial or sample bottle, frozen and stored in the dark. Filtration should be conducted out of direct sunlight, as exposure to sunlight will accelerate the degradation of chlorophyll-a (Indiana University, 2021). If requested, filtration apparatuses and filter membranes can often be provided by the analyzing laboratory, along with the sample collection bottles.

The amount of sample water required to prepare a filtered sample will vary based on the algae content of the waterbody. When collecting samples from lakes, 50-500 mL of water can be passed through the filter. When collecting samples from rivers, 500-1000 ml of water can be passed through the filter (Alberta 2006). Sample water should be filtered until a light green/brown colour is visible on the filter, or until the maximum volume of water recommended for a lake or river is reached. Be sure to record in your field notes and on the sample vial, the volume of water filtered. Complete and detailed instructions for the collection and handling of samples collected for the analysis of chlorophyll-α are provided in SOP E1-08.

8 Sample Storage and Shipping

Care should be taken to ensure that sample packaging and shipping procedures are adequate to maintain the physical, chemical, and legal integrity of the samples. The quality and reliability of the data produced from a sampling event can be compromised by broken sample containers, samples stored at temperatures outside specified limits, samples which exceed recommended hold times, or sample containers which may have been broken or tampered with.

To maintain the integrity of samples after collection, they must be cooled, packaged, and shipped to the receiving laboratory in a manner that preserves the integrity of the samples and delivers those samples to the testing laboratory within the shortest hold-time of the sampling event's required analyses. Proper packing techniques must be deployed to protect each sample from damage, breakage, and contamination, and to maintain the required preservation temperature for the duration of their transportation to the laboratory.

8.1 Sample Hold Times

Sampling plans must include a sampling schedule with logistics that will ensure that samples are received by the laboratory within their hold-time. Sample hold-times must be strictly adhered to.

A hold time is defined as the time that elapses between the time a sample is collected and the initiation of analytical preparations for that sample by laboratory staff. For planning purposes, the initiation of analytical preparations can be approximated as the receipt of a sample by the laboratory. Parameters with prescribed hold-times of 15 minutes (e.g. pH and DO) should be measured in the field and preferably in-situ. Regardless of prescribed hold-times, an accurate record of both the date and time of sample collection must be recorded on the requisition forms for each sample collected.

Sampling plans should consider a courier's pick-up or drop-off deadline as well as their guaranteed delivery times and any other logistical considerations in order to prevent the exceedance of hold-times and to ensure that the samples are maintained at proper preservation temperatures while in transit. Courier collections or drop-offs on Friday's may result in samples sitting in a warehouse over the weekend which may in turn, result in a hold time exceedance and/or sample temperatures exceeding their limits. To avoid either exceedance, samples can be stored in a clean refrigerator over the weekend as long as hold times will not be exceeded.

Always consult with the shipping company and the laboratory to ensure that the samples will be received by the laboratory without undue delay, within the shortest hold time prescribed for all of the analytical tests requested and at a temperature that ensures they are fit for those tests.

ENV maintains a 'table' of required sample containers, storage temperatures, preservation requirements and holding times on their website at:

https://www2.gov.bc.ca/gov/content?id=A9BE9DDAB0674DD29D1308C4BEE7FBB4

The table is maintained as part of the B.C. Environmental Laboratory Manual. Note 3 of the 'table' states that samples collected for all tests where refrigeration at ≤ 6°C is required at the laboratory, should be packed with ice to maintain a temperature of ≤10°C during transport to the laboratory. However, microbiological samples should be stored at 4±3°C (or as per reference method) during transport to the laboratory.

8.2 Sample Packing and Delivery/Shipment

Samples should be packaged in a protective container in a manner that will ensure that the samples will be received by the laboratory intact and at the appropriate temperature. Samples should be double bagged, adequately spaced and firmly packed. Glass containers should be individually protected within a bubble envelope or bubble wrap. Foam packing material, bubble wrap or other inert materials should be used to fill any void spaces in the shipping container to prevent the samples from shifting or breaking during transport. Samples should be cooled upon collection by placing them into pre-cooled containers such as hard-bodied coolers. Samples should be maintained at or below 10°C from the time of collection until their arrival, receipt, and handling at the laboratory. A common approach is to ship the samples in a clean, insulated cooler with double bagged ice cubes or plastic bottles filled with water and frozen. In order to maintain the samples at a temperature at or below 10°C the volume of ice should, at a minimum, be similar to that of the samples. In warmer months, it is recommended that the ratio of ice to sample volume be doubled. A temperature blank may be included in the cooler so that the lab can check the temperature of the samples upon receipt although most laboratories deploy non-intrusive instruments to measure sample temperature. The completed Chain-of-Custody form should be sealed in a plastic bag and taped to the inside lid of the shipping container.

Labs may apply a "Cooling Initiated" qualifier on their analytical reports to identify samples that were received above a required storage temperature but were sampled less than 8 hours before arrival at the lab and packed appropriately in coolers with ice or cold packs to initiate the cooling process.

Note that reusable chemical ice packs are not recommended as they may not keep the sample cool enough and may cause cross-contamination if the ice packs leak during shipment. Dry ice is also not acceptable, as it may cause samples to freeze in whole or in part and may result in container breakage (Nielsen, 2006).

After samples have been collected and securely packaged, they must either be delivered or shipped to the laboratory within the required hold time. The preferred method is for the sampler to deliver the samples to the laboratory as it reduces the number of people in possession of the samples and ensures the samples have been handled correctly. If transporting samples using a vehicle, it is recommended that the samples be stored within the passenger compartment or trunk of the vehicle, especially during cold weather, as the samples may freeze if left in the box of a truck.

If samples are shipped by a third party courier, custody seals must be applied on the shipping container or cooler to maintain chain-of-custody integrity. The shipment and receipt of samples should be coordinated with the laboratory prior to the sampling event to ensure the samples arrive within their hold time. Samples can be stored in a refrigerator to avoid after hours delivery delays however as a general rule the samples should be received by the testing laboratory within 24 to 48 hours of collection.

Samples that are shipped using a courier must comply with applicable shipping regulations. If the samples are classified as dangerous goods, they must be shipped in accordance with the Transportation of Dangerous Goods (TDG) Act. In general, surface water samples will not fall under this category, although shipping of certain preservatives (e.g., methanol) and samples of fuel or other chemicals may classify as dangerous goods. A list of dangerous goods is supplied in the TDG regulations. The shipping carrier can provide assistance in shipping dangerous goods.

The following packaging and shipment procedures must be followed to maintain the integrity of the samples during transit:

1. Place each sample in a pre-chilled cooler as soon as they are collected and processed. Ensure the lids of each sample container are firmly closed. Individual glass sample containers should be placed in bubble wrap bags or otherwise adequately protected with bubble-wrap or an equally protective product.

2. Sample containers should be stored in a chilled cooler along with enough cooling products (e.g. ice or bottles of frozen water) to maintain the samples at or below a temperature of 10º C for the duration of their transport to the testing laboratory.
3. Bagged ice cubes or plastic bottles filled with water and frozen are strongly recommended for cooling. Remember that melted ice poses a potential source of contamination. If using ice cubes always double-bag the loose ice. Place the ice in a plastic sealable bag. Place this bag of ice into a second sealable plastic bag and ensure each bag is fully sealed.
4. Do not use gel-type ice packs for cooling during moderate to hot weather periods (ambient air temperatures greater than 20º C). Ice packs do not provide enough cooling to maintain a temperature at or below the 10º C temperature point prescribed for the preservation of most sample types. Broken ice packs pose a potential source of contamination. For instances where gel-type ice packs are used, ensure they are sealed within a sturdy resealable bag.
5. Ice blocks are strongly discouraged. Blocks of ice may shift during transport and break glass sample containers.
6. Place the double-bagged ice or frozen water bottles in the bottom of the cooler in a manner that maximizes package integrity.
7. To ensure the samples are maintained at a temperature at or below 10º C during transport, inspect the shipping container (cooler) immediately prior to shipment and if necessary, add and or replace the ice or bottles of frozen water with fresh ice or bottles.
8. Fill the cooler with as many bags or bottles of frozen water as needed based on the total volume of sample material in the cooler, the ambient temperature, and the duration of travel to the laboratory. In cool to warm weather conditions (ambient air temperature below 20º C) the ratio of ice to sample material should at a minimum, be 1:1 by volume.
9. Place the samples upright in the shipping container. Do not overfill the shipping container with samples.
10. Intersperse/alternate glass sample containers with plastic sample containers.
11. Arrange the sample containers and cooling products in a manner that provides a measure of physical protection for the sample containers especially the glass sample containers.
12. Use packing material to provide further protection by filling any voids left in the shipping container. This will reduce shifting during transport. Remember that as the ice melts space will result which in turn will provide opportunity for the samples to shift and move about during transport. Densely packed bubble-wrap will provide partial compensation as this occurs.
13. Complete the chain of custody per Section 8.3 and/or Ministry requisition form/s and enclose it/them in a sealed plastic bag. Place the bag in the cooler on top of the samples or tape it to the inner lid. The recommended minimum information that should be included in each requisition form is listed below:
    - Project number,
    - Client/owner name,
    - Site name,
    - EMS site number/s,
    - Date and time of collection for each sample,
    - Total number of bottles submitted,
    - Name of sampler/collector,

- Field measurements,
- Analytical tests requested for each sample,
- Comments on sample appearance,
- Weather conditions; and,
- Any other observations that may assist in interpreting data.

14. Seal the cooler with heavy duty packing tape to reduce the possibility of it accidentally opening and to prevent tampering. Coolers arriving at the laboratory with torn or absent tape should be noted by lab staff with notification sent by lab reception to the sample submitter.
15. Attach a shipping label on top of the cooler, if shipping by courier, to prominently display the destination.

8.3 Chain of Custody (COC)

Water samples collected as part of an SWQMP and submitted for laboratory analysis are required to be recorded on a Chain-of-Custody (CoC) form. This form, which is typically provided by the laboratory, is a legal document used to record the collection of samples and to document the control, transfer, analysis, and disposition of those samples to assure regulatory sample integrity and legal defensibility (ASTM D4840, 2010). The CoC form ensures that all individuals in possession of a sample and or sample container, such as a cooler, can be identified. The CoC is also used to provide sample identification, the number of containers included in a sample, the date and time of collection, and, to indicate which analytical tests are to be conducted on each sample submitted.

All areas of the CoC form must be legibly and accurately completed. Incomplete or inaccurate forms, missing bottles, or mislabelled containers can cause unnecessary delays at the laboratory and put the reliability of the sample information into question. In general, the following CoC procedures should be followed when preparing and shipping water samples:

1. Complete the CoC form as samples are acquired in the field,
2. Complete a separate CoC form for each shipping container (cooler). All samples including laboratory prepared QA/QC samples must be identified on the CoC,
3. Ensure that each field on the CoC form has been completed as required and is correct. This includes project and client specific information, as well as the sampler's name, sample IDs, sample dates and times, the sample matrix, the number of containers used for each sample, a list of analyses to be conducted, preservatives used, requested turn-around times, requested regulatory criteria, and hold requests,
4. Ensure that each sample bottle is labelled correctly and that each label matches its entry on the CoC form,
5. Sign and date each CoC form upon release of the samples (coolers) to the shipping company or the laboratory if the samples are delivered directly to a laboratory; and,
6. At least one copy of the CoC must accompany the samples at all times. One copy should be retained by the sampler.

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10 Revision History

May 2021:	Entire Section E1 was revised and updated.
October 2013:	This section republished without change. Notes added to Appendix 4: Sample Container, Preservation, and Hold Times for Water and Effluent Samples updated
November 1996:	Initial publication.

Appendix 1

Field Forms

Field Data Sheet

Site Name: Date:
Sample Station ID: Arrival Time:
Coordinates: Departure Time:
Program/Project: Field Staff:

Ambient Temp: Sun/Cloud Cover: Precipitation: Wind:
General Weather Observations:
Deviations from Sample Plans:
Observations of Site & Water Conditions:

Field Measurements

Parameter	Reading		Instrument Type / ID	Calibration Date
Temperature:				
Specific Conductance:				
pH:				
DO:				
ORP:				
Clarity:		Decent:	Ascent:	Clarity = (Decent + Ascent) / 2
Other:				
Notes:				

Field Notes

Appendix 2

Standard Operating Procedures (SOPs)

Sampling Method/Media: **Quality Control Samples / Surface Water**	**Standard Operating Procedure for the Collection of Quality Control Samples**
Revision No: Original **Revision Date: 09 January, 2024**	**Reference No: SOP-E1-01** **Parent Document: BC Field Sampling Manual – Part E1**

1. Introduction and Scope

This Standard Operating Procedure (SOP) provides operating guidelines and instruction for the preparation of quality control (QC) samples. Quality control samples fulfill two primary quality assurance objectives. The first objective is to provide an early warning of a sampling or analytical process that begins to move out-of-control. The second objective is to provide analytical data that can be used to demonstrate that field activities and laboratory processes are in control; or conversely to identify and estimate sources of random and systemic errors such as contamination.

The purpose of this SOP is to provide clear and consistent instructions for the collection of quality control samples that satisfy the Province's requirements for data quality assurance. This SOP includes a general list of common materials, methods, and data required for surface water quality monitoring programs. Note that special considerations, such as client demands, project-specific data quality objectives (DQO), ambient conditions, and/or regulatory requirements may necessitate the collection of sample types not covered in this SOP or variations of the instructions provided in this SOP.

