SURFACE WATER QUALITY STEWARDSHIP TOOLBOX

Community-based Water Monitoring: Start Up Guide

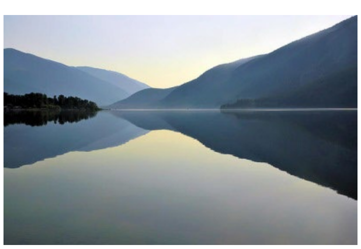
INTRODUCTION

Many citizens of British Columbia are interested in learning more about their local watersheds. This interest has prompted many to begin their own monitoring programs and become involved in community watershed groups. One important aspect of this work is to assess surface water quality. This guide provides instruction on how to establish a community watershed-based monitoring program that involves sampling and analysis of surface water quality. Though other types of monitoring (e.g., flow monitoring) are also important, they are not within the scope of this document.

This guide is divided into the following sections:

- Program design
- Preparing for sampling
- Field safety
- Field monitoring
- Quality assurance/quality control (QA/QC)
- Reporting and analysis

Please refer to additional detailed information sheets on the above subjects as part of Ministry of Environment and Climate Change Strategy (ENV) Surface Water Quality Stewardship Tools.



PROGRAM DESIGN

Obtaining high-quality, reliable results will require a detailed project plan based on objectives. Monitoring should always be completed following provincial protocols so that the data you collect can be used by government agencies when making decisions about activities in your watershed. The following step-by-step approach will help to define and build a valuable monitoring program. Enlisting the help of a qualified professional (QP) specializing in water quality (i.e., Registered Professional Biologist [R.P.Bio.], Registered Biology Technologist [R.B.Tech.]) at this stage is advised in order for the data to be considered for use in management, policy, or regulatory recommendations.

While working through the six steps below, you should also consider budget, time required to coordinate and maintain the monitoring program, the availability and expertise level of the samplers, and the intended use and accessibility of the data upon completion.

Qualified Professional (QP) is a person who (a) is registered in BC with a professional association, acts under that professional association's code of ethics, and is subject to disciplinary action by that professional association; and (b) through suitable education, experience, accreditation, and knowledge may be reasonably relied on to provide advice within their area of expertise.

Step 1: Define Program Objectives

Start by broadly stating the reason for monitoring or problem that you wish to study. Next, begin to refine this statement into a more specific objective. The objective should be a statement of intent that can be addressed using the data you will be collecting. Objectives should be specific, measurable, agreed-upon, realistic and time-bound. To refine your objectives, review existing water quality data, reports, and maps of the area. Making use of existing reports (i.e., building on their recommendations) can save time and money and avoid duplication of efforts. Also seek out local knowledge of your watershed.

Examples of objectives:

- Broadly stated: *Determine if old septic systems in the watershed cause excess nutrients and bacteria to be released into the creek*
- More refined: *In three sampling locations in Clear Creek, take five weekly samples in 30 days for suspended sediment during the fall flush period to determine if forestry activities in the watershed increase suspended sediments in surface waters during rainfall events*
- *Establish a sample site in Green Creek upstream and downstream of Bob's Farm and collect monthly samples from May to September for total phosphorus to determine if agricultural activity in the watershed increases nutrient levels*

Step 2: Identify the Parameters of Concern

Parameters of concern should be chosen based on the types of water use (e.g., drinking water, recreational, aquatic habitat), water quality concerns, and activities occurring in the watershed. See Appendix A for a list of water quality parameters that are associated with different activities. Once the parameters of concern have been identified, it is time to determine how you will test for each of the parameters. Many parameters are analysed by sending bottles of sample water to the lab, while others like pH, dissolved oxygen, temperature, and specific conductance/conductivity can be measured in the field using specialized meters or test kits. It is important at this point to be aware of your budget as laboratory analysis, testing equipment, and the maintenance of the equipment can be expensive.

Step 3: Selecting Monitoring Sites

Sites should be chosen to meet your monitoring objectives. They should be representative of the area under study and have safe access. Ensure agreements are in place with private property owners for access through their land. Check for any existing monitoring programs or sites in your area to avoid duplication. The following are general considerations for site selection:

- **Mouths of watercourses:** reflect all upstream inputs. Sample upstream of tidally influenced areas to capture freshwater conditions.
- **Upstream (control) and downstream influenced site combination:** One site is located upstream of the activity, impact of concern (e.g., eroding streambanks or road runoff), or input (e.g., tributary) and a second site is located downstream. By comparing water quality at the two sites one can isolate an impacted area (for non-point source impacts such as urban centres) or the impact of the activity of concern (e.g., industrial projects, resource extraction, sewage outfalls, etc.)
- **Near-shore lake locations:** reflect nearby inputs (septic systems, runoff, etc.)
- **Deepest point in lake:** reflects overall lake conditions
- **Points of major water withdrawals:** to evaluate WQ relative to specific use (e.g., drinking water)

Step 4: Timing, Frequency, and Duration

Sample timing and frequency can vary widely depending on your objectives. For newly established sites, samples may initially be collected at a high frequency to evaluate variability, cycles and trends.

