WATER QUALITY OBJECTIVE SERIES

Guidance for the Derivation of Water Quality Objectives in British Columbia

British Columbia Ministry of Environment & Climate Change Strategy

BRITISH COLUMBIA

No. WQO-04

The **Water Quality Objective Series** is a collection of British Columbia (B.C.) Ministry of Environment and Climate Change Strategy (ENV) water quality objectives (WQOs) reports and supporting documents. WQOs are developed for waterbodies to promote the protection and stewardship of aquatic resources. Once approved, WQOs constitute formal Ministry policy and must be considered in any decision affecting water quality made within ENV. For additional information visit: https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/water-quality-objectives.

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Columbia River, B.C.

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Introduction

The British Columbia (B.C.) Ministry of Environment and Climate Change Strategy (ENV) uses sound science and policy to inform resource management decisions, with respect to activities on the land base, to ensure our supply of clean water is sustainable. ENV provides leadership in the development of water strategies, policy, and legislation to protect and manage the quality of surface water and groundwater. To support its goal of effective protection and conservation of the environment, ENV develops water quality objectives (WQOs) for specific bodies of fresh, estuarine, and coastal marine waters in B.C.

WQOs are scientifically derived numerical concentrations or narrative statements considered to be protective of the water uses and values for a specific waterbody, in ambient conditions. They are established on a priority basis for waterbodies of regional, provincial, inter-provincial, international, or Indigenous significance and set with the goal of protecting aquatic habitats by maintaining existing water quality, improving existing water quality, or protecting water quality for a specific use or value. WQOs set benchmarks used to assess water quality, inform resource management decisions, promote water stewardship, and support long-term watershed planning. They also support other key water initiatives such as managing cumulative effects and climate change, developing and implementing transboundary water management agreements, and implementing the *Water Sustainability Act*.

WQOs apply to the water quality of a specific waterbody. While they can inform resource management decisions within a watershed, they cannot be used to solely address complex water issues, such as Indigenous rights and title, or fisheries, wildlife, and lands management. They are one tool that contributes to a more complex resource management framework and provide a means to increase environmental awareness and promote shared environmental stewardship. When the minimum requirements to protect water quality have been defined and formalized as WQOs, all parties with an interest in the waterbody have results-based goals to help guide water-related decisions.

In support of the Draft Principles that Guide the Province of British Columbia's Relationship with Indigenous Peoples and the *Declaration on the Rights of Indigenous Peoples Act*, ENV seeks to engage with Indigenous nations to collaborate and co-develop WQOs. This may include weaving together and synthesizing Indigenous Knowledge and western science to define the most appropriate objectives for a waterbody.

This document updates and replaces *Guidance for the Derivation and Application of Water Quality Objectives in British Columbia* (ENV 2013) and is intended for use by ENV staff and collaborators. It updates ENV's approach to developing WQOs to ensure efficient program delivery reflecting Government's current mandate and needs. It provides guidance on when to develop WQOs and outlines the derivation process for WQOs in B.C. As each WQO project will be different, it is recognized the components of the process and timing may vary from project to project.

Authority to Set Water Quality Objectives

The purpose and functions of ENV are outlined in the *Ministry of Environment Act*. Section 4(2)(a) states that ENV is "to encourage and maintain an optimum quality environment through specific objectives for the management and protection of land, water, air and living resources of British Columbia". Additionally, Section 5(e) of the *Environmental Management Act* authorizes the Minister to prepare and publish "policies, strategies, objectives, guidelines and standards for the protection and management of the environment". WQOs are approved by the Executive Director of ENV's Water Protection and Sustainability Branch. Once approved, WQOs constitute ENV policy and are considered in any decisions affecting water quality made within the ENV.

Section 43 of the *Water Sustainability Act* enables the Province to make regulations establishing Water Objectives for a watershed, stream, aquifer or other specified areas in order to sustain water quantity, water quality and aquatic ecosystems. Water Quality Objectives established under the authority of the *Ministry of Environment Act* and *Environmental Management Act* may also be used to support the development of Water Objectives under the *Water Sustainability Act*.

Compliance with Water Quality Objectives

WQOs are not directly enforceable but may provide the basis for waste discharge limits specified in permits, approvals, and orders, which are enforceable. It should be noted that the attainment of WQOs does not relieve any other legislative obligations (e.g., *Environmental Management Act*, *Drinking Water Protection Act*, *Water Sustainability Act*).