This SOP forms part of the British Columbia Field Sampling Manual (BCFSM). Additional information on quality assurance, quality control, and the collection of quality control samples is provided in Part A – Quality Control and Quality Assurance, and Part E1 – Surface Water, which must be used in conjunction with the information provided in this SOP. This SOP and the BCFSM are available at:

https://www2.gov.bc.ca/gov/content?id=307726C4B5C64194BA39E51605E33827.

Further guidance is provided in the Water Sustainability Act (WSA) which is available at:

https://www2.gov.bc.ca/gov/content?id=6C2C94A8E26D4F5994D8086A83398FF6.

Quality control samples collected for regulatory purposes within the provincial jurisdiction of BC must be carried out with consideration to the WSA as applicable, Part A and Part E1 of the BC Field Sampling Manual, and this document.

2. Document Control

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.

3. Principle of the Sampling Method

The collection of quality control (QC) samples is based on the principle of inherent errors. QC samples are collected to verify the integrity of samples collected in the field and subsequently to demonstrate the reliability of analytical data produced during a sampling event or program.

4. Quality Control

Field Preparations

- Prior to each sampling event, ensure that field equipment has been adequately cleaned, has been properly calibrated where necessary and is functioning as per manufacture's specifications.

- Ensure that accurate coordinates or benchmarks for each sampling location (station) is known.
- Ensure field staff are properly trained for the collection of each type of surface water sample required.
- Check the laboratory supplied sample containers and preservatives to ensure that caps are firmly secured and that preservatives have not exceeded their expiry dates.

In-Field Activities

- Field staff must keep their hands clean, wear laboratory/medical-grade gloves, and refrain from eating or smoking while working with water samples. Remember that products such as sunscreen and insect repellent can contaminate samples.
- The inner portion of sample and preservative bottles and caps must not come into contact with anything including bare hands, gloved hands, thermometers, probes, or preservative dispensers.
- If sampling from a motorized boat, ensure that samples are collected up-wind of the motors exhaust.
- De-ionized water bottles should be clearly labeled with both the filling date and disposal date. De-ionized water should not be used beyond its 6 month shelf-life period.
- Ensure that accurate notes are taken to record the station a QC sample is collected from, the purpose and details of the sample (e.g. filter blank, filter + pump blank, etc.) and in the case of duplicates, the identity of the regular sample the duplicate sample will be evaluated with.
- Immediately following collection and any necessary preparations, place QC samples into a chilled container such as a cooler to initiate the cooling process.
- Record accurate and comprehensive notes of all field activities and conditions.

5. Recommended Equipment and Materials

The final selection of materials required for the collection of quality control samples should be made with due consideration of sampling methodology, potential contaminants of concern, regulatory/permit requirements, and other site-specific factors.

Typical materials and equipment required for the collection of quality control samples include:

- De-ionized or distilled water.
- Contaminant-free sample bottles provided by the issuing laboratory.
- Preservatives provided by the issuing laboratory .
- Individually wrapped 0.45 µm filters and syringes.
- Pre-made labels and writing utensils.
- Required water quality sampling equipment and field measurement instrumentation.
- Coolers and ice packs / bagged ice cubes / filled and frozen water bottles.

6. Quality Control Sample Considerations

- For any sampling event the number and types of quality control samples required must be chosen to satisfy the DQOs of the sampling program. Section 7 of this SOP provides instructions for the collection of most types of quality control samples however, the types of quality control samples and the numbers of those collected must be established specifically for each sampling program or event. Table 3.2 in Part E1 of the BCFSM provides recommended frequencies for the collection of quality control samples.

7. Procedures

Regardless of the type of QC sample being collected, the details of that sample must be recorded in field notes to identify its purpose, sample ID and any link to a regular sample, any equipment the deionized water came in contact with in the preparation of equipment blanks, station name, and details of the sampling environment including weather.

Trip Blank

1. Trip blanks are of limited value and are only recommended on a conditional basis for sampling events involving VOCs. In order to realize the full potential of a trip blank it must be prepared and provided by the analytical laboratory that will be testing the monitoring programs regular samples.
2. Trip blanks are typically provided by the testing laboratory along with the sample bottles and supplies required for the sampling event.
3. Trip Blanks should be brought to the field in the same containers used to transport the sample bottles that will be used for the collection of regular samples. Trip blanks must remain **unopened** throughout the sampling event. At the end of the sampling event, trip blanks are transported along with the regular samples, to the testing laboratory.
4. Trip blanks should be analysed for potential contaminants of concern or contaminants identified in previous sampling events at the sampling station.

Ambient Blank

1. Ambient blanks are prepared in the field in a manner that replicates the conditions of interest and always using the same protocol used to collect regular samples.
2. If sampling from a boat, the ambient blank should be prepared in the boat immediately following the collection of the regular sample of the same type. Open the ambient blank bottle, fill with de-ionized water, add preservative if required, cap the bottle, and ensure it is securely closed.
3. When sampling from shore or after wading into a stream the collection of an ambient blank is more efficient with two samplers as you will need to have possession of and manoeuvre, a container of de-ionized water at the point of collection. Once in place collect the regular sample first and then fill the field blank bottle with de-ionized water, add preservative if required, cap the bottle, and ensure it is securely closed.
4. Place the regular and blank samples into a pre-chilled container.

Equipment Blank

1. Equipment blanks can be prepared to isolate and assess a single piece of equipment such as a Kemmerer or pump or it can be prepared to assess the complete chain of sampling equipment. The type and number of equipment blanks required for a sampling event should be established in a sampling plan or program. It is important that the purpose of the equipment blank and details of its collection be clearly recorded in field notes.
2. Equipment blanks must be collected using the same protocol as regular samples of the same sample type. Ensure the equipment has been properly decontaminated and rinsed prior to collecting the equipment blank. In most situations, the equipment blank should be collected after decontamination and prior to the collection of regular samples.
3. For samples collected with equipment such as a Van Dorn sampler, fill or partially fill the device with de-ionized water. Shake and rotate the device to ensure the de-ionized water comes into contact with all of the materials and components as that of the regular sample. Decant the water from the drain valve into the equipment blank bottle, add preservative if required, cap the bottle, and ensure it is securely closed.
4. For samples collected using a pump, pour a volume of de-ionized water into a laboratory supplied, contaminant-free sample bottle, such as a 1 L amber bottle. It is important to note that the volume of de-ionized water required for this procedure exceeds that of the equipment blank, as some of the de-ionized water will remain in the pump and its tubing. For this reason, it is prudent to decant twice the volume of de-ionized water required for the equipment blank. Place the inlet hose of the pump into the aliquot of deionized water, start the pump and allow a small volume of the de-ionized water to flush through the sample train including tubing and discharge to ground surface or into a catchment. Fill the equipment blank bottle, add preservative if required, cap the bottle, and ensure it is securely closed.
5. Place the blank sample into a pre-chilled container.

Filtration Blank

1. For sampling plans that include dissolved/filtered samples it is recommended that filtration blanks be prepared and analysed along with regular samples to confirm that the filtration apparatus did not affect the integrity of regular samples.
2. If samples are to be filtered using a syringe and disc filter, it is strongly recommended that individually wrapped units be deployed. If bulk units are used, they should be brought to the field in clean, sealable bags or containers. Unwrap each unit, fit the filter onto the syringe, fill the syringe with de-ionized water, and flush 10 mL of the water through the filter and then proceed to fill the filtration blank bottle with the filtered de-ionized water. Add preservative if required, cap the bottle, and ensure it is securely closed.
3. If samples are to be filtered using a purpose-built apparatus, clean/decontaminate and thoroughly rinse the unit prior to preparing the blank. Set up the filtration apparatus in the same configuration used to filter regular samples. Fill the apparatus with deionized water, flush a small amount (approx. 10 mL) of the deionized water through the apparatus and then fill the filtration blank bottle. Add preservative if required, cap the bottle, and ensure it is securely closed.
4. Place the blank sample into a pre-chilled container.

Replicate/Duplicate Samples

1. During pre-trip preparations select the sample station(s) from which the replicate sample(s) will be collected. Establish a nomenclature to identify the regular sample and its duplicate/replicates in a manner that conceals their purpose. Field notes should clearly identify the samples. Label the replicate and regular sample bottles.
2. Record in field notes, the identification of both the regular sample and its duplicate/replicates, the coordinates and or name of the sampling station, and any other information pertinent to the replicate samples.
3. Use a laboratory supplied sample bottle, or decontaminated sampling device to collect a sample. Decant the sample water into each bottle by adding equal aliquots alternately into the replicate sample bottles, until both sample bottles are full. Alternatively, the duplicates can be collected in-situ simultaneously (co-located). Add preservative if required, cap the bottle, and ensure it is securely closed.
4. Follow the same procedure to collect a triplicate or as many replicates as needed for the QA objective.
5. Place the replicate samples into a pre-chilled container.

Split Samples

1. Prior to sampling, the sample splitter must be cleaned.
    a. Soak the vessel in deionized water.
    b. If the vessel was previously used to split samples of water containing hydrocarbons, oils, or grease, or the vessel's interior walls exhibit an oily film, soak the vessel in a 0.1 to 2 percent non-phosphate, laboratory grade detergent solution,
    c. Scrub all of the vessel's sample supporting parts using a non-metallic brush,
    d. Rinse well with de-ionized water flushing some of the rinse water through the spigot; and,
    e. Rinse twice more with deionized water flushing some of the rinse water through the spigot.
2. Estimate the volume of water required for all of the split samples to be collected at the sampling station.
3. Wearing laboratory/medical-grade gloves, fill the clean split sample vessel using a single container; preferably a laboratory supplied contaminant-free, 1L amber jar.
4. Mix the contents of the sample splitter by raising and lowering the agitator rod through the height of the water contained in the splitter. Keep the churning plate submerged while mixing. Constant or near-continuous mixing will provide the most homogenous sample. The rate at which the rod is raised and

lowered does not have to be quick but should be uniform throughout the sampling process. The USGS suggests a rate of approximately 22 cm (9 in) per second. Mixing should be carried out for a minimum of 10 strokes before subsampling.

5. Discharge a small volume of water to purge the spigot and discard. Fill each sample bottle from the spigot while continuing to mix the contents of the sample splitter.
6. If multiple sample containers are required, the containers should be filled in an alternating pattern to produce homogenous split samples.
7. To prepare split samples for dissolved parameters, fill a filtration apparatus from the sample splitter and dispense equal aliquots of the filtered media to each bottle in an alternating manner until each container has been filled.
8. Add preservative if required, cap the bottle, and ensure it is securely closed.
9. Place the split samples into a pre-chilled container.

Spiked Samples

1. During field preparations arrange for the provision of a spike solution which is typically prepared by the analytical laboratory and provided to the sampler in a small vial. Label both bottles. In some cases, it may be preferred that the spiked sample is not discernible from the regular sample in which case it should be labelled accordingly. Clearly identify both the regular sample and the spiked sample in field notes. As with split and replicate samples, a spiked sample should be collected along with a regular sample.
2. Prepare the two water samples in accordance with the appropriate protocol for the sample type of interest, leaving a small void in the bottle collected for a spiked sample.
3. Add the aliquot of spike solution to the designated sample bottle and recap the bottles. Tilt the spiked sample bottle to mix in the spiked solution.
4. Place the spiked and regular samples into a pre-chilled container.

8. References

1. USGS, 2002. National Field Manual for the Collection of Water Quality Data, Chapter A5: Processing of Water Samples. U.S. Geological Survey, dated April 2002.
2. ENV, 2019. Split Sample Audit Program, Guidance Document for Permit Holders. BC Ministry of Environment and Climate Change Strategy, dated February 2019.
3. ENV, 2013. BC Field Sampling Manual – Part E Water and Wastewater Sampling. BC Ministry of Environment and Climate Change Strategy, dated 2013.
4. Alberta Environment and Parks. 2006. Aquatic Ecosystems Field Sampling Protocols. Government of Alberta, dated March 2006.

Revision History: 0.0 (New document)

Approval:

Sampling Method/Media: **Decontamination / Equipment**	**Standard Operating Procedure for Cleaning and Decontamination of Sampling Equipment**
Revision No: Original Revision Date: 09 January, 2024	**Reference No: SOP-E1-02 Parent Document: BC Field Sampling Manual – Part E1**

1. Introduction and Scope

This Standard Operating Procedure (SOP) provides operating guidelines and instruction for the cleaning and decontamination of water quality sampling equipment. Cleaning and decontamination should be an integral component of a Quality Assurance Manual and consistently deployed during each sampling event. Effective cleaning will mitigate the potential for contamination and cross-contamination of samples collected during a sampling event and between sampling events. Decontamination is particularly important when trace parameters such as trace metals, or trace organic constituents are being sampled. Cleaning is also used to remove manufacturing residues from new equipment and to remove dust and foreign substances from equipment that has been in long-term storage (CCME, 2011).

This SOP forms part of the British Columbia Field Sampling Manual (BCFSM). Additional information on cleaning and decontamination is provided in Part A – Quality Control and Quality Assurance and Part E1 – Surface Water, of the BCFSM, which must be used in conjunction with the information provided in this SOP. This SOP and the BCFSM are available at:

https://www2.gov.bc.ca/gov/content?id=307726C4B5C64194BA39E51605E33827.

2. Document Control

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.