Commonly, five weekly samples are taken over a 30-day period to compare with chronic (long-term average) BC Water Quality Guidelines (BCWQG). This is essential for parameters like *E. coli,* which must be sampled at this frequency to be compared to guidelines. Often this more intensive level of sampling may focus on critical periods for certain water uses. For instance, if your objective is to determine if water quality is safe for spawning fish, then sampling efforts should be concentrated around spawning season. Alternatively, more frequent sampling can target "worst-case" conditions, when levels of parameters of concern may be highest (e.g., first flush, high runoff events).

BC Water Quality Guidelines (BCWQG) are safe levels of substances (physical or biological characteristics) for the protection of water uses such as aquatic life, drinking water, recreation, agricultural, and industrial. Monitoring results can be compared to BCWQGs as part of your analysis.

In most cases, sampling should also consider seasonal variation of water chemistry by sampling at different times of year. To monitor seasonal variation, it is important to sample across the spring freshet (if present), summer and winter low flows, and fall flush (if present). It is important to consider the dominant driver of streamflow in your watershed (i.e., snowmelt, rain, groundwater, lake outflow and/or seasonal varying combination of some or all) when defining an effective monitoring program.

In other cases, sampling can be timed around a particular project or event. For instance, if the objective is to monitor the effects of a particular construction project, monitoring should occur before, during, and after the project.

Duration of monitoring is dependent on the monitoring objectives and can range from a single grab sample to long-term trend analysis that may require 10 or more years of monitoring.

Step 5: Confirm monitoring, data storage, data analysis and reporting plan meets requirements of end user

It is important to touch base with the intended end user of the data (e.g., collaborative partners, government agency) to inform them of the proposed project and confirm that the various components (locations, timing of sampling, methods, QA/QC protocols, data storage, reporting style) meet their needs. Know the steps you have to take during preparation (e.g., including certain information request to the lab) to get data where it needs to be.

Chronic vs. acute BCWQG

Long-term average (i.e., chronic) WQGs are intended to protect the most sensitive species and life stage against sub-lethal and lethal effects for indefinite exposures.

A short-term maximum (i.e., acute) WQG is a level that should never be exceeded in order to meet the intended protection of the most sensitive species and life stage against severe effects such as lethality over a defined short-term exposure period (e.g. 96 hrs).

Communicating with intended end-users before the project start will provide information that can improve utility of the data for decision making, maximize compatibility of data, ensure raw data are accessible to all intended users, and ensure reports are targeted to the appropriate audience. This ensures time, energy and materials are efficiently spent. Groups that work with their data end-users early on are more likely to establish trusting relationships, further increasing the likelihood that the data will be used.

Step 6: Start your report and review and adjust the program

Determine the best data communication type (e.g., progress report, annual report, assessment report, brochure) for the audience you are trying to reach. Begin preparing your report as if you had already completed your sampling, leaving room for data to be inserted to answer the questions posed. As you prepare your report, consider if your sample plan will allow you to obtain all the information you will need to answer the questions stated in your objectives. This stage will help to refine your program and reveal any gaps or unnecessary elements. See the reporting and analysis section at the end of this document for more information on reporting.

PREPARING FOR SAMPLING

Being well prepared for field work is essential for a successful sampling trip. Discover and use available training. Make a comprehensive list of what you need. The following steps will help prepare for sampling:

- Develop your field sampling safety plan
- If sampling requires laboratory analysis, select a lab, discuss sampling plan, and order appropriate amount and type of bottles and supplies. Refer to BC ENV Directory of Qualified Laboratories at https://www.nrs.gov.bc.ca/qualified-labs/ for a complete list of qualified laboratories and the chemical analyses that they are competent to perform

- Find out courier times in advance, plan timing of sampling accordingly. Sampling early in the week will help avoid delays in analysis or expiration of hold times of samples. Some carriers may not be able to ship overnight near the end of the week
- Prepare paperwork for laboratory. If applicable (i.e., for provincial governmental partnership agreements), information is added to paperwork to ensure data will be uploaded by lab to provincial database.
- Package paperwork in resealable bags (e.g., Ziploc) with courier waybills and shipping labels
- Plan your route, take an appropriate vehicle
- Test and clean field equipment
- Check expiration dates on preservatives, test kits, calibration solutions, etc.
- Calibrate your meters
- Label bottles
- If sampling multiple sites, bag bottles and preservatives by site in large resealable bags
- Bring extra bottles, equipment (especially items that may fail in the field, e.g., meters), dry clothing, and time

FIELD SAFETY

When sampling, your primary concern should be safety. Groups should establish field safety protocols and have insurance in case of an accident. The following general safety guidelines should be included in the safety protocol:

- Use appropriate personal protective equipment (PPE): life jackets, throw bags, non-slip footwear, wading staff, etc. Shoulder length rubber gloves may help in cold conditions.

