BRITISH COLUMBIA | Ministry of Environment

Technical Guidance 8

Environmental Management Act Applications

A Framework for the Development and Use of Freshwater Science-Based Environmental Benchmarks for Aquatic Life in *Environmental Management Act* Permitting for Mines

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Environmental Protection Division

Regional Operations Branch

Disclaimer

This document does not replace the *Environmental Management Act* or its regulations. It does not list all provisions relating to waste discharges. If there are differences or omissions in this document, the Act and regulations apply.

This document is intended to provide a high-level overview of the process for establishing science-based environmental benchmarks and is intended specifically for mining project applicants. Those requiring more detail on the process or seeking to attain a discharge permit are strongly advised to contact the British Columbia Ministry of Environment.

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Executive Summary

The *Environmental Management Act* (EMA) (SBC 2003, Chapter 53) prohibits the discharge of waste to the environment unless specifically authorized. Authorizations under EMA may be issued for air emissions, refuse disposal or effluent discharges. A permit authorizes the discharge of wastes from an industry, trade, business, operation or activity to the environment, and sets the terms and conditions under which the discharge may occur so that pollution is prevented.

The release of effluent into the environment has the potential to result in changes to receiving water quality in streams, lakes, and groundwater, which in turn has the potential to affect local aquatic life and/or other water uses. An impact assessment for a proposed discharge must be conducted as part of preparing an application to inform effluent permit discharge decisions about potential risks to water quality and to ensure appropriate terms and conditions are set to protect water uses.

In British Columbia, water quality guidelines (WQGs) and water quality objectives (WQOs) have been utilized to assess impacts of chemical or physical water conditions on aquatic life or other water uses (agriculture, drinking water, recreation, wildlife). WQGs represent levels that, when met, provide confidence that given water uses will not be adversely affected. Exceeding a WQG does not necessarily mean that detrimental effects will occur; rather, risks to water uses are increased and further assessment is needed to reduce uncertainty to fully inform resource management decisions. WQGs are intended to be applicable throughout the province, but do not account for all of the site-specific factors. WQOs take into consideration site-specific conditions and are generally developed to protect or enhance existing water quality in an area. Once developed, WQOs become official ministry policy and must be considered in all ministry decisions in the watershed.

In some circumstances, science-based environmental benchmarks (SBEBs) may be developed to support permitting or other regulatory decisions. SBEBs should only be considered after best-achievable technologies (BAT) and best management practices have been considered and incorporated into development plans. SBEBs must be protective of the most sensitive aquatic species and life stages at a site.

An SBEB is defined as a quantifiable receiving environment parameter or attribute developed by a qualified professional through a rigorous scientific process, with the intent to guide management decisions and mitigative actions for a regulated activity at a specific location. SBEBs are developed to support the impact assessment for a specific effluent discharge decision. The SBEB may be proposed by permit applicants, where appropriate.

This document provides a framework for the development and acceptance of SBEBs including:

- when SBEBs can be developed;
- the process for developing SBEBs;
- acceptable approaches and the minimum scientific requirements; and,
- how SBEBs can be used in effluent permitting.

The SBEB development process occurs in two phases:

1. The proponent provides rationale for the use of SBEBs and submits an SBEB development plan to the ministry for review and acceptance.
2. Once the SBEB development plan, including methods and study design for SBEB development, has been accepted by the ministry, the proponent conducts studies and collects all required data in support of proposed SBEB(s) to submit to the ministry for final review and sign-off.

Prior to submitting an SBEB development plan for review and acceptance by the ministry, it will be necessary to engage with First Nations and with stakeholders regarding the development of SBEBs as early in the process as possible. Consultation with First Nations is typically triggered by a decision that may potentially impact aboriginal interests, including treaty rights and recognized aboriginal rights. The adoption of an SBEB in a permit decision may trigger such consultation; the scope of which can be best determined under those particular circumstances. Typically consideration of such a decision is undertaken during the pre-application and application development phases. Proponents should be aware of any First Nations water quality policies made available by any nations in whose territory a project is located. The ministry will provide direction to proponents for delegated procedural aspects of consultation. Information regarding the proponent's role and obligations in procedural aspects of First Nations consultation is available in the *Guide to Involving Proponents When Consulting First Nations* (Government of BC 2014).

The development of an SBEB must be based on sound science and peer-reviewed methods, or methods approved by the ministry, as described in this document.

The following conditions must be met when developing SBEBs:

- best-achievable technology (BAT) (MOE 2015a) and best management practices must first be incorporated into the mine plan;
- SBEBs must not result in exceedance of drinking water guidelines for human health;
- SBEBs must not be in conflict with codes, regulations, area-based management plans, existing WQOs, or provincial or federal legislation;

- SBEBs must not result in the creation of a contaminated site as defined under the *Contaminated Sites Regulation* (CSR) (BC Reg 375/96); and,
- an adaptive management approach should be undertaken in a manner that ensures ongoing monitoring and protection of key values and interests related to water quality.

Acronyms

AEMP - aquatic effects monitoring plan

BAT – Best-achievable technology

BC – British Columbia

CSR – *Contaminated Sites Regulation*

EIA – Environmental impact assessment

EMA – *Environmental Management Act*

IDZ – Initial dilution zone

MOE – Ministry of Environment

PCBs – Polychlorinated biphenyls

QP – Qualified professional

RISC – Resources Inventory Standards Committee

SBEB – Science-based environmental benchmark

SDM – Statutory Decision Maker

WQ – Water quality

WQG – Water quality guideline

WQO – Water quality objective

Introduction

The *Environmental Management Act* (EMA) prohibits the discharge of waste to the environment unless specifically authorized. While there are different types of authorizations under EMA, most mining operations require an effluent discharge permit.

To obtain an effluent discharge permit or permit amendment under the EMA in British Columbia (BC), a proponent must submit a permit application to the Ministry of Environment (hereafter referred to as the ministry, or MOE). A permit authorizes the discharge of wastes to the environment from an industry, trade, business, operation or activity, and sets the terms and conditions under which the discharge may occur so that pollution is prevented. The terms and conditions include limiting the quantity and quality of waste contaminants, monitoring the discharge and the receiving environment, and reporting information to the ministry.

The release of effluent into the environment has the potential to result in changes to receiving water quality in streams, lakes, and groundwater which in turn has the potential to affect local aquatic life and/or other water uses. An impact assessment for a proposed discharge must be conducted as part of preparing an application. The assessment informs effluent permit discharge decisions regarding potential risks to water uses so that appropriate terms and conditions may be set.

In BC, water quality guidelines (WQGs) and water quality objectives (WQOs) are used to assess water quality and inform management decisions (e.g., permitting decisions). Where WQGs and WQOs are met there is a high degree of certainty that water uses are protected. Concentrations above WQG levels do not imply that unacceptable risks are present, but that the potential for adverse effects is increased and additional investigation is needed for managing water resources. Where there is a need to define water quality on a site-specific basis (e.g., in watercourses where natural background[1] concentrations exceed WQGs), WQGs can be adapted as water quality objectives (WQOs) which take local conditions into account. WQOs are water quality conditions considered to be protective of the most sensitive designated water use for a specific waterbody. Where degradation of water quality has occurred, WQOs can be used to establish benchmarks to prevent further degradation and define goals for future improvements in water quality. Both WQGs and WQOs are approved by ministry Executive and constitute formal policy that must be considered in any decisions made within the MOE that affect water quality.