3. Principle of the Sampling Method

The equipment decontamination instructions provided in this document is based on the principles of process control and contamination prevention. Most sampling environments contain contaminants and as such controls are required to mitigate the potential for those contaminants from entering the sample water, equipment, and bottles. Contaminants are also available as residue in or on new equipment, and in the form of dust and foreign materials which may collect in or on stored equipment and as such require decontamination.

4. Quality Control

- Equipment, filter units and related apparatus must be decontaminated using routine procedures such as washing with phosphate free detergent or acid washes and rinses with de-ionized water.
- Field cleaning is often not as effective as cleaning equipment at a support facility. The level of cleaning required for equipment used to collect samples for low and ultra low level analyte concentrations may only be possible at a support facility, rather than in the field.
- Avoid using bleaches and strong detergents; specialty cleaning compounds are available. Store cleaned equipment and filter units in labelled, sealed plastic bags where possible.

5. Recommended Equipment and Materials

The final selection of materials for equipment decontamination should be made with due consideration of the type of analysis required, contaminants of concern, the material the equipment is made of, contaminants present in the samples most recently collected, and program-specific factors.

Typical decontamination materials include:

- Non-phosphate detergent
- Scrub brushes
- Distilled water
- De-ionized water
- 5% hydrochloric acid solution
- 10% nitric acid solution
- Fume hood
- Safety glasses and gloves
- SDS for each chemical used
- Hazardous waste container
- Parafilm
- Re-sealable plastic bags
- Organic solvent – acetone, hexane, or methanol

6. Equipment Decontamination Considerations

- Extra care should be taken during any steps in the decontamination protocol that use acids or solvents. These steps should only be carried out in a fume hood or if a fume hood is not available, while wearing a respirator.
- Prior to handling acids and solvents, consult the Safety Data Sheet (SDS) for each product used.
- When handling acids or solvents, safety glasses and gloves must be worn at all times.
- When preparing an acid solution, always add acid to water as opposed to adding water to acid.
- Do not store acids next to solvents. Do not mix acids and solvents.
- Leftover acids and solvents should be discarded into **separate hazardous waste containers** labelled specifically for “organic solvents” or “acids”.

7. Procedures

Trace Inorganic Analysis – Decontamination Protocol

1. The following procedures should be carried out in a controlled environment free of airborne contaminates when possible.
2. To remove particulate matter, residual oils and grease, scrub equipment with brushes and non-phosphate detergent (e.g., Liquinox, Contrad, Extran).
    a. A 0.1 – 2.0 % (v/v) detergent solution can be used to clean between field trips.
    b. Field cleaning solutions should not exceed 0.2% (v/v) detergent.
3. To remove detergent residues, rinse with tap water followed by a distilled water rinse.
4. Non-metallic equipment can undergo an acid rinse or 30-minute soak with a 5% (v/v) solution of hydrochloric acid or a 10% (v/v) solution of nitric acid. Do not use nitric acid if the samples collected with the equipment will undergo nitrogen analysis.
    a. Consult the Safety Data Sheet (SDS) for each chemical used.
    b. Wear safety glasses and gloves.
    c. Always add acid to water; never add water to acid.
    d. Prepare and carry out acid rinses/soaks within a fume hood (or wear a respirator if fume hood is not available).
    e. Leftover acid should be stored in a labelled hazardous waste container, and properly disposed of.
    f. Do not store acids next to solvents.

5. To remove acid residues, three to five distilled water rinses should be performed. The last rinse should be done with de-ionized water.
6. Air dry clean equipment and store in clean containers or new re-sealable plastic bags. Equipment openings can be covered with Parafilm.

Trace Organic Analysis – Decontamination Protocol

1. Containers must be constructed of stainless steel, glass, or Teflon.
2. To remove particulate matter, residual oils and grease, scrub equipment with brushes and non-phosphate detergent. For organic analysis, this should be done in the fume hood.
3. To remove detergent residues rinse with tap water, followed by a distilled water rinse.
4. Rinse with organic solvents (e.g., acetone, hexane, or methanol). CCME (2011) recommends rinsing with hexane, allow the equipment to air dry, then rinse with acetone.
    a. Consult the SDS for all chemicals used.
    b. Wear safety glasses and gloves.
    c. Conduct the solvent rinses/soaks within a fume hood (or wear a respirator if fume hood is not available).
    d. Discard solvent waste into a labelled container for organic solvents, and store in hazardous waste area for disposal.
    e. Do not store acids next to solvents.
5. To remove solvent residues, three to five distilled water rinses should be performed. The last rinse should be done with de-ionized water.
6. Air dry clean equipment on a surface covered in new aluminum foil and store in clean containers or new re-sealable plastic bags. Equipment openings can be covered with Parafilm.

Stainless Steel – Decontamination Protocol

1. Wash stainless steel equipment with a non-phosphate detergent.
2. Rinse thoroughly with deionized water.
3. Air dry and store in clean containers or new re-sealable plastic bags.

Peristaltic Pump Tubes and Other Specific Equipment – Decontamination Protocol

1. Rinse with water (de-ionized, distilled or tap) inside and out. Remove all metal components and valves from the tubing.
2. Soak or fill sampling tubing with 5% HCl and leave for 6-12 hours. Do not soak metal components of the sampling apparatus in acid.
3. To remove acid residues, three to five distilled water rinses should be performed. The last rinse should be done with de-ionized water.
4. Store tubing in clean containers or new re-sealable plastic bags. Tubing should be replaced annually.

8. References

1. USGS, 2004. National Field Manual for the Collection of Water-Quality Data (NFM), Chapter A3, Cleaning of Equipment for Water Sampling. U.S. Geological Survey, dated April 2004.
2. CCME, 2011. Protocols Manual for Water Quality Sampling in Canada. Canadian Council of Ministers of the Environment. ISBN 978-1-896997-7-0, 180 pp.
3. Alberta Environment and Parks. 2006. Aquatic Ecosystems Field Sampling Protocols. Government of Alberta, dated March 2006.

Revision History: 0.0 (New document)

Approval:

Sampling Method/Media: **Sampling from Shore / Surface Water**	**Standard Operating Procedure for Sampling from Shore**
Revision No: Original **Revision Date: 09 January, 2024**	**Reference No: SOP-E1-03** **Parent Document: BC Field Sampling Manual – Part E1**

1. Introduction and Scope

This Standard Operating Procedure (SOP) provides operating guidelines and instruction for collecting water quality samples from a shore or near-shore sampling station at a lake, reservoir, river, or stream. The purpose of this SOP is to provide competent and safe instructions for the collection of samples that can be relied upon to produce analytical data that is representative of the water body from which it is collected. Samplers are encouraged to follow the instructions of the SOP consistently throughout the duration of the monitoring program. Consistency in sampling is especially important for long-term trend monitoring.

This SOP forms part of the British Columbia Field Sampling Manual (BCFSM). Additional information water sample collection methodologies is provided in Part E1 – Surface Water of the BCFSM, which must be used in conjunction with the information provided in this SOP. This SOP and the BCFSM are available at:

https://www2.gov.bc.ca/gov/content?id=307726C4B5C64194BA39E51605E33827.

Further guidance is provided in the Water Sustainability Act (WSA) which is available at:

https://www2.gov.bc.ca/gov/content?id=6C2C94A8E26D4F5994D8086A83398FF6.

Surface water samples collected for regulatory purposes within the provincial jurisdiction of BC must be carried out with consideration to the WSA as applicable, Part E1 of the BC Field Sampling Manual, and this document.

2. Document Control

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.

3. Principle of the Sampling Method

The methods described in this SOP are based on the principle objective of collecting samples that are representative of the source water.

4. Quality Control

- Field staff should keep their hands clean and free of products such as sunscreen, wear nitrile gloves, and refrain from eating, drinking, or smoking while working with water samples.
- The inner portion of sample bottles and caps must not be touched with anything including bare hands, gloved hands, thermometers, probes, and preservative dispensers.
- Keep sample bottles capped until you are ready to collect or decant a sample. Remove caps immediately prior to sampling and re-cap right away. During sample collection, store bottle caps in a clean, resealable plastic bag, not in pockets, etc.
- Sample bottles, including bottle caps, should be provided by the issuing laboratory, and certified as 'contaminant free'. Use only the type of sample bottle recommended by the issuing laboratory for each analysis.
- Keep sample bottles in a clean environment, away from dust, dirt, fumes, and grime. Bottles must be capped at all times and stored in clean shipping containers (coolers) both before and after the collection of the sample. Vehicle cleanliness is an important factor in eliminating contamination problems.

- After collection, cool samples to ≤ 10° C as quickly as possible. Samples should be placed into coolers packed with bagged ice cubes and shipped to the laboratory so that they arrive within 24 hours of sampling.

5. Recommended Equipment and Materials

The final selection of materials when sampling from shore depend on the type and size of the water body being sampled (i.e. lake vs. river), safety considerations, equipment available, contaminants of concern, the desired analysis, regulatory requirements, and other site-specific factors.

Typical materials used when sampling from shore include:

- Hip or chest waders
- Safety tether/harness (if warranted)
- Personal Floatation Device (if warranted)
- Swing Sampler
- Empty sample bottles
- Preservative
- Filtration apparatus
- 0.45 µm filters

6. Sampling from Shore Considerations

- Review the sampling plan to confirm the coordinates of the sampling station/s.
- A **Swing Sampler** can be used when sampling from shore to extend the sampler's reach into the waterbody and mitigate the potential for sediment inclusion.
- Never wade into water that appears deep or fast flowing. Always wear a PFD when wading, have a second person nearby, and wear a safety line.
- Samplers must be wary of uneven, slippery or non-visible stream bottoms, especially under turbid conditions. ENV strongly recommended that individuals who sample by wading, take swift-water training and adhere to all water safety precautions.
- Regardless of the coordinates sampling station, sampling from a stream bank may be necessary for large rivers in cases where (1) the current is too strong or the water is too deep to safely wade into the flow, or (2) the ice is too thin to safely sample through the ice.
- Water samples must always be collected facing upstream in rivers or oriented towards the centre of a lake.

7. Procedures

Lake / Reservoir

1. Visually inspect potential access points and substrates, to identify a safe entry point and to avoid obstructions and or drop offs.
2. With gloved hands obtain labelled bottles and wade into the lake or reservoir from a safe entry point.
3. Once you reach a sufficient depth, where substrate materials will not interfere with the sample, stop, and orient yourself towards the centre of the lake or reservoir.
4. Remove the bottle cap and hold it aside without touching the inner surface.
5. Collect the water sample:
    a. **Handheld Collection:** While grasping the bottle well below the neck, lean out towards the centre of the lake or reservoir and in one continuous motion, plunge the bottle beneath the surface and slowly force it through the water until it is full.

b. **Swing sampler with a sample bottle holder / snapper attachment:** Securely attach a laboratory supplied contaminant free sample bottle to the end of the swing sampler using the snapper attachment. Remove the cap and place it in a clean sealable bag. Hold the swing sampler out towards the centre of the lake or reservoir, lower the end of the swing sampler beneath the surface, and slowly force it through the water until the sample bottle is full.

6. Recap the sample bottle/s.
7. Return to shore and pack the sample(s) in a pre-chilled cooler.
8. Filter and preserve as required.

River / Stream

1. Visually inspect potential access points and substrates, to identify a safe entry point and to avoid obstructions and or drop offs.
2. With gloved hands obtain labelled bottles and wade into the river at a safe entry point. Always wade into the river downstream from the point at which the sample will be collected, then wade upstream to the sample station.
    a. If wading is not an option (i.e., stream is too small to wade, or current is too strong) and sampling must be conducted from the streambank skip to Step #4.
3. Once you reach a sufficient depth (where bottom material will not interfere with the sample), stop, and orient yourself in an upstream facing direction.
4. Remove the lid of the bottle and hold it aside without touching the inner surface.
5. Collect the water sample:
    a. **Handheld Collection:** While grasping the bottle well below the neck and while facing upstream plunge the bottle into the water in front of you with the opening facing directly down, then immediately orient the bottle into the current. Once the bottle is full, remove it from the water by forcing it forward (into the current) and upwards.
    b. **Swing sampler with a sample bottle holder / snapper attachment:** Securely attach the sample bottle to the end of the swing sampler using the snapper attachment. Hold the swing sampler out towards the centre of the river in an upstream direction and lower the end of the swing sampler beneath the surface. Slowly force the sampler through the water and against the current until the sample bottle is full.
6. Recap the sample bottle.
7. Return to shore and pack the sample/s in a cooler until time and conditions permit for other necessary procedures such as filtration and/or preservation.
8. Filter and preserve as required.

8. References

1. ENV, 2013. BC Field Sampling Manual – Part E Water and Wastewater Sampling. BC Ministry of Environment and Climate Change Strategy, dated 2013.
2. Alberta Environment and Parks. 2006. Aquatic Ecosystems Field Sampling Protocols. Government of Alberta, dated March 2006.
3. CCME, 2011. Protocols Manual for Water Quality Sampling in Canada. Canadian Council of Ministers of the Environment. ISBN 978-1-896997-7-0, 180 pp.