- Always sample with a partner
- Use a contact person who knows your whereabouts and have a check in time. Be explicit as to what is expected of the contact person if the check-in does not occur when scheduled
- Carry a cell phone and/or satellite location device
- Carry a first aid kit and have basic first aid training
- Park vehicle safely off road or, if on shoulder, mark with a safety cone for visibility.
- Review safety plan before entering the sampling area (tailgate meeting). Focus on safety plan content and identify any additional hazards that may be present at the time of sampling (animals, water conditions, wind, weather, etc.)
- If travelling on logging roads, use appropriate company road protocols and communication
- If using a boat, follow Transport Canada boat safety requirements
- Avoid wading in the stream, if possible. Sample from shore using a sampling pole or safely at arm's reach, using caution to avoid slips and falls.
- Samplers should always use common sense and never put themselves at risk

FIELD SAMPLING

It is essential to follow appropriate sampling protocols to ensure data are collected correctly and thus will be defensible. The following section provides information on bottle preparation, grab sampling, sampling from a boat, field measurements, field notes, and sample shipping.

More detailed water sampling protocols are provided in the 2013 ENV Field Sampling Manual (https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/laboratory-standards-quality-assurance/bc-field-sampling-manual).

Bottle Preparation

Discuss with your laboratory if they recommend rinsing the bottles they provide with sample water. If bottles are pre-cleaned by the lab, they do not need to be rinsed before sampling. If bottles contain preservatives, they must not be rinsed before sampling. Check that the caps have not come off in transport and do not use bottles that have opened.

If bottles are not pre-cleaned they should be rinsed. To properly rinse a sample bottle, fill the sample bottle ½ full with sample water, close the lid and shake the bottle. Dispose of the rinse water on land away from your sample location. Repeat three times and then take the sample.

Sampling from shore or by wading

Note: A sampling pole is always preferred to wading to avoid the need to wade potentially unsafe conditions.

Sampling from the shore of the watercourse reaching out (at arms length or using as sampling pole) and filling a bottle is the simplest and most common way to take a water sample. Very shallow water depth near shore may necessitate some wading. The following is the correct protocol for sampling from shore or by wading:

1. If sampling in **flowing water,** avoid contamination of the sample by entering the water from downstream of the sample location and sampling facing upstream. Sample in well-mixed flowing water, away from shore.

   If sampling in **still water,** wade into the water beyond where bottom sediment is affected by wave action or use a dock if available.

2. Remove the lid, ensuring not to touch inside of lid or mouth of sample container.
3. Sampling depth should be 15-30 cm below the water surface. If water is very shallow be careful not to disturb bottom sediment and sample in the middle of the water column.
4. Dip the bottle as shown in Figure 1. Exception: if bottle contains a preservative, do not invert the bottle, but tip it just enough so the preservative does not fall out.
5. If "No Headspace" is required for the sample, fill the container until a meniscus forms above the lip. Tighten the lid down over the meniscus. If significant air bubbles are visible, the sample should be recollected using a fresh container.

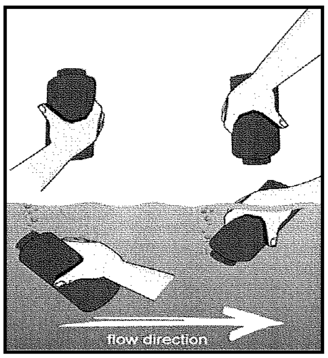


Figure 1: Grab Sampling

6. Filter and/or preserve samples immediately after collection (if required) and keep samples cold (1-4°C).

Boat Sampling

1. Sample from boat's bow (front) to prevent contamination from the boat or motor.
2. Take the sample at arm's length from boat. If in flowing water, sample facing the current with the boat facing into the current as well.
3. Submerge bottle 15-30 cm below water surface and fill sample bottle.
4. If a deep-water sample is required, a depth sampling device (Van Dorn) can be used.
5. Preserve samples immediately (if required) after collection and keep samples cold (1-4°C).
6. Be aware of impending changes in weather and water conditions.

