BRITISH COLUMBIA

INFORMATION NOTICE

July 2016 Ministry of Environment

A User Guide for the Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators

What is the Purpose of this Document?

This User Guide is a companion document to ***Technical Guidance 6: Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators*** (Technical Guidance 6). As such, it provides a high-level overview of the information provided under each chapter in the technical guidance document; including:

- A summary of the minimum baseline study and information requirements necessary for impact assessment related to air and water;
- A brief description of study approaches that are acceptable to the Ministry of Environment (ENV) and the Ministry of Forests, Lands and Natural Resource Operations (FLNRO); and,
- A high level overview of impact prediction approaches.

Alternative study designs and rationale should be discussed with ENV on a site specific basis.

Both documents are primarily intended to apply to metal and coal mines and, to a lesser extent, to aggregate and other industrial mineral projects that are triggered by the Reviewable Project Regulation in the *Environmental Assessment Act* or the *Mines Act*. However, the principles provided apply to all types and scales of mines. It is intended to be used by mine proponents and operators undertaking a new project or project expansions.

It is essential that proponents read the full Technical Guidance 6 document (ENV 2012), meet with regional ENV and FLNRO representatives to obtain advice on monitoring plans, and initiate baseline information collection as early in the mine development process as possible.

This document does not cover all of the information needed when proposing a mine. Proponents are advised to contact relevant federal agencies, the Environmental Assessment Office, the Ministry of Energy and Mines, ENV, FLNRO, and other agencies as appropriate to

ensure their respective requirements are being addressed.

What is the Purpose of an Environmental Baseline Study?

Baseline environmental studies are designed to characterize the environmental resources at a site prior to any site development. They provide a benchmark and reference against which to compare the environmental conditions influenced by the construction, operation and closure phases of a mine. The information is also used to assess the effectiveness of any proposed mitigation measures and to implement adaptive management, if needed.

Environmental Baseline Study Objectives[1]

The environmental baseline study must collect, assess, and interpret enough physical, chemical and biological information to: (i) support the characterization of the resources at risk; (ii) enable determination of possible impacts; (iii) help predict the significance of impacts and the effectiveness of any proposed mitigation; (iv) establish thresholds for indicators of ecosystem health; and (v) facilitate the design of monitoring programs.

Key Highlights

Data Quality Assurance and Quality Control

It is necessary to have a high level of confidence in the data being used to make resource management decisions. Consistent and rigorous data quality assurance and quality control (QA/QC) practices will enable the collection of meaningful and scientifically credible data.

Data and practices that do not meet accepted QA/QC guidelines may be rejected by ENV representatives.

Geology and Geochemistry[2]

In this context, baseline conditions are the existing geological and geochemical conditions of the deposit and surrounding environment at the time when the proposed mine development will occur.

[1] Technical Guidance 6, Section 1.2.
[2] Technical Guidance 6, Section 2.

The geologic component of a mine development is the fundamental basis for the project's existence and for the identification of sources for contaminant discharges; therefore it will comprise a significant portion of the initial information collected. The deposit type, location, physical environment, mineralogy, geochemistry, structure, and other features, will determine the economics, development strategy, potential short- and long-term environmental issues, and ultimately the legacy of a given project.

Purpose

The geological and geochemical baseline characterizes the physical environment and materials to be disturbed, identifies potential effects from disturbing these materials, and directs the development proposal in order to eliminate, reduce, or mitigate potential impacts on the receiving environment.

Key Points

- Proponents are required to review existing geological and geochemical information, collect baseline information during initial exploration stages through to advanced exploration (and beyond), and provide detailed information about the potential for metal leaching and acid rock drainage (ML/ARD);
- ML/ARD is a critical component of project assessment due to the long-term nature of ML/ARD issues and the potential for severe environmental and economic costs. Prevention of ML/ARD through predictive work and mine planning is preferred and is a critical over-arching aspect of any mining development proposal; and
- It is very important for the geologic and geochemical baseline study to be linked with other baseline studies, as they are all intimately linked throughout project design, development, and closure.

Meteorology, Climate, and Air Quality[3]

Purpose

The meteorology and climate baseline studies characterize the atmospheric environment in its current state and support the assessment of the potential impacts of weather and climate on the project and the potential impacts of the project on air quality, climate, and hydrology.