Revision History: 0.0 (New document)

Approval

Sampling Method/Media: **Sampling from a Boat / Surface Water**	**Standard Operating Procedure for Sampling from a Boat**
Revision No: Original **Revision Date: 09 January, 2024**	**Reference No: SOP-E1-04** **Parent Document: BC Field Sampling Manual – Part E1**

1. Introduction and Scope

This Standard Operating Procedure (SOP) provides operating guidelines and instruction for the collection of water quality samples from a boat in lake/reservoir or river/stream situations. The purpose of this SOP is to provide competent and safe instructions for the collection of water quality samples that can be relied upon to produce analytical data that is representative of the water body from which it is collected. Samplers are encouraged to follow the instructions of the SOP consistently throughout the duration of the monitoring program. Consistency in sampling is especially important for long-term trend monitoring.

This SOP forms part of the British Columbia Field Sampling Manual (BCFSM). Additional information water sample collection methodologies is provided in Part E1 – Surface Water of the BCFSM, which must be used in conjunction with the information provided in this SOP. This SOP and the BCFSM are available at:

https://www2.gov.bc.ca/gov/content?id=307726C4B5C64194BA39E51605E33827.

Further guidance is provided in the Water Sustainability Act (WSA) which is available at:

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Surface water samples collected for regulatory purposes within the provincial jurisdiction of BC must be carried out with consideration to the WSA as applicable, Part E1 of the BC Field Sampling Manual, and this document.

2. Document Control

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3. Principle of the Sampling Method

The methods described in this SOP are based on the principle objective of collecting samples that are representative of their parent material.

4. Quality Control

- Petroleum products such as gasoline, oil, and exhaust fumes are prime sources of contamination. Fuel spills or drips (which often occur in boats) must be cleaned up immediately. Exhaust fumes and cigarette smoke can contaminate samples with lead and other heavy metals.
- Field staff should keep their hands clean, free of sunscreen and insect repellent, wear laboratory/medical-grade gloves, and refrain from eating or smoking while working with water samples.
- The inner portion of sample bottles and caps must not be touched with anything including bare hands, gloved hands, thermometers, probes, and preservative dispensers.
- Remove caps immediately prior to sampling and re-cap the bottle immediately following sample collection. During sample collection, store bottle caps in a clean, resealable plastic bag, not in pockets, etc.
- Sample bottles, including bottle caps, should be provided by the issuing laboratory and certified as ‘contaminant free’. Use only the type of sample bottle recommended by the issuing laboratory for each analysis.

- Keep sample bottles in a clean environment, away from dust, dirt, fumes and grime. Bottles must be capped at all times and stored in clean shipping containers (coolers) both before and after the collection of the sample. Vehicle cleanliness is an important factor in eliminating contamination problems.
- After collection, cool samples to ≤10° C as quickly as possible. Samples should be placed into coolers packed with bagged ice cubes and shipped to the laboratory so that they arrive within 24 hours of sampling.

5. Recommended Equipment and Materials

The selection of materials required for sampling from a boat depends on the type and size of the water body being sampled (i.e. lake vs. river), safety considerations, required sample depths, analytical requirements, regulatory requirements, sampling plans and site-specific factors.

Typical materials used when sampling from a boat include:

- Boat, safety equipment (e.g. bailer), and certified boat operator
- Personal Floatation Devices (PFD), First Aid kit
- Navigation equipment, GPS, Sample Station Coordinates, Communications device
- Secchi Disc, Field Measurement Instrument/s (e.g. sondes, meters)
- Field notebook, map, requisition forms (e.g. COC),
- Swing Sampler, Van Dorn or Kemmerer Sampler
- Peristaltic Pump, tubing/attachments, weight
- Davit and winch to launch and retrieve depth samplers
- Laboratory supplied sample bottles, Preservatives, Cooler/s, Ice
- Filtration apparatus, 0.45 µm filters

6. Boat Sampling Considerations

- Weather forecast and marine conditions should be obtained prior to departure to the field. If conditions are poor, the sampling trip should be postponed.
- On board each member of the field crew must wear a personal floatation device (PFD). An inventory of boat-specific safety equipment (extra paddles, bailer, flares etc.), as required by Transport Canada, must be ensured prior to departure.
- ENV strongly recommends the use of a four-stroke motor for propulsion. Two-stroke motors tend to discharge a mixture of unburned gas and oil which increases the potential of hydrocarbon contamination.
- Jet boats are preferred over propeller boats for river operations for their maneuverability in shallow water. Additionally, jet propulsion does not pose the challenges of propellers in shallow water.
- Ideally, there should be three field crew aboard a boat during a sampling event. Two crew members are responsible for the collection of samples from the bow, as well as field measurements and field notes. The third crew member is responsible for boat operation only.

7. Procedures

General

1. Sampling should always begin at the most downstream sampling station.
2. When the boat has reached the sampling station, the engine remains on and the boat operator idles into the current to maintain the boats position and orientation, using a reference point on shore to do this. When the boat is properly positioned and stable, surface water samples and samples at depth can be collected.
3. If the boat must be anchored conduct a cursory safety assessment. If there are no safety concerns, anchor the boat and turn off the engine, to minimize the chance of hydrocarbon contamination.

4. When the boat operator confirms control of the vessel, the crew member(s) positioned at the bow (front) is cleared to collect the water samples. Tip: the bow is the anchor point and, even in slow moving water, the boat will drift so that the bow is upstream.
5. Collect water samples using one of the three methods outlined below.

Surface Water

6. Obtain a labelled sample bottle and remove the lid without touching the inside of the lid or bottle. Place the lid in a clean, sealable bag.
7. Plunge the inverted bottle into the water and in one continuous motion move the bottle upstream and then up-through the water column. Alternately, attach the empty sample bottle to a swing sampler, remove the lid and place it into a clean, sealable bag. Deploy the swing sampler as an extension of your arm. Rotate the sampler to invert the bottle. Plunge the inverted sample bottle into and through the water in an upstream direction.
8. Samples should be collected at a depth of approximately 0.2 meters.
9. Samples that do not require further processing can be re-capped and placed into a chilled storage container.
10. Samples that require preservation and or filtration should be processed following collection. Filtration must be conducted prior to preservation. Place the processed sample into a chilled storage container. ENV recommends that processing take place in the boat immediately following collection. If this is not possible, place the sample in a chilled storage container and conduct the processing once ashore.

Deep Water (Van Dorn / Kemmerer Sampler)

1. Ensure that the sampler is clean and free of contamination prior to deployment.
2. Collect an equipment blank if required.
3. Close the drain valve(s) and open the two ends of the sampler following the manufacturer's instructions.
4. Set the trip mechanism.
5. Lower the sampler to the desired depth.
6. While maintaining a taut rope, send the messenger down to "trip" the mechanism that closes the end seals.
7. Raise the sampler to the surface.
8. Open the drain valve and allow a small volume of water to flush through the drain valve. This will reduce the potential of contaminating your sample with water from the previous site.
9. Decant water from the Van Dorn or Kemmerer sampler into the individual sample bottles via the drain valve. Take care to avoid contact with the drain spout as contamination at this stage often occurs.
10. Samples that do not require further processing can be re-capped and placed into a chilled storage container.
11. Samples that require preservation and or filtration should be processed following collection. Filtration must be conducted prior to preservation. Place the processed sample into a chilled storage container. ENV recommends that processing take place in the boat immediately following collection. If this is not possible, place the sample in a chilled storage container and conduct the processing once ashore.

Deep Water (Peristaltic Pump)

1. Attach the intake and output hoses to the peristaltic pump.
2. Collect an equipment blank if required.
3. Attach a weight to the end of the intake hose.
4. Lower the intake hose into the water to the desired sampling depth.

5. Flush the pump for five minutes.
6. Direct the pump's output hose to fill each sample bottle. Do not touch the end of the hose to the sample bottles.
7. Samples that do not require further processing can be re-capped and placed into a chilled storage container.
8. Samples that require preservation and or filtration should be processed following collection. Filtration must be conducted prior to preservation. Place the processed sample into a chilled storage container. ENV recommends that processing take place in the boat immediately following collection. If this is not possible, place the sample in a chilled storage container and conduct the processing once ashore.
9. Lower the intake hose to the next sampling depth and flush the pump again. Alberta Environment (2006) recommends flushing the pump for 1 minute per 10 m of tubing.
10. Repeat steps 4 through 8 as required.
11. Pull in the intake hose and run the pump to flush all the water from the system. Shut off the pump.

8. References

1. ENV, 2013. BC Field Sampling Manual – Part E Water and Wastewater Sampling. BC Ministry of Environment and Climate Change Strategy, dated 2013.
2. Alberta Environment and Parks. 2006. Aquatic Ecosystems Field Sampling Protocols. Government of Alberta, dated March 2006.
3. CCME, 2011. Protocols Manual for Water Quality Sampling in Canada. Canadian Council of Ministers of the Environment. ISBN 978-1-896997-7-0, 180 pp.

Revision History: 0.0 (New document)

Approval:

Sampling Method/Media: **Sampling in Winter / Surface Water**	**Standard Operating Procedure for Surface Water Sampling in Winter**
Revision No: Original **Revision Date: 09 January, 2024**	**Reference No: SOP-E1-05** **Parent Document: BC Field Sampling Manual – Part E1**

1. Introduction and Scope

This Standard Operating Procedure (SOP) provides operating guidelines and instruction for the collection of water quality samples during the winter. The purpose of this SOP is to provide competent and safe instructions for the collection of water quality samples during winter conditions. Samples collected following these instructions can be relied upon to produce data that is representative of the water body from which it was collected. Samplers are encouraged to follow the instructions consistently throughout the duration of the monitoring program. Consistency in sampling is especially important for long-term trend monitoring.

This SOP forms part of the British Columbia Field Sampling Manual (BCFSM). Additional information regarding sampling in winter is provided in Part E1 – Surface Water of the BCFSM, which must be used in conjunction with the information provided in this SOP. This SOP and the BCFSM are available at:

https://www2.gov.bc.ca/gov/content?id=307726C4B5C64194BA39E51605E33827.

Further guidance is provided in the Water Sustainability Act (WSA) which is available at:

https://www2.gov.bc.ca/gov/content?id=6C2C94A8E26D4F5994D8086A83398FF6.

Surface water samples collected for regulatory purposes within the provincial jurisdiction of BC must be carried out with consideration to the WSA as applicable, Part E1 of the BC Field Sampling Manual, and this document.

2. Document Control

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.

3. Principle of the Sampling Method

The methods described in this SOP are based on the principle objective of collecting samples that are representative of their parent material.

4. Quality Control

- Field staff must keep their hands clean, wear nitrile gloves, and refrain from eating or smoking while working with water samples.
- The inner portion of sample bottles and caps must not be touched with anything (e.g., bare hands, gloves, thermometers, probes, preservative dispensers, etc.) other than the sample water and preservative. Remove caps immediately prior to sampling, place the caps in a clean resealable bag, and re-cap immediately following collection and any preparations.
- Sample bottles, including bottle caps, should be provided by the issuing laboratory and certified as ‘contaminant free’. Use only the type of sample bottle recommended by the issuing laboratory for each analysis.
- Keep sample bottles in a clean environment, away from dust, dirt, fumes, and grime. Bottles must be capped at all times and stored in clean shipping containers (coolers) both before and after the collection of the sample. Vehicle cleanliness is an important factor in eliminating contamination problems.

- After collection, cool samples to ≤ 10°C as quickly as possible. Samples should be placed into coolers packed with bagged ice cubes or ice packs and shipped to the laboratory so that they arrive within 24 hours of sampling.

5. Recommended Equipment and Materials

The final selection of materials for sampling events conducted in winter conditions depends on the type and size of the water body being sampled (i.e. lake vs. river), weather conditions and safety considerations, availability of equipment, water quality parameters, contaminants of concern, regulatory requirements, and site-specific factors.

Typical materials include:

- Ice auger and plastic sieve
- Measuring tape
- Safety rope / tether / lifeline
- Personal floatation device or floatation suit
- Swing sampler
- Empty sample bottles
- Peristaltic pump, tubing/attachments, weight
- Van Dorn or Kemmerer sampler
- Preservatives
- Filtration apparatus
- 0.45 µm filters
- Jugs of warm water

6. Winter Sampling Considerations

- Sampling in winter presents extra elements of danger including hypothermia, icy and slippery ground, and drowning. Always proceed with caution over ice and NEVER jeopardize your safety to collect a water sample.
- Individuals required to work on freshwater floating ice covers should review and follow the protocols outlined in the Government of Alberta's (2009) *Field Guide to Working Safely on Ice Covers* prior to heading out into the field.
- Work in pairs to check the ice for thickness with a rod or ice chisel every few steps. Both individuals should wear floatation suits, carry a length of rope (tied around the waist) to use as a lifeline, remain at least 10 m apart, and be trained in rescue and self-rescue techniques.
- For an individual walking, the ice should be a minimum of 10 cm thick. Because the stress on the ice will increase the longer a weight stays in place, if you plan to be at the sampling station for more than two hours, the ice should be a minimum of 15 cm thick.
- When sampling in the winter, care should be taken to ensure that the samples do not freeze, as this could cause the sample containers to rupture. If at the time of sample collection, it is below freezing, add jugs of warm water as needed to the sample storage coolers to prevent freezing of the samples and maintain the sample temperature between 4 and 10 °C

7. Procedures

1. Work in pairs to check the ice thickness using a rod or ice chisel every few steps. For an individual walking, the ice should be a minimum of 10 cm thick. Because the stress on the ice will increase the longer a weight stays in place, if you plan to be at the sampling station for more than two hours, the ice should be a minimum of 15 cm thick.