Field Measurements

Field measurements should accompany water samples and can include many different parameters. Multi-meter probes can be used to measure water quality parameters like dissolved oxygen (DO), pH, specific conductance/conductivity, and temperature. However, these meters can be prohibitively expensive for sampling groups. To sample these parameters more economically, groups should consider test strips for pH, thermometers for temperature, and Winkler titration kits for DO.

It is very important that your field measuring equipment is functioning properly. If using pH strips and Winkler titration kits, they should be stored correctly, and the expiry dates should be observed. Field meters should be regularly maintained (e.g., ensure fresh batteries before heading into the field) and calibrated, and details recorded in a logbook.

Field Notes

Detailed field notes should be taken every time

water samples are collected. Field notes are essential as they are often used to interpret results, explain strange values, etc. Thorough field notes should be recorded on waterproof paper in a dedicated field notebook and should include:

- Time and date
- Sample location/site name
- Site description and sketches
- GPS coordinates
- Names of samplers
- Weather conditions, including any recent events
- Unusual occurrences or conditions
- Deviations from standard protocols
- Data from field measurements (including units)
- Any observations that may influence water quality results, including changes in site conditions since last visit

Transcribe field notes to electronic record and save all photo documentation as soon as possible. Field use of tablets can streamline this process.

Shipping

Since laboratories are often far from the monitoring site, samples are often shipped via courier. Finding a courier who will be able to get samples to the laboratory quickly to avoid exceeding holding times of parameters is essential. Most holding times are within 48 hours.

Note: Some couriers may be able to provide shipping to a lab within the holding times (< 48 hours), but for only a portion of the week (e.g., usually Friday and weekends are longer shipping times from remote areas of BC). Please be sure to verify the delivery time you are purchasing to avoid complications of exceeding holding times (>48 hours).

Testing for most water quality parameters requires that the sample is kept cool. Therefore, it is necessary to ship in an insulated cooler that contains ice weighing approximately 50% of the weight of samples. Use ice packs or bottled ice as loose ice will melt and make a mess of your cooler.

Bottled ice can be made at home, using clean, empty plastic container (such as sealable used beverage containers), filled to 3/4 the bottle's volume and frozen for a few days prior to sampling.

Make sure to protect glass bottles from breakage by separating them from each other with clean packing non-compressible material. Place completed laboratory forms in a resealable bag inside the cooler and securely tape the cooler shut before shipping.

QUALITY ASSURANCE/QUALITY CONTROL

Quality Assurance/Quality Control (QA/QC) encompasses all the ways that we aim to ensure that samples are uncontaminated and without errors. A proper QA/QC program will help ensure that the data you collect are defensible.

QA includes: all appropriate sampling protocols, training of staff, quality of laboratory analysis, etc.

QC tests the sampling procedure to ensure that samples are valid and no contamination or errors have occurred. QC commonly includes blank and replicate samples.

- **Blank Sample:** A sample bottle filled with de-ionized (DI) water (available from an approved laboratory) is brought along on the sampling trip and subjected to the same conditions as the real sample (i.e., the lid is removed as if a sample is to be taken at the sample location, but the bottle is not dipped into the water). The sample is then analyzed by the lab. Since DI water is pure water, the lab should not be able to detect anything other than pure water in the sample. If anything else is detected by the analysis, this could indicate sample contamination. Blanks are used to assess the quality of various parts of the sampling process.

- **Replicate samples:** Two separate samples are taken from the waterbody as close as possible in time and location to each other. The results are then compared and should be very similar to each other. Replicates are commonly taken to assess precision of sampling and are an additional check for sample contamination.

QC samples should constitute a minimum of 10% of the samples (i.e., one for every ten). A more detailed explanation of QC samples is contained in the BC ENV Field Sampling Manual (2013).

ANALYSIS AND REPORTING

Archiving data

Field and lab measured data, field observations, photographs and instrument calibration records should be able to be accessed by future data users. Archive data according to your data storage needs determined at the start of the project. This may range from well kept digital records to publicly available databases, depending on the data type and data sharing agreements. Regardless of the data type, any files should be clearly and methodically labelled

Analysis and Reporting

Analysis and reporting can be one of the most challenging stages for any watershed group. Getting the help of a qualified professional who specializes in water quality at this stage is recommended in order for the results to be considered for use in management, policy, or regulatory recommendations.

The type of analysis that can be performed with your data can vary widely based on the objective(s) of the sampling program. As a general rule, the analysis should be tailored such that it will be useful to decision makers.

In BC, a simple start to water quality data analysis is to compare results to the BCWQGs. This can be done by preparing a summary table of data showing the average and range for each of the parameters measured (or other summary statistic as specified in specific WQG), which will make it easier to compare them to WQGs. Graphs can also be a useful visual tool to evaluate baseline conditions, changes from upstream to downstream or to evaluate trends over time. Parameters that do not have established BCWQGs (e.g., conductivity) may have working WQGs or, if not, could be presented relative to known background concentrations for a given area.

More information about interpretation of results can be found in the 1998 BC ENV Guidelines for Interpreting Water Quality Data (https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/nr-laws-policy/risc/guidlines_for_interpreting_water_quality_data.pdf).

Once the analysis is complete, results should be communicated to stakeholders, decision- makers, group members, and the community. It is important to tailor your communications to meet the expertise and interests of each group. Reporting methods may involve scientific style reports, newsletters, posters, presentations, etc.

APPENDIX A: Parameters to test based on activities in watershed

Oil and Gas	Pulp and Paper	Wood Preservation	Transformers	Food/Meat Processing	Municipal Effluent	Fish Hatchery	Fish Farms	Mining	Fruit/Veg Cannery	Cement	Feedlot	Leather Tanning	Urban Run-off	Compost Facility
VH, VPH, EPH, BTEX, Oil and Gas, TOC, Metals, Turbidity, TSS, pH, Phenols, NH_3	BOD, TSS, pH, Resin Acid, LC_{50}, LT_{50}, Metals, NH3, Cond., TOC, DOC, COD, BOD, Cl, Sulfides, Microbio.	DDAC, Cu-8, PAH, Phenols, Heavy Metals, pH	PCB	Oil and Gas, NH_3, pH, BOD, TOC, Bact., T-P, O-P, TSS, TSS-Fixed, Acidity to pH 8.3	NH_3, BOD, Oil and Gas, TOC, COD, Nitrogen, Phosphorus, Metals, pH, Cond., Microbio., Tox., DO, Temp, TS, TSS, TDS, TVS	TSS, T-P, NH_3	H_2S, TVR, Sed. Grain Size, Metals, P (available), Temp, Redox	CN, Metals, Hg, NH_3, PAH, H_2S, TSS, pH, DO, Cond., Cl	BOD, TSS, pH	Temp., TSS, pH, Total Chromium (Cr) and Hexavalent Chromium (Cr(VI)). Cr(III) (calculated)	BOD, pH, TDS, Microbio., Nutrients	BOD, Oil and Gas, TSS, pH	TSS, Turb, Cond., DO, NH_3, NO_2, NO_3, COD, BOD, Na, Cl, SO_4, Metals, Cr(VI) species, HC's, Microbio., Chlorophyll a	BOD, TSS, pH, NH_3, NO_2, NO_3, chloride, phosphorus, microbio.

Smelters	Laundromats	Landfill-Leach	Agri Sites	Waste Oils	Dust Supression	Industrial Effluent	Wood Chips	Sawmills	Textiles	Plastics	Coal Mines	Dairy Products	Forestry	Pot Ash/Coal bulk handling Terminals
HG, Metals, NO_2, NO_3	NH_3, P, pH, Surfactants, Oil and gas, TSS, BOD	pH, NO_2, NO_3, Hg, Tox., Metals, BOD, Microbio., chloride	NO_2, NO_3, pH, Pesticides, Herbicides, Bact., NH_3, T-P, O-P, TSS, COD, TSS-Fixed, Metals, Microbio.	Oil and gas, SWOG, EPH, PCB, Metals	PCB, Anions	Alk, Acidity, TOC, Cl, Br, Metals, NO_2, NO_3, BOD, COD, TSS, Turb, NH_3, Microbio., LC/LT_{50}	Cholorophenols, COD, Resin Acids, Acidity to pH 8.3	Tox, DDAC/Cu-8, Resin Acid, HC's	pH, Phenols, Colour, COD, BOD, TSS, Oil and Gas, Sulfides, FC, Cr	BOD, TSS, Cr, pH, Zn, Phenols, COD	TSS, PAH, NH_3, NO_2, NO_3, Metals, Se, SO_4	BOD, TSS, pH, DO	Temp, TSS, Turb., DO, NO_2, NO_3, T-P, Chlorophyll a	KCl tox., TSS, Metals

Important Concurrent Tests:	Legend:
Metals- hardness	Cond. - Conductivity
NH_3- pH, field temp., Chloride	Tox. - Toxicology
Aluminum- for surface water Al (dissolved)	Temp. - Temperature
Copper - for surface water Cu (dissolved)	Microbio. - Microbiological factors