The air quality baseline study characterizes the current state of the substances in the atmosphere and supports the assessment of both the incremental and the cumulative influences of a project on air quality, climate, and hydrology.

[3] Technical Guidance 6, Section 3.

Key Points

- Proponents are required to review existing climatological and air quality information and install meteorological and air quality stations to collect representative data;
- A proponent is expected to demonstrate an understanding of weather and climate over a project's entire footprint;
- Air quality and atmospheric dispersion modelling is required for most Environmental Assessment (EA) reviews; and
- Typical data requirements include:
    - Meteorology and climate monitoring data which includes wind speed and direction to predict the distribution of trace metals in soils from fugitive dust derived from tailings and waste rock piles;
    - Air temperature, net radiation, wind, turbulence and sometimes precipitation data are typically required for atmospheric dispersion modelling;
    - Snowmelt and precipitation data are necessary for run-off prediction and calibration of regional hydrologic analysis; and
    - Solar radiation, precipitation, and evapotranspiration data are required to estimate design parameters for water management infrastructure.

Sampling Frequency and Period of Record	
What to measure, the sampling frequency and the period of record will vary depending on the scope of the proposed project, the magnitude and type of emissions, the sensitivity of the air-shed and ecosystems, and whether or not atmospheric dispersion modelling is a requirement.	
Examples	
Meteorology	**Air Quality**
Climate Conditions: will require a longer period of record with less temporal resolution Dispersion Modelling: Typically requires 1-5 years of meteorological data.	Due to the uniqueness of each project, air quality baseline requirements are project specific and should be discussed with the appropriate ENV Air Quality Meteorologist.

Proponents should consult ENV staff to ensure that all instrumentation used meets the ministry's standards.

Surficial Hydrology[4]

Purpose

The purpose of the hydrologic study for a proposed resource project is to characterize

[4] Technical Guidance 6, Section 4.

existing surface water resources and to support the estimation of the impact that resource development may have on the water quantity flow in these systems.

A thorough understanding of the water management needs associated with the mine proposal is required to correctly design mine water systems such as milling processes, tailings impoundments, treatment plants, sediment ponds, culverts, and diversion ditches and to clarify post-closure water management scenarios.

Main Objectives

- Provide calibration data for the development of integrated mine site water balances and hydrologic regionalization's;
- Evaluate seasonal and inter-annual patterns in surface water discharge (including intermittent/ephemeral streamflow);
- Provide baseline information on the surface water resource for subsequent water quantity and water quality modelling and monitoring (dilution modelling, in-stream flow estimates, run-off modelling etc.); and
- Provide annual and event data for flow frequency analyses (i.e., low flows, peak flows, etc.).

Key Points

- Proponents are required to review existing surficial (and if available local) hydrology information prior to collecting field data. The objective is to provide an outline of the general characteristics for the watershed(s) of interest;
- ENV and FLNRO staff should be consulted to discuss data, guidelines, and standards, and to establish hydrometric monitoring sites;
- Many phases of the EA and subsequent permitting process depend on reliable hydrometric data. Multiple hydrometric stations will likely need to function for several years; therefore, correct siting and a durable installation is very important;
- Resource Information Standards Committee (RISC) standards should be followed when establishing hydrometric monitoring sites. Any deviations must be defensible and documented; and
- Hydrometric stations should collect and record as much continuous water level (stage) data as possible.

The minimum period of record for surface water flow data is 2 years. However, a longer period of record may be required for some projects.

Hydrogeology[5]

Purpose

The hydrogeology baseline study defines and supports the assessment of potential environmental effects on groundwater resources and the development of prevention, mitigation, and monitoring measures to ensure that the quantity and quality of the groundwater can support present and future uses.

Main Objectives

- Provide baseline information on the extent, physical and chemical characteristics, uses, and potential of the groundwater resource in and around the proposed development for subsequent water quantity and water quality impact prediction and monitoring;
- Outline measures to ensure that the groundwater resource is maintained for present and future uses;
- Characterize the pre-development groundwater flow regime for calibration of a numerical flow model to be used to predict impacts to water quantity and quality (if modelling is required);
- Evaluate seasonal changes in groundwater flow patterns, groundwater levels, and groundwater quality, where applicable; and
- Layout/map groundwater flow paths and flow speed to support assessment of possible changes resulting from proposed developments.