2. Check to ensure you have reached the sampling station before setting up. If you are establishing a sampling station, chose a location where the water is known to be deep enough to avoid stirring up bottom sediments and ensure that there is water movement under the ice of the sampling station.
3. Clear loose ice and snow from the sampling location, and drill through the ice with a hand or motorized auger.
4. Keep the area around the hole clear of potential contaminants (e.g., dirt, fuel, oil, etc.). Ice chips and slush can be removed from the hole using a plastic sieve.
5. Collect water samples with a swing sampler, Van Dorn or Kemmerer sampler, or peristaltic pump using the protocols outlined in SOP E1-03 and SOP E1-04.
6. Filter and preserve the samples as required following the protocols outlined in SOP E1-07.

8. References

1. ENV, 2013. BC Field Sampling Manual – Part E Water and Wastewater Sampling. BC Ministry of Environment and Climate Change Strategy, dated 2013.
2. Government of Alberta. 2009. Field Guide To Working Safely on Ice Covers. Work Safe Alberta, dated November 2009.
3. Alberta Environment and Parks. 2006. Aquatic Ecosystems Field Sampling Protocols. Government of Alberta, dated March 2006.
4. CCME, 2011. Protocols Manual for Water Quality Sampling in Canada. Canadian Council of Ministers of the Environment. ISBN 978-1-896997-7-0, 180 pp.

Revision History: 0.0 (New document)

Approval:

Sampling Method/Media: **Sampling from a Bridge / Surface Water**	**Standard Operating Procedure for Sampling from a Bridge**
Revision No: Original **Revision Date: 09 January, 2024**	**Reference No: SOP-E1-06** **Parent Document: BC Field Sampling Manual – Part E1**

1. Introduction and Scope

This Standard Operating Procedure (SOP) provides operating guidelines and instruction for the collection of water quality samples from a bridge. The purpose of this SOP is to provide competent and safe instructions for the collection of water quality samples collected from a bridge. Samples collected following these instructions can be relied upon to produce data that is representative of the water body from which it was collected. Field staff are encouraged to follow these instructions consistently throughout the duration of the monitoring program. Consistency in sampling is especially important for long-term trend monitoring.

This SOP forms part of the British Columbia Field Sampling Manual (BCFSM). Additional information regarding surface water sampling is provided in Part E1 – Surface Water of the BCFSM, which must be used in conjunction with the information provided in this SOP. This SOP and the BCFSM are available at:

https://www2.gov.bc.ca/gov/content?id=307726C4B5C64194BA39E51605E33827.

Further guidance is provided in the Water Sustainability Act (WSA) which is available at:

https://www2.gov.bc.ca/gov/content?id=6C2C94A8E26D4F5994D8086A83398FF6.

Surface water samples collected for regulatory purposes within the provincial jurisdiction of BC must be carried out with consideration to the WSA as applicable, Part E1 of the BC Field Sampling Manual, and this document.

2. Document Control

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.

3. Principle of the Sampling Method

The methods described in this SOP are based on the principle objective of collecting samples that are representative of the source water.

4. Quality Control

- Field staff must keep their hands clean, wear laboratory/medical-grade gloves, and refrain from eating or smoking while working with water samples.
- Ensure field equipment is contaminant free, maintained and calibrated.
- The inner portion of sample bottles and caps must not come into contact with anything (e.g., bare hands, gloves, thermometers, probes, preservative dispensers, etc.) other than the sample water and preservative. Remove caps immediately prior to sampling. During sample collection, store bottle caps in a clean, resealable plastic bag, not in pockets, etc.
- Be careful not to knock or kick loose paint or debris from the bridge into the water. Check the area below the bridge to ensure there are no obstacles that may prevent the sampler from entering the water.
- Sample bottles, including bottle caps, should be provided by the issuing laboratory and certified as ‘contaminant free’. Use only the type of sample bottle recommended by the issuing laboratory for each analysis.

- Keep sample bottles in a clean environment, away from dust, dirt, fumes and grime. Bottles must be capped at all times and stored in clean shipping containers (coolers) both before and after the collection of the sample. Vehicle cleanliness is an important factor in eliminating contamination problems.
- After collection, cool samples to 10ºC as quickly as possible. Samples should be placed into coolers packed with bagged ice cubes or ice packs and shipped to the laboratory so that they arrive within 24 hours of sampling.

5. Recommended Equipment and Materials

Sampling from a bridge typically requires an established set of equipment and materials.

Typical materials include:

- Safety vest and pylons
- Multi-Sampler
- Length of rope
- Pre-labelled sample bottles
- Preservatives, filtration apparatus, and 0.45 µm filters, all as required.

6. Bridge Sampling Considerations

- Sampling from a bridge allows samples to be collected from the central flow of rivers where wading or boating is not an option.
- If the bridge is located over navigable waters, sample equipment and ropes may need to be flagged to provide a visible caution to boat operators. Ideally, sample events should be scheduled during periods of low or no boat traffic.
- Special care should be taken when working around traffic. Always wear high visibility vests, use sidewalks whenever possible, and set out safety pylons and placards where possible.

7. Procedures

1. Remove the lid/cover from the multiple sampler.
2. Secure all sample bottles (lids on) into the multiple sampler.
3. Refit the lid to the multiple sampler. Secure one end of the rope to the handle of the multiple sampler.
4. Secure the free end of the rope to the bridge. Ensure the rope is free of potential snags and knots.
5. Remove the lids from the sample bottles and place them in a clean resealable plastic bag.
6. Lower the multiple sampler to the water where it is allowed to submerge and drift slightly downstream with the current.
    - Whenever possible, lower the multiple sampler over the upstream side of the bridge, being careful not to disturb bridge surfaces with the rope or sampler. This mitigates the potential for contamination from the bridge itself or substances falling into the water or into the open bottles from the bridge (e.g., fuel, oil, salt, paint chips etc.).
7. The multi-sampler is then lifted and swung back upstream where it is allowed to submerge once again. This process is repeated until all of the bottles have been filled. During this process, tension of the rope must be slack enough to allow the multi-sampler to submerge but taut enough to prevent it from hitting the stream bed.
8. With sample bottles full, haul the multiple sampler up, remove each sample bottle, filter and add preservative (as per SOP E1-07) where required, and recap each bottle.

8. References

1. ENV, 2013. BC Field Sampling Manual – Part E Water and Wastewater Sampling. BC Ministry of Environment and Climate Change Strategy, dated 2013.
2. CCME, 2011. Protocols Manual for Water Quality Sampling in Canada. Canadian Council of Ministers of the Environment. ISBN 978-1-896997-7-0, 180 pp.

Revision History: 0.0 (New document)

Approval:

Sampling Method/Media: **Filtration and Preservation / Surface Water**	**Standard Operating Procedure for Field Filtration and Preservation**
Revision No: Original **Revision Date: 09 January, 2024**	**Reference No: SOP-E1-07** **Parent Document: BC Field Sampling Manual – Part E1**

1. Introduction and Scope

This Standard Operating Procedure (SOP) provides operating guidelines and instruction for the filtration and chemical preservation of surface water samples. The purpose of this SOP is to ensure that surface water samples are processed as required for their intended analysis.

This SOP forms part of the British Columbia Field Sampling Manual (BCFSM). Additional information on filtration and preservation is provided in Part E1 – Surface Water of the BCFSM, which must be used in conjunction with the information provided in this SOP. This SOP and the BCFSM are available at:

https://www2.gov.bc.ca/gov/content?id=307726C4B5C64194BA39E51605E33827.

Surface water samples collected for regulatory purposes within the provincial jurisdiction of BC must be filtered and preserved with consideration to Part E1 of the BC Field Sampling Manual, and this document.

2. Document Control

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.

3. Principle of the Sampling Method

The methods described in this SOP are based on the principles of separation and stability. Filtration is required to separate the dissolved phase of target analytes from the sample water. Preservation is required to maintain the chemical composition of the sample.

4. Quality Control

- Reagents and preservatives must be analytical grade and certified by the issuing laboratory to be contaminant free. Containers holding chemical reagents and preservatives should be clearly labeled and indicate their contents and the expiry date. No reagent or preservative should be used after it's expiry date. Return expired reagents to the laboratory for proper disposal.
- ENV strongly recommends that single use products such as individually wrapped syringes and filters be used.
- Filtration apparatuses that are not single use must be decontaminated before use, between each use in the field, and isolated and wrapped in between uses.
- Field staff must keep their hands clean and free of products such as sunscreen and insect repellent, wear laboratory/medical-grade gloves, and refrain from eating, drinking or smoking while working with water samples.
- A new pair of gloves must be worn at each sample station.
- The inner portion of sample bottles and caps must not come into contact with anything (e.g., bare hands, gloves, thermometers, probes, preservative dispensers, etc.) other than the sample water and preservative.

- Remove caps immediately prior to sampling. During sample collection, store bottle caps in a clean, resealable plastic bag, not in pockets, etc. Cap sample bottles immediately following collection and any required processing such as filtration and chemical preservation.
- Sample bottles with securely fastened caps should be provided by the issuing laboratory and certified as 'contaminant free'. Use only the type of sample bottle recommended by the issuing laboratory for each analysis.
- Keep sample bottles in a clean environment, away from dust, dirt, fumes and grime. Bottles must be capped at all times and stored in clean shipping containers (coolers) both before and after the collection of the sample. Vehicle cleanliness is an important factor in eliminating sources of potential contamination.
- After collection, cool samples to ≤ 10ºC as quickly as possible. Samples should be placed into coolers packed with filled and frozen water bottles and or bagged ice cubes (preferred) or ice packs and shipped to the laboratory so that they arrive within 24 hours of sampling.

5. Recommended Equipment and Materials

The final selection of materials for filtration and preservation depend on safety considerations, available equipment, contaminants of concern, the desired analysis, regulatory requirements, and other site-specific factors.

Typical materials used when field filtering and preserving samples include:

- Preservative (pre-measured liquid aliquot, pellet, or pre-charged bottles)
- Laboratory/medical-grade gloves
- Eye protection
- Sample bottles
- Filtration apparatus
- Individually wrapped 0.45 µm disc filters or capsule filter
- Individually wrapped syringe with lure lock tip

6. Filtration and Preservation Considerations

- Samples requiring filtration and chemical preservation must be filtered before the preservative is applied.
- Samples should be preserved or filtered and preserved as soon as possible following collection to reduce the sample materials exposure to the atmosphere.
- ENV recommends single use, individually wrapped filters to mitigate the probability of contamination and cross-contamination. Regardless of filter type, filters cannot be re-used, and a new field filter must be used at each sample station.
- If there is a concern regarding potential bias caused by the filter, a filter blank should be collected by passing distilled water through the filter and collecting the discharge into a sample bottle for analysis.
- Ensure preservation requirements as outlined in the BC ENV Sample Preservation and Hold Time Requirements (linked below) are being met.

7. Procedures

Disc Filter

1. Collect the water samples as per the protocols outlined in SOP E1-03 through SOP E1-06. Samples requiring filtration should not be collected directly into the sample bottle that will be submitted for analysis. Instead, collect the water sample in a clean sample bottle and decant into the sampling apparatus.
2. Unwrap the syringe, peel back the paper portion of the disc filter's packaging and use the rigid plastic portion of the packaging to hold the filter while screwing its flanged end into the threaded tip of the syringe.

3. Remove the plunger from the syringe being careful not to touch the interior of the syringe or the base of the plunger. Fill the syringe with sample water and pre-condition the disc filter by pushing 10 mL of the sample water through the disc filter. Discard the water.
4. After filling and preconditioning there may be water present on the exterior of the filtration assembly. This 'standing water' may be un-filtered and may be contaminated and as such must be removed to ensure it is not entrained into the flow of water being decanted from the filter into the sample bottle. Use a paper towel to dry off any standing water from the exterior of the filtration assembly. This can also be achieved by giving the assembly a controlled shake or two.
5. Fill the sample bottle by applying an even pressure on the syringe's plunger to force sample water through the disc filter and into the receiving sample bottle.
6. Each time the syringe requires filling, ensure the filtration assembly is free of standing water before decanting the filtered sample water into the bottle.
7. It is important to note that highly turbid water may clog the filters membrane resulting in significant restriction to flow. If this occurs replace the filter and repeat the procedure ensuring that each new filter is pre-conditioned before decantation. If the filter begins to clog, watch for break-through on the filtration apparatus. If break-through occurs, discard the sample and start over again using less force and more filters and ensure to record these details in the field log book.
8. Add preservative as required. Securely cap the bottle and place it immediately into a pre-chilled cooler. If a preservative is added invert the sample bottle a few times to mix.

Capsule Filter

1. Ensure your sampling equipment, including tubing if any, are contaminant free.
2. Unwrap the filter and connect it in-line at the discharge end of your sampling equipment such as the output hose of a peristaltic pump.
3. Pre-condition the capsule filter by passing two filter volumes, or 0.5 L of water, through the filter:
    a. The preferred method of pre-conditioning for capsule filters to use sample water.
    b. If distilled or deionized water is used to precondition a capsule filter, the sampler must ensure that a volume of at least 0.6 L of sample water is pushed through the filter prior to sample collection to mitigate the potential of sample dilution.
4. Collect sample filtrate into the sample bottles, being careful not to touch the outlet of the capsule filter to the mouth of the sample bottles.
9. Add preservative to the collected samples as required. If a preservative is added invert the sample bottle a few times to mix. Securely cap the bottles and place immediately into a pre-chilled cooler.
5. Discard the capsule filter – do not re-use at the next sample location.