Updated Guidance for Developing Water Quality Objectives

WQOs are widely recognized as important benchmarks for managing water quality and there is an ongoing need to develop new WQOs and update existing WQOs. This guidance document provides clarity and direction on all aspects of WQOs to ensure the program is effective, considers current policies and science, reflects Government's current direction, respects Indigenous values and Knowledge, and meets ENV's operational needs. This includes:

- ***When to develop WQOs.*** WQOs are developed when there is a need to establish water quality benchmarks to protect, maintain, or improve water quality conditions in a specific waterbody. Ideally, WQOs are set before intensive development or human activities occur in the vicinity of a sensitive or priority waterbody to inform resource management decisions.
- ***Who develops WQOs.*** WQOs are developed by ENV; this may be done in partnership with other levels of government, including Indigenous nations, and stakeholders where appropriate.
- ***Appropriate selection of waterbodies for WQOs.*** WQOs are developed to promote the stewardship of waterbodies of regional, provincial, inter-provincial, international, or Indigenous significance. WQO development projects are prioritized according to need, available resources, and capacity.
- ***Update of approved WQO derivation methods.*** Previous guidance documents (e.g., ENV 2013) listed four methods to develop WQOs in B.C. However, two of the methods have never been used (i.e., the Resident Species Approach and the Water Effects Ratio) and have been removed in this update. These two methods allowed the adjustment of WQGs depending on site-specific conditions, recognizing that WQGs may be over- or under-protective in some situations. In developing WQOs, ENV does not seek justification to increase contaminant concentrations above WQG levels. These methods are more suitable for the development of Science-Based Environmental Benchmarks (SBEBs) as part of the waste discharge permitting process for mines (ENV 2016).
- ***Identification of water uses and values.*** In the past, WQOs have focussed on protection of "designated uses". This term implies that water is a commodity to be consumed in some way and may not recognize its intrinsic or ecological worth. Going forward, the term "water uses and values" is used and includes the previous "designated uses", as well as the traditional, cultural and social values associated with a waterbody to support a more balanced stewardship of the water.
- ***Allocation of the environmental assimilative capacity.*** The development of WQOs includes consideration of the available assimilative capacity of the waterbody. Assimilative capacity is a water body's ability to receive contaminants without deleterious effects to the water quality. In the past, the development of WQOs often adopted WQG values directly, inadvertently allocating all the assumed assimilative capacity of the environment available at that time. In practice, the allocation of assimilative capacity should be minimized to account for future land uses and cumulative effects.

- ***Desired level of protection.*** Determining and documenting the desired level of protection for a waterbody is essential for deriving meaningful WQOs. The desired level of protection reflects the management goals for the waterbody and how much of its assimilative capacity can be allocated.
- ***Biomonitoring.*** In the past, WQOs have focussed on the chemical and physical aspects of water quality to establish benchmarks. This update includes the use of biomonitoring, specifically, the Canadian Aquatic Biomonitoring Network (CABIN), to provide a more robust and direct measure of aquatic ecosystem health.

Indigenous Knowledge

To support the protection of traditional, cultural and social values in WQOs, Indigenous nations will be invited to participate in the WQO development process at their discretion. Indigenous Knowledge, which includes the Traditional Knowledge gained over thousands of years and direct observations and experiences related to the waterbody of interest, may be used alongside western science and local knowledge to derive the most appropriate objectives for a waterbody. Indigenous Knowledge is complementary to western science and may include the values, stewardship, and other obligations of Indigenous communities regarding what they consider important, the extent to which they feel those values are at risk or have been adversely affected, and their identified priorities for restoring ecological health.

The following principles, adapted from EAO (2020), provide the basis for applying Indigenous Knowledge in the development of WQOs:

- ***Respect*** – Indigenous Knowledge and western knowledge are equally valid as distinct ways of knowing that can work together.
- ***Relationship Based*** – Relationships with Indigenous nations and knowledge holders are foundational.
- ***Iterative, Interconnected and Broad Application*** – Indigenous Knowledge should be applied throughout the WQO development process.
- ***Acknowledgement of Context*** – Indigenous Knowledge is to be understood within the context it was given.
- ***Transparency*** – Transparency of the WQO development process will be maintained throughout WQO projects.
- ***Permission of Use*** – Indigenous Knowledge must be used with appropriate permission and according to the governance, laws, policies and practices of the Indigenous nation.

Guiding Principles

There are 14 guiding principles for the development of WQOs in B.C.:

1) WQOs are established for waterbodies (fresh, estuarine, and marine) of regional, provincial, inter-provincial, international, or Indigenous significance to inform resource management decisions and promote water stewardship.
2) Waterbodies are selected on a priority basis depending on the current state of water quality, ENV's responsibility and jurisdiction, the level of impending development, available capacity and resources, and input from other governments (including Indigenous nations).
3) Unless specified otherwise, WQOs apply to the whole waterbody except for any initial dilution zone (IDZ) associated with a permitted waste discharge. For more information on IDZs, refer to ENV (2019).

4) WQOs are informed by a water quality assessment to evaluate the physical, chemical, and biological characteristics of the waterbody. The water quality assessment uses the best available science and information at the time of their derivation, and considers past, current, and future land use and development.
5) WQOs may be developed in partnership with other levels of government (Federal, Indigenous nations, Local), and with input from regulated interests or non-governmental organizations.
6) Indigenous nations whose territorial lands include the waterbody of interest will be engaged at the beginning of each WQO project. Co-development of WQOs with Indigenous nations will be at their discretion and based on an inclusive working partnership utilizing both Indigenous knowledge and western science to protect the ecological integrity and health of the waterbody. Each contributing Indigenous government will be consulted on how they wish for their Indigenous Knowledge to be applied in the development of WQOs.
7) Third party stakeholders may contribute information for consideration in deriving WQOs for a waterbody. Information submitted by stakeholders will be reviewed and approved for use by the appropriate BC ENV qualified professionals (e.g., R. P. Bio., P. Ag., P. Geo., P. Eng.) before it is included in the development of WQOs.
8) WQOs are established to protect the most sensitive water uses and values associated with a waterbody; these include:
    - aquatic life and its habitat;
    - human health, including drinking water sources and consumption of fish and shellfish;
    - recreational use and aesthetics;
    - wildlife and its habitat;
    - agriculture (livestock watering and irrigation); and
    - traditional, cultural, and social values.
9) WQOs specify the desired level of protection for a waterbody. This will depend on the values to be protected and anthropogenic influences.
10) WQOs are developed for parameters of concern. These are the parameters that may be altered due to anthropogenic activities or natural conditions and may need to be managed to protect the identified water uses and values.
11) WQOs may be specified for the short-term (e.g., <5 years) and apply to current conditions, or the long-term (e.g., >5 years) to provide a goal for future improvement. Both short- and long-term WQOs may be appropriate. They may be numerical (e.g., a chemical concentration to be met) or narrative (e.g., aesthetic quality of drinking water sources), but in either case the WQO must be measurable.
12) WQOs include a technical water quality assessment report(s) and a WQO policy report. The technical assessment includes the watershed profile and water quality characterization. The WQO policy report provides a summary of the technical assessment report and the final WQOs for a given waterbody. As appropriate, collaborating Indigenous nations may also prepare separate reports to describe their values and interests in the waterbody.
13) WQO policy reports include a recommended monitoring program to properly assess WQOs attainment, identify trends in water quality, report on attainment, and refine the WQOs, if necessary, over time.
14) WQOs should be reviewed and updated over time and when new information comes available, such as trend monitoring information or relevant scientific findings, updated WQGs, and/or new contaminants of concern.

Water Quality Objectives Derivation Process

The derivation of WQOs involves the steps illustrated in Figure 1 and described in the following sections. The process is dynamic, and the individual steps may occur in a different order or simultaneously.

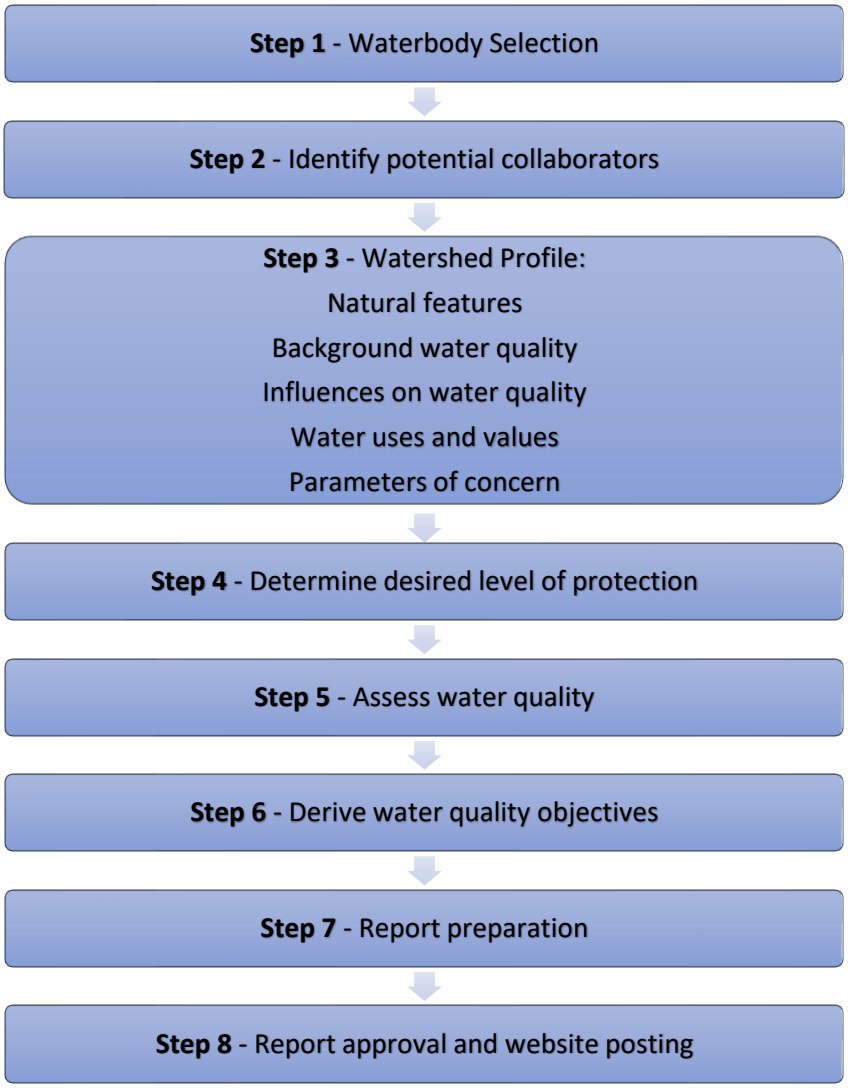

Figure 1. Overview of the process to develop water quality objectives in British Columbia.

Step 1: Waterbody Selection

The selection of waterbodies for WQOs development is determined by ENV. Other parties may propose waterbodies for the development of WQOs, but the decision to proceed lies with ENV. To be considered, waterbodies should have regional, provincial, inter-provincial, international, or Indigenous significance and ENV should have some level of responsibility for decision-making related to water quality. Projects are not initiated until adequate resources have been identified.

Several factors are considered when selecting waterbodies, including:

- the immediate need for guidance or benchmarks given the current state of water quality and impending risks;

- information needs and available data;
- the potential for cumulative effects in a watershed of interest;
- available resources and capacity; and
- potential collaborators and availability.

Step 2: Identify Potential Collaborators

During the development of WQOs, it is important to engage with potential collaborators. These include those internal to the Provincial Government or other levels of government. Examples of internal government collaborators include other business areas within ENV or other ministries, depending on the concerns (e.g., Ministry of Health if drinking water is a value of interest). Engaging with other levels of Government will be informed by local activities and concerns. Other levels of Government include Indigenous nations, Federal, Regional Districts, Regional Health Authorities, and Local Government. Engagement with potential collaborators should be done as early as possible to learn about related work, build relationships, and determine the best way to work together.

Step 3: Watershed Profile

The watershed profile describes the important attributes and characteristics of the waterbody in question and provides the context for deriving the WQOs. There are five main components that need to be assessed and described:

Natural Features

The watershed profile describes the natural features of the waterbody and its watershed relevant to the water quality. This includes, but is not limited to, the following:

- location and size of the watershed;
- geological features;
- climate and precipitation;
- general hydrology, limnology and/or oceanography and drainage characteristics and processes;
- lake morphology characteristics;
- trophic status;
- biota and species of concern; and
- any other natural features relevant to water quality.

Background Water Quality

A fundamental component to the water quality assessment is the establishment of the natural background conditions of the waterbody to measure against future changes. In most situations, background conditions be will defined as one of the following:

- Pre-development, natural background – the establishment of upstream or other suitable reference stations not under anthropogenic influences. When an upstream station cannot be identified, an adjacent watershed with similar catchment areas and geological settings can be used.
- Post-development background – the establishment of conditions influenced by legacy impacts and past land development, recognizing that restoration to pre-development conditions is not likely.

The data used to determine background levels should consider the natural variability of water quality both spatially and temporally. If the available data are insufficient to determine background concentrations for the parameters of concern, additional data should be collected. It will be necessary to take samples during "worse case scenarios" such as low-flow and high-flow periods when parameter concentrations are likely to be elevated. To be consistent with other ENV policies and procedures (e.g., the Contaminated Sites Regulation), the 95th percentile of available data should be used to determine the upper limit of background concentrations. In some cases, it may be appropriate to examine background levels on a seasonal basis; for example, turbidity may be measured according to the clear and turbid-flow portions of the hydrograph.

Understanding the ameliorating influences of the waterbody will help characterize the background water quality and existing water quality conditions. The water quality assessment should include constituents (e.g., hardness, pH, temperature) that may modify the toxicity of a parameter of concern. Other influences on water quality characteristics, such as seasonal variation and stream flow, should be included.

The characterization of background conditions is key to the derivation of meaningful WQOs. The unique circumstances of each waterbody should be considered, and the appropriateness of the data evaluated. This process requires sound professional judgement and clear documentation in the water quality assessment.

Influences on Water Quality

Both the anthropogenic and natural influences on water quality should be documented.
Anthropogenic influences include, but are not limited to:

- major land use activities and developments;
- authorized waste discharges;
- non-point source waste discharges; and
- water withdrawals and flow alterations (withdrawals and dams).

Natural influences include features that contribute elevated levels of organic matter (e.g., peat bogs or vegetation), local geology, natural turbid flow periods, and natural land disturbances (e.g., wildfire, landslides).

Water Uses and Values

Water uses and values are the attributes of a waterbody that have been identified to protect. These can be defined by their intrinsic value (e.g., aquatic habitat) or their value to humans (e.g., drinking water) and include:

- Aquatic life and its habitat, including, but not limited to, fish, amphibians, invertebrates, and plants;
- Drinking water sources and domestic uses;
- Human consumption of fish and shellfish.
- Recreational uses (primary and secondary contact) and aesthetics;
- Wildlife and its habitat;
- Agriculture (livestock watering and irrigation); and
- Traditional, cultural, ceremonial, and social values and uses.

WQOs are set to protect the most sensitive water use or value and in doing so protect all other water uses and values associated with the waterbody. All uses and values should be identified and documented to ensure they are considered in future applicable resource management decisions.

Parameters of Concern

The parameters of concern are those characteristics that may need to be managed to protect the identified water uses and values. These will depend on the uses and values associated with the waterbody, the historic, current and proposed human activities, and the basin characteristics. Identifying the parameters of concern helps to focus the water quality assessment on aspects that require further investigation and to determine which parameters will ultimately be proposed as WQOs.

First, the parameters associated with the existing and proposed land use activities should be identified. Table 1 lists parameters typically associated with the main land uses and developments in B.C. To help focus on potential parameters of concern specific to the waterbody in question, a review of the existing land uses, authorized discharges, permit limits, and ambient monitoring programs should be conducted.

Next, the key parameters associated with the water uses and values for the waterbody should be identified. These include any parameters that may need to be managed in order to ensure the identified uses and values are protected. The potential parameters of concern typically associated with common water uses and values are listed in Table 2.

The parameters listed in Tables 1 and 2 provide a general starting point for parameter selection. It may be necessary to consider new and emerging contaminants, such as pesticides, persistent pollutants, microplastics, and pharmaceuticals and personal care products, which are increasingly being found in B.C.'s waterbodies, and the potential impacts of chemical mixtures.

The available water quality data should be reviewed to identify any parameters that may be elevated above background or WQG levels, or any parameters showing an increasing trend despite being below WQG levels. Parameters which do not have B.C. approved or working WQGs should still be identified and included in the water quality assessment. The final selection of potential parameters of concern should reflect the nature of the waterbody, the land uses, and the water uses and values.

Step 4: Determine the Desired Level of Protection

The desired level of protection refers to the acceptable amount of change in water quality due to anthropogenic influences. Identifying, rationalizing, and documenting this is important in the establishment and justification of WQO values. The *Yinka Dene 'Usa'hné Surface Water Management Policy* (Nadleh Whut'en and Stellat'en 2016) includes a water classification system that provides a systematic basis for classifying receiving waterbodies relative to their importance and sensitivity to disturbance. The following levels of protection are based on this system to allow consideration of the natural and anthropogenic characteristics of each waterbody and its watershed (see Figure 2).

- **Full protection** maintains existing water quality with no degradation, substantial alteration, or impairment by human activities. Numerical WQOs should be within 20% of established baseline or background conditions. This would apply where the goal is to fully protect the existing water quality and values or if a parameter of concern has naturally elevated levels such that the WQG cannot be met. In each instance, a change of 20% in current conditions is considered acceptable recognizing the precision for measurement of low-level concentrations in replicate samples is not usually better than

Table 1. Potential parameters of concern in relation to select land uses and sources (adopted with modifications from Chapman 1996). Note: X – XX – XXX indicates a low – medium – high likelihood that the parameter will be affected. Local conditions will dictate which parameters to select and it may be necessary to include parameters not indicated in this table.

	Municipal Wastewater	Urban Runoff	Agriculture	Forestry	Mining	Municipal Solid Waste	Pulp and Paper	Oil, Gas & LNG
General Variables								
Temperature	X	X	X	XX	X		X	XX
Colour	X	X	X	X	X	X	X	
Odour	X	X	X		X		X	
Suspended solids	XXX	XX	XXX	XXX	X	XX	XXX	XXX
Total dissolved solids	X	X	XXX		X	XXX	X	
Turbidity		XX	XX	XXX				
Conductivity	XX	XX	XX	X	XXX	XXX	XXX	
pH	X	X	X		XXX	XX	X	XXX
Dissolved oxygen	XXX	XXX	XXX	XXX	XXX	XXX	XXX	
Hardness	X	X	X		XX		X	
Chlorophyll *a*	XXX	XX	XXX	XX				
Nutrients								
Ammonia	XXX	XX	XXX		X	XX	X	XX
Nitrate/nitrite	XXX	XX	XXX	XX	X	XX	X	XX
Phosphorus	XXX	XX	XXX	XX		X		
Organic matter								
TOC	X	X	X	X	X		XXX	
DOC	X	X	X	X	X		XXX	
COD	XX	XX	X		X	XXX	XXX	
BOD	XXX	XX	XXX	X	X	XXX	XXX	
Major Ions								
Bromide								XX
Sodium	XX	XX	XX					XX
Potassium	X	X	X					
Calcium	X	X	X				X	XX
Magnesium	X	X	X				X	XX
Carbonates					X	X		
Chloride	XXX	XX	XXX		XXX	XX	XXX	XX
Sulphate	X	X			XX	X	X	
Other Inorganic Variables								
Sulphide	XX	XX	X		X		XXX	
Silica	X	X			X			XX
Fluoride	X	X			X			
Boron			X		X		X	
Cyanide					X			
Trace Elements								
Heavy metals	XX	XXX	XX	X	XXX	XXX	X	X
Arsenic		X	XX		X	XX		X
Selenium		X	XX		X	X		X
Organic Contaminants								
Oil & hydrocarbons	XX	XXX				XX		XXX
Organic solvents	X	X				XXX	XXX	X
Phenols	X					XX	XXX	
Pesticides		X	XXX			XX		
Surfactants	XX		X				X	
Microbiological Indicators								
Fecal coliforms	XXX	XX	XX			XXX	XX	
Escherichia coli	XXX		XX			XXX	XX	
Pathogens	XXX		XX			XXX		

TOC Total organic carbon DOC Dissolved organic carbon LNG Liquified natural gas
COD Chemical oxygen demand BOD Biochemical oxygen demand

Table 2. Potential parameters of concern in relation to select water uses and values (adopted with modifications from Chapman 1996). Note: X – XX – XXX indicates a low – medium – high likelihood that the use or value will be affected. Local conditions will dictate which parameters to select and it may be necessary to include parameters not indicated in this table.

	Aquatic Life	Drinking Water Sources	Recreation	Wildlife	Agricultural – Irrigation	Agricultural – Livestock Watering
Temperature	XXX	X	X	X		X
Colour		XX	XX	X		
Odour		XX				
Suspended solids	XXX	XXX	XXX			
Total dissolved solids	X	X		X	XXX	
Turbidity	XX	XX	XX	X	X	X
Conductivity	X	X			X	
pH	XX	X	X		XX	
Dissolved oxygen	XXX	X			X	
Hardness	X	XX				
Chlorophyll *a*	XX	XX	XX			
Ammonia	XXX	X				
Nitrate/nitrite	X	XXX		XX		XX
Phosphorus		X				
TOC				X		
DOC		X	X	X		
COD	XX					
BOD	XXX	XX				
Sodium		X			XXX	
Potassium						
Calcium	X			X	X	X
Magnesium	X	X				
Chloride		X		X	XXX	
Sulphate	X	X		X		X
Fluoride		XX		X	X	X
Boron				X	XX	X
Cyanide	X	X				
Trace Elements						
Heavy metals	XXX	XXX		X	X	X
Arsenic	XXX	XX		X	X	X
Selenium	XXX	XX		XX	X	X
Oil & hydrocarbons	X	XX	XX	X	X	X
Organic solvents	X	XXX		X		X
Phenols	X	XX		X		X
Pesticides	XX	XX		X		X
Surfactants	X	X	X	X		X
Fecal coliforms		XXX	XXX		XXX	
Escherichia coli		XXX	XXX		XXX	
Pathogens		XXX	XXX		XXX	XX

TOC Total organic carbon DOC Dissolved organic carbon

COD Chemical oxygen demand BOD Biochemical oxygen demand

20% in ideal laboratory conditions and natural variability is often greater than 20%. For example, if current conditions for a parameter is a 30-day average of 10 mg/L, a WQO of 12 mg/L would be established to protect the identified water uses and values.

- ***Modified protection*** allows for some use of the assimilative capacity, recognizing that changes to water quality are generally associated with land development but these can be well within levels considered protective of the values. The portion of assimilative capacity (e.g., 50%) to be allocated must be clearly stated and explained in a clear and logical manner.
- ***Use protection*** allows for full use of the assimilative capacity while still protecting water uses and values. The B.C. approved and working WQGs that provide the basis for water quality assessments are conservative estimates of low-risk conditions and when achieved should, at a minimum, provide protection of the identified values. However, WQGs are developed on a parameter-specific basis and when deriving WQOs at this level of protection the potential for cumulative or synergistic effects must also be considered.

The desired level of protection should be clearly articulated and justified as it may have implications for resource development. For example, waterbodies altered due to existing development may be designated for use protection in the short-term to prevent further degradation, with reduced concentrations set as a goal for improvements in the long-term. The level of protection is not intended to prevent development, but rather to identify the need for improved water quality management and stewardship to ensure all identified uses and values are protected.

Figure 2 illustrates how the desired level of protection is used with WQGs to derive appropriate benchmarks (and WQOs) for water quality assessments.

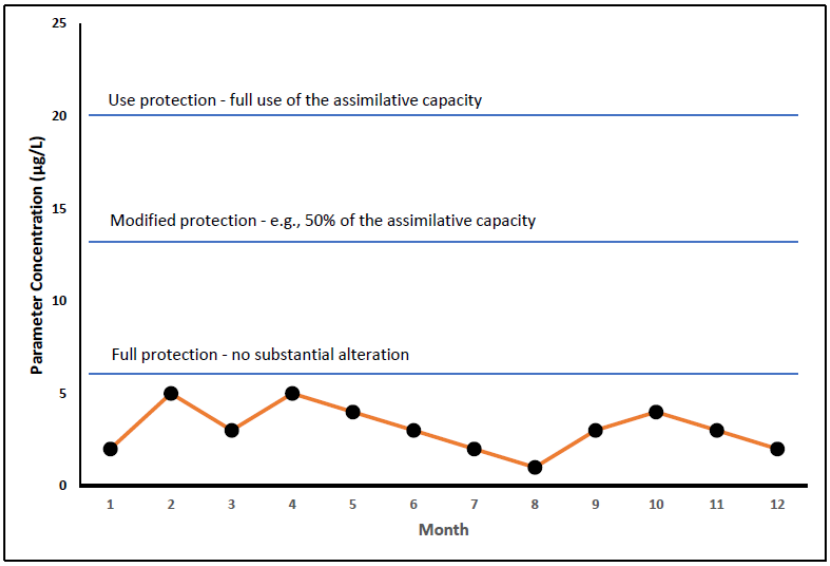

Figure 2. Examples of a water quality objectives based on desired levels of protection for a parameter with a water quality guideline of 20 µg/L. In this example, the 95th percentile of the data is 5 µg/L and a full protection WQO would be set at this level plus 20% which would be 6 µg/L. The assumed assimilative capacity would be 14 µg/L (20 µg/L – 6 µg/L = 14 µg/L). A modified WQO allocating 50% of the assimilative capacity (14 µg/L ÷ 2 = 7 µg/L) would be 13 µg/L (6 µg/L + 7 µg/L = 13 µg/L), and a use protection WQO allowing full use of the assimilative capacity would be 20 µg/L.

Step 5: Assess Water Quality

The water quality assessment involves compiling the available water quality data for the waterbody of interest and comparing it to background levels, WQGs (approved and working) or other benchmarks (see Figure 2) for the identified water uses and values. The physical, chemical and biological aspects of water quality should be examined in relation to how human activities and natural processes may influence these both spatially and temporally. The water quality assessment can be based on existing data, new data generated specifically for the project, or a combination of both.

The specific approach used to assess the water quality is at the discretion and professional judgement of the assessor. Guidance is provided in *Guidelines for Interpreting Water Quality Data* (Cavanagh et al. 1998a) and *Guidelines for Designing and Implementing a Water Quality Monitoring Program in British Columbia* (Cavanagh et al. 1998b). Additional guidance is provided in Chapman (1996). The approach taken must be scientifically defensible, transparent, and clearly documented and should include the following key components:

- *Data Management*
    - Compile and present the available ambient raw data in a logical manner. The data should be screened for outliers and include a description of how outliers are treated. Data gaps should be identified and considered in the assessment.
    - Review and present the quality assurance and quality control aspects of the assessment.
    - Describe how censored data have been handled and how this may influence your results. Note that older data have often been produced from methods with higher minimum detection limits and require special consideration when interpreting and assessing the data.
- *Data Analysis*
    - Examine the range of values obtained at each monitoring station relative to background levels and applicable water quality benchmarks (e.g., WQGs).
    - Document the number and extent of benchmark exceedances for each parameter.
    - Assess the influence, within expected conditions for the waterbody itself, of toxicity-modifying parameters such as pH, temperature, conductivity, and hardness.
    - Evaluate the dilution capacity of downstream waterbodies, which may have more sensitive water uses and values than upstream waterbodies.
    - Consider how lake depth levels, streamflow, or tides and currents influence parameter concentrations.
    - Examine loadings and potential increases or decreases in the water quality parameters in the waterbody from natural sources, such as tributary streams.
    - Review and consider any available biological data including phytoplankton, zooplankton, macrophytes, aquatic invertebrates, and fish.
    - Where possible (e.g., wadable streams), include biomonitoring data following Canadian Aquatic Biomonitoring Network protocol (see page 16 for additional information).
    - Examine loadings and potential increases or decreases in the water quality variables in the waterbody from anthropogenic sources.
- *Data Presentation*
    - Present data in clear, logical graphs and tables.
    - Include a detailed discussion of results. This will be the basis for any WQOs proposed in subsequent steps.

Biomonitoring

The health of the aquatic ecosystem should be characterized as part of the water quality assessment. WQOs have previously focused on the chemical and physical aspects of water quality, which generally represent conditions at the time of sampling and may miss pulses of contaminants unless properly timed. In addition, chemical and physical measurements do not account for the synergistic or antagonistic effects associated with multiple contaminants, nor do they account for other stressors that may be influencing the aquatic environment.

Biomonitoring can address these limitations and should be included in the development of WQOs, where possible, to provide a direct measure of aquatic ecosystem health. ENV works in partnership with Environment and Climate Change Canada (ECCC) to deliver the Canadian Aquatic Biomonitoring Network (CABIN) in B.C., a program that provides nationally standardized protocols for sampling and analyzing benthic invertebrate communities in wadable streams (Environment Canada 2012).

CABIN uses the reference condition approach (RCA) study design, which requires the collection of standardized biological and habitat data from a wide range of reference sites within a study area. These data are used to build predictive models to assess the condition of "test" (i.e., potentially impacted) sites. The difference between the test site benthic invertebrate community and that found at similar reference sites provides an indication of the severity of disturbance. The addition of biomonitoring data to chemical and physical water quality data provides a more complete, robust, and defensible environmental assessment. CABIN results can confirm interpretation of traditional water quality data; if CABIN results do not agree with the water quality assessment, further assessment of the waterbody may be warranted.

The CABIN database, predictive models, and other web-based tools are available on the CABIN website (https://www.canada.ca/en/environment-climate-change/services/canadian-aquatic-biomonitoring-network.html). Note that CABIN training and certification are required to gain access to the CABIN database.

Step 6: Derive Water Quality Objectives

The derivation of WQOs requires knowledge of the existing water quality and baseline conditions, the WQGs, the desired level of protection, and the identified uses and values to be protected. The existing water quality describes current conditions and provides the starting point for WQO derivation. This is compared to WQG levels and background levels (upstream or historical) to assess the level of change resulting from land use activities. Knowledge of the WQGs is necessary to ensure they are applied correctly in assessing water quality. Details on the B.C.-approved WQGs are provided in the WQG technical report for each parameter and should be reviewed as required.

The desired level of protection summarizes the management and stewardship goals for a waterbody and will inform what portion of the assimilative capacity can be allocated in setting WQOs. In any case, the allocation of assimilative capacity should be minimized to reduce the risk of cumulative effects of future development or unforeseen conditions. Levels of protection are described in Step 4 and the concept of using the desired level of protection in the derivation of a WQO is illustrated in Figure 2.

When co-developing WQOs with Indigenous nations, consensus will be achieved with respect to the final WQO policy document. A clear record of all actions and decisions will be maintained.

Numerical WQOs

Numerical WQOs are typically set to protect against chronic effects to aquatic life as this is generally, but not always (e.g., molybdenum) the most sensitive value. Chronic WQOs are based on average values calculated from at least five results from evenly spaced samples collected over a 30-day period when

water quality concentrations are likely to be highest (e.g., low-flow or high-flow periods). No more than 20% of the individual results should exceed the chronic WQO value, accounting for some of the dynamic nature of most water quality constituents. If there are less than five samples collected, each result should meet the chronic WQO value.

Acute WQOs may also be set for a parameter to assess the magnitude from transient or episodic events (e.g., spills). These are set to compliment the chronic WQOs, recognizing that managing to acute WQO levels would likely result in significant chronic effects to environmental receptors.

In some situations, it may be desirable to set short-term (<5 years) or long-term (> 5 years) WQOs. Short-term WQOs would be set to address deteriorating trends in water quality and prevent further degradation. Long-term WQOs provide goals for improvements to impacted water quality over time.

Numerical WQOs should be fully described to ensure the proper assessment of attainment. This includes:

- the form of the substance to be measured (e.g., dissolved or total);
- the statistical measure (e.g., maximum, minimum, 95th percentile, median, geometric mean, etc.);
- the geographic locations and depths (if applicable) for which the WQOs apply; and
- the minimum number of samples, the type of samples (e.g., grab or composite), and the sampling period.

Narrative WQOs

Narrative WQOs can be used where quantitative measures are not possible, for example, the acceptability of drinking water with respect to taste and odour, or the visual appearance of surface waters. Narrative WQOs may be particularly appropriate when addressing cultural, traditional, or social water values and purely quantitative measures do not provide adequate goals. They should be used in place of numerical WQOs and must include a full description of how they are to be measured and reported.

Step 7: Report Preparation

There are three main reports associated with WQOs: a water quality technical assessment report; a WQO policy report; and WQO attainment monitoring reports. In addition, Indigenous nations participating in the co-development of WQOs may prepare supporting documents to be included.

The ***water quality technical assessment report*** describes the waterbody of interest and assesses the water quality. It focuses on all aspects of the waterbody of interest and documents the information gathered in Steps 3 – 5. It may also include recommendations for the WQOs to be derived in Step 6 and monitoring recommendations for future assessments. The technical assessment report may be co-developed with other partners involved in the project (e.g., Indigenous nations).

The ***WQO policy report*** provides an overview of the waterbody of interest, the justification for its selection for WQOs, a concise description of the WQOs, and the monitoring recommendations. The policy report is prepared and approved by ENV but may also be co-signed by partners (e.g., Indigenous nations or other levels of government) involved in the derivation of the WQOs. Once approved, the WQO policy report constitutes formal ENV policy and must be considered in any ENV decisions affecting water quality.

As part of the WQO policy report, collaborating Indigenous nations may wish to provide supporting documentation. For example, an Indigenous nation may wish to prepare a separate document describing their Indigenous Knowledge, values, traditions, and perspectives with respect to water quality. These supporting documents can either be made public with the WQO policy and technical assessment reports or kept confidential with the sole purpose of informing WQO development.

The ***WQO attainment report*** documents the results of any WQO attainment monitoring efforts. Attainment monitoring follows the recommendations made in the WQO policy report and the results are used to determine if the WQOs are being met and can be used to support or inform ongoing resource management. The results are also used to assess the appropriateness of the WQOs and provide the basis for updates over time. The parties conducting the monitoring are responsible for preparing the report.

Step 8: Approval and Posting Online

The technical assessment report is reviewed internally (ENV and any partners), approved by the Division responsible for producing it (Environmental Protection or Environmental Sustainability Division), and posted on the Water Quality Monitoring Documents webpage: (https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/water-quality-monitoring/water-quality-monitoring-documents).

The WQO policy report is reviewed internally and externally by any partners who have co-developed the WQOs (e.g., Indigenous nations). It is approved by the Executive Director, Water Protection & Sustainability Branch and posted on the Water Quality Objectives webpage: (https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/water-quality-objectives).

Attainment monitoring reports are approved by the authoring agency and posted on the Water Quality Objectives webpage with the corresponding waterbody: (https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/water-quality-objectives).

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