Key Points

- Proponents are required to review existing information on groundwater in the study area prior to collecting field data (if available);
- A network of monitoring locations must be established to collect data on groundwater levels, flow direction and speed, and quality. The monitoring program must consider the life cycle of the project with monitoring sites established for baseline, operational, and closure requirements. It may be necessary to conduct numerical modelling; in this instance, contact ENV representatives to discuss the work before the actual modelling proceeds;
- The *Groundwater Protection Regulation* under the *Water Sustainability Act* of British Columbia must be followed during

The groundwater quantity and quality baseline studies should have a minimum of 1 year of quarterly data.

[5] Technical Guidance 6, Section 5.

the construction, maintenance, deactivation and decommissioning of monitoring wells and geotechnical wells;

- Field data collection should allow the proponent to adequately characterize the groundwater flow system and identify aquifers and boundary conditions, hydraulic properties, water budget and groundwater-surface interactions with adequate certainty; and
- Aspects of the physical hydrogeology of the study area must be discussed in the EA application (e.g., geographic and geologic setting, characterization of aquifers and aquitards etc.).

Water Quality: Physical and Chemical Parameters[6]

Purpose

The water quality baseline study assesses ambient surface and groundwater conditions before project development to identify whether baseline conditions naturally exceed provincial water quality guidelines and whether site-specific benchmarks need to be established.

Water quality describes the physical, chemical, biological, and aesthetic characteristics of water, which strongly influence its suitability for aquatic life, wildlife, livestock, irrigation, human consumption, and industrial use.

Main Objectives

- Assess the ambient surface and groundwater conditions before effects from the proposed mine(s) occur (i.e., baseline monitoring);
- Identify whether baseline concentrations naturally exceed provincial water quality guidelines and whether site-specific water quality benchmarks need to be established;
- Use baseline information to support prediction and assessment of impacts;
- Determine the need for monitoring and management during the life of the mine; and
- Allow the comparison of baseline data with operational and post-closure water quality data in order to identify whether water quality is affected by mine-related activities and to verify that established water quality guidelines or site specific benchmarks are being met and water quality is being protected.

Key Points

- Proponents are required to review existing physical and chemical water quality information, if available;

[6] Technical Guidance 6, Section 6.

- The necessary conditions to support and protect the most sensitive water use (including aquatic life) must be identified as early as possible for surface water and groundwater that could be affected by mine activities. Identification of these conditions can be achieved by comparing existing water quality and mine-effluent-affected water quality to water quality guidelines (WQGs). If WQGs are not suitable (e.g., when natural concentrations exceed water quality guidelines), site-specific water benchmarks may be developed to define acceptable receiving water quality. Either WQGs or site specific benchmarks should be used to assess the predicted impacts from the proposed project;

Water quality guidelines (WQGs) provide water quality ranges for the protection of designated users.

- Water quality sampling locations should be discussed with regional ENV and FLNRO representatives. Site locations should include upstream and downstream sites, including lakes if applicable. Keep in mind that sampling locations should be coordinated with other baseline study site locations (e.g. hydrology, meteorology, climate, air quality etc.);
- A full suite of analyses is required to provide a complete picture of the natural constituents in the water; and
- Water quality data can become voluminous. An early decision on how to best structure, store and report water quality results is important.

1 year of quarterly data is the minimum requirement for the groundwater quality baseline. For surface water, a minimum of monthly sampling with additional weekly sampling during periods of maximum hydrograph fluctuation (high flow and low flow) is required. BC WQGs for chronic exposure require an appropriate monitoring frequency to determine whether the guideline is met. BC maximum WQGs to prevent short-term lethality apply to each sample.

Water Quality: Aquatic Sediments[7]

Sediments represent an important component of the aquatic environment near mine sites. Bottom sediments support aquatic life by providing habitat for attached algae, rooted plants, sediment microorganisms, and burrowing or sediment-feeding invertebrates. All of these provide a food base or habitat for local fish. Fine-grained sediments can bind contaminants (e.g., metals, nutrients, and organics) that may be discharged by mines.

[7] Technical Guidance 6, Section 7.

Sediment characterization can be advantageous to impact assessment, because fine sediments tend to integrate periodic or storm-based contamination events that may be missed by regularly scheduled water quality sampling. Also, particularly during mine construction and early operational phases, sediment loads themselves can be well above natural levels, and are of interest. Either degraded sediment chemistry or the addition of large quantities of fine sediment to the aquatic environment can adversely affect structure and/or function of the aquatic system. Guidelines for the protection of aquatic life have been established for many metal and organic parameters. Accordingly, sediment characterization is a necessary component of mine baseline, operational, and post-closure assessments.

Purpose

The aquatic sediments baseline study identifies spatial and temporal trends in sediment chemistry at key locations in the vicinity of a mine site.

Key Points

- Proponents are required to review existing aquatic sediments information, if available;
- Sampling sites should be located upstream from, adjacent to, and downstream from the proposed mine. Their locations should be coordinated with the sampling locations for water, tissues, benthic organisms, and fish habitat, as it provides the opportunity to examine relationships between these components of the aquatic community;
- Proponents are required to collect samples for grain size, metals, and organics analyses. **Samples must be analyzed for the <63 µm sediment fraction** and ENV representatives should be consulted to discuss whether the <177 µ fraction or larger should also be included;
- Finer sediment particles are of greater interest in terms of contaminant loads, because most mine-related chemical contaminants preferentially bind to silts and clays;
- The proponent is responsible for using updated and appropriate detection limits;
- An accredited laboratory must be used for sample analyses;
- The BC Strong Acid Leachable Metals (BC SALM) digestion method must be used for the analysis of all metals in sediments. Special requests must be made in advance for laboratories to analyze only the <63 µm fraction since the BC SALM method measures the <2 mm fraction by default; and
- An in-depth description of sampling methods is provided in Technical Guidance 6 (ENV 2012).

Sediment sampling should be conducted at least once per year through the baseline and operational phases during late summer low flow periods.

Water Quality: Tissue Residues[8]

Biological tissue samples are an important aspect of the mine-related baseline study and impact assessment. Similar to sediments, tissues can absorb metal or organic contaminants discharged by operational or post-closure mines. Contaminants may be taken up directly from the water column via facilitated diffusion (e.g., inorganic metals) or, in the case of organic selenium and methyl-mercury, may be taken up via dietary sources, stored in fat and proteins, and biomagnified up the food chain.

Purpose

The tissue residues baseline study quantifies tissue contaminant levels and provides references for assessing future contaminant accumulation in aquatic organisms.

Key Points

- The proponent must consider how to minimize the unnecessary destructive sampling of fish, amphibian, and aquatic bird species, particularly target species that may be threatened over time;
- The aquatic or semi-aquatic organisms from which tissue is usually collected for residue analysis include birds (eggs), attached algae (periphyton), aquatic macrophyte vegetation, benthic invertebrates (including bivalves), amphibians, mammals (hair or tissue), and fish. Avian (usually bird eggs) or mammalian tissue assessment may need to be included where mercury or selenium has been found to be an issue;
- Proponents are required to review existing tissue inventory data, if available, and to consult with ENV staff before monitoring begins and during the site selection process;
- Sample site selection may be largely determined by the availability of tissues but they should include select sites upstream, adjacent to, and downstream from mine influence. Stream and lake/wetland environments should also be included, if applicable;
- Sites selected for the collection of tissues should correspond with sediment sampling locations, particularly if contaminant uptake is via the food chain that originated in those sediments (i.e., for organic selenium or methyl mercury);
- It is necessary to obtain the appropriate fish and wildlife collection permits;
- The proponent is responsible for using updated and appropriate detection limits; and

The minimum requirement for tissue residues is a 1-year baseline study (1/year sampling) prior to mine construction. In most cases, sample collection should occur during the summer/fall low flow period. The fish baseline may extend over 2 years if necessary.

[8] Technical Guidance 6, Section 8.

- An in-depth description of sampling methods is provided in Technical Guidance 6 (ENV 2012).

Water Quality: Aquatic Life[9]

Purpose

The aquatic life baseline study provides information about the health of the aquatic ecosystem.

Main Objectives

A primary objective of monitoring ecosystem health is to ensure the protection of aquatic and aquatic food-web dependent terrestrial organisms, some of which are important for human sustenance.

Key Points

- Developing a conceptual model of the ecosystem to be studied is a crucial first step in the design of the baseline study. A model provides a context from which to pose and refine the questions to be investigated in the study (Lindenmayer and Likens, 2009). Once clear questions are set, the proponent can design a monitoring program to gather the necessary data;
- Proponents are required to review existing aquatic life information, where available;
- Sampling sites should be selected with long-term monitoring in mind. Monitoring programs must include the rivers, streams, lakes, and wetlands that may be impacted by mine development;
- Proponents should determine the organisms to sample (typically benthic or planktonic invertebrates, periphytic or planktonic algae, and macrophytes) and consult with ENV staff to determine the most suitable design for analyzing benthic macro invertebrates;
- The ENV recommends that the reference condition approach (RCA) sampling design through the Canadian Aquatic Biomonitoring Network (CABIN) be used for benthic macroinvertebrate monitoring;

ENV requires a minimum of 1 complete survey for the baseline study but prefers data from ≥ 2 consecutive years. 2 years is the minimum time required to define inter-annual variability.

[9] Technical Guidance 6, Section 9.

- Macroinvertebrates should be identified and enumerated by a certified taxonomist to the lowest practical taxonomic level (usually genus or species), or as agreed with regional ENV representatives; and
- GIS analyses are required to determine values for the predictor variables used in many regional RCA models. Because BC government GIS layers are not readily available to the public, the ENV must conduct these analyses.

Fish and Fish Habitat[10]

The fish and fish habitat baseline study provides information about fish population abundance and distribution by species and life stage as well as the habitats fish use on an annual basis in order for regulatory agencies to evaluate the impacts of mine development on fish and fish habitat.

Purpose

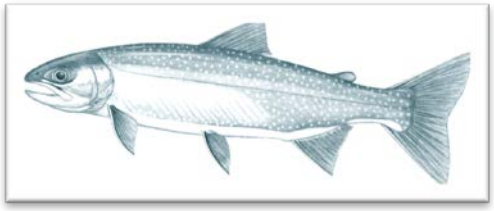
The purpose is to fully understand the fish and fish habitat values to be impacted locally and to be able to place these impacts in the context of the wider landscape.

Main Objectives

- Describe the abundance and distribution of fish habitats in the project area;
- Determine whether previous land and water uses have affected the habitats;
- Support the determination of the extent to which the proposed development will affect fish habitat;
- Determine to what extent the population is likely to be able to sustain itself through an understanding of population dynamics including sustaining recruitment needs to adult habitats (streams, lakes, reservoirs and rivers);
- Support the determination of whether First Nations harvest and angling is likely to be affected by the mining development;
- Allow for a robust assessment of how alterations to fish habitats and connectivity between habitats required seasonally and (or) by different life stages will affect fish population processes and productivity;
- Identify potential physical and biological bottlenecks to fish productivity and survival, and corroborate them with population data whenever possible; for example, populations limited by spawning habitat, intrinsic reproductive capacity, and factors affecting growth (e.g., water temperature or trophic regimes) have different characteristics than those that are not; and,

[10] Technical Guidance 6, Section 10.

- Lay the foundation for monitoring programs that will measure project effects during mine construction, operation, and closure.