Preservation

1. Check preservation requirements for each analytical test included in the sampling plan.
2. Preservation requirements are published by BC ENV in a document titled 'Sample Preservation and Hold Time Requirements' which is available at the following link: https://www2.gov.bc.ca/assets/gov/environment/research-monitoring-and-reporting/monitoring/emre/summary-of-sample-preservation-and-hold-time-requirements.pdf
3. Collect the water samples as per the protocols outlined in SOP E1-03 through SOP E1-06.
4. Filter samples, if required, following the instructions provided above.

5. If using sample bottles pre-charged with preservative, add the sample water directly into the sample bottle. Do not add additional preservative. Be careful to avoid overfilling. Do not submerge pre-charged bottles in water to collect a sample. In both cases this will result in the loss of preservative. Depending on the sample collection protocol and conditions during sampling it may be safer to collect the sample in a spare contaminant-free sample bottle and carefully decant the collected water into the pre-charged bottles.
6. If the sample bottles are not pre-charged, fill the bottles with sample water leaving some headspace at the top to allow for the addition of preservative.
7. Wearing gloves and eye protection, pour the aliquot of laboratory-supplied preservative into the sample bottle and recap. Invert the sample bottle a few times to mix, and then place in a chilled cooler.

8. References

1. ENV, 2013. BC Field Sampling Manual – Part E Water and Wastewater Sampling. BC Ministry of Environment and Climate Change Strategy, dated 2013.
2. ASTM D6564-00(2012)e1, 2012. Standard Guide for Field Filtration of Groundwater Samples, ASTM International, West Conshohocken, PA.
3. USGS, 2002. National Field Manual for the Collection of Water-Quality Data (NFM), Chapter A5, Processing of Water Samples. U.S. Geological Survey, dated April 2002.

Revision History: 0.0 (New document)

Approval:

Sampling Method/Media: **Chlorophyll-α Sampling / Surface Water**	**Standard Operating Procedure for Chlorophyll-α Collection and Handling**
Revision No: Original **Revision Date: 09 January, 2024**	**Reference No: SOP-E1-08** **Parent Document: BC Field Sampling Manual – Part E1**

1. Introduction and Scope

This Standard Operating Procedure (SOP) provides operating guidelines and instruction for the collection and handing of chlorophyll-α samples. The purpose of this SOP is to provide competent and safe instructions for the collection of samples that can be relied upon to produce analytical data that is representative of the water body from which it is collected. Samplers are encouraged to follow the instructions of the SOP consistently throughout the duration of the monitoring program. Consistency in sampling is especially important for long-term trend monitoring.

This SOP forms part of the British Columbia Field Sampling Manual (BCFSM). Additional information on analyte-specific collection and handling is provided in Part E1 – Surface Water of the BCFSM, which must be used in conjunction with the information provided in this SOP. This SOP and the BCFSM are available at:

https://www2.gov.bc.ca/gov/content?id=307726C4B5C64194BA39E51605E33827.

Surface water samples collected for regulatory purposes within the provincial jurisdiction of BC must be carried out with to Part E1 of the BC Field Sampling Manual, and this document.

2. Document Control

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.

3. Principle of the Sampling Method

The methods described in this SOP are based on the principle objective of collecting samples that are representative of the source water.

4. Quality Control

- Sample containers and filtration devices required for Chlorophyll-α analysis, should be provided by the issuing laboratory, and certified as 'contaminant free'.
- Field staff should keep their hands clean and free of products such as sunscreen and insect repellent, wear laboratory/medical-grade gloves, and refrain from eating or smoking while working with water samples.
- The inner portion of sample containers and caps must not be touched with anything (e.g., bare hands, gloves, thermometers, probes, preservative dispensers, etc.) other than the filter.
- Keep the sample container capped until you are ready to collect and filter the sample water. Remove caps immediately prior to inserting the processed filter and replace the cap as soon as the filter is ready for freezing and storage.
- Keep sample bottles in a clean environment, away from dust, dirt, fumes, and grime.

5. Recommended Equipment and Materials

The final selection of materials for collecting chlorophyll-α samples should be made with due consideration of the sampling method and equipment used, potential contaminants of concern, regulatory/permit requirements, and other site-specific factors.

Typical materials and equipment include:

- Chlorophyll-α filtration apparatus
- 0.45 µm, 47 mm Cellulose acetate or GF/C filter membrane
- Tweezers
- Opaque vial
- Laboratory/medical-grade gloves
- Pre-made labels and writing utensils
- Required water quality sampling equipment (e.g., swing sampler, Van Dorn, filtration apparatus, peristaltic pump, etc.)
- Coolers, filled and frozen water bottles and or bagged ice cubes

6. Chlorophyll-α Sampling Considerations

- If requested, chlorophyll-α filtration apparatuses and filter membranes can often be provided by the analyzing laboratory, along with the sample collection bottles.
- Filtration should be conducted out of direct sunlight, as exposure to sunlight will accelerate the degradation of chlorophyll-α.

7. Procedures

1. Rinse the components of the Chlorophyll-α filtration apparatus with deionized water and assemble.
2. Carefully unwrap the filter membrane and wearing laboratory/medical-grade gloves, use tweezers to place the membrane onto the filter apparatus.
3. Pour a volume of sample water into the filter apparatus.
    a. The amount of water to be filtered will vary based on the algae content of the waterbody. When collecting samples from lakes, 50-500 mL of water can be passed through the filter. When collecting samples from rivers, 500-1000 ml of water can be passed through the filter.
    b. Sample water should be filtered until a light green/brown colour is visible on the filter, or until the maximum volume of water recommended has been reached.
    c. Record the final volume of water filtered on the vial, on the chain of custody (CoC) or requisition and in your field notes.
4. Draw the sample water through the filter apparatus using a hand pump or a peristaltic pump. If using a peristaltic pump, avoid cells from rupturing by ensuring that the pump pressure does not exceed 3.4 psi.
5. As soon as the required volume of sample has been drawn through the filter, turn off the pump or stop operating the hand pump.
6. Using the tweezers, carefully fold the membrane into quarters, ensuring that the side of the membrane with the Chlorophyll-α is folded inwards (i.e., once folded the exposed filter material does not contain a layer of Chlorophyll-α).
7. Transfer the folded membrane into an opaque vial, cap the vial, and freeze the sample during storage.

8. References

1. OWRB. 2019. Standard Operating Procedure for the Collection and Processing of Chlorphyll-α Samples in Lakes. Oklahoma Water Resources Board, Water Quality Programs Division, dated November 2019.
2. Alberta Environment. 2020. Chlorophyl-A Filtration, Standard Operating Procedure. Ministry of Environment and Parks, Resource Stewardship Division, dated June 2020.

Revision History: 0.0 (New document)

Approval:

Sampling Method/Media: **Ultra-Clean Sampling / Surface Water**	**Standard Operating Procedure for Ultra-Clean Sampling**
Revision No: Original **Revision Date: 09 January, 2024**	**Reference No: SOP-E1-09** **Parent Document: BC Field Sampling Manual – Part E1**

1. Introduction and Scope

This Standard Operating Procedure (SOP) provides samplers with the information they need to ensure that the water quality samples they collect, process, and submit for analysis of parameters at low and ultra-low concentrations are competent for that purpose. Water quality parameters reported at low and ultra-low concentrations are highly susceptible to trace amounts of non-target constituents and as such require stringent controls for sampling and handling. The purpose of this SOP is to provide a level of assurance that environmental data, reported at low and ultra-low concentrations, to the Province, is reliable and defensible.

This SOP forms part of the British Columbia Field Sampling Manual (BCFSM). Additional information on analyte-specific collection and handling is provided in Part E1 – Surface Water of the BCFSM, which must be used in conjunction with the information provided in this SOP. This SOP and the BCFSM are available at:

https://www2.gov.bc.ca/gov/content?id=307726C4B5C64194BA39E51605E33827.

Surface water samples collected for regulatory purposes within the provincial jurisdiction of BC must be carried out with consideration to Part E1 of the BC Field Sampling Manual, and this document.

2. Document Control

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.

3. Principle of the Sampling Method

The principle of this sampling method is 'control'. A three-person sampling team is required to establish and maintain control of applicable sample collection steps. One team member is designated as 'dirty hands', one member is designated as 'clean hands' and the third team member is assigned the responsibilities of recording field notes and taking field measurements. The 'dirty hands and clean hands' pair strictly follow the protocol prescribed for the applicable sample collection method while deploying 'measured control' in every aspect of sample collection, processing, handling, and shipping.

4. Quality Control

- In preparation for the sampling event, identify the person who will carry out the 'clean hands' tasks and the person who will carry out the 'dirty hands' tasks. Ensure each member understands their role and the sequence of activities required to collect a sample. The third team member is responsible for taking field notes and measurements.
- Extreme care is required to mitigate the potential for exposure of the sample to contaminants.
- Ensure field equipment and instrumentation has been decontaminated, maintained, and calibrated.
- Field staff should keep their hands clean and free of skin care products including sunscreen, wear non-talc laboratory/medical-grade gloves at all times, and refrain from eating or smoking while working with water samples.
- Sample bottles, including bottle caps, must be prepared, and issued to the sampler by the testing laboratory. Use only the type of sample bottle recommended by the issuing laboratory for each analysis.

- The inner portion of sample bottles and caps must not come into contact with anything including bare hands, gloved hands, thermometers, probes, tubing, or preservative dispensers.
- The sample team should approach the sample station from a down-current and down-wind direction where possible.
- Ensure that sample bottles are secured in a clean environment, away from dust, dirt, fumes, and grime at all times. Vehicle cleanliness is an important factor in eliminating contamination problems.
- One bottle blank should be prepared in a controlled environment prior to heading to the field.
- One ambient blank and one equipment blank (if equipment is used to collect samples) should be collected and submitted for every 10 samples collected.
- After collection, cool samples to ≤ 10ºC as quickly as possible. Samples should be placed into coolers packed with filled and frozen water bottles and or bagged ice cubes and shipped to the laboratory so that they arrive within 24 hours of sampling.

5. Recommended Equipment and Materials

The final selection of materials for ultra-clean sampling should be made with due consideration of the sampling method and equipment used, potential contaminants of concern, regulatory/permit requirements, and other site-specific factors.

Typical materials and equipment used during the collection of ultra-clean samples include:

- Double-bagged sample bottles prepared and provided by the testing laboratory
- Preservatives provided by the testing laboratory
- Non-talc polyethylene, latex, vinyl or PVC gloves. Shoulder length gloves are required for samples collected by direct submersion of the sample bottle (manual method)
- Individually-wrapped 0.45 µm disc filters
- Individually-wrapped syringes
- Pre-made labels and writing utensils
- Required water quality sampling equipment (e.g., swing sampler, Van Dorn, filtration apparatus, peristaltic pump, etc.)
- Coolers and bagged ice cubes

6. Sampling Considerations

- Ultra-clean methods require two people be involved in the sample collection; one individual is designated as the "Clean Hands" and the second person is the "Dirty Hands". "Dirty Hands" is responsible for operating sampling equipment, and any additional activities that could potentially contaminate the sample. "Clean Hands" must only touch the sample, syringe and disc filter where needed, and sample container.
- If filtration is required when ultra-clean sampling methods are being used, the filters and syringes should be individually wrapped.

7. Procedures

Preparations for all Sampling Methods

1. In preparation for the sampling event ensure that all required sample collection equipment has been thoroughly cleaned and decontaminated as per SOP E1-02 and covered in clean plastic wrap or otherwise contained to mitigate the potential for contamination during storage and transport to the field.
2. It is highly recommended that a bottle blank and an equipment blank be prepared in a controlled and clean environment. Use de-ionized water supplied by the testing laboratory to prepare the blanks while wearing non-talc gloves. Equipment blanks should be prepared for each piece of equipment that will be used in the field. After the equipment blanks have been prepared the equipment must be covered in clean plastic wrap

or otherwise contained to mitigate the potential for contamination during storage and transport to the field.

3. Blanks should be analysed to satisfy the data quality objectives of the monitoring program or sampling event. Analytical requests for blanks should consider contaminants of concern, parameters included in the sampling event, and constituents with the potential to react with those parameters.

4. If sampling for trace metals, samples should be collected at a conservative distance from bridge structures, wires, poles, emission stacks, and heavily travelled roadways. If sampling must occur in the vicinity of these potential sources of contamination record the reason and all observations regarding the sampling environment.

Sampling from Shore or Near Shore

5. Once on site, establish a clean workspace or staging area where equipment and sample bottles can be set up and accessed. If possible, set up a portable table as a work surface and canopy to minimize airborne particles from entering the workspace.

6. When the workspace has been prepared, dirty hands and clean hands must don gloves prior to any sample collection activity. Clean hands should don shoulder-length gloves; dirty hands don regular-length gloves.

7. Dirty hands opens the container to access and remove a double-bagged sample bottle.

8. When clean hands is ready to collect a sample, dirty hands opens/unzips the outer bag.

9. Clean hands reaches into the open bag, opens the inside bag, removes the sample bottle, and reseals the inside bag.

10. Dirty hands seals the outer bag.

11. Clean hands removes the bottle cap and holds the cap, opening down, in one hand while submerging the inverted sample bottle into the water and in one fluid motion pushes the bottle through the water and against any current until full.

12. Clean hands replaces the cap while the bottle is still submerged. With the cap secured, clean hands brings the bottle up out of the water and shakes off any excess standing water.