Situations where WQG exceedance may not result in impacts to aquatic life include: in receiving waters where natural background exceeds WQGs; where the most sensitive taxonomic groups

[1] "Natural background" refers to water quality not influenced by a discharge or anthropogenic source(s) of contamination.

used in the development of WQGs do not inhabit the area; and/or where natural background water quality conditions limit the toxicity of specific parameters.

In some circumstances, science-based environmental benchmarks (SBEBs) may be developed to support permitting or other management decisions.

SBEBs are intended to support decision-making in situations where alternatives to WQGs are protective of the most sensitive aquatic life at a site and in downstream environments. As such, SBEBs are an additional impact assessment tool, like WQGs or WQOs, used to inform the Statutory Decision Maker (SDM) when making permitting decisions pertaining to specific waste discharges.

This document provides the framework for the development and application of freshwater SBEBs for use in permitting under the EMA. It identifies when SBEBs may be acceptable and provides guidance on how to develop them. The development of SBEBs should not be initiated without first obtaining agreement from the ministry on the need for SBEBs, as well as on the methods to be used.

Aquatic Environmental Benchmarks Used in Permitting

The fundamental approach to aquatic environmental impact assessment (EIA) in BC is through the use of WQGs, site-specific WQOs and SBEBs. To protect water resources, the WQGs for the most sensitive water use should be the foundation for any impact assessment in BC. When justified, WQOs are developed by following the process described in *Guidance for the Derivation and Application of Water Quality Objectives in British Columbia* (MOE 2013a). While WQOs are developed on a watershed basis, SBEBs are developed to inform resource management decisions at a specific site. SBEBs should be used within an adaptive management approach where new scientific information and monitoring program results inform ongoing management efforts.

Water Quality Guidelines

WQGs are generic numerical concentrations or narrative statements recommended to protect designated water uses (e.g., aquatic life, wildlife, drinking water, recreational use) on a provincial basis. Aquatic life WQGs are set after considering the scientific literature, results from toxicity tests, guidelines from other jurisdictions, and conditions in BC. It is recognized there is a level of uncertainty associated with the derivation of WQGs, which is accounted for by incorporating uncertainty factors. Both Approved (MOE 2015b) and Working (MOE 2015c) WQGs are the main tools used to assess water quality in BC and inform water quality-related management decisions. WQGs have no direct legal standing, but can be used to derive limits for effluent discharge permits and other authorizations, which are legally enforceable. WQGs represent levels that,

when met, are highly unlikely to result in adverse effects on a given water use (MOE 2012a). Exceeding a WQG does not necessarily mean detrimental effects will occur; it simply means that the potential risk to water uses may be increased and should be considered in resource management decisions. Permitting decisions that affect water quality should be relatively straightforward in situations where the model projected parameter concentrations are below WQG levels.

Water Quality Objectives

WQOs are narrative statements or concentrations of substances that are established to protect water quality conditions in a specific watershed (MOE 2013a). WQOs may be developed for specific waterbodies based on designated water uses.

WQOs may be equivalent to WQGs (e.g., when natural background does not exceed WQGs), or adapted based on local conditions. Site-specific WQOs are appropriate when naturally elevated concentrations of a given substance occur at a site or where species used to derive the WQG do not exist. Ideally, WQOs are established prior to development occurring to inform future management decisions that may influence water quality. Where development has occurred and water quality has been impacted, WQOs can be established to reduce the risk of degradation to water quality and identify goals for improvement over time.

As part of the technical assessment, a rigourous evaluation of the watershed is carried out for the waterbody of interest to characterize impacts and activities that may influence the water quality. The assessment must include characterization of the unique hydrological processes, land uses, water uses, and existing water quality. A water quality assessment considers all sources of impacts on water quality including past, present, and if appropriate, future impacts. A comprehensive report is produced and reviewed externally by stakeholders, First Nations and other interested agencies. Once approved by ministry Executive, WQOs are adopted as formal ministry policy and must be considered by the ministry in resource management and permitting decisions (MOE 2013a).

Science-Based Environmental Benchmarks

SBEBs are receiving water quality benchmarks developed and applied to support a specific effluent discharge permit decision. SBEBs are site-specific (e.g., at the edge of an effluent's initial dilution zone[2] (IDZ)) and are intended to protect aquatic life where an existing or proposed

[2] An initial dilution zone is the initial portion of the larger effluent mixing zone. The extent of an initial dilution zone is defined on a site-specific basis and considers water uses, aquatic life including migratory fish, and other waste discharges.

permitted activity may result in effects to aquatic life due to changes in water quality, sediment quality, and biota.

The definition of an SBEB is: *a quantifiable receiving environment parameter or attribute protective of freshwater aquatic life that is developed by a qualified professional through a rigorous scientific process with the intent to inform management decisions and guide mitigative actions for a regulated mining activity at a specific location.*

In the definition of an SBEB, a qualified professional (QP) means an applied scientist or technologist specializing in an applied science or technology applicable to the duty or function including, if applicable, and without limiting this, agrology, biology, chemistry, engineering, geology, or hydrogeology and who is registered with the appropriate professional organization, is acting under that organization's code of ethics and is subject to disciplinary action by that organization. A QP, through suitable education, experience, accreditation and/or knowledge, may be reasonably relied on to provide advice within their area of expertise. Further information regarding QP requirements may be found on the Environmental Protection websites (MOE 2010).

SBEBs should be developed to protect water quality for the most sensitive aquatic life (e.g., species and life stage) at a site and in downstream receiving environments to the extent the mine operations have influence. For this document, the term “site” pertains to a location in a waterbody where an existing or proposed permitted activity may result in effects to aquatic life due to changes in water quality, sediment quality, and biota. The extent of the site will be determined by the conceptual site model. SBEBs can be attributes of water, sediment and/or biota that are applied at specific locations to protect aquatic resources at the site and in downstream receiving environments.

When developing an SBEB, an aquatic effects monitoring program (AEMP) is also needed to verify that the SBEB is protective of aquatic life. The extent and implementation schedule of such a program depends on the situation and may be prescribed in the effluent permit or an approved plan. The monitoring results are to be used in an adaptive management approach. Adaptive management is a systematic process for continually improving management and practices to meet objectives by learning from the outcomes of operational programs. An adaptive management cycle typically includes five steps: assessment, design, implementation, evaluation, and adjustment (Figure 1).

In the context of SBEBs, an adaptive management approach may be applied to ensure that:

- SBEBs are achieved through permit conditions;
- SBEBs protect the environment, human health and other water uses, where they exist; and,
- the monitoring program meets its objectives.

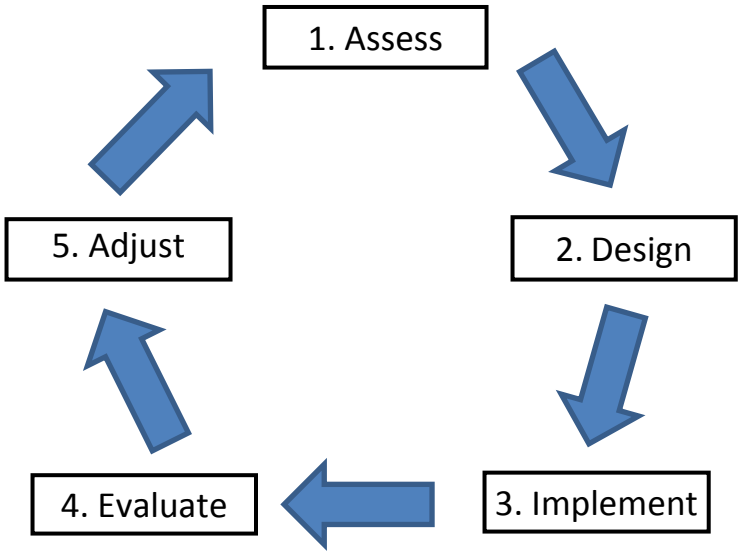


Figure 1. Steps in the adaptive management cycle.

The primary differences between SBEBs and WQOs are:

- WQOs are intended to assist in maintaining or enhancing water quality and/or to protect the most sensitive water use in an entire waterbody; whereas SBEBs focus on ensuring any site-specific changes to ambient water quality as a result of a particular permitted activity, are still protective of aquatic life;
- WQOs are developed to protect the most sensitive water use such as aquatic life, wildlife, drinking water, and recreation; whereas SBEBs are developed for freshwater aquatic life only. However, all existing water uses must be protected at a site;
- SBEBs inform SDM decisions for a specific permit and therefore are not subject to the same process and level of ministry approval that is required for establishing WQOs as policy;
- WQOs are considered for all decisions in a watershed, whereas SBEBs are specific to a single permitted activity in a watershed; and,

- WQOs attainment monitoring and reporting is done by the ministry; whereas attainment and effectiveness monitoring and adaptive management approaches for SBEBs are developed on a permit-by-permit basis.

When to Use Science-Based Environmental Benchmarks

The ministry will only consider the use of an SBEB if the following exists:

- best-achievable technology (BAT) (BC MOE 2015) has been incorporated into the proposed or existing project along with best management practices;
- sufficient site condition data are available to assess the effects of proposed or existing changes to water quality, sediment quality and/or biota for the most sensitive aquatic species and life stage at the site; and,
- an evaluation of current and/or model-projected future water quality has been completed and site conditions suggest that exceedances to WQGs will not likely result in effects to aquatic life and/or cumulative effects. Clear rationale must be provided.

The development of an SBEB should only be undertaken when existing scientific data indicate that benchmarks greater than WQGs can still be protective of the most sensitive aquatic life and life stages at a particular location and in downstream receiving environments. When cumulative effects[3] exist, or are projected based on modelling, from either permitted activities or non-point source inputs, then discussions with the ministry are necessary to determine if SBEBs are appropriate or whether other benchmarks such as WQOs should be considered. SBEBs for parameters of concern from mining activities will only be considered in the following situations:

- best-achievable technology (BAT) (MOE 2015a) has been incorporated into the proposed or existing project along with best management practices;
- all other existing water uses can be protected;
- new peer-reviewed scientific literature exists that is applicable to the site and/or biota, but was not available when the WQG was developed or updated; and/or,
- site characteristics make a site-specific assessment more appropriate, including the following circumstances:
    - natural background water quality exceeds WQGs;

[3] Cumulative effects are changes to the environment that are caused by project related activities in combination with other past, present and foreseeable (or planned) future human activities.

- the most sensitive species or taxonomic group used in the development of the WQGs are naturally absent at the site; and,
- site-specific conditions (based on natural background) at the site have the potential to modify toxicity of one or more parameters (e.g., naturally elevated levels of dissolved organic carbon in water or organic carbon in sediments).

The decision tree in Figure 2 should be consulted when determining which water quality approach is most appropriate for the situation.

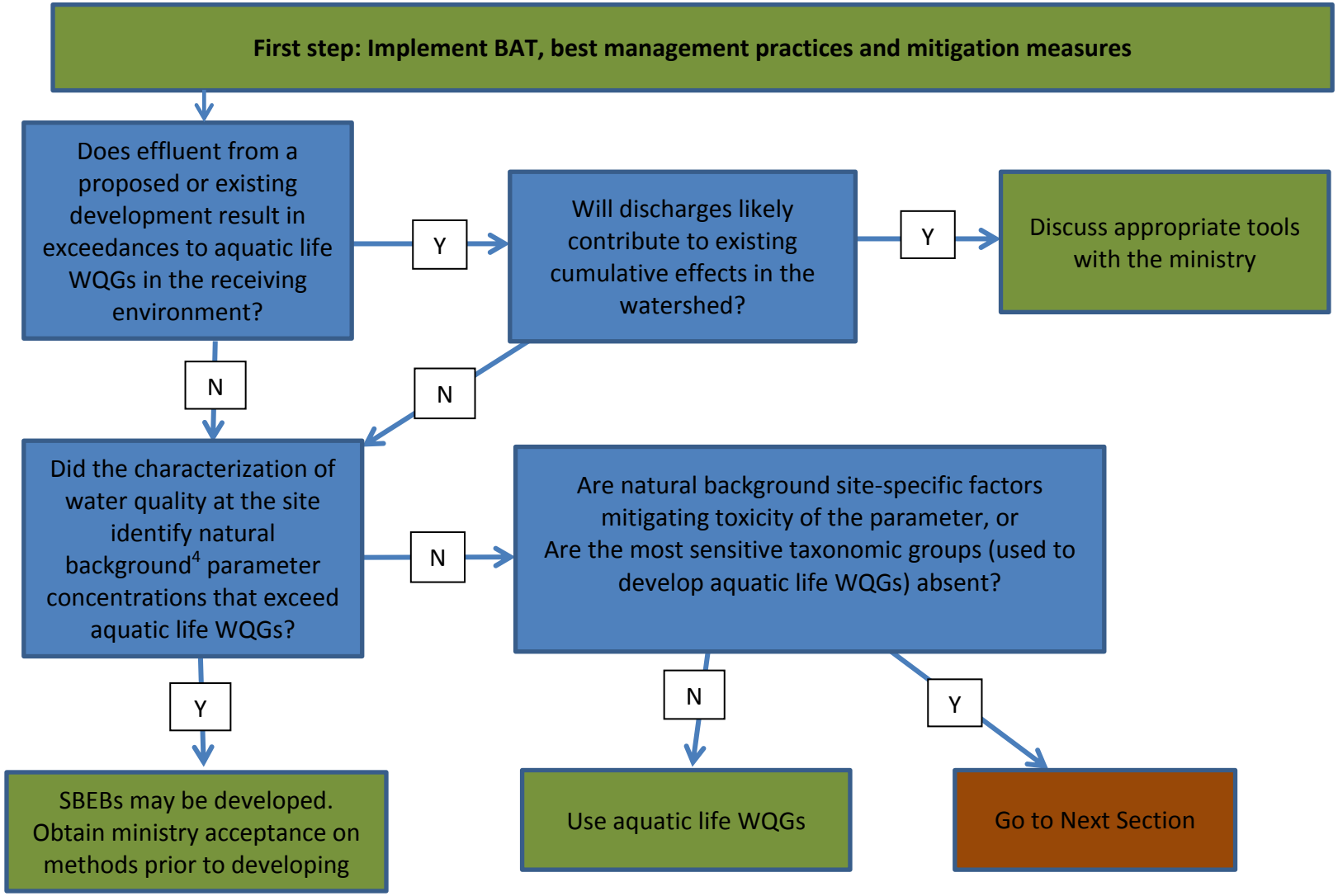


Figure 2. Decision tree to determine whether SBEBs are the appropriate tool for a specific effluent permit application under EMA.

[4]**Note:** if historical activities preclude evaluation of natural background and no appropriate reference sites exist, additional management plans may be required to improve water quality to acceptable levels based on appropriate benchmarks.

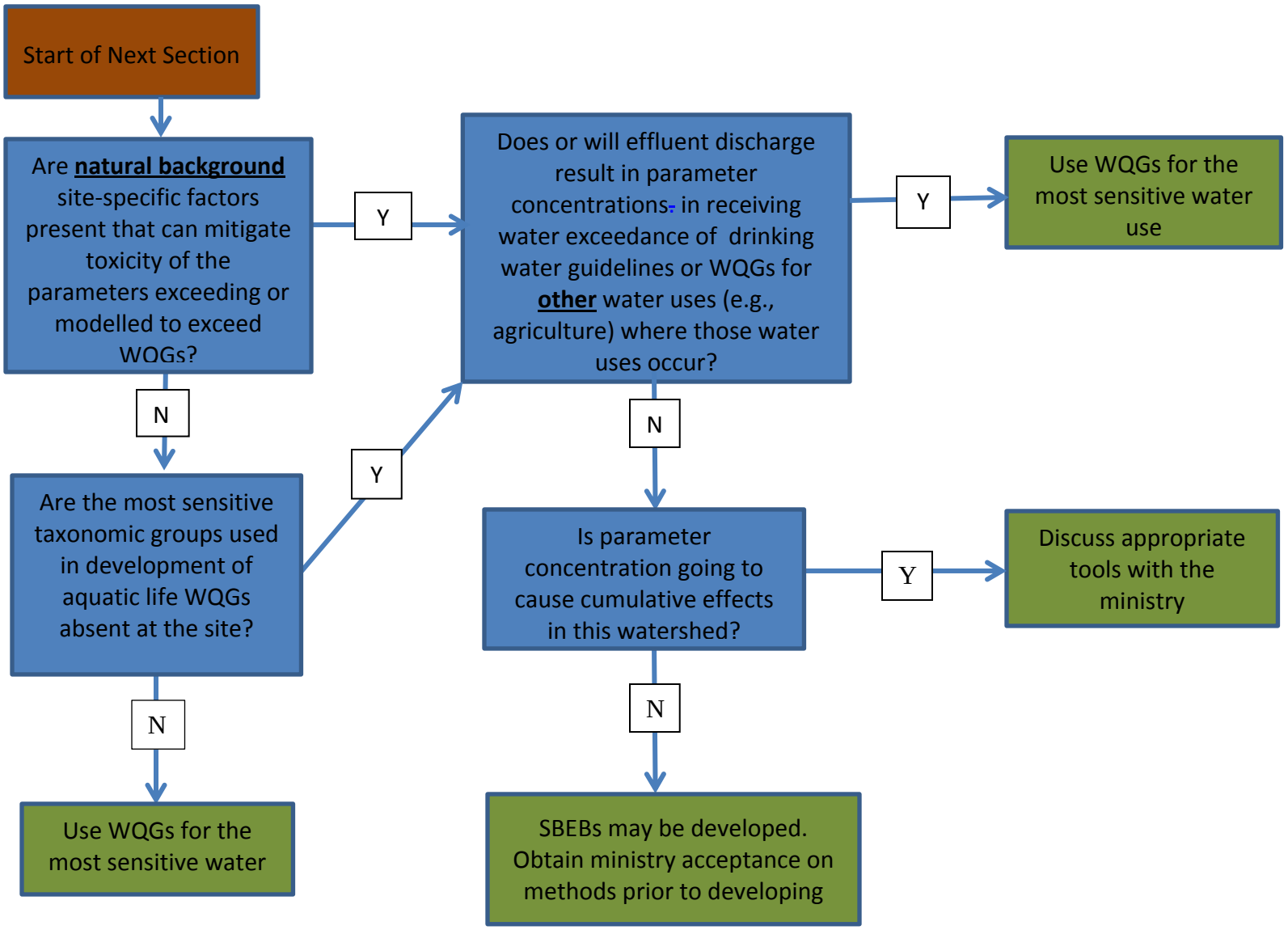


Figure 2 (con't). Decision tree to determine whether SBEBs are the appropriate tool for a specific effluent permit application under EMA.

Restrictions on Use of Science-Based Environmental Benchmarks

SBEBs must not cause exceedance of drinking water guidelines for human health at any location in the province. Guidelines applicable to other water uses, such as agricultural, cannot be exceeded where those uses could occur. SBEBs cannot be developed where a WQO already exists for the same parameter nor should they result in exceedances of existing WQOs. SBEBs must not conflict with existing approved area-based management plans (as defined under EMA). SBEBs must comply with all other applicable provincial and federal policy, codes, regulations and legislation. SBEBs must not result in the creation of a contaminated site. SBEBs are not applicable to mercury or to persistent organic pollutants (e.g., polychlorinated biphenyls (PCBs)). SBEBs developed for parameters that are nutrients, must consider both toxicology and nutrient enhancement. A nutrient management plan may be required to prevent risk of eutrophication in the near and far field of the receiving environment.

Process for Developing a Science-Based Environmental Benchmark

SBEBs are intended to inform site-specific management decisions regarding effluent discharges into receiving environments. SBEBs are typically proposed by applicants as part of an effluent discharge application. Proposed SBEBs must be submitted as a stand-alone document. Qualified professionals provide the required scientific assessment and supporting information for proposed SBEBs. Each parameter of concern may require its own SBEB and therefore several SBEBs may need to be developed for an individual site. Large volumes of data and large reports already available in permit applications should be summarized and clearly cited in SBEB documents.

Phase 1 – SBEB Development Plan

It will be necessary to engage with First Nations and stakeholders regarding the development of SBEBs as early in the process as possible. Consultation with First Nations is typically triggered by a decision that may potentially impact aboriginal interests, including treaty rights and recognized aboriginal rights. The adoption of an SBEB in a permit decision may trigger such consultation; the scope of which can be best determined under those particular circumstances. Typically consideration of such a decision is undertaken during the pre-application and application development phases. Proponents should be aware of any First Nations water quality policies made available by any nations in whose territory a project is located. The ministry will provide direction to proponents for delegated procedural aspects of consultation. Information regarding the proponent's role and obligations in procedural aspects of First Nations consultation is available in the *Guide to Involving Proponents When Consulting First Nations* (Government of BC 2014).

Prior to proposing an SBEB for consideration, an SBEB development plan must be submitted to the ministry for review and acceptance. The SBEB development plan should follow a problem formulation process similar to that described in the US EPA's *Framework for Ecological Risk Assessment* (i.e., as Phase 1 - Problem Formulation) (US EPA 1992). Part of the problem formulation process is the development of a conceptual site model that defines the sources, fate and pathways of the parameters of concern as well as the aquatic receptors and likely effects. The ministry's Land Remediation Branch provides guidance on conceptual site models (Landis *et al*. 1998), which may be used to generate a similar model for parameters involved in SBEBs.

It is recommended that the applicant meets with the ministry prior to submitting an SBEB development plan to discuss and clarify suitable design requirements. In some instances, previous or historical activities may preclude evaluation of natural background conditions for parameters of concern, and/or there may be no appropriate reference sites. In such cases, additional management planning may be required to improve water quality within suitable timelines to acceptable levels as indicated by an appropriate benchmark.

To avoid implementing costly projects that may not meet the requirements of the ministry, an SBEB development plan should be submitted at least three months prior to the start of any additional SBEB-related laboratory tests, field work, or research. A development schedule should be included with an SBEB development plan and reviewed to ensure it is achievable by both the ministry and the applicant.

The SBEB development plan must include the following items (please see **Appendix A** for a detailed list):

- the rationale for developing an SBEB versus using WQGs;
- documentation of the BAT (BC MOE 2015) and best management practice options that were incorporated into the existing or proposed mine plan and any that were rejected;
- comprehensive site characterization;
- effluent characterization and receiving water model projections;
- problem formulation and high level conceptual site model
- proposed scientific approaches for SBEB development;
- the completed **Appendix A** checklist indicating which items are included in the SBEB development plan submission; and,
- raw data tables.

Once an SBEB development plan is submitted, ministry staff will review the content of an SBEB development plan to assess the adequacy of the submission and the acceptability of the

methods. If the methods proposed in a plan do not already exist in guidance documents, the ministry may use additional expertise to determine if the approaches being proposed are scientifically defensible and acceptable to MOE. A meeting with the ministry should be scheduled to discuss the rationale, the approach to lines of evidence, scope, data collection and analytical methods. The meeting may be combined with other meetings at the pre-application stage of the mine permit application process as described in the ministry's effluent permitting process guidance document (MOE 2013a). Further work may be needed by the applicant as a result of this meeting to achieve agreement on an SBEB development plan. Once an agreement is reached, SBEB development should follow the agreed approach and methods. Changes to the schedule and contingency procedures should be discussed with the ministry as soon as possible and any adjustments agreed to by the MOE and proponent should be documented.

Phase 2 – SBEB Submission

Once the applicant has ministry agreement on the SBEB development plan, data collection for the proposed SBEB may proceed.

A proposed SBEB must be prepared by a QP and submitted along with relevant data and accompanying documents to the ministry for review and sign-off. The document must include the following items (please see **Appendix B** for a detailed list):

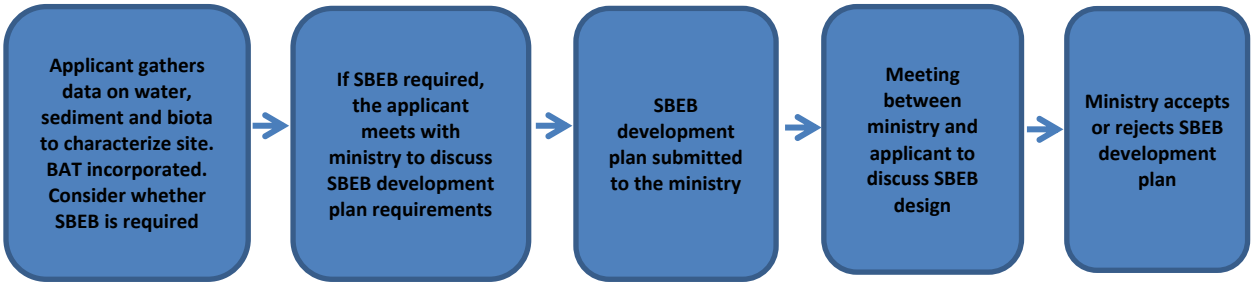
- summary of the ministry-accepted SBEB development plan (if applicable, with conditions);
- description of the lines of evidence and scientific approaches used;
- study results, data analysis and resulting rationale for proposed SBEBs;
- proposed aquatic effects monitoring plan (AEMP); and,
- the completed **Appendix B** checklist indicating which items are included in the SBEB submission.

Once submitted, the ministry Environmental Impact Assessment (EIA) Biologist will review the SBEB and provide comments and advice to the relevant EIA Mining Section Head for sign-off and submission to the SDM under the EMA. The ministry may consult internal and/or external scientific expertise to assist with the review of the SBEB. The length of the review will depend partly on the intricacy of the site, the aquatic receptors of concern, the level of potential risk and the amount of uncertainty associated with an SBEB, as well as the complexity in the lines of evidence. SBEBs may be above or below WQGs, depending on the protection required for sensitive uses or species. A well-structured, clear, concise document that includes all the required information will condense the time needed for review.

If the review identifies requirements for additional work, this will likely result in longer permit processing timelines. A follow-up meeting or other communication between the ministry and the applicant may be necessary for clarification or to discuss the additional information requirements.

An example of the steps involved in SBEB development is illustrated in Figure 3. Timelines should coincide with the project design and mine permit application processes and will depend greatly on the time needed for the applicant's collection of site characterization and SBEB supporting data and subsequent analysis and interpretation. The timelines for the development of SBEBs should be established at the development phase.

Phase 1: SBEB Development Plan



Phase 2: SBEB Submission

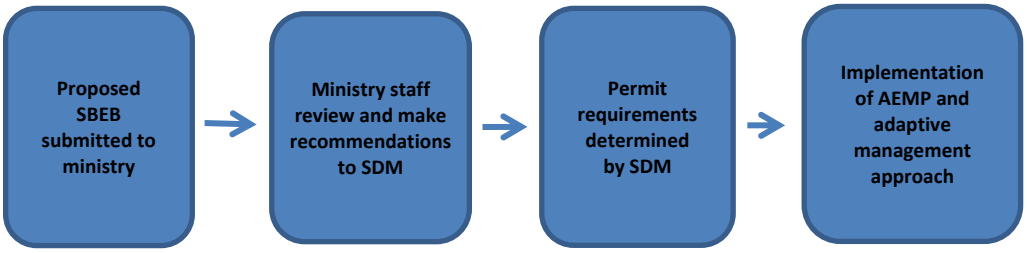


Figure 3. Steps in the design and development of science-based environmental benchmarks.

Use of Science-Based Environmental Benchmarks in Permitting Decisions

BAT (MOE 2015a) and best management practice options must be thoroughly explored before SBEBs are considered and developed. SBEBs may not be used instead of the application of BAT, but can be considered, if applicable, to manage any residual risks after implementation of BAT

and best management practices. If SBEBs are accepted by the ministry, SBEBs will be considered in statutory decisions for specific applications.If SBEBs are accepted by the ministry, recommendations on their use will be included in the EIA Section's review comments of the permit application to the SDM.

SBEBs inform and support discharge standards set as "end-of-pipe limits" or as receiving environment "site performance objectives". Site performance objectives may be standards that must be met, conditions that must be true for a discharge to occur, or triggers for implementation of adaptive management measures.

Minimum Requirements for Science-Based Environmental Benchmarks

A proposed SBEB must be signed-off by qualified professionals and must be based on science that meets the criteria listed below. Proposed SBEBs may require an uncertainty factor to account for unknowns such as changes to site conditions, differences between laboratory and field characteristics, differences between laboratory and site species, and potential parameter mixtures in the field. If no uncertainty factor is applied, clear rationale must be provided. Additional information regarding the use of uncertainty factors can be found in *Derivation of Water Quality Guidelines for the Protection of Aquatic Life in British Columbia* (MOE 2012a).

Minimum Requirements

All applicant-initiated scientific studies and testing must be site-specific and involve ministry acceptable scientific methods including proper quality assurance and appropriate statistical analyses. Existing ministry guidance on monitoring specific to mining, such as sampling protocols, and data and analytical requirements must be considered and, where appropriate, incorporated into developing SBEBs. Minimum data requirements for SBEB development should be consistent with those for developing water quality guidelines (see details below).

Ministry water quality reference documents are available on-line at http://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/water-quality-reference-documents. The Resource Inventory Standards Committee (RISC) documents related to aquatic ecosystems provide additional guidance and may be found at https://www.for.gov.bc.ca/hts/risc/pubs/aquatic/index.htm.

Site Characterization

Site characterization must follow the guidance outlined in the ministry's *Water and Air Baseline Monitoring Guidance* document (MOE 2012). To characterize short-term, seasonal, or between-

year variability in water quality conditions with reasonable certainty to support SBEB development, a mandatory minimum of 18 to 24 months of monthly site water quality data is required. Additional 5 samples collected over approximately 30 days may be required for critical periods of the year to compare with MOE guidelines.

Seasonal variations in water quality must be considered in development of SBEBs and need to be incorporated into modelling projections for water quality through all stages of mine life, from construction to closure. This comprehensive approach to the water quality analysis is necessary to ensure the lines of evidence are relevant to the worst-case scenarios in the receiving environment and applicable to the most sensitive species or taxonomic group and life stages.

All SBEBs must be based on the most sensitive species or taxonomic group and life stages applicable to the site. A thorough biological inventory of species (including rare and/or endangered species) located at the site will be necessary to identify the most sensitive species and life stages for SBEB parameters being developed. Non-invasive species that have been known to occur historically (before land or resource development) at the site must also be considered when developing SBEBs.

Acceptable Approaches to Science-Based Environmental Benchmarks

The scientific approaches listed below for SBEB development can be complicated and costly; therefore, discussions with the ministry must begin prior to initiating any studies. SBEB development plans must be accepted by the ministry before embarking on SBEB development. It is strongly advised that engagement with First Nations and with stakeholders also begin early in the process.

Site inventories of biota, habitat use, and receiving environment conditions are necessary to select the most suitable scientific approaches for SBEBs. All lines of evidence must rely on rigorous scientific methods. Where multiple SBEBs are developed, a mixture toxicity study may be required in order to validate that all SBEBs will be protective of aquatic life at the site. For each SBEB, toxicity testing should include at least one vertebrate and one invertebrate representative of the most sensitive local taxonomic groups and life stages. Toxicity testing may also be required on plants and/or algae if they are known to be sensitive to the parameter that the SBEB is being developed for. Where previously degraded sites exist, communities of aquatic life may be altered. In these instances, information from a suitable reference site should be used to identify species that may be relevant to the site and subsequently, in refining the toxicological data set, used for deriving SBEBs.

Examples of acceptable scientific approaches for existing and proposed mine projects or discharges include but are not limited to:

- scientific literature review for new science;
- conventional toxicity testing (including mixture studies);
- background concentration procedure;
- recalculation procedure;
- resident species approach;
- water effects ratio (US EPA 1994, 2001);
- toxicity modelling;
- toxicity testing with alternative approaches (e.g., omics, molecular approaches to predict toxicity); and,
- other lines of evidence such as benthic community structure.

Ideally SBEBs should be based on at least two lines of evidence (e.g., toxicity testing and literature review). At least one line of evidence must be generated from site-specific information. Development of an SBEB based solely on peer-reviewed scientific literature will not be accepted. Existing mine projects or discharges with more complex situations may require more than two lines of evidence.

Further information and guidance on scientific approaches acceptable to the ministry are provided below.

Scientific Literature Review

In situations where WQOs or WQGs do not exist, or newer substantiated information has become available following WQG development for a particular parameter, a review of all available scientific literature can be conducted for SBEB development. If this approach is used to develop an SBEB, all literature reviewed must be applicable to species or taxonomic groups present at the site. A list of all the scientific literature reviewed for this line of evidence must be provided in table format. All literature must be classified using the criteria in **Appendix C** as primary, secondary or unacceptable with rationale for the classification. This classification process must be signed by a qualified professional. Peer-reviewed scientific literature used directly for the establishment of an SBEB must meet the primary classification as described in **Appendix C**.

Background Concentration Procedure, Residence Species Approach, Water Effects Ratio and Recalculation Procedure

The selected lines of evidence should, at a minimum, meet the methods and standards set out in the ministry's *Guidance for the Derivation and Application of Water Quality Objectives in British Columbia* (BC MOE 2013a).

Conventional Toxicity Testing

Standard toxicity testing as a line of evidence for an SBEB should follow approved standard methods. If deviations are required, strong rationale at the SBEB design phase should be provided. All applicant-initiated toxicity testing must meet the primary data requirements described in **Appendix C**. Guidance on toxicity testing protocols may be found in the Environment and Climate Change Canada biological test methods and guidance documents (ECCC 2016). Protocols from other jurisdictions (e.g., US EPA 2002) may be used if provided to, and accepted by the ministry at the SBEB development plan phase.

Toxicity Testing with Alternative Approaches

As research in ecotoxicology evolves, alternative ways to determine effects on the environment may become available. New approaches such as genomics can be considered for SBEBs if they can be demonstrated to provide ecologically relevant, reliable and repeatable measurements. Rationale for the use of alternative lines of evidence must include guidance documents or peer-reviewed scientific literature demonstrating that the proposed approach uses validated methods that provide repeatable and quantifiable parameters.

Toxicity Modelling

For SBEB development, only standard, peer-reviewed scientifically defensible models that are vetted through the ministry at the SBEB development plan stage are acceptable. For selenium bioaccumulation modelling, guidance on an acceptable approach is provided in the ministry's *Companion Document to Ambient Water Quality Guidelines for Selenium Update* (MOE 2014). Also consult **Appendix C** for guidance on toxicity data classification requirements in BC.

Other Options for Lines of Evidence

In addition to parameter concentrations in water, sediment and biota, attributes of the receiving environment will be considered for SBEBs such as benthic invertebrate community structure and algal species composition. If available, peer-reviewed scientific literature and standardized protocols relevant to the attributes being considered should be used by

proponents and submitted with SBEB development plan designs. Scientific approaches for these lines of evidence need to be discussed and accepted by the ministry before embarking on data collection or analysis for SBEB development. These methods may require additional expertise when reviewing SBEB development plans.

SBEB Monitoring Plan

A comprehensive monitoring program is part of an adaptive management approach that includes monitoring and evaluation, adjustment and mitigation. Monitoring prior to the establishment of SBEBs provides a baseline in the adaptive management approach. As part of an adaptive management approach, SBEBs are used to set permit requirements and effectiveness monitoring evaluates whether SBEBs are achieved and are protecting aquatic life. The information is then used to adjust permit requirements as needed. This approach should also identify feasible mitigation measures if unexpected effects occur and new information suggests changes to permit requirements and/or monitoring programs are appropriate.

Effectiveness monitoring is critical to the implementation of SBEBs within the context of an adaptive management approach. Therefore, an aquatic effects monitoring plan (AEMP) must be included as part of the SBEB submission to the ministry. The AEMP is the program used to evaluate the effectiveness of the EMA permit, including related SBEBs. The SBEB proposal must include an AEMP to determine the effects of effluent discharges, seepages, and mining related disturbances, separately and cumulatively on the receiving environment. This program provides weight of evidence assessment information using a range of tools commensurate with the risk posed by the project.

The AEMP will likely include measures related to water, sediment, benthic invertebrates and fish. Other ecosystem components or assessment endpoints (e.g., periphyton, or tissue analysis of fish or other wildlife species) may also be appropriate as identified in the background impact prediction studies and SBEB proposal. The AEMP should be planned in consultation with ministry staff and First Nations. The monitoring plan should demonstrate both the achievement of an SBEB as well as its effectiveness in protecting the most sensitive water uses at the site in the receiving environment. Monitoring will need to be comprehensive and sensitive enough to verify SBEB achievement and detect SBEB-related effects on water uses. Qualified professionals developing monitoring plans should follow the standards and procedures provided in BC guidance documents and published by the RISC, available at https://www.for.gov.bc.ca/hts/risc/pubs/aquatic/index.htm.

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Appendix A - Checklist for Phase 1: SBEB Development Plan

The SBEB Development Plan should include the items listed below and this table must be part of the plan submission.[4]						
Information Requirements	**Information Provided**				**Location in Document** (page number and section)	**Comments**
	Provided	**Partially Provided**	**Not Provided**	**Not Applicable**		
Qualified Professionals						
• Qualified professionals has (have) developed and signed the SBEB Development Plan	☐	☐	☐	☐		
• The qualified professionals are practicing in the area of their expertise	☐	☐	☐	☐		
Site Characterization Information						
• Inventory of water quality (18 to 24 months), sediment quality, and biota for critical sites, including spatial and temporal trends.	☐	☐	☐	☐		
• Inventory of all water uses in the area affected by the mine, including drinking water and/or agriculture.	☐	☐	☐	☐		
• Identification of critical aquatic life receptors at the site, including sensitive species, taxonomic groups and/or life stages.	☐	☐	☐	☐		
• Identification of applicable trends related to flows, TSS, or other measures reflective of site conditions.	☐	☐	☐	☐		
• Data tables including basic statistics such as maximum, minimum, median, and mean with confidence intervals.	☐	☐	☐	☐		

[4] The SBEB Development Plan must be a stand-alone document with all the referenced applicant-produced information included in an appendix (or multiple appendices).

Appendix A - Checklist for Phase 1: SBEB Development Plan

The SBEB Development Plan should include the items listed below and this table must be part of the plan submission.[4]						
Information Requirements	**Information Provided**				**Location in Document** (page number and section)	**Comments**
	Provided	**Partially Provided**	**Not Provided**	**Not Applicable**		
• WQGs and pertinent parameters for derivation including hardness, pH, chloride, dissolved organic carbon and temperature. Ensure dependent WQGs are calculated using pertinent parameters from the same sample event, not a mean.	☐	☐	☐	☐		
• Summary of WQG exceedances by parameter, including frequencies and magnitudes of exceedance.	☐	☐	☐	☐		
Site Characterization Information (cont'd)						
• All relevant raw data tabled in an appendix or appendices.	☐	☐	☐	☐		
Effluent Characterization and Model Projections						
• Identification of applicable best-achievable technology (BAT) and best management practices for existing and proposed mine operations pertaining to water quality.	☐	☐	☐	☐		
• Description of how best management practices and BAT have or will influence existing and/or model projected water quality in the effluent and receiving waters.	☐	☐	☐	☐		
• Characteristics of existing permitted mine effluent discharges and any seepage, including seasonal flow rates and model projected changes for future project phases.	☐	☐	☐	☐		
• Identification of parameters exceeding WQGs in existing and/or model-projected effluent and receiving waters.	☐	☐	☐	☐		

Appendix A - Checklist for Phase 1: SBEB Development Plan

The SBEB Development Plan should include the items listed below and this table must be part of the plan submission.[4]						
Information Requirements	**Information Provided**				**Location in Document** (page number and section)	**Comments**
	Provided	**Partially Provided**	**Not Provided**	**Not Applicable**		
• Identification of the project phase and seasons for which worst-case water quality is projected in receiving waters.	☐	☐	☐	☐		
• Identification and description of site-specific toxicity modifying factors (e.g., water hardness, pH, temperature, chloride, dissolved organic carbon) in the receiving environment.	☐	☐	☐	☐		
Rationale for the development of SBEBs						
• Problem formulation that describes the purpose of the work including questions to be addressed.	☐	☐	☐	☐		
• High-level conceptual site model that defines the sources, fate and pathways of the parameters of concern as well as the aquatic receptors and potential effect on these at the site.	☐	☐	☐	☐		
• Description of parameters SBEBs will be developed for.	☐	☐	☐	☐		
• Rationale for the use of SBEBs vs. WQGs.	☐	☐	☐	☐		

Appendix A - Checklist for Phase 1: SBEB Development Plan

The SBEB Development Plan should include the items listed below and this table must be part of the plan submission.[4]						
Information Requirements	**Information Provided**				**Location in Document** (page number and section)	**Comments**
	Provided	**Partially Provided**	**Not Provided**	**Not Applicable**		
Proposed Scientific Approaches for SBEB Development						
• Identification and evaluation of scientific approaches used to develop the SBEB(s) with justification for the scientific approaches chosen.	☐	☐	☐	☐		
• Description of the selected scientific approaches, including methods, standards and/or protocols, species, and endpoints, quality assurance/quality control (QA/QC) procedures, rationale for the selected approaches.	☐	☐	☐	☐		
• Proposed data analyses (including statistical methods and data quality objectives).	☐	☐	☐	☐		
• Explanation of how results of scientific approaches address questions from the problem formulation.	☐	☐	☐	☐		
• Discussion of uncertainty related to the scientific approaches used.	☐	☐	☐	☐		
Proposed Scientific Approaches for SBEB Development (cont'd)						
• A detailed schedule of SBEB development, including timelines for laboratory work, field work, statistical analysis, document write-up, and meetings.	☐	☐	☐	☐		

Appendix A - Checklist for Phase 1: SBEB Development Plan

The SBEB Development Plan should include the items listed below and this table must be part of the plan submission.[4]						
Information Requirements	**Information Provided**				**Location in Document** (page number and section)	**Comments**
	Provided	**Partially Provided**	**Not Provided**	**Not Applicable**		
• Deliverables associated with the SBEB development, including documents in support of the proposed SBEBs, such as laboratory results, inventory data, statistical methods and analyses.	☐	☐	☐	☐		

Appendix B - Checklist for Phase 2: SBEB Submission

This checklist identifies items to be included into the submission of a proposed SBEB.

Information Requirements	Information Provided				Location in Document (page number and section)	Comments
	Provided	Partially Provided	Not Provided	Not Applicable		
Qualified Professionals						
• Qualified professional(s) has (have) developed and signed the SBEB submission.	☐	☐	☐	☐		
• The qualified professionals are practicing in the area of their expertise.	☐	☐	☐	☐		
Document Requirements						
• Executive summary is included.	☐	☐	☐	☐		
• Raw data is included.	☐	☐	☐	☐		
• Graphs showing seasonal trends for parameters of concern and/or used to determine toxicity have been included.	☐	☐	☐	☐		
• Field notes for sampling and any field work were submitted.	☐	☐	☐	☐		
• Toxicity test laboratory reports and laboratory technician notes included.	☐	☐	☐	☐		
• Toxicity test checklists are completed and included.	☐	☐	☐	☐		
• Literature review data classifications are included.	☐	☐	☐	☐		
• Aquatic effects monitoring plan (AEMP) is included.	☐	☐	☐	☐		
• Adaptive management approaches are included.	☐	☐	☐	☐		
• Applicable drinking water guidelines and other WQGs are listed.	☐	☐	☐	☐		

Appendix B - Checklist for Phase 2: SBEB Submission

This checklist identifies items to be included into the submission of a proposed SBEB.

Information Requirements	Information Provided				Location in Document (page number and section)	Comments
	Provided	Partially Provided	Not Provided	Not Applicable		
SBEB Development History						
• Summary of site conditions, effluent quality projections, aquatic receptors, toxic factors unique to the site and parameters for SBEB.	☐	☐	☐	☐		
• Summary of problem formulation and conceptual site model.	☐	☐	☐	☐		
SBEB Development History (cont'd)						
• Summary of the rationale for creating an SBEB vs. using WQGs.	☐	☐	☐	☐		
• Summary of any conditions or directions during ministry review of SBEB Development Plan	☐	☐	☐	☐		
Lines of Evidence/Scientific Approach						
• Summary of peer-reviewed scientific literature and/or reference documents used to develop the approaches and lines of evidence including methods used.	☐	☐	☐	☐		
• A table describing key details of toxicology studies that were classified and used in SBEB development.	☐	☐	☐	☐		
• A detailed description of tests, models or sampling methods used for SBEB development, including documentation of any ministry-accepted changes to methods or protocols.	☐	☐	☐	☐		

Appendix B - Checklist for Phase 2: SBEB Submission

This checklist identifies items to be included into the submission of a proposed SBEB.

Information Requirements	Information Provided				Location in Document (page number and section)	Comments
	Provided	Partially Provided	Not Provided	Not Applicable		
• A detailed explanation of the quality assurance and quality control procedures implemented.	☐	☐	☐	☐		
• Sampling details and analysis results of water, sediments and/or biota for toxicity tests applicable for SBEB development.	☐	☐	☐	☐		
• Description of data quality and how data were handled that did not meet data quality objectives.	☐	☐	☐	☐		
• Detailed summary of all statistical analyses, and statistical results.	☐	☐	☐	☐		
• Data tabulation with summary statistics (i.e., maximum, minimum, median, and mean with confidence intervals).	☐	☐	☐	☐		
• Description of SBEB including discussion supporting the value or attribute proposed based on the lines of evidence.	☐	☐	☐	☐		
Lines of Evidence/Scientific Approach (cont'd)						
• Demonstration of how SBEB will meet WQGs in the downstream environment and will not conflict with area based management plan or policies and legislation.	☐	☐	☐	☐		

Appendix B - Checklist for Phase 2: SBEB Submission

This checklist identifies items to be included into the submission of a proposed SBEB.

Information Requirements	Information Provided				Location in Document (page number and section)	Comments
	Provided	Partially Provided	Not Provided	Not Applicable		
• Discussion of uncertainties (including but not limited to test results, statistical analyses, water quality and species variabilities, and toxicological uncertainties) related to SBEB development and resulting effectiveness in protecting aquatic life.	☐	☐	☐	☐		
Monitoring and Adaptive Management Approach to Mitigation or Future Monitoring						
• Detailed monitoring plan proposal to evaluate SBEB achievement in the receiving environment and effectiveness in protecting aquatic life.	☐	☐	☐	☐		
• Monitoring protocols, sampling and analysis methods, statistical analyses methods, and QA/QC protocols.	☐	☐	☐	☐		
• Detailed explanation of how the monitoring program will accomplish its objective (i.e., why certain times of year should be sampled, how the frequency evaluates the effectiveness, etc.).	☐	☐	☐	☐		
• Description of an adaptive management approach under the permit.	☐	☐	☐	☐		
• Detailed summary of contingency measures planned should SBEBs not be achieved or protective of aquatic life (e.g., treatment options, site management practices, further research to reduce uncertainties related to an SBEB).	☐	☐	☐	☐		

Appendix B - Checklist for Phase 2: SBEB Submission

This checklist identifies items to be included into the submission of a proposed SBEB.

Information Requirements	Information Provided				Location in Document (page number and section)	Comments
	Provided	Partially Provided	Not Provided	Not Applicable		
• Planned reporting of monitoring result, including data analyses, reporting frequency, report content and format.	☐	☐	☐	☐		

Appendix C – Data Classification Guidance

When peer-reviewed scientific literature is included in an SBEB document, it must be classified into primary, secondary, and unacceptable based on the criteria provided below. The classification process must be signed by a qualified professional and include a table describing key details of the study. The table should provide the title of the scientific paper, the author(s), the year, the species involved, the life stage(s), the endpoint(s) testing, the length of each test, all parameters of concern, the hardness or other parameters (applicable to toxicity or stress) and the type of test conducted. Any literature that refers to field situations should include the details of site conditions and any information relevant to the classification process.

Applicant-initiated toxicity testing for SBEB development must meet the primary data requirements as provided below. The attached checklist and data evaluation should be completed for each toxicity study reviewed.

Data Classification

Primary Data:

- Toxicity tests must employ currently acceptable laboratory practices of exposure and environmental controls. Other types of tests using more novel approaches (e.g., omics including genomics, proteomics, metabolomics) will be evaluated on a case-by-case basis;
- Toxicity test methods must have adequate replication, incorporate a sufficient number of concentrations and tests must demonstrate an appropriate dose-response;
- As a minimum requirement, substance concentrations must be measured and reported at the beginning and end of the exposure period. Calculated concentrations or measurements taken in stock solutions are unacceptable;
- Generally, non-renewed static tests are unacceptable for primary data unless it can be shown that substance concentrations did not change during the test and that adequate environmental conditions for the test species were maintained;
- Preferred endpoints from a partial or full lifecycle test include a determination of effects on embryonic development, hatching, germination success, survival of juvenile stages, growth, photosynthesis, reproduction, and survival of adults;

- Endpoints should be demonstrated to be ecologically relevant toxic endpoints. These generally include but are not exclusive to reproduction, growth, development and survival of young and adults. Other endpoints (e.g., behaviour, deformities etc.) will be evaluated on a case-by-case basis;
- Response and survival of controls must be measured and reported, and appropriate for the life stage of the test species used; and,
- Measurements of abiotic variables such as temperature, pH, dissolved oxygen, and water hardness should be reported so that any factors that may affect toxicity can be included in the derivation process.

Secondary Data:

- Toxicity tests may employ a wider array of methods (e.g. measuring toxicity while test species are exposed to additional stresses such as low temperatures, lack of food, or high salinity);
- Static tests are acceptable;
- Preferred test endpoints include those listed for primary data as well as pathological, behavioural, enzymatic, and physiological effects. These endpoints should be linked to some ecological relevance;
- Calculated substance concentrations are acceptable;
- All relevant environmental variables should be measured and reported; and,
- The survival of controls must be measured and reported.

Unacceptable Data:

- Toxicity data that do not meet the conditions of primary or secondary data.

Literature Data Evaluation Checklist

Reference: _____

Chemical/Compound Tested: _____

Organism Information:

Test Organism - Common: _____ Latin: _____

Freshwater/ Marine

Life Cycle Stage: egg / embryo / larva / tadpole / alevin / juvenile / adult

Toxicity Test Information:

Duration: _____ Endpoint: _____ Effect: _____

Life Cycle Test Duration: full / partial

Endpoint: Short-Term (Acute) / Long-term (Chronic)

Exposure (aquatic vs dietary, is it appropriate): _____

Other information: _____

Chemical/Physical Properties:

Purity/Form of Chemical: _____

Carrier Solvent Used: Y / N (if yes, specify: _____)

pH: _____

O_2 (mg/L): _____

Temperature (°C): _____

Total Alkalinity (mg CaCO3/L): _____ or (meq/L): _____

Total Hardness (mg CaCO3/L): _____

Conductivity (mS/cm): _____

Freshwater ( ) / Marine ( ): Salinity (‰): _____

Other(s): _____

Additional Notes: _____

	Data Evaluation Summary		
Parameter	**Primary**	**Secondary**	**Unacceptable**
Reporting of Abiotic Variables (See above)	All Relevant Variables ( )	Partial ( )	Lacking ( )
Test Condition	a) Flow through ( ) b) Renewal ( ) c) Static ( )	a) Static ( ) b) Other ( )	
Toxicity Testing Methods	Standard: (ECCC/ASTM/EPA/WHO/OTHER) Novel (Specify) ( ): _____	Novel (Specify) ( ): _____ Additional stressors: _____	Not Specified ( )
Analytical Techniques	Standard ( ) Novel (Specify) ( ): _____	Novel (Specify) ( ):_____	Not Specified ( )
Statistical Analyses	Appropriate Tests Used: Y Description:	Appropriate Tests Used: Y / N Description:	Unacceptable ( ) Not Specified ( )
Replication	Adequate replication : Y	Adequate replication : Y / N	Unacceptable ( )
Toxicant Concentrations	Measured Directly ( ) Beginning: _____ End: _____	Calculated ( ) Beginning: _____ Measurements From Stock Solutions: _____	Not measured ( )