Key Points

- The baseline study requires proponents to conduct an extensive review of existing fish and fish habitat information;
- The degree and extent of sampling will depend on the nature of the project, the fish habitat in the area, and site-specific conditions that will influence the sensitivity of both populations and habitats to potential impacts. The baseline survey must include all waterbodies that may be affected by the mine components (e.g., the pit, waste dumps, access road, etc.) or waste discharges;
- A key objective of baseline fish data collection is the design and establishment of monitoring programs. Some form of fish monitoring will be required any time there is potential for a population-level impact;
- Proponents must obtain the appropriate fish and wildlife collection permits from provincial and federal agencies;
- The proponent is required to collect fish community data, including presence and absence, species and life stages, abundance, distribution, and life history timing. Fish habitat inventory data should also be collected and entered into the provincial database using the Field Data Information System (FDIS);
- A wide range of ecosystem components require that a minimum instream flow be maintained. If the applicant proposes to divert large quantities of water to and from streams, then an Instream Flow Study (IFS) must be conducted;
- Mining projects and associated works such as tailings or potentially acid generating (PAG) storage facilities may result in a harmful alteration, disruption or destruction (HADD) of fish habitat. To consider the authorization of a HADD of fish habitat, the Department of Fisheries and Oceans Canada (DFO) will require that a detailed fish habitat compensation plan be prepared by the proponent and submitted for approval;

The baseline study should be conducted for several years at reference and impact sites prior to project development. A minimum of 2 years of monitoring prior to construction is recommended.

- Fish habitat values can change due to the dynamic processes associated with stream morphology. Proponents should conduct overview habitat surveys in the event of high-flow events and if significant channel impacts are observed, the proponent may need to repeat detailed habitat surveys; and
- Proponents must also consider the cumulative effects of impacts to fish and fish habitat. This involves considering the potential interactions between existing resource uses and

the proposed project, including existing and requested water licences and water licence applications (both upstream and downstream) and land uses that may significantly affect instream processes (e.g. forestry, mining, urbanization, etc.).

Environmental Impact Prediction[11]

In addition to outlining the data requirements for various environmental resources of concern, Technical Guidance 6 provides high level guidance on ENV's and FLNRO's expectations for environmental impact assessment/prediction for mine projects.

Purpose

The purpose of an environmental impact assessment is to ensure that decision-makers consider environmental impacts before deciding whether to proceed with new projects. It is also used to select appropriate environmental mitigation measures.

It is necessary to understand the concentration and movement of mining contaminants and their effect on the ecosystem in order to assess the impact of mining-related activities on the receiving environment.

Key Points

- The environmental impact and risk assessment requires that proponents complete the following tasks:
    - Characterize the resources at risk through baseline data collection;
    - Describe the ecosystem and analyze its sensitivity;
    - Identify potential hazardous conditions and predict impacts through scientific environmental models;
    - Design an Environmental Effects Monitoring (EEM) program; and,
    - Propose a safe-discharge plan that is protective of the air and the aquatic environment.
- The principal components to be assessed include effects on:
    - Hydrology;
    - Hydrogeology;
    - Water quality;
    - Sediment and invertebrates; and
    - Aquatic biological data and tissue residues.
- The potential effects from all operations, such as dewatering, blasting, and contaminant sources associated with all phases of the project life cycle must be included; and
- In addition to site specific effects, the proponent should consider the contribution of project impacts to (regional) cumulative effects. Critical information gaps that still exist

[11] Technical Guidance 6, Section 11.

at the end of the study should be identified and methods of rectifying the gaps discussed.

List of Abbreviations

ARD – acid rock drainage

EA – environmental assessment

ENV – Ministry of Environment

FLNRO – Ministry of Forests, Lands and Natural Resource Operations

ML – metal leaching

QA – quality assurance

QC – quality control

RCA – reference condition approach

WQG – water quality guideline

References

Biggs, B.J.F. and C. Kilroy. 2000. Stream Periphyton Monitoring Manual. National Institute of Water and Atmospheric Research, Christchurch, New Zealand. 224 pp. www.niwa.co.nz/sites/default/files/import/attachments/peri_complete.pdf

Lindenmayer, D.B. and E.G. Likens. 2009. Adaptive monitoring: a new paradigm for long-term research and monitoring, Trends in Ecology and Evolution Vol.24 No.9. http://biology.ucf.edu/~rnoss/papers/Lindenmayer%20and%20Likens%202009.pdf

Ministry of Environment (ENV). 2012. Technical Guidance 6: Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators, Environmental Protection Division, Environmental Sustainability and Strategic Policy Division, Victoria, B.C. Available online at:

http://www2.gov.bc.ca/assets/gov/environment/waste-management/industrial-waste/industrial-waste/water_air_baseline_monitoring.pdf