13. If filtration and or preservation are not required clean hands places the sample bottle into the inner bag and seals the bag. Dirty hands seals the outer bag and places the sample bottle into a chilled cooler.

Filtration and Preservation

14. If filtration and or preservation are required, clean hands brings the sample bottle to the workspace, sets it down in a clean and secure location to prepare the filtration and or preservation items.

15. If preservation is the only requirement, clean hands opens the sample bottle, places the cap in a clean sealable bag and seals the bag, decants a small amount of the sample water, adds the aliquot of preservative, recaps the sample bottle and inverts it several times to mix. If preservation is the only requirement, move to step 19.

16. If filtration and preservation are required, dirty hands opens the sample storage container and removes a double-bagged sample bottle. Dirty hands opens the outer bag.

17. Clean hands reaches into the outer bag, opens the inner bag, removes the sample bottle, and closes the inner bag.

18. Dirty hands closes the outer bag.

19. Clean hands places the empty sample bottle on the work surface near the full sample bottle. Clean hands prepares the filtration apparatus, opens the full sample bottle placing the cap in a clean sealable bag, seals the bag and places that bag on the work surface.

20. Clean hands fills the filtration apparatus with sample water, and re-caps the full sample bottle. Clean hands then pre-conditions the filter by passing sample water through the filter (10 mL for a disc filter) and

discharges the water into a disposal container or to ground as applicable. Clean hands shakes off any excess standing water from the exterior of the filtration apparatus.

21. Clean hands then opens the empty sample bottle, placing the cap in a clean sealable bag, seals the bag and places it on the work surface. Clean hands begins filling the empty sample bottle with the filtered sample water without contact between the filter and bottle. Depending on the capacity of the filtration apparatus and the required volume of sample, steps 15 and 16 may need to be repeated.
22. When the sample bottle has been filled, clean hands adds the required aliquot of preservative, re-caps the sample bottle and inverts the bottle several times to mix.
23. Dirty hands retrieves the double-bag and opens the outer bag. Clean hands opens the inner bag, places the sample bottle inside the inner bag and then seals the inner bag.
24. Dirty hands closes the outer bag and places the sample bottle into a pre-chilled cooler.

Swing Sampler

5. Once on site, establish a clean workspace or staging area where equipment and sample bottles can be set up and accessed. If possible, set up a portable table as a work surface and canopy to minimize airborne particles from entering the workspace.
6. When the workspace has been prepared, dirty hands and clean hands must don gloves prior to any sample collection activity.
7. Dirty hands unwraps the swing sampler and sets it in a clean and secure location. Dirty hands opens the sample bottle container, retrieves a double-bagged sample bottle, and opens the outer bag.
8. Clean hands reaches into the outer bag, opens the inner bag, pulls out the sample bottle, and reseals the inner bag.
9. Dirty hands reseals the outer bag and sets it in a clean secure location. Dirty hands lifts the swing sampler into a position that allows clean hands to attach a sample bottle to the swing assembly.
10. Clean hands attaches the sample bottle to the swing assembly, removes the bottle's cap and places the bottle cap into a clean and sealable bag.
11. Dirty hands adjusts the telescopic pole to the required length and locks it in place. Dirty hands orients the swing sampler over the water body and submerges the inverted bottle to collect the sample. Once full, dirty hands recovers the swing sampler and positions the sample bottle (without touching it) to provide clean hands with access to the sample bottle.
12. Clean hands removes the bottle's cap from the clean resealable bag and fastens it to the sample bottle. Clean hands removes the sample bottle from the swing sampler.
13. Dirty hands positions the swing sampler in a clean secure location.
14. If preservation and or filtration and preservation are required, follow steps 14 through 24 for *Sampling from Shore or Near Shore.*
15. If preservation and or filtration and preservation are not required, dirty hands retrieves the double-bag, and opens the outer bag.
16. Clean hands reaches into the outer bag, opens the inner bag, places the sample bottle into the inner bag and seals the inner bag.
17. Dirty hands seals the outer bag and places the sample bottle into a pre-chilled cooler.

Sampling from a Boat

5. Ensure the interior of the boat is clean and reasonably free of potential contaminants. Load the boat with all of the equipment and materials required to collect an ultra-clean sample using the most appropriate method (e.g. Van Dorn Sampler). Sample collection equipment must be wrapped and remain wrapped until the boat has reached the sampling station.

6. Establish a clean working area within bow area of the boat. Dirty hands and clean hands must don gloves prior to any sample collection activity.
7. When the boat has reached the sampling station, dirty hands unwraps the sampling equipment without touching tubing if a peristaltic pump is being used, or input or output fixtures such as drain valves if a manual sampling device such as a Van Dorn or Kemmerer sampler is being used, and holds the equipment allowing clean hands to complete pre-deployment preparations.
8. Clean hands completes any pre-deployment preparations involving materials, such as tubing/hosing for pumps or end seals for manual samplers, that come in contact with the sample material.

Pumps

5. If a pump is being used, dirty hands connects the power source to the pump. Clean hands submerges the inlet end of the tubing into the water body.
6. Both clean hands and dirty hands replace gloves with new gloves.
7. Dirty hands turns the pump on and allows the pump to run for a minimum of 10 minutes to purge the tubing. While purging, clean hands holds the discharge end of the tubing overboard or into a bucket. When the purge is complete, dirty hands turns off the pump. If a bucket was used to capture the purge water, dirty hands dumps its contents overboard.
8. Clean hands lowers the tubing to the desired sampling depth.
9. If the sample does not require filtration move to step 13.
10. If the sample requires filtration, clean hands unwraps and attaches a filter to the outlet/discharge end of the tubing.
11. Clean hands directs the filter to discharge overboard or into a bucket. Dirty hands starts the pump and allows the pump to run until a minimum of 0.6 L of water has passed through the filter for preconditioning. If a bucket was used to capture the purge water, dirty hands dumps its contents overboard.
12. Dirty hands turns off the pump. Clean hands dries off or shakes off any water that may have collected on the exterior of the filter during preconditioning and places a clean bag over the filter.
13. Dirty hands opens the sample bottle storage container, retrieves a double-bagged sample bottle, and opens the outer bag.
14. Clean hands reaches into the outer bag, opens the inner bag, retrieves the sample bottle, closes the inner bag, and positions the sample bottle to receive the filtered sample water. Dirty hands closes the outer bag and stores it in a clean secure location.
15. Clean hands opens the sample bottle, places the cap in a clean sealable bag, seals the bag and stores it in a clean secure location. Clean hands positions the discharge end of the tubing or removes the bag from the filter and positions it to decant into the sample bottle without touching the tubing or filter to the sample bottle.
16. Dirty hands turns on the pump. Clean hands monitors the fill and notifies dirty hands to stop pumping when the required volume of sample material has been achieved.
17. If preservation is not required clean replaces the bottle cap and secures it in place.
18. If preservation is required clean hands places an aliquot of the appropriate preservative into the sample bottle, replaces the cap and secures it in place, inverts the sample bottle several times to mix.
18. Dirty hands retrieves the double-bag and opens the outer bag. Clean hands reaches into the outer bag, opens the inner bag, places the sample bottle into the inner bag and seals the inner bag. Dirty hands seals the outer bag and places the sample bottle into a pre-chilled cooler.

Manual Sampling Devices

5. If a manual sampling device such as a Kemmerer sampler is being used, dirty hands prepares the demarcated line of the sampling device to ensure a smooth deployment. Dirty hands positions the sampling device over the water without touching the seals, ends or discharge ports. Dirty hands lowers the sampling device to the target sampling depth and after a brief pause of approximately 30 seconds, releases the messenger weight to close both ends of the sampler.
6. Dirty hands pulls the sampler up and into the boat without touching the ends or discharge port and sets the sampler in a clean secure location.
7. Both clean hands and dirty hands replace their gloves with new gloves.
8. Dirty hands obtains a double-bagged sample bottle from the storage container and opens the outer bag. Clean hands opens the inner bag, removes the sample bottle, and reseals the inner bag. Clean hands positions the sample bottle in a clean secure location where the bottle will be filled from the sampling device.
9. Clean hands removes the lid of the sampling device, places the lid in a clean sealable bag, seals the bag and places it near the sample bottle.
10. Dirty hands lifts the sampling device into a position that allows its discharge to flow into the sample bottle. Clean hands opens the discharge valve while maintaining the open sample bottle in a position to collect and fill with the water from the sampling device.
11. When the sample bottle has been filled clean hands closes the discharge valve, returns the lid of the sample bottle, and ensures it is securely fastened.
12. If only one sample is required dirty hands places the sampling device in a secure location. Dirty hands opens the outer bag for the sample bottle. Clean hands opens the inner bag, places the sample bottle inside the inner bag, and seals the inner bag. Dirty hands seals the outer bag and places the double-bagged sample bottle into a pre-chilled cooler.
13. If more than one sample is required steps 5 to 12 are repeated.
14. If preservation is required for one or more sample, clean hands decants the aliquot of preservative into the sample bottle, securely fastens the lid and inverts the bottle several times to mix and step 12 is repeated.
15. If filtration and preservation are required clean hands prepares the filtration device. Dirty hands retrieves a double-bagged sample bottle from the storage container and opens the outer bag. Clean hands reaches into the outer bag, opens the inner bag, pulls out the sample bottle and seals the inner bag. Dirty hands seals the outer bag and places it in a clean secure location. Clean hands places the empty (second) sample bottle next to the full sample bottle.
16. Clean hands removes the lid of the full (first) sample bottle, places it into a clean sealable bag, and places it near the sample bottle and completes the following steps:
    a. Fills the filtration device with sample water from the first sample bottle and replaces its lid.
    b. Precondition the filter by pushing sample water through the filter (10 mL for a disc filter, 60 mL for a capsule filter) discharging the water overboard or into a bucket.
    c. Remove any free-standing water from the filtration apparatus. Place the apparatus in a clean secure location next to the first sample bottle.
    d. Removes the lid of the second sample bottle, place it into a clean sealable bag, and place the bagged lid next to the bottle.
    e. Decant filtered sample water into the second sample bottle until full. This entire step may have to be repeated to obtain the required volume of sample material.
17. If preservation is not required clean hands replaces the lid, ensures the lid is secure and continues to step
18. If preservative is required clean hands decants the aliquot of preservative into the filtered water, replaces the lid, ensures the lid is secured and inverts the bottle several times to mix.

19. Dirty hands retrieves the double-bags for the sample bottle and opens the outer lid. Clean hands reaches in, opens the inner bag, places the sample bottle inside and reseals the inner bag. Dirty hands seals the outer bag and places the double-bagged sample bottle into a pre-chilled cooler.

8. References

1. ALS. 2014. Ultra-Trace Mercury Sampling: Step-by-Step Guide on How to Collect an Ultra-Trace Mercury Sample. ALS Global, dated April 2014.
2. EPA. 1996. Method 1669, Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels. U.S. Environmental Protection Agency, Office of Water, dated July 1996.

Revision History: 0.0 (New document)

Approval:

Sampling Method/Media: **Field Measurements / Surface Water**	**Standard Operating Procedure for Taking Field Measurements**
Revision No: Original **Revision Date: 09 January, 2024**	**Reference No: SOP-E1-10** **Parent Document: BC Field Sampling Manual – Part E1**

1. Introduction and Scope

This Standard Operating Procedure (SOP) provides operating guidelines and instruction for obtaining surface water quality parameters using field equipment, referred to herein as *field measurements*. Field measurements include parameters such as temperature, dissolved oxygen, turbidity, conductivity, pH, ORP and clarity. Field measurements are typically obtained using electronic instrumentation which report the response of sensors that are placed into the water body or into a sample collected for the sole purpose of obtaining a field measurement.

The purpose of this SOP is to provide clear and consistent instructions for field measurements. This SOP includes a general list of common materials, methods, and data required for surface water quality monitoring programs. Note that special considerations, such as client demands, project-specific data quality objectives (DQO), ambient conditions, and/or regulatory requirements may necessitate the collection of sample types not covered in this SOP or variations of the instructions provided in this SOP.

This SOP forms part of the British Columbia Field Sampling Manual (BCFSM). Additional information on field measurements is provided in Part E1 – Surface Water of the BCFSM, which must be used in conjunction with the information provided in this SOP. This SOP and the BCFSM are available at:

https://www2.gov.bc.ca/gov/content?id=307726C4B5C64194BA39E51605E33827.

2. Document Control

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.

3. Principle of the Sampling Method

Field measurements are typically obtained using electronic field instrumentation or manual devices such as a Secchi disc. Electronic instrumentation use of one or more sensors that react to a target parameter and as such each parameter's value is generated upon a unique principle. Given the number of parameters measured in the field, their principles are not provided in this document. Regardless of principle, most field parameters are measured in the field to obtain a point in time measurement of a parameter that would otherwise exhibit a relatively rapid change if collected and handled as a discrete water quality sample.

4. Quality Control

- Ensure that equipment is clean, properly maintained and calibrated before each sampling event.
- Parameters such as temperature, DO and ORP should always be measured by submerging the sensor or sonde directly into the waterbody being sampled, if feasible. Other parameters such as pH, conductivity and turbidity can be measured in a sample drawn from the source.
- Field measurements should never be made on a water sample collected for submission to a laboratory.

5. Recommended Equipment and Materials

The final selection of instrumentation depends on the type and size of the water body being sampled (i.e. lake vs. river), safety considerations, equipment availability, required field measurements, DQOs and site-specific factors.

Typical materials used when taking in-situ field measurements include:

- Single parameter meters OR multi-parameter meter
- Extra batteries
- Carrying case
- Extra parts
- Calibration reagents / materials
- Cleaning and decontamination materials
- Tool kit for minor repairs
- Sampling equipment for deep sample stations
- Secchi Disc

6. Field Measurement Considerations

- Since numerous makes and models of field measurement instruments are available, the instructions provided in this SOP are limited to common deployment and operational requirements. Field staff are directed to, and should be familiar with, the specifications and operating procedures detailed in the instrument manual of each piece of equipment used in the field.
- Secchi disc readings should only be taken from two hours after dawn to two hours before dusk. During the winter months, readings should only be taken between 10 A.M. and 2 P.M. Sunglasses should not be worn while taking the Secchi disc measurement.

7. Procedures

Water Quality Meters

Pre-Trip Preparations

1. Ensure that the instrument's range, resolution, and accuracy meet the requirements of the sampling program.
2. Complete routine maintenance on each meter or each of an instruments sensors.
3. A logbook should be created for each 'owned' instrument. The logbook should record all maintenance details, calibration frequencies (manufacturers, or as established for the sampling program) for each parameter and a running tally of operating hours between calibrations. The logbook can also be used to record calibration details and any anomalies observed during routine maintenance, calibration and operation. Some instruments log the date and time of calibration which can be accessed with the user interface software; some instruments include a programable calibration prompt.
4. It is strongly recommended that field instruments be calibrated prior to each sampling event.
5. Conduct a thorough cleaning of the sensors prior to calibration or routine maintenance.
6. Rinse the sensors with deionized water after calibration or any maintenance carried out on a sensor.
7. While in the field, if it appears that a sensor may have drifted or is unstable when submerged in water, complete a calibration for the parameter.
8. Turn the meter on and set the display screen to display all the parameters of interest, ensuring that the correct units are applied for each parameter.
    a. At a minimum, measured parameters should include temperature (°C), dissolved oxygen (% saturation and/or mg/L), conductivity/salinity (µS/cm), pH, turbidity (NTU) and ORP (mV).
    b. Some multi-parameter instruments require that sensors be installed and then configured and or enabled. Ensure your instrument is set up for each parameter required for field measurements.

9. If using a multi-parameter instrument with datalogging capabilities, create a new file for the sampling event, create 'sample station/data IDs' and set the sampling frequency of the sonde.
10. Ensure the battery/s are fully charged and have enough capacity for the duration of the sampling event.

Field Deployment

11. Field measurements should be taken at the same location and depth from which samples will be collected.
12. If sampling from a shore or near-shore sampling station, avoid placing the sonde in stagnant water or an isolated pool of water. If possible and safe, wade into the river's flow or to a section of the lake that is at least 0.5 metres deep, to deploy the sonde. If you've stirred up sediment while wading to the sampling station, let the sediment settle before deploying the sonde.
    a. When the water is clear, and while facing upstream, lower the sonde to a depth of approximately 0.2 metres.
    b. Hold the probe steady at this depth and allow the sensors to equilibrate before recording the values. Monitor the parameter reading/s on the instruments display, when they have stabilized record the values in the field logbook, a Site Data Sheet (Lake/Reservoir) or a Site Data Sheet (River) provided in Appendix 1 of the BCFSM.
    c. Field measurements should be recorded in addition to data logging.
    d. If sampling in deep flowing water, or in a lake/reservoir with wave action, additional weight may have to be attached to the sonde to maintain a vertical profile in the water column. Some instruments include a weight that can be attached to the sonde guard.
13. If sampling deep water (i.e., lake, reservoir, or deep river), lower the sonde to a depth of approximately 0.2 metres.
    a. Hold the probe steady at this depth and allow the sensors to equilibrate before recording the values. Monitor the parameter reading/s on the instruments display, when they have stabilized, record the parameters readings in the field logbook, a Site Data Sheet (Lake/Reservoir) or a Site Data Sheet (River) provided in Appendix 1 of the BCFSM.
    b. Field measurements should be recorded in addition to data logging.
    c. Lower the sonde to the next target depth, using the graduated cable markings or the sonde's depth sensor readings and allow the sensors to equilibrate. If using graduated cable markings, confirm that the instrument cable is taut and vertical. Record the parameters readings in the field logbook.
    d. Repeat this routine until field measurements have been recorded for each target depth, typically every 1 to 2 metres. To improve the reliability of your field readings, take a second set of readings during the ascent of the sonde and use the average of the two readings.
    e. Some sensors such as pH and ORP sensors have a maximum depth. Ensure you know the maximum depth of all sensors deployed for the sampling event.
14. Clear any debris from the instruments sensors and cable. Rinse off the instrument with fresh or deionized water, pat dry and store in the instruments carrying case.

Secchi Disc (Water Clarity)

1. Lower the Secchi disc over the **shaded** side of the boat and into the water ensuring the demarcated rope is vertical (free-falling).
2. Without the use of sunglasses, record the depth at which the pattern of the disc (the black and white contrast) is no longer discernible.
3. Lower the Secchi disc further and then retrieve the disc at a slow and steady pace until the pattern of the disc is once again discernible. Record this depth.
4. Average the two depth readings to calculate the extinction depth. Measurements should be to the nearest 0.1 meter.
5. Record the value in the field notebook along with the weather and water surface conditions (e.g., cloudy, sunny, windy, surface chop, etc.).

6. A viewing tube can be used to standardize surface water conditions. Viewing tubes eliminate reflections, ripples, and waves which may otherwise interfere with Secchi disc readings. If using a viewing tube, record the values obtained both with the viewing tube and without the use of a viewing tube.

8. References

1. ENV, 2013. BC Field Sampling Manual – Part E Water and Wastewater Sampling. BC Ministry of Environment and Climate Change Strategy, dated 2013.
2. Alberta Environment and Parks. 2006. Aquatic Ecosystems Field Sampling Protocols. Government of Alberta, dated March 2006.
3. USGS, 2008. National Field Manual for the Collection of Water-Quality Data (NFM), Chapter 6.0, Guidelines for Field-Measured Water-Quality Properties. U.S. Geological Survey, dated October 2008.

Revision History: 0.0 (New document)

Approval:

Sampling Method/Media: **Storage and Shipping / Water Samples**	**Standard Operating Procedure for Sample Storage and Shipping**
Revision No: Original **Revision Date: 09 January, 2024**	**Reference No: SOP-E1-11** **Parent Document: BC Field Sampling Manual – Part E1**

1. Introduction and Scope

This Standard Operating Procedure (SOP) provides operating guidelines and instruction for the storage, handling, and shipping of surface water samples. The purpose of this SOP is to provide clear and consistent instructions for the storage, handling and shipping of surface water samples that are designed to protect their integrity until receipt by the testing laboratory. Samplers are encouraged to follow the instructions of the SOP consistently throughout the duration of the monitoring program.

This SOP forms part of the British Columbia Field Sampling Manual (BCFSM). Additional information on sample storage and shipping is provided in Part E1 – Surface Water, which must be used in conjunction with the information provided in this SOP. This SOP and the BCFSM are available at:

https://www2.gov.bc.ca/gov/content?id=307726C4B5C64194BA39E51605E33827.

2. Document Control

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.

3. Principle of the Sampling Method

The principle of this method is integrity. The main objective of a shipping and handling protocol is to ensure that the integrity of the water quality sample is maintained. A chain of custody (CoC) form is a legal document that is used to record the collection of samples and to document the control, transfer, analysis, and disposition of those samples to assure regulatory sample integrity and legal defensibility (ASTM D4840, 2010).

4. Quality Control

- After collection, cool samples as quickly as possible. Samples must never be permitted to get warm; they should be stored in a cool, dark place. Coolers packed with bagged ice cubes or ice packs are recommended (most samples must be cooled to 10°C during transit to the laboratory). Conversely, samples must not be permitted to freeze unless freezing is part of the preservation protocol.
- Samples must be shipped to the laboratory without delay so that they arrive within 24 hours of sampling. Certain analyses must be conducted within 48 hours of collection or within specified time limits.
- Shipping coolers must be kept clean and regularly decontaminated.

5. Recommended Equipment and Materials

The final selection of materials for shipping and storage should be made with due consideration of the type of sample bottles (glass vs. plastic), the number and types of samples included in the sampling event, ambient temperature, and the anticipated duration of shipping.

Typical shipping and storage materials include:

- Clean sturdy coolers
- Chain-of-Custody (CoC) forms
- Ministry requisition form
- Filled and frozen water bottles or double bagged ice cubes
- Shipping labels
- Re-sealable plastic bags
- Packing material (e.g., Bubble wrap)
- Writing utensils
- Packing tape

6. Storage and Shipping Considerations

- Sample hold times must be strictly adhered to. A hold time is defined as the time that elapses between sample collection and sample reception and preparation by the laboratory.
- Samples must be shipped to the laboratory without delay so that they arrive within 24 hours of sampling. Certain analyses must be conducted within 48 hours of collection or within specified time limits.
- ENV maintains a 'table' of required sample containers, storage temperatures, preservation requirements and holding times on their website at: https://www2.gov.bc.ca/gov/content?id=6C06E7FC3FB242738BAB41458A2121A3.
- The table is maintained as part of the BC Environmental Laboratory Manual.
- Samples collected for all tests where refrigeration at ≤ 6°C is required at the laboratory, should be packed with ice to maintain a temperature of ≤10°C during transport to the laboratory. However, microbiological samples should be stored at <8 °C during transport to the laboratory.

7. Procedures

Sample Packing and Delivery / Shipment

1. Develop a sampling event schedule to ensure that all of the samples collected during a single day can be processed, packaged, and transported to the testing laboratory within the shortest hold time of the sample types collected. To do this identify the parameter type with the shortest hold time and use this time frame to coordinate the collection, processing, packaging, and transportation of the day's samples.
2. Place each sample in a pre-chilled cooler as soon as they are processed. Ensure the lids of each sample container are firmly closed. Individual glass sample containers should be placed in bubble wrap bags or otherwise adequately protected with bubble-wrap or an equally protective product.
3. Filled and frozen water bottles and or double bagged ice cubes are strongly recommended for cooling. Loose ice poses a potential source of sample contamination. Always double-bag ice and place it in the bottom of the cooler in a manner that maximizes package integrity.
4. Do not use gel-type ice packs for cooling during moderate to hot weather periods (ambient air temperatures greater than 20° C). Gel-type ice packs do not provide enough cooling to maintain a temperature at or below the 10° C temperature point prescribed for the preservation of most sample types. Broken gel-type ice packs pose a potential source of contamination. For instances where ice packs are used (ambient air temperatures below 20° C), ensure they are sealed within a sturdy bag.

5. In moderate to hot weather, it is recommended that shipping containers, such as hard-bodied coolers, be repacked with fresh ice immediately prior to shipment.
6. If using loose ice, place the ice in a plastic sealable bag. Place this bag of ice into a second sealable plastic bag and ensure each bag is fully sealed. Fill as many bags as needed based on the total volume of sample material in the cooler, the ambient temperature, and the duration of travel to the laboratory. In cool to warm weather conditions (ambient air temperature below 20° C) the ratio of ice to sample material should at a minimum, be 1:1 by volume.
7. Place the samples upright in the shipping container. Do not overfill the container with samples.
8. Intersperse/alternate glass sample containers with plastic sample containers and bags of ice.
9. Arrange the sample containers and ice in a manner that provides a measure of physical protection for the glass sample containers.
10. Use packing material to provide further protection by filling any voids in the shipping container. This will reduce shifting during transport. Remember that as ice melts, space will result which in turn will provide opportunity for the samples to shift and move about during transport. Densely packed bubble-wrap will provide partial compensation as this occurs.
11. Complete the chain of custody form and/or Ministry requisition form/s and enclose it/them in a sealed plastic bag. Place the bag in the cooler on top of the samples. The recommended minimum information that should be included in each requisition form is listed below:
    a. Project number,
    b. Client/owner name,
    c. Site name,
    d. EMS site number/s,
    e. Date and time of collection for each sample,
    f. Name of sampler/collector,
    g. Field measurements,
    h. Analytical tests requested for each sample,
    i. When warranted, pertinent details for samples,
    j. Weather conditions; and,
    k. Any other observations that may assist in interpreting data.
12. Place a copy of the CoC into a sealable plastic bag and place this bag on top of the samples.
13. Close and seal the cooler with heavy duty packing tape to reduce the possibility of it accidentally opening and to prevent tampering. Coolers arriving at the laboratory with torn or absent tape should be noted by lab staff with notification sent by lab reception to the sample submitter.
14. Attach a shipping label on top of the cooler to prominently display the destination.

8. References

1. CCME, 2011. Protocols Manual for Water Quality Sampling in Canada. Canadian Council of Ministers of the Environment. ISBN 978-1-896997-7-0, 180 pp.
2. ENV, 2021. British Columbia Field Sampling Manual, Part E2 Groundwater. Environmental Protection Department, BC Ministry of Environment and Climate Change Strategy. Victoria, BC, Canada.
3. ENV, 2013. BC Field Sampling Manual – Part E Water and Wastewater Sampling. BC Ministry of Environment and Climate Change Strategy, dated 2013.

4. ASTM D4840-99, 2010. Standard Guide for Sampling Chain-of-Custody Procedures, ASTM International, West Conshohocken, PA.

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Approval: