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Comprehensive Environmental Monitoring Plan 2019

Submitted to:

Ministry of Environment and Climate Change Strategy
Environmental Protection Division
South Interior Region – Cariboo

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ACRONYMS

°C	degrees Celsius
µm	micrometer
µS/cm	micro Siemens per centimetre
ADP	Annual Discharge Plan
AERR	Annual Environmental and Reclamation Report
ARD	acid rock drainage
BC	British Columbia
CALA	Canadian Association of Laboratory Accreditation
CCS	Central Collection Sump
CEMP	Comprehensive Environmental Monitoring Plan
cm	centimetre(s)
COPC	constituents of potential concern
CRM	certified reference material
CRP	Conceptual Remediation Plan
CSM	Conceptual Site Model
CSR	Contaminated Sites Regulation
DFO	Fisheries and Oceans Canada
DGT	diffusive gradients in thin-film
DQO	data quality objectives
EEM	Environmental Effects Monitoring
EMA	*Environmental Management Act*
EMP	Environmental Monitoring Plan
EMPR	Energy, Mines, and Petroleum Resources
ENV	Ministry of Environment and Climate Change Strategy
ERA	Ecological Risk Assessment
Golder	Golder Associates Ltd.
ha	hectares
HHRA	Human Health Risk Assessment
IDZ	initial dilution zone
km	kilometre(s)
km^2	square kilometre(s)
LOR	limit of reporting
LTWM	long term water management
m^3/s	cubic metres per second
masl	metres above sea level
MDL	method detection limit
Minnow	Minnow Environmental Inc.
mL	millilitre(s)
ML	metal leaching
mm	millimetre(s)
MPMC	Mount Polley Mining Corporation
MDMER	Metal and Diamond Mining Effluent Regulations
PAG	potentially acid-generating

PAO	Pollution Abatement Order
PEEIAR	Post-event environmental impact assessment report
PETBP	Perimeter Embankment Till Borrow Pond
PLC	Public Liaison Committee
QA	quality assurance
QC	quality control
RCP	Reclamation and Closure Plan
RPD	relative percent difference
SCIB	Soda Creek Indian Band
SFS	Society for Freshwater Science
SOP	standard operating procedure
SWL	static water level
TAR	Technical Assessment Report
TOR	terms of reference
TSF	Tailings Storage Facility
TSS	total suspended solids
WaterSmith	WaterSmith Research Inc.
WLIB	Williams Lake Indian Band
WM	work method
WTP	water treatment plant

1 INTRODUCTION

The Mount Polley Mine is located eight kilometres (km) southwest of Likely and 56 km (100 km by road) northeast of Williams Lake, British Columbia (BC; Figure 1.1). On November 29, 2015, Mount Polley Mining Corporation (MPMC), which operates the mine, received an amendment to Permit 11678 (herein referred to as the Permit) issued by the BC Ministry of Environment and Climate Change Strategy (ENV; previously known as the Ministry of Environment) pursuant to the *Environmental Management Act* (EMA; SBC 2003, Chapter 53) for a short-term water management strategy to discharge treated mine effluent into Quesnel Lake via Hazeltine Creek. The most recent amendment of the Permit was granted April 7, 2017 for a long-term water management strategy to discharge treated mine effluent directly to Quesnel Lake. Section 3.2 of the amended Permit requires MPMC to develop and implement a Comprehensive Environmental Monitoring Plan (CEMP) for the Mount Polley Mine site and surrounding receiving environment that combines pre-existing monitoring programs into an integrated plan as follows:

> *"The Permittee must continue to develop, submit, and implement an ongoing Comprehensive Environmental Monitoring Plan (CEMP) to evaluate the effects of mining-related activities on the physical, chemical, and biological characteristics of Hazeltine Creek, Edney Creek, Bootjack Lake, Morehead Creek, Polley Lake, Quesnel Lake, Quesnel River, and associated riparian and upland areas.*
>
> *The CEMP will consolidate and integrate all of the pre-existing monitoring programs that are being conducted in the vicinity of the mine site and include, at minimum, surface water (quality and quantity), groundwater (characterization and interactions with surface water), sediments, soils, periphyton, phytoplankton, benthic invertebrates, zooplankton, fish, floodplain and upland vegetation, and wildlife.*
>
> *The CEMP must at minimum address a three year time span, as well as at a minimum include all sampling sites, frequency of sampling, variables to be analysed, method detection limits, sampling methods, sample analysis methods, and data analysis methods."*

The June 23, 2016 version of the CEMP was approved in the April 7, 2017 Permit amendment. Subsequently, in 2017, MPMC submitted several versions of a CEMP to ENV for review, however, a plan for 2017 was not approved. This CEMP covers the 2018 to 2020 time period and was developed based on the approved updated Terms of Reference (TOR) included as Appendix A. Based on the requirements of the permit, the next CEMP will be submitted in March 2020.

This CEMP is a unique and integrated monitoring plan that has been developed to capture a number of independent and interdependent monitoring programs, including; site monitoring, water discharge, *Metal and Diamond Mining Effluent Regulations* (MDMER) requirements, and Tailings Storage Facility (TSF) embankment breach response and remediation. Monitoring programs are normally developed by requirements of sector-specific regulations (e.g., MDMER of the federal *Fisheries Act* [Government of

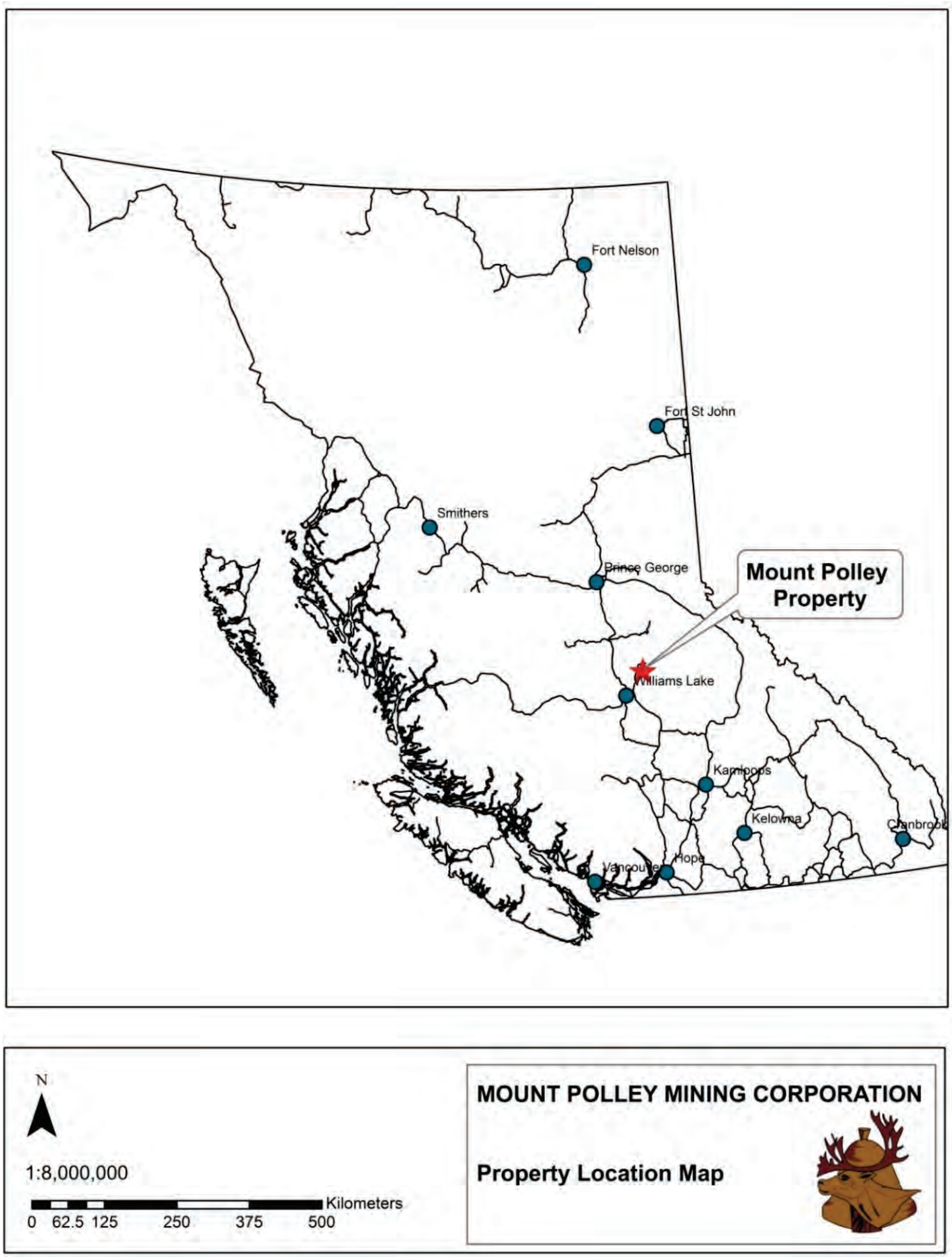


Figure 1.1 Mount Polley Mine property location

Canada 2018]) or by conditions in a permit with a specific monitoring plan that ties together permit-required and MDMER-required monitoring. As there is no ENV Technical Guidance document for this type of plan, this CEMP has been developed through an extensive consultative process that encompasses a number of permitting and other regulatory processes. Through these efforts, it has been suggested by various parties that all of the monitoring programs (e.g., water discharge monitoring, MDMER, TSF embankment breach response, etc.) be combined into one overarching program that takes advantage of the broader data set. This integrated monitoring plan offers the additional benefit of facilitating more efficient monitoring plan review by regulatory agencies, First Nations, and stakeholders. A constraint on this CEMP is where there are specific programs compelled by regulation such as the Environmental Effects Monitoring (EEM) Program that is required under the MDMER. In such instances, transparency of objectives and best efforts will be required to consolidate these different programs to the extent possible.

The CEMP is structured as follows:

- **Section 1:** Describes the CEMP objectives, a brief summary of the monitoring programs that have been integrated into the CEMP, and regulatory requirements.
- **Section 2:** Provides an overview of the integration of the various environmental monitoring programs being undertaken at the mine. Conceptual Site Models (CSMs) for the mine site and the TSF breach affected areas have also been provided, along with further details of the monitoring plans that have been integrated into the CEMP.
- **Section 3:** Provides an overview of First Nations and Stakeholders.
- **Section 4:** Provides a summary of the mine operations and the receiving environment.
- **Section 5:** Describes the environmental management practices in place, including water management.
- **Section 6:** Describes all monitoring components, including climate, surface water, hydrology, groundwater, contact water, seepage water, effluent, sediment quality, benthic invertebrate, plankton and chlorophyll *a*, periphyton, fish, wildlife, amphibian and reptile, soil, soil invertebrate, vegetation, and biosolids.
- **Section 7:** Describes the process for CEMP revisions and updates, along with a summary of changes made since the approved plan was submitted on June 23, 2016.
- **Section 8:** Summarizes relevant components of the post-TSF breach reclamation and remediation plans and interactions with CEMP components.
- **Section 9:** Provides an overview of the reporting of CEMP results.
- **Section 10:** Provides an overview of the future outlook.

The appendices attached to the CEMP are summarized below:

- **Appendix A:** Approved CEMP TOR (April 28, 2017).
- **Appendix B:** Contains the Detailed Study Designs for CEMP components, as referenced in document.
- **Appendix C:** Sample of Monthly Monitoring Schedule, which is a sample of the monthly environmental monitoring schedule provided to environmental department staff.

- **Appendix D:** Site Matrix, which describes all water sample locations in the CEMP, including site descriptions, site locations, access or safety concerns, and rationale for monitoring.
- **Appendix E** Declarations of Competency forms for Qualified Professionals contributing to the CEMP

1.1 OBJECTIVES

As specified in the Permit, the CEMP describes monitoring activities intended to support the evaluation of the potential for effects of mine-related activities on the physical, chemical, and biological characteristics of Bootjack Lake and Morehead Creek in the Springer Pit area, the Hazeltine and Edney Creek drainages, Polley Lake, Quesnel Lake, and Quesnel River, and associated riparian and upland areas. Specifically, the CEMP objectives are:

1. To evaluate if pollution[1] is occurring in the receiving environment as a result of the existing water discharge or mine-related activities;
2. To evaluate the environmental impacts of the August 2014 TSF embankment breach, to inform the rehabilitation plan, as well as to evaluate the effects of mitigation measures that are implemented as part of the rehabilitation strategy;
3. To integrate, to the extent feasible, the requirements of the MDMER; and
4. To inform reclamation and closure (*Mines Act* Permit M-200).

This CEMP includes monitoring of: effluent, surface water, groundwater, sediment, periphyton, plankton, benthic invertebrates, and fish in the aquatic environments; and soil, floodplain and upland vegetation, and wildlife in the terrestrial environments. Specific objectives for individual monitoring program components are stated in the subsequent sections. Supporting summary tables and maps are also provided.

Since the original integration of these plans and submission of the CEMP on March 31, 2016, many iterations of the CEMP have been reviewed, revised, and submitted in 2016 and 2017. Pre-existing monitoring plans that were integrated into the initial CEMP and have subsequently been revised within CEMP revisions (instead of individually) are:

- The *Monitoring Plan for Discharge of Treated Effluent to Quesnel Lake via Hazeltine Creek* (MPMC 2016a);
- The *Annual Monitoring Plan* for surface water and groundwater (MPMC 2015a);
- The *Biological Monitoring and Lake Sampling Plan* (MPMC 2015b); and
- The *Post-TSF Breach Monitoring Plan – 2015 Revision 1* (MPMC 2015c), which references the *Post Breach Fish Tissue Collection Plan – 2015* (MPMC 2015d) and the *Sampling and Analysis Plan: Detailed Site Investigation and Human Health and Ecological Risk Assessment* (Golder 2015a).

[1] Pollution as defined in the BC EMA (S.1(1)) means "*…the presence in the environment of substances or contaminants that substantially alter or impair the usefulness of the environment*".

Previous results were used to inform and structure this version of the CEMP and are summarized below in their respective sections or provided in Appendix B, as appropriate. A summary of results along with a discussion is provided in each relevant section. Throughout the CEMP, references are made to semi-*x* monitoring. This refers to monitoring that occurs twice per unit time, for example semi-annual monitoring indicates twice per year, and semi-monthly monitoring indicates twice per month.

It is expected that monitoring will be updated from time to time, consistent with an adaptive monitoring program (see Section 2.3). When changes are made to the monitoring, this amended plan (or relevant replacement pages) will be resubmitted to the Director and MPMC's Implementation Committee.

Work plans will be developed for all future monitoring programs and submitted to the ENV at least 30 days prior to commencing the program. These programs will be developed by a Qualified Professional (QP) and will consider linkages and dependencies with existing programs using previous data and review of the CSMs, which are presented in Section 2.2.

2 Integration of Monitoring Activities

The CEMP integrates environmental monitoring programs being carried out at the mine to meet multiple requirements which have different drivers and, therefore, objectives. Figure 2.1 shows the linkage between these drivers and associated monitoring objectives, as well as the resulting monitoring components that addresses those objectives. Further discussion is provided on these linkages in the sections following.

Driver → Monitoring Objective → Monitoring Component

Ongoing Operations

Permit 11678

Permit M-200

EEM Program

1. Site water management
2. Treatment efficacy
3. Effluent limits are being met
4. Pollution is not being caused
5. MMER requirements are being met
6. Communication of findings to interested other parties

Special Purpose

Breach Response

Finalized:
- Post-Event Environmental Impact Assessment Report
- Detailed Site Investigation
- Human Health Risk Assessment
- Ecological Risk Assessment
- Remediation Plan

1. Quantification of impact in aquatic habitat
2. Quantification of impact in terrestrial habitat
3. Quantification of potential human health effects
4. Identification of remediation activities
5. Identification of habitat rehabilitation measures and success
6. Communication of findings to external parties

Future Purpose

Reclamation and Closure Plan (Permit M-200)

1. Confirmation that remediation activities are successful
2. Monitoring of site discharge and environment quality to confirm success of reclamation and closure activities
3. Identification of additional reclamation and closure activities that may be necessary

Mine Site
- Climate (precipitation, temperature)
- Dust
- Site water quantity and quality (chemistry)
- Influent quantity and quality (chemistry)
- Effluent quantity and quality (chemistry, toxicity)

Aquatic Environment
- Water quantity and quality (chemistry, toxicity)
- Sediment quality (chemistry, toxicity)
- Benthic invertebrate tissue chemistry
- Benthic invertebrate community
- Periphyton biomass
- Plankton chemistry
- Plankton community
- Fish condition
- Fish tissue chemistry
- Fish population
- Fish habitat

Terrestrial Environment
- Soil quality (chemistry, toxicity)
- Soil invertebrate community
- Invertebrate tissue chemistry
- Invertebrate community
- Plant tissue chemistry
- Plant community

Figure 2.1 CEMP integration framework

2.1 Monitoring Drivers and Objectives

There are three different drivers for current monitoring activities: ongoing operations, the TSF embankment breach response (special purpose program distinct from normal mine operations monitoring), and reclamation and closure planning (future purpose; note that some progressive reclamation has been done to date). These drivers and their associated monitoring objectives are described below. Previous monitoring results are continually reviewed to inform and structure the monitoring as well.

2.1.1 Ongoing Operations

Mount Polley Mine is an operational facility that is governed by provisions of the provincial EMA and *Mines Act* and the federal MDMER (a sector-specific regulation of the *Fisheries Act*). These permits and regulations contain specific requirements for on-going monitoring of site activities and downstream aquatic receiving environments. The objectives of ongoing operations monitoring are to:

1. Evaluate and plan for site water management.
2. Evaluate treatment efficacy to provide information for the ongoing management of the water treatment system installed at the time.
3. Verify that effluent limits are being met.
4. Verify that pollution is not being caused.
5. Verify that MDMER requirements are being met.
6. Communicate the findings to all interested parties.

Monitoring in accordance with conditions contained within BC *Mines Act* Permit M 200 is also summarized in the CEMP. This monitoring is only described in the CEMP for completeness purposes. Monitoring is summarized and future changes will be presented in CEMP revisions, but changes to this monitoring are subject to BC *Mines Act* Permit M-200 and not Section 7 in the CEMP or Section 5 in the CEMP TOR (Appendix A). This permit requires monitoring for metal leaching and acid rock drainage (ML/ARD) characteristics, water quality of on-site contact water (Section 6.11), and water quality of seeps from open pits and waste rock piles (Section 6.10). Permit M-200 also contains conditions related to reclamation and closure planning and monitoring. Results of monitoring conducted under the M-200 permit will continue to be reported annually, along with the monitoring results directed under the CEMP, in a combined AERR (Annual Environmental and Reclamation Report) that is submitted to ENV and the BC Energy, Mines, and Petroleum Resources (EMPR; formerly Ministry of Energy and Mines). Refer to Section 9 for information on reporting associated with the CEMP.

MPMC is also subject to the conditions of the BC *Water Sustainability Act* (which replaced the *Water Act* in 2016) that includes provisions related to sediment and erosion control and working around water. MPMC holds conditional water licences and is subject to Order 76930-40 following the TSF embankment breach, both of which were issued under the former *Water Act*.

2.1.2 Special Purpose

On August 4, 2014, a foundation failure of the Mount Polley TSF perimeter embankment occurred. ENV issued a Pollution Abatement Order (PAO) that specified the need for specific impact studies and monitoring to address impacts of the breach event, inform remedial measures, and evaluate changes over time. These studies are referred to as "special purpose" studies (now primarily monitoring) because they relate to a unique event with program objectives that differ considerably from an operating mine. The objectives of the special purpose monitoring are to:

1. Monitor and assess impact to aquatic habitat.
2. Monitor and assess impact to terrestrial habitat.
3. Monitor and assess potential human health risks.
4. Identify remediation activities needed to address identified impacts.
5. Identify habitat rehabilitation measures and related works as well as the success of those works.
6. Communicate findings of the impact assessment and ongoing monitoring to external parties.

2.1.3 Future Purpose

As an operating mine, MPMC is required to plan for eventual closure. Reclamation and closure monitoring takes place after the closure plan is implemented. Although progressive reclamation and reclamation research have already been initiated at the site, the Reclamation and Closure Plan (RCP) continues to be refined during operations in preparation for closure and is not yet finalized. However, in the context of a CEMP, future monitoring needs are appropriate to start considering. Because this CEMP is intended to be an adaptive plan, these will be updated as reclamation and closure planning progresses and greater certainty of locations, measurement endpoints, etc. are available.

The objectives of the future monitoring program are to:

1. Confirm that mine site reclamation activities are successful in achieving their stated objectives.
2. Monitor site discharge quality and receiving environment quality as appropriate to confirm that reclamation and closure works have been successful in preventing pollution and that discharges are compliant with applicable requirements.
3. Identify additional reclamation and closure activities that may be necessary.

Additional and more specific objectives will be developed as the reclamation and closure planning process progresses.

2.2 Monitoring Components and Conceptual Site Model

Figure 2.2 provides an overview of the Mount Polley Mine, in particular the CEMP study areas along with their respective monitoring components. Figure 2.3 and Figure 2.4 show greater detail of the TSF area and the mine site, respectively, of the sources of mine-contact water to the surrounding aquatic receiving environment and areas of ground disturbance. The measurement endpoints are detailed in the applicable sections later in this plan.

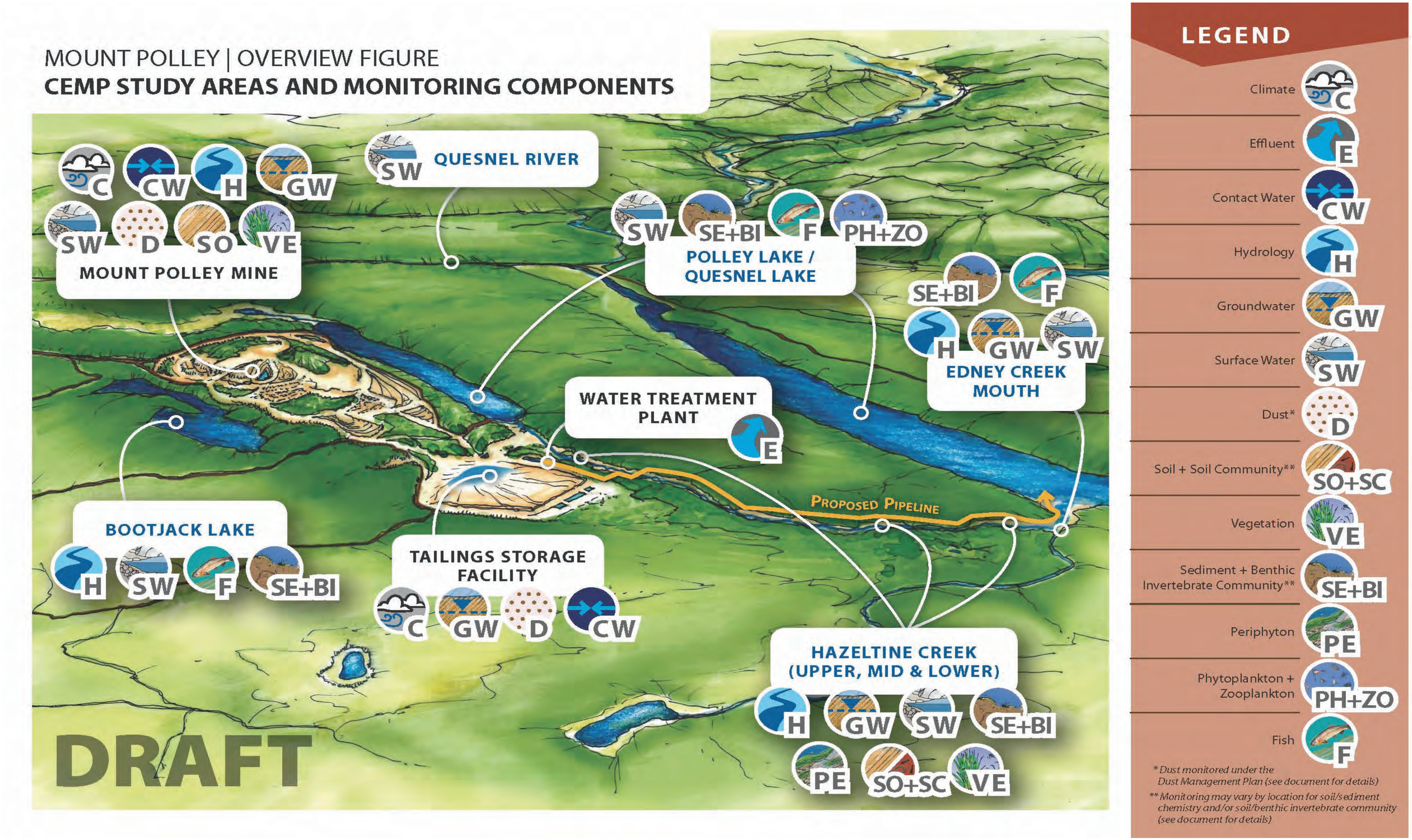


Figure 2.2 CEMP Study Areas and Monitoring Components

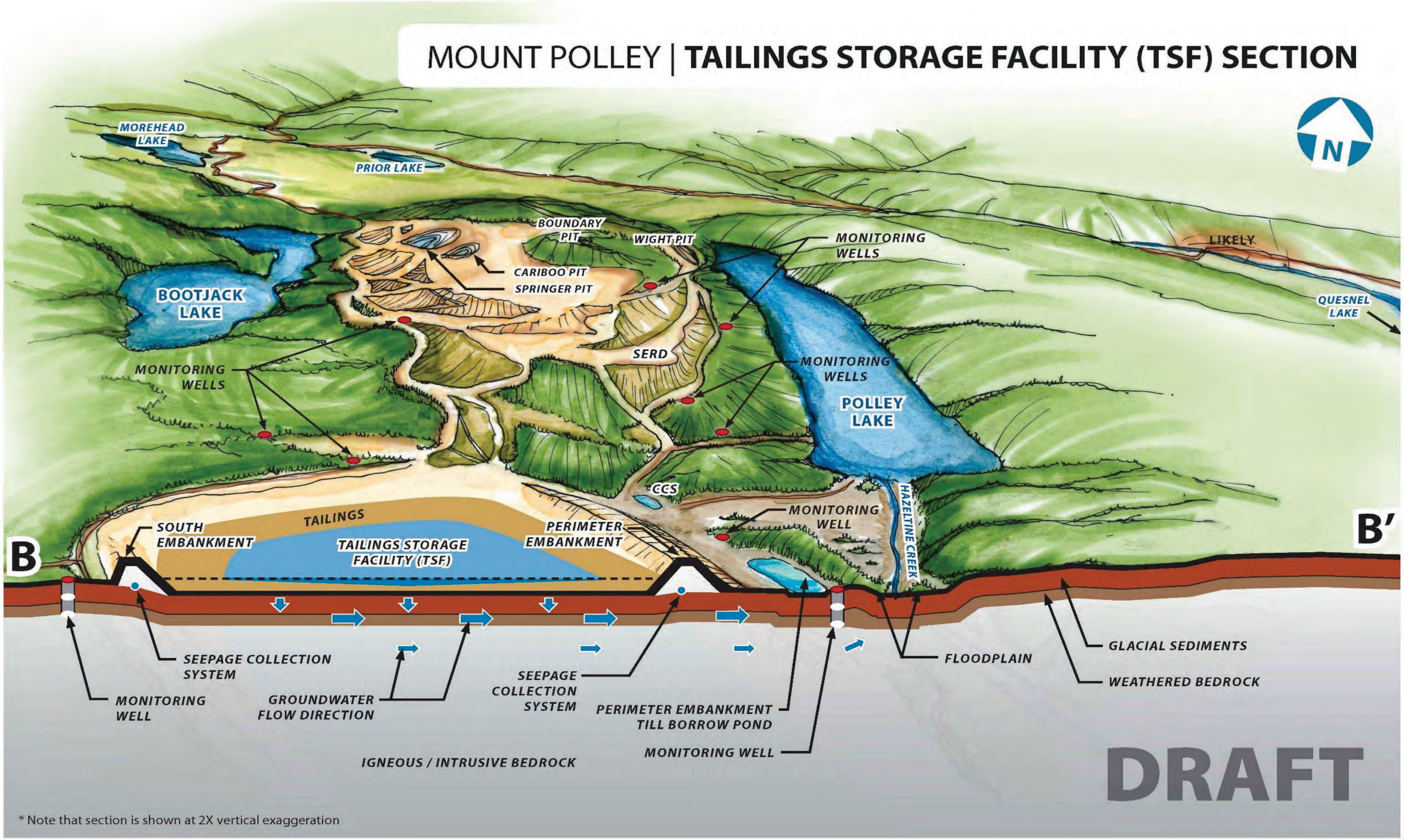


Figure 2.3 Tailings Storage Facility Section

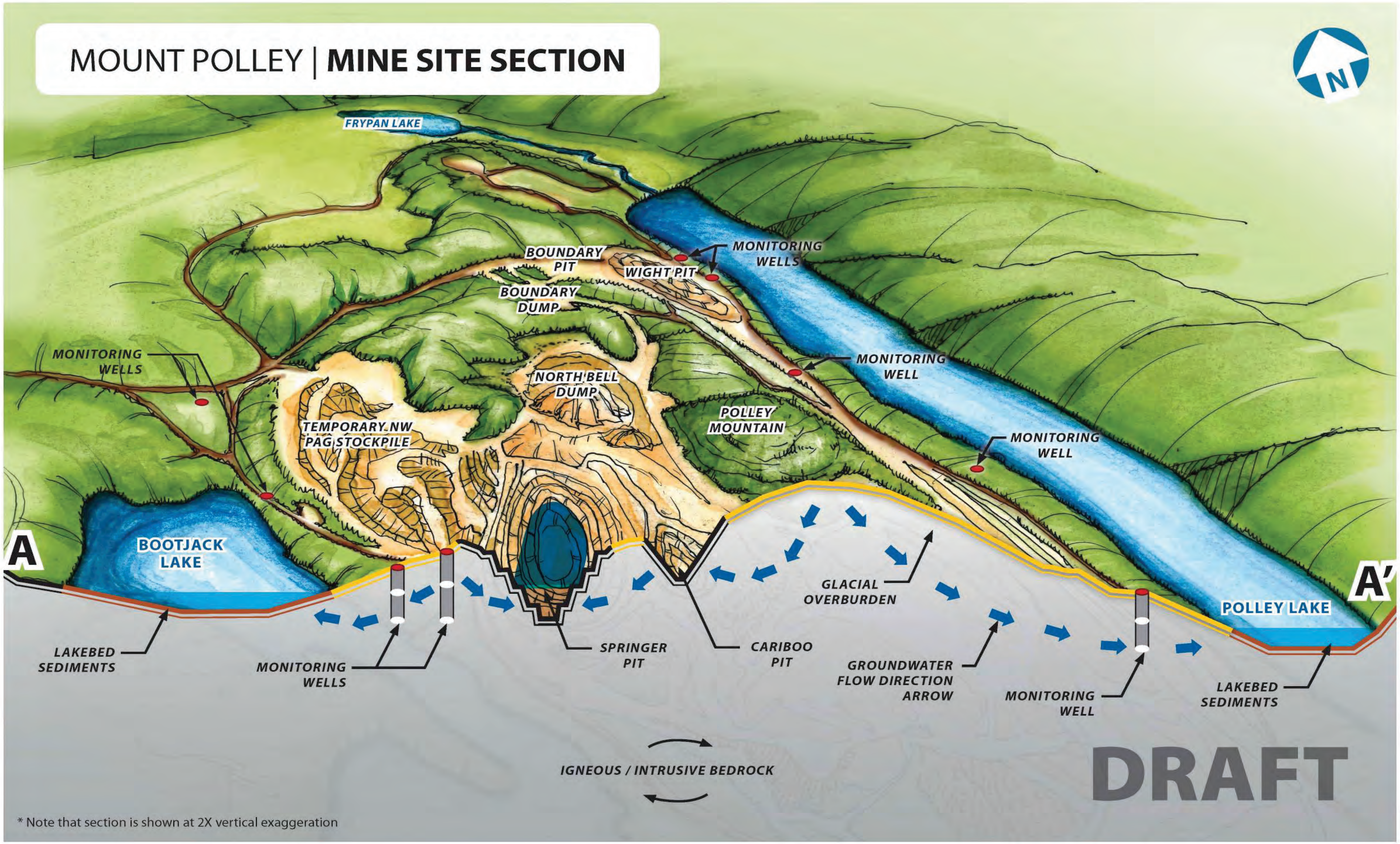


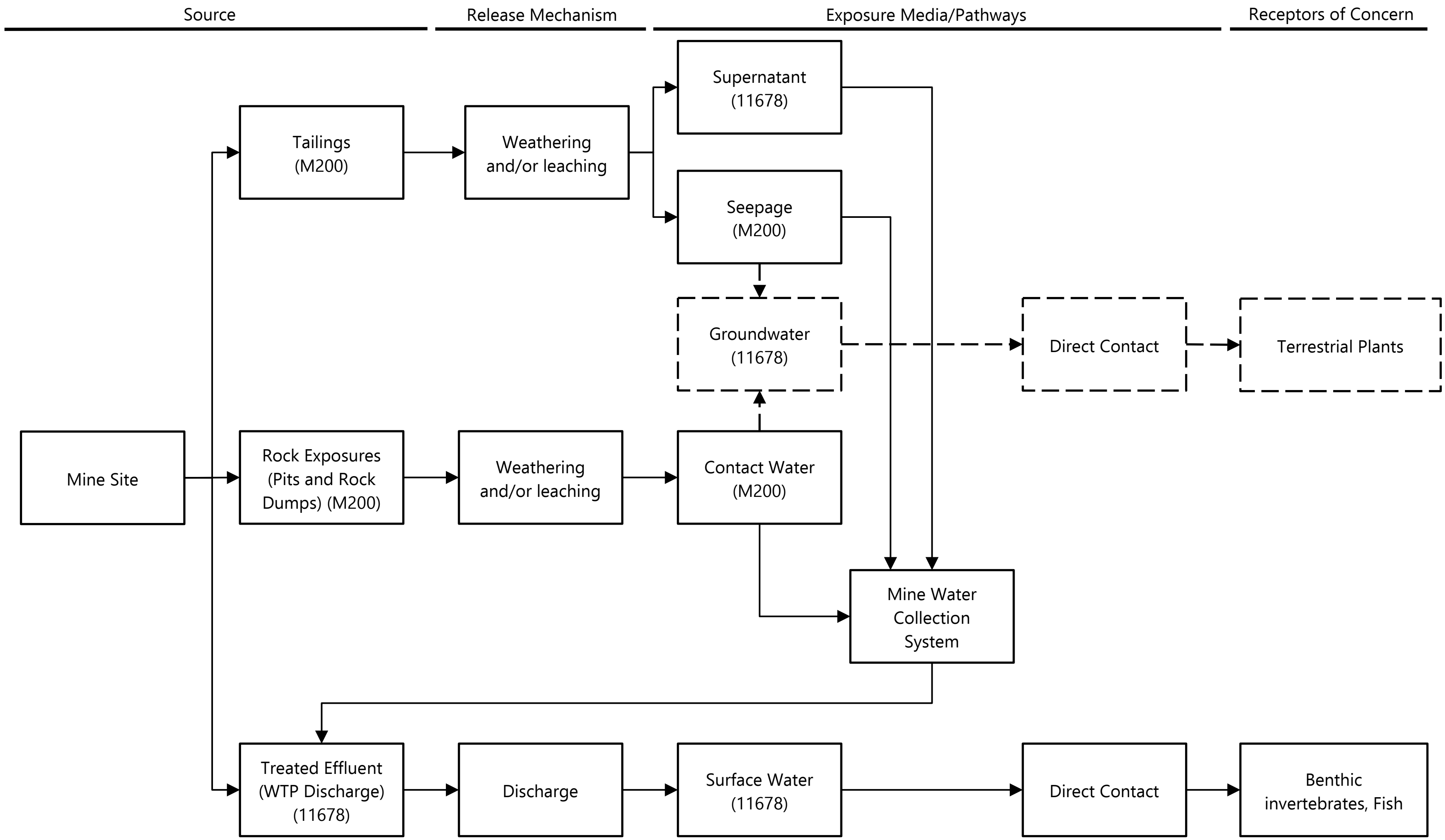
Figure 2.4 Mine Site Section

A CSM helps provide the basis for selecting appropriate monitoring components and suitable locations for those measurements. A CSM provides a graphical articulation of the understanding upon which the CEMP is based including movement of substances, pathways by which organisms (receptors) might become exposed to and interact with those substances in the environment. CSMs are often used in risk assessments to communicate similar concepts; however, in this CEMP, the focus of the study on specific constituents of potential concern (COPCs) has not been an objective because the monitoring program includes broader purposes and will include, for example, the full commercial analytical package for elemental analysis (frequently called "metals analysis"). Groups of substances that will be analyzed for, however, are those related to the potential sources. A CSM specific to the mine site was developed and is shown in Figure 2.5. A CSM for the TSF breach affected areas was developed for the Ecological Risk Assessment (ERA; Golder 2017) and is shown in Figure 2.6.

As discussed in Section 2.1.1, the mine has ongoing operational monitoring needs that centre on permit compliance that include management of site water and ultimately treated water discharges. The mine also needs to address disturbed ground through dust management in the short term. The measurable characteristics or components that contribute information to the stated monitoring objectives can then be identified as variables such as: precipitation and temperature (i.e., climate); dust; mine contact water, groundwater, and surface water quantity and quality; and influent and effluent quantity and quality. These are considered "Site" monitoring components (Figure 2.1). This information contributes to understanding the site water balance, function of site water collection systems, and management of the water treatment plant (WTP; e.g., capacity and treatment efficacy). This information is also useful in understanding the groundwater and seepage flow pathways to Bootjack and Polley lakes.

Ongoing operational activities at the site also have the potential to influence aquatic receiving environments related to effluent discharges. Under the long-term water management plan effluent is discharge from the WTP to Quesnel Lake. Relevant monitoring components for "Aquatic Habitat" include receiving water and sediment chemistry and toxicity, as well as biotic (e.g., plankton, benthos, fish) communities and tissue chemistry as summarized in Figure 2.1.

Following the TSF embankment failure in 2014, the environmental monitoring program was expanded to either incorporate additional monitoring components or increase the frequency of sampling. Many of the same existing operational monitoring components applied to this program and others were added. Additional measurements, related to physical impacts from the event, were collected to contribute to the Post-event Environmental Impact Assessment Report (PEEIAR) and to contribute to the Human Health Risk Assessment (HHRA) and the ERA. This "special purpose" monitoring information is relevant to the Remediation Plan for which an annotated table of contents has been submitted to ENV. As noted in the Risk Monitoring Considerations section of the ERA, further sample collection and evaluation of monitoring data will be done to further refine toxicity reference values for wildlife and confirm bioavailability of copper continues to be low and does not present a risk to wildlife.



<u>Notes:</u>
Solid lines indicate pathways that are likely to be complete or operative.
Dotted lines indicate pathways that are likely to be incomplete or inoperative.

Figure 2.5 Conceptual Site Model for the mine site

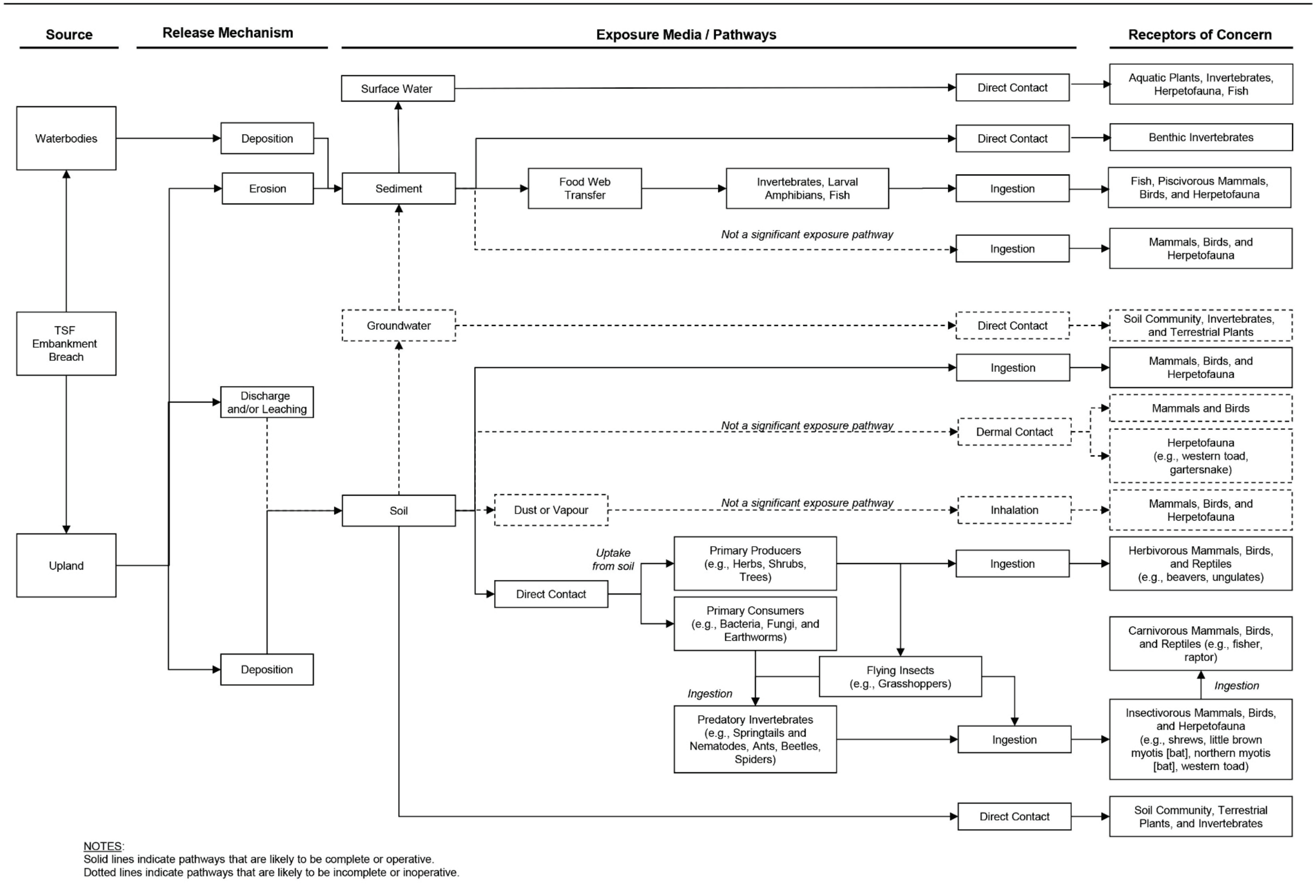


Figure 2.6 Conceptual Site Model for TSF breach affected areas, as developed for the ERA (from Golder 2017)

2.3 Adaptive Management Framework

The CEMP will be adaptive based on the results of ongoing operational and special purpose monitoring (illustrated in Figure 2.7) and based on the developing RCP. The adaptive framework recognizes that studies and monitoring can lead to new information that should be used to inform future monitoring. The framework provides feedback of this new information into the decision-making process that links monitoring and management actions that may need to be implemented to keep MPMC in compliance. For example, more immediate management actions may need to be undertaken in response to pre-defined triggers for unexpected changes in condition. The progressive implementation of the adaptive management framework will also include an annual review of the monitoring program to determine the potential need for revisions to planned sampling and analysis tasks. This review could include cessation of monitoring components that data show may no longer be necessary, or increase of monitoring based on changing conditions or monitoring results. Recommendations for monitoring related to the findings of post-breach-related studies have been included in this CEMP with the intention of forecasting monitoring that may be undertaken in the next three years. Monitoring for a specific year will be verified in monitoring program work plans following the adaptive management framework.

Figure 2.7 Adaptive Management Framework

3 FIRST NATIONS AND STAKEHOLDERS

3.1 FIRST NATIONS ENGAGEMENT

First Nations with recognized claimed traditional territory for the Mount Polley Mine are the T'exelc (Williams Lake Indian Band; WLIB) and the Xatśūll First Nation (Soda Creek Indian Band; SCIB). In 2011 and 2012, MPMC executed Participation Agreements with the WLIB and the SCIB, respectively. Through these respective Participation Agreements, Implementation Committees were formed to facilitate open dialogue between each of the First Nations and MPMC, providing a formalized and regular venue to discuss environmental, social, and economic matters related to mine development, operation, reclamation, and closure (e.g., mine updates, permitting, environmental protection, reclamation, employment opportunities, and potential joint ventures). Meetings with the WLIB have taken place since March 16, 2012 and since July 19, 2012 with the SCIB. Effective October 18, 2012, Joint Implementation Committee meetings have been held with representatives from MPMC, the WLIB, and the SCIB, replacing the previous MPMC/SCIB and MPMC/WLIB Implementation Committee meetings. Joint Implementation Committee meetings are held at minimum quarterly, but typically more frequently. These meetings and associated documentation (TOR, minutes, and action items) provide a well-defined, constructive forum in which issues, reviews, and comments relating to the current and anticipated future operations of the Mount Polley Mine may be discussed. This CEMP and the AERR will be provided in their current form to the SCIB and the WLIB for review, and discussion regarding any comments or concerns will be facilitated through the Joint Implementation Committee.

3.2 PUBLIC LIAISON COMMITTEE

The Public Liaison Committee (PLC) for the Mount Polley Mine was formed in 1999, and meetings have been maintained through the operating years of the Mine. Meetings were historically scheduled in conjunction with updates on proposed developments and projects, with a minimum frequency of one meeting per year. An annual PLC meeting became a requirement of the Permit in 2013 and quarterly meetings became a requirement in 2015. The PLC is intended to provide an opportunity for MPMC to share information about mine activities and the results of monitoring programs with its members, and for members to share such information with their respective membership. The PLC does not replace or diminish the use of other communication procedures that MPMC will use regularly to inform the public, including but not limited to: public meetings, newsletters, emails, and internet websites. The PLC is seen as a medium to add value to parties with interest in the Mount Polley Mine, including, but not limited to: MPMC and its personnel, the public and public interest groups, local communities, First Nations, and regulators.

3.3 COMMUNICATION PLAN

The Permit requires a Communication Plan between MPMC and the WLIB, SCIB, Cariboo Regional District, and the Community of Likely to be in place. The original Communication Plan was submitted to the Director (ENV Statutory Decision Maker) on March 20, 2016 and was approved by the Director on May 11, 2016. The amended Permit required that an updated Communication Plan be submitted by June 30, 2017. The final Communication Plan was submitted to ENV on March 20, 2016.

4 MOUNT POLLEY MINE PROJECT OVERVIEW

4.1 PROJECT HISTORY

Mount Polley Mine, operated by MPMC (a wholly-owned subsidiary of Imperial Metals Corporation), is an open pit copper/gold mine with an underground component, and has the capacity to process 20,000 to 22,000 tonnes per day (tpd) of ore. The Mount Polley property covers 18,892 hectares (ha), which consist of seven mining leases totaling 2,007 ha, and 43 mineral claims encompassing 16,855 ha, as of March 2018.

Clearing of the site and construction of the entire facility began in 1995, with the mill being commissioned in June 1997. In May 1997, the Mine received an ENV (known as the Ministry of Water, Land and Air Protection at that time) Effluent Permit, issued under the provisions of the provincial EMA. This permit authorized the discharge of concentrator tailings, mill site runoff, mine rock runoff, open pit water, and septic tank effluent to a tailings impoundment. Approval of the "Mount Polley Mine Reclamation and Closure Plan" by the EMPR resulted in the issuance of Permit M-200 in July 1997. The first full year of mining and milling at Mount Polley Mine took place in 1998. The mine suspended operations in October 2001 due to low metal prices, then reopened in December 2004 with mill production commencing again in March 2005. A summary of Permit 11678 amendments is provided in Table 4.1.

Table 4.1 Summary of Permit 11678 amendments

Date	Scope of Amendment
30-May-1997	Original permit
20-Oct-1997	Amended authorized tailings discharge rate (10,000 tpd increase)
12-Jun-1998	Amended reporting requirements
08-Sep-1999	Amended monitoring requirements
01-Feb-2000	Amended authorized tailings discharge rate (4,500 tpd increase)
07-Feb-2002	Approval to discharge effluent from the PESCP and MESCP; approval to store TSF supernatant and Mine Site contact water in the Cariboo and Bell Pits
04-May-2005	Amended authorized tailings discharge rate (5,000 tpd increase); discharge of groundwater to Polley Lake; updates to reference analytical procedures and monitoring program
17-Apr-2009	Amended monitoring, water level and supernatant characteristic requirements for the Cariboo and Bell Pits
07-Nov-2012	Approval to discharge to Hazeltine Creek
07-Jun-2013	Sulphate guidelines
09-Jul-2015	Tailings discharge to the Springer Pit
29-Nov-2015	Approval to discharge to Hazeltine Creek
04-Apr-2016	Discharge of additional tailings to the Springer Pit
09-Sep-2016	Hazeltine Creek discharge total suspended solids limit change
07-Apr-2017	Approval to discharge directly to Quesnel Lake

Notes: tdp: tonnes per day; PESCP: Perimeter Embankment Seepage Collection Pond; MESCP: Main Embankment Seepage Collection Pond; TSF: Tailings Storage Facility

As a result of a foundation failure of the perimeter embankment of the TSF on August 4, 2014 (see Section 2.1.2), the mine was placed in care and maintenance until August 5, 2015, when restricted operations under a short-term permit commenced. This restricted operations permit allowed processing of up to 4 million tonnes of ore over a one-year period, with tailings deposition into the Springer Pit.

The Mount Polley Mine became subject to the MDMER on April 10, 2014, following a planned discharge of mine effluent into Hazeltine Creek. The MDMER are also applicable to the long-term discharge approved for the Mount Polley Mine.

4.2 Current Operations

MPMC was granted full restart permits on June 23, 2016 and has been operating at full capacity since June 27, 2016. The Mount Polley Mine site includes a crusher and mill (includes office spaces), a TSF, waste rock disposal sites, seepage collection ponds, haul roads, access roads, and various small buildings and storage areas (Figure 4.1). Concentrate is transported by truck from the site to the Port of Vancouver, where it is shipped to smelters overseas.

4.3 Environment

4.3.1 Topography and climate

The Mount Polley property is located on the eastern edge of the Fraser Plateau physiographic sub-division, characterized by rolling topography and moderate relief. Elevations range from 920 metres above sea level (masl) at Polley Lake to 1266 masl at the summit of Mount Polley. Volcanic rocks generally underlay this part of the plateau with inclusions of intrusive rocks. Most of the area is covered by a deposit of unconsolidated till which contains fluvial, lacustrine, and colluvial deposits. Some patches of organic soils are present in poorly drained areas (i.e., wetlands). The property is located in an alkali porphyry copper-gold deposit hosted in the Central Quesnel Belt along the Intermontaine Belt of BC.

The site is located within the Interior Cedar Hemlock biogeoclimatic zone. Local forests consist of Western red cedar, Douglas-fir, hybrid spruce, and subalpine fir, with a lesser presence of trembling aspen, black cottonwood, and paper birch. Much of the area has been harvested in commercial logging operations and is also used for cattle grazing.

Average annual precipitation in the study area is 670 millimetres (mm). Precipitation typically occurs as snowfall from November through March, with an average maximum of snowpack of 178 mm snow water equivalent occurring at the end of March (Golder 2015b). Average monthly temperatures at the Mount Polley Mine range from -6.0 degrees Celsius (°C) in January to 15.3°C in July and August (MPMC 2016b). Prevailing winds are from the north-north-east and from the south-south-west near the TSF, and from the northwest (and to a lesser extent the southeast) near the mill, with a predominance of winds designated as calm (below 3 metres per second; Golder 2015b).

Figure 4.1 Mount Polley Mine site facilities

4.3.2 HYDROGEOLOGY

The groundwater flow at the site occurs primarily in the bedrock units in response to recharge from precipitation in the area between Polley Lake and Bootjack Lake. Flow in the overburden is less significant due to its limited thickness and discontinuous nature. Prior to mining, the water table at the site generally followed the surface topography, but the water table was deeper below the topographic heights and shallower in the low areas. At that time, the direction of groundwater flow was inferred to be from the top of the ridge between the Polley Lake and the Bootjack Lake towards the low lying areas associated with these lakes northeast and southwest from the ridge.

Mine dewatering has altered the groundwater flow pattern at the site, with the open pit and underground workings acting as sinks for groundwater flow. Mine dewatering lowered the water table elevation and created radial patterns of groundwater flow towards these facilities. Following the formation of the pit lake in the Cariboo Pit, seepage from this pit started to provide a contribution to groundwater inflow to the Springer Pit. At present, Springer Pit and Cariboo Pit continue to act as groundwater sinks. The currently available information suggests that some seepage from the Springer Pit lake towards Bootjack Lake occurred when the pit lake level exceeded 1030 m elevation in 2016 (Golder 2016b).

4.3.3 DRAINAGE AND HYDROLOGY

The mine is located on the divide of two sub-watersheds within the Quesnel Lake watershed. Quesnel is a large, deep fjord lake with a surface area of 255 square kilometres (km^2), and is composed of East, West, and North Arms. It is the deepest fjord-type lake in the world, with a maximum depth of more than 511 m in the East Arm (Laval et al. 2008). The West Basin is a shallower (113 m maximum depth) portion of the west arm that is demarcated in the east by a shallow sill near Cariboo Island that is approximately 35 m deep (Laval et al. 2008). The lake drains to the west via the Quesnel River to the Fraser River. The Horsefly River, Mitchell River, and Niagara Creek are the main tributaries to Quesnel Lake, entering from east of the sill.

The western watershed, which includes drainage from Bootjack Lake, Trio Lake, and Morehead Lake, discharges to Quesnel River via Morehead Creek and drained approximately 60% of the Mount Polley area prior to mine construction.

The eastern watershed includes Polley Lake (surface area of 3.8 km^2), which discharges to the east via Hazeltine Creek and then to the western arm of Quesnel Lake. The Hazeltine Creek and Edney Creek watershed areas at Quesnel Lake are currently approximately 30.2 km^2 and 87.4 km^2, respectively. Approximately 10.5 km^2 that historically reported to this watershed is now within the mine contact water runoff collection system catchment.

Bootjack Creek is a small tributary that previously flowed into Hazeltine Creek downstream of Polley Lake. Following the TSF embankment breach, Bootjack Creek was re-routed to Polley Lake; fish access is currently restricted. Historically, Bootjack Lake (surface area of 1.2 km^2) discharged into Hazeltine Creek via Bootjack Creek, but in 1913 a dam was constructed at the south end of Bootjack Lake and the flow direction was reversed in order to direct water into Morehead Lake for hydropower production. This resulted in 14 km^2

being diverted from the Hazeltine Creek catchment. The Morehead Creek watershed, including the Bootjack Lake catchment area, is approximately 11.2 km^2. Approximately 2.3 km^2 that historically reported to this watershed is now within the mine contact water runoff collection system catchment.

Pre-mining watersheds are shown in Figure 4.2. In general, the hydrology of the Mount Polley area is snowmelt driven, with the majority of annual runoff occurring in April and May during snowmelt (i.e., freshet; Knight-Piésold 2014).

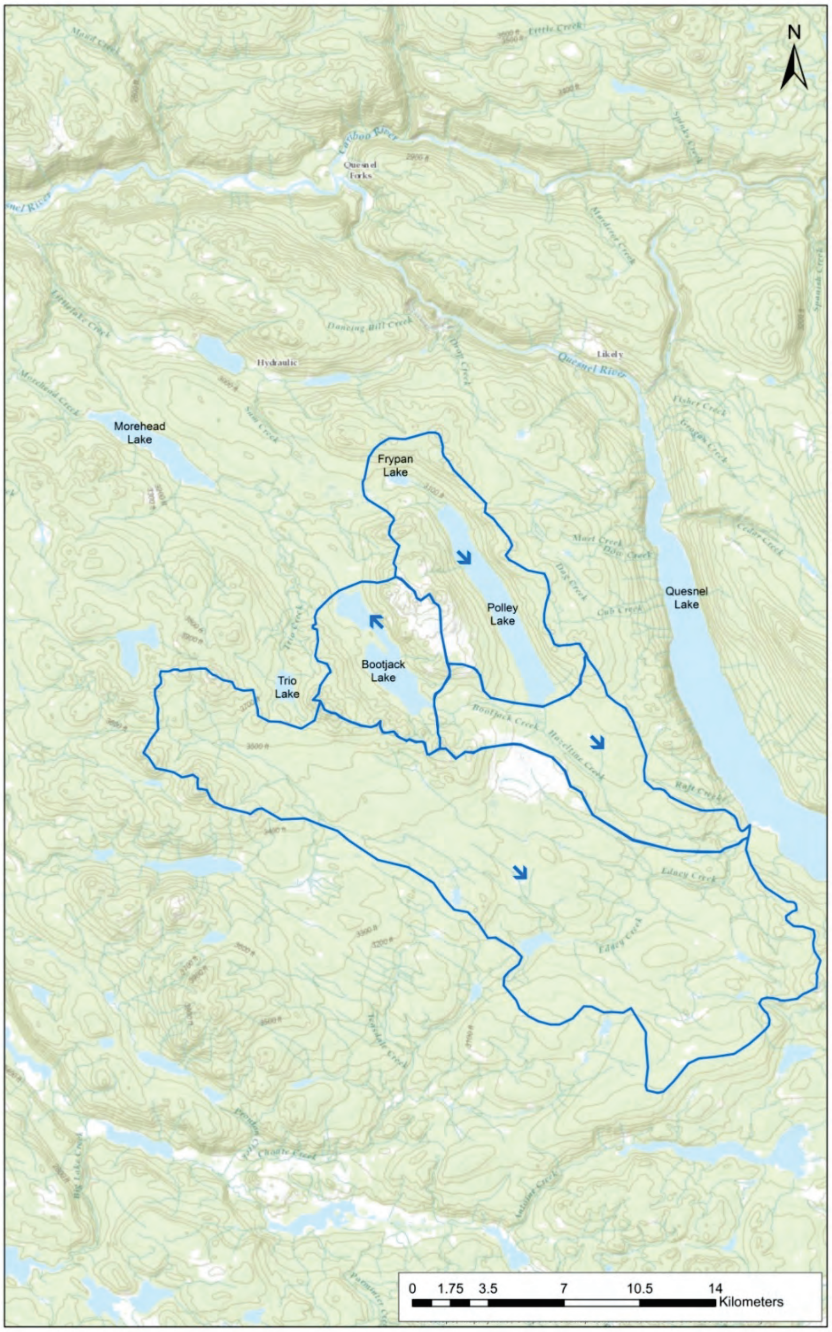


Figure 4.2 Mount Polley area pre-mining watersheds

5 ENVIRONMENTAL MANAGEMENT

5.1 WATER MANAGEMENT

To protect natural watercourses from mine-influenced contact water from roads, haul roads, waste rock piles, and other Mine areas, water is collected in a system of ditches and sumps located around the Mine site. Based on site water management objectives, site contact water is either pumped directly to the TSF or reports to the gravity-driven sections of the West Ditch or Long Ditch, the latter two of which both flow to the Central Collection Sump (CCS). Water in the CCS is currently allowed to overflow to the Perimeter Embankment Till Borrow Pond (PETBP) where it is pumped to the WTP or can be returned to the TSF. Pumping infrastructure also exists at the CCS such that it can be directed to the TSF. Water from the TSF is primarily pumped to the Mill via the Booster Station to meet process requirements, but can also be diverted to the CCS. A map of water collection infrastructure, including site collection ditches (including flow direction) and sumps, is shown in Figure 5.1. All water, primarily rain and snow melt, ultimately reports to the PETBP from which it is pumped to the WTP. At the time of writing, any contact water that requires temporary storage on site (i.e., when flows exceed those able to be treated and discharged) is pumped to the TSF. Tailings and process water from the Mill reports by gravity from the Mill to the TSF.

The Mount Polley site has a positive water balance, and a permit for a long-term water discharge system was received on April 7, 2017. Treatment is conducted for removal of suspended solids and associated metals using a Veolia ACTIFLO® system, which is described in detail in Section 5.1.2. Under the long-term water management strategy, treated mine effluent is discharged to Quesnel Lake via a direct pipeline to the submerged diffusers installed in the lake. A continuous discharge of up to 0.6 m^3/s, with an annual average of 0.33 m^3/s is currently permitted until December 31, 2022.

5.1.1 ANNUAL DISCHARGE PLAN

Permit 11678 requires the yearly submission of an Annual Discharge Plan (ADP). The intent of the plan is to identify the specific sources and quantities of water that will be discharged; however, the discharge system (which is described in Section 5.1.2) at Mount Polley is not designed to be able to solely discharge from specific sources and it is not realistic for MPMC to estimate the volumes of precipitation that will occur from year to year. The overall water management at the mine is described in detail in the Long-Term Water Discharge Technical Assessment Report (TAR) that was submitted to ENV October 17, 2016 (Golder 2016e).

5.1.2 DISCHARGE SYSTEM

The WTP sources water from the PETBP. During treatment, the feed water of the WTP undergoes suspended solids removal using Veolia ACTIFLO® water treatment technology. The WTP doses the raw water with coagulant to a tank where a polymer is injected to create floc particles. Microsand is added to ballast the flocculants, which move on to another tank that allows them to swell and mature. The water flows to the next stage, which uses lamella to clarify the water and promote fast settling of the microsand ballasted sludge. The clarified water is discharged and the sludge is separated from the microsand, which is reused.

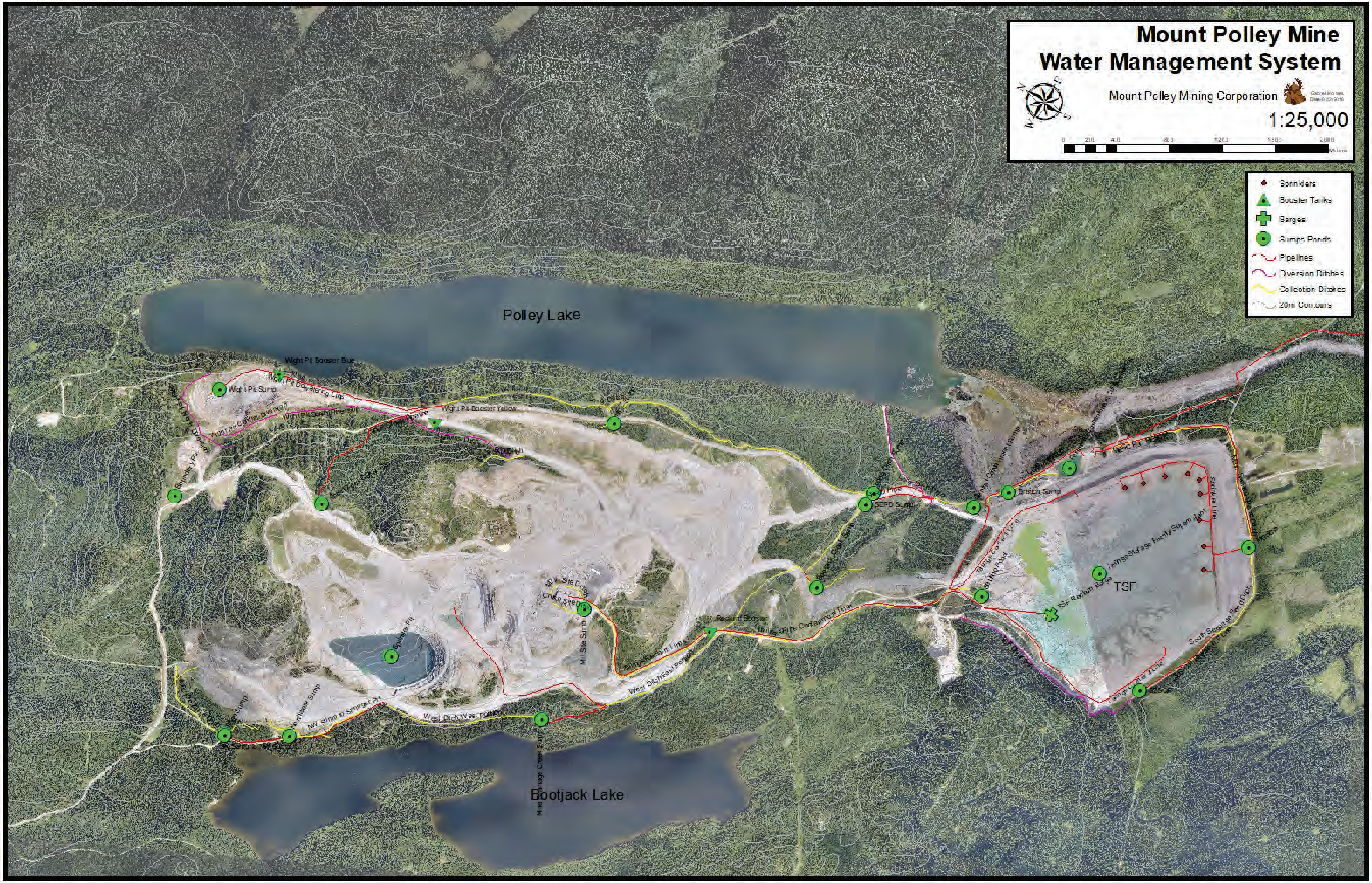


Figure 5.1 Mount Polley Mine water management system

An on-line turbidity meter measures the turbidity every ten seconds, where the WTP human-machine interface calculates the total suspended solids (TSS) using a calibrated factor based on a site-specific correlation between turbidity and TSS for the treated effluent. If the calculated on-line TSS is greater than 13 mg/L for 10 minutes, or greater than 14 mg/L instantaneously, an alarm sounds to alert the operator and the WTP automatically goes into recirculation mode and ceases discharge.

Treated water from the WTP is discharged, by gravity, to Quesnel Lake via a pipeline (installed as of November 2017) connected to two submerged diffusers. Effluent discharge to the Hazeltine Creek channel ceased as of September 30, 2017.

5.2 Sediment and Erosion Control Management Plan

MPMC has developed a RCP that has been submitted to EMPR under the *Mines Act* Permit M-200. This plan includes several Environmental Management Plans including a Sediment and Erosion Control Plan.

5.3 Invasive Plant Management Plan

MPMC developed an Invasive Plant Management Plan in 2010 and has regularly updated this plan to include newly disturbed areas and to follow the Cariboo Regional District Strategic Plan for Invasive Plant Management. This plan is included in the RCP.

5.4 Dust Management Plan

MPMC maintains a Dust Management Plan that is also included in the RCP.

5.5 Project Environmental Monitoring Plans

MPMC develops a project specific Environmental Monitoring Plans (EMPs) for any development project that has potential to impact the environment. The requirement for these EMPs is outlined in the Erosion and Sediment Control Plan (Section 5.2).

5.6 Waste Management

MPMC recognizes the value of responsible waste management and recycling. MPMC Recycling and Waste Management Awareness presentations are given to Mount Polley employees annually and MPMC promotes several recycling programs for used materials including waste oil, scrap steel, batteries, plastic pails, electronic waste, light bulbs and associated fixtures, paper, cardboard, and beverage containers. Waste management information is also presented to employees and contractors during site orientation. Each year, Mount Polley donates the funds generated by its beverage container recycling program to local charities.

In the course of its ongoing operations, Mount Polley utilizes potentially hazardous chemicals, reagents, and other products. Sumas Environmental Services Ltd. routinely removes and disposes of these waste products in an environmentally safe manner compliant with all relevant waste management legislation. Products removed include: aerosol cans; contaminated gasoline and diesel; waste oil (in drums); waste oil filters; waste grease fuel or oil soaked rags, debris, and floor dry; and leachable liquid toxic waste, such as glycol/anti-freeze mix. The site waste oil tanks are emptied and the oil removed from site by a third party contractor. MPMC is registered (BCG-01559) with the ENV under the *Hazardous Waste Regulation* for generation and temporary storage of these materials.

5.7 Incident Reporting

All non-compliance incidents are reported to the Director or to Emergency Management BC. All incidents are recorded and tracked, and are included in the AERR. As outlined in the Communication Plan (see Section 3.3) and required by Section 2.5 of the permit, incidents or emergencies that have the potential to have adverse impacts on the environment will be reported to the SCIB, WLIB, Cariboo Regional District and community of Likely.

5.8 Inspections

MPMC Environmental Department staff conduct weekly inspections on the site with a focus toward regulatory compliance and waste management (Section 5.6). These inspections are documented and communicated regularly to the site management and their respective departments. Guidance is provided by the Environmental Department for proper internal reporting and follow-up. The goal of these inspections is to provide all departments the capability to engage in proper environmental management practices and open lines of communication with the Environmental Department.

6 MONITORING

The subsections below outline general procedures at MPMC for scheduling of environmental monitoring and data review and management. Field methods, laboratory analysis, data quality control and objectives, as well as data analysis methods are included in the following sections with their respective monitoring components. Note that frequencies may change due to weather conditions or construction work and will be dependent on accessibility and, most importantly, safety of the field crews. Declarations of Competency for relevant Qualified Professionals are provided in Appendix E.

6.1 SCHEDULING

To coordinate sampling and schedule all planned monitoring, as per the CEMP, MPMC prepares internal monthly sampling schedules. An example monthly sampling schedule has been included as Appendix C.

6.2 FIELD METHODS

Monitoring procedures that will be used in carrying out the CEMP are consistent with the *BC Field Sampling Manual for Continuous Monitoring and the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment, and Biological Samples* (2013 or most recent version, herein referred to as the "BC Field Sampling Manual"; MoE 2013a). As appropriate, monitoring procedures will also be consistent with the *Metal Mining Technical Guidance for Environmental Effects Monitoring* (Environment Canada 2012) and the *Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators* (MoE 2012). MPMC's procedures are also consistent with applicable sections of the *British Columbia Environmental Laboratory Manual* (MoE 2015), such as sample collection and preservation requirements.

Quality assurance/quality control (QA/QC) methods will follow procedures outlined in the *MPMC Environmental Department QA/QC Manual* (most recent version: MPMC 2016c, herein referred to as the "QA/QC Manual", developed for the Mount Polley Mine. This manual provides detailed Standard Operating Procedures (SOPs) and Work Methods (WMs) of the protocols for environmental monitoring at MPMC and is a requirement of the Permit (April 7, 2017: Section 3.8). Procedures described in the manual are consistent with the BC Field Sampling Manual (MoE 2013a). The QA/QC Manual is reviewed and updated as appropriate (at minimum annually) to reflect changes to the ENV procedures and recommendations, and industry best practices. Should the manual be updated, the ENV Environmental Protection Division will be notified within 30 days of implementation as required by the Permit.

The QA/QC Manual protocols include collection of samples by trained personnel using standardized procedures, and use of field notebooks and chain of custody forms for sample documentation and tracking. These protocols are summarized for the different CEMP monitoring components below, where appropriate.

6.3 LABORATORY ANALYSIS

Sample analysis will be conducted at a laboratory registered for the designated parameter under the *Environmental Data Quality Assurance Regulation*. MPMC will participate in QA audits as required by the regulation.

6.4 Data Quality Review and Data Management

A data quality review of results will be conducted, including screening of laboratory QA/QC data, sample integrity issues, detection limits achieved, and metadata accuracy, as well as potential outliers/extreme values. This information will be catalogued in the MPMC sample tracking spreadsheets and the laboratory is contacted if any problem is identified. Water, soil, sediment, and tissue chemistry data as well as weather station data will be uploaded into the MP-5 database using files generated by the analytical laboratory. Accompanying field data will be manually entered and uploaded into the MP-5 database. Original laboratory-produced results files are filed on the MPMC network by date, and are linked to the data stored in the MP-5 database. Field data undergo a QC screening prior to upload and parameter restrictions are in place to reduce the likelihood of a typographical or laboratory reporting error being uploaded.

Non-chemistry data, including toxicity testing results, benthic invertebrate and plankton taxonomy data, and hydrology data (logger downloads and FlowTracker exports) are filed according to year and site on the MPMC network.

6.5 Climate Monitoring

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.5.1 Section Authors and Study Component Design Professionals

This section was written by MPMC and is guided by Section 3.6 of the Permit (April 7, 2017).

6.5.2 Monitoring Objectives

The objective of the climate monitoring program is to track site weather data to support maintenance of the site water balance, water flow and accumulation predictions, and the design of water management infrastructure. Climate data are also considered important basic site characterization information that inform a number of other activities, such as reclamation revegetation prescriptions or building snow load requirements. Climate monitoring is also required under the Permit Section 3.6 (April 7, 2017).

6.5.3 Monitoring Overview

MPMC maintains two automated HOBO weather stations. Both stations are connected via telemetry allowing real time viewing of weather conditions. Four snow course sites are located around the mine site to target different exposure conditions. Table 6.1 provides an overview of the climate monitoring. Further details of monitoring sites, including site access descriptions, access or safety concerns, and a brief rationale for monitoring, is provided in the Site Matrix in Appendix D. Figure 6.1 shows monitoring locations of the meteorological monitoring locations.

Table 6.1 Climate monitoring overview

Station Name	EMS Code	Description	Frequency	Parameters Measured	Guidelines
Weather Station #1	N/A	Continuous monitoring weather station beside tree plots near Mill Site	Logged every 5 minutes	Temperature, wind speed and direction, solar radiation, relative humidity, rainfall	N/A
Weather Station #2	N/A	Continuous monitoring weather station adjacent to the TSF	Logged every 5 minutes	Temperature, wind speed and direction, solar radiation, relative humidity, rainfall	N/A
JCP	N/A	Snow course site located east of the start of the Long Ditch in a clearing	End of month and after major snowfall and melting events	Snow depth, snow volume	N/A
Weather Station #1	N/A	Snow course site located near Weather Station #1	End of month and after major snowfall and melting events	Snow depth, snow volume	N/A
PAG Stockpile	N/A	Snow course site located beside the NW sump	End of month and after major snowfall and melting events	Snow depth, snow volume	N/A
TSF	N/A	Snow course site located near Weather Station #2, near the TSF	End of month and after major snowfall and melting events	Snow depth, snow volume	N/A

Notes: N/A: not applicable, TSF: tailings storage facility, JCP: Joe's Creek Pipe, PAG: potentially acid generating; NW: Northwest

Figure 6.1 CEMP monitoring locations: Climate monitoring

6.5.4 High-Level Monitoring Design Description

Meteorological monitoring will occur as per the SOPs and WMs for Meteorological Data Collection and Snowpack Measurements in the QA/QC Manual. There are two automated HOBO weather stations located on the mine site that continuously record wind speed and direction, precipitation, solar radiation, relative humidity, and temperature. Evaporation is calculated based on data collected from these stations. The data are downloaded from the automated weather stations monthly or as required by remote radio telemetry. If necessary, data are also stored for 30 days on the weather logger and can be downloaded manually using a data shuttle.

The snowpack measurement method will change in 2018 to align with the *Snow Survey Sampling Guide* written by ENV (MoE 2016). A workshop will be given to the Environmental Staff at first snowfall in fall 2018. The SOP and WM for Snowpack Measurements will be updated at this time and submitted to ENV for review.

Table 6.2 is a summary of previous climate monitoring undertaken and includes recommendations for future monitoring. Further rationale is provided in the following sub-sections, if appropriate, and is referenced in the table where applicable.

Table 6.2 Summary of climate monitoring

Summary of Monitoring and Findings	**Monitoring Objective**		
	Operational	**Post-Breach**	**Reclamation**
Previous monitoring undertaken	Two weather stations collect temperature, wind speed and direction, solar radiation, and precipitation data. Snowpack data was collected at four representative snow course sites. The weather and snow course stations are situated to encompass the topographical and geographic range of the mine site.	N/A	N/A
Summary of findings	Weather data collected were compared to site averages. Evaporation was calculated using measured parameters.	N/A	N/A
Recommendations for 2018-2020 monitoring	The snowpack measurement method will be changed to align with the *Snow Survey Sampling Guide*. The program will otherwise continue unchanged because the two current weather stations and snow course sites provide adequate information for the conditions on site.	N/A	N/A

Notes: N/A – not applicable

6.5.5 Data Quality Control, Objectives, and Review

Data ranges are set in the MP-5 database to detect erroneous data collected during station malfunctions. Weather station data that are erroneous (e.g., sensor malfunctions) will be investigated.

6.5.6 Laboratory Analysis

No laboratory analysis is required for climate monitoring.

6.5.7 Data Analysis and Reporting

Climate statistics, including mean, minimum, and maximum temperature, will be calculated and reviewed monthly. Daily evaporation is calculated using the Penman-Monteith equation for open water in the WaSIM software (developed by Cranfield University), based on data collected from the weather stations and site-specific factors, such as weather station elevation. These data are reported annually in the AERR.

6.6 Surface Water Monitoring

Surface water monitoring is characterised below into the following locations: Hazeltine Creek, streams and creeks adjacent to the mine site (receiving environment of the mine site), Bootjack Lake, Polley Lake, Edney Creek, Quesnel Lake, and Quesnel River.

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.6.1 Section Authors and Study Design Professionals

The mine site environmental monitoring was developed during the Environmental Assessment process in 1995, which included input from several QPs. For the purpose of the CEMP, MPMC will continue to monitor with the understanding that this program is well-established to monitor any mine-related effects. The mine site monitoring described below was written by MPMC.

6.6.2 Monitoring Objectives

The objective of water chemistry monitoring in Hazeltine Creek is to evaluate the Hazeltine Creek aquatic environment following the TSF embankment breach and track changes to the aquatic environment over time and/or as a result of implementation of rehabilitation and sediment and erosion control work.

The objective of water chemistry monitoring in streams and creeks adjacent to the mine site, as well as Bootjack Lake and Polley Lake, is to identify water quality changes in waterbodies that run through or are adjacent to the mine site to assess efficacy of the mine water management systems and to stimulate applicable management actions.

The objective of water chemistry monitoring in Polley Lake, Quesnel Lake, and Quesnel River is to support ongoing evaluation of water chemistry following the TSF embankment breach in the downstream environments.

The objective of water chemistry monitoring in Quesnel Lake at the boundary of the initial dilution zone (IDZ) is to verify that the discharge of treated effluent is not causing an exceedance of the applicable ambient BC Water Quality Guidelines at the edge of the IDZ, as required by the Permit, and to verify the discharge model, as described in the ADP.

Monitoring of the far-field receiving environment in Quesnel Lake in the West Basin will be carried out downstream and upstream (for reference) of the mouth of Hazeltine Creek for the verification of the discharge model as described in the ADP.

6.6.3 MONITORING OVERVIEW

Table 6.3 summarizes the parameters analysed for surface water quality. The lake field parameters are measured at each sampling depth and for each limnological profile (excluding Secchi depth, which is taken from the surface of each lake sampling point). Table 6.4 provides an overview of the surface water monitoring. The location “Mine Site” refers to the streams and creeks adjacent to the mine site. Further details of monitoring sites, including site access descriptions, access or safety concerns, and a brief rationale for monitoring, is provided in the Site Matrix in Appendix D. Figure 6.2 shows monitoring locations of the surface water sampling locations.

Table 6.3 Surface water chemistry parameters

Parameter	LOR	Unit
Field Parameters - Lake		
pH	-	pH
Specific conductance	-	µS/cm
Temperature	-	°C
Turbidity	-	NTU
Dissolved oxygen	-	%, mg/L
Secchi depth	-	m
Field Parameters - General		
pH	-	pH
Conductivity	-	µS/cm
Temperature	-	°C
Turbidity	-	NTU
Physical Tests		
Conductivity	2	µS/cm
Hardness (as $CaCO_3$)	0.5	mg/L
pH	0.1	pH
Total Suspended Solids	1	mg/L
Total Dissolved Solids	10	mg/L
Turbidity	0.1	NTU
Anions and Nutrients		
Alkalinity, Total (as $CaCO_3$)	1	mg/L
Ammonia, Total (as N)	0.005	mg/L
Chloride (Cl)	0.5	mg/L
Fluoride (F)	0.02	mg/L
Nitrate and Nitrite (as N)	0.003	mg/L
Nitrate (as N)	0.001	mg/L
Nitrite (as N)	0.005	mg/L
Total Nitrogen	0.03	mg/L
Orthophosphate-Dissolved (as P)	0.001	mg/L
Phosphorus (P)-Total Dissolved	0.002	mg/L
Phosphorus (P)-Total	0.002	mg/L
Sulfate (SO_4)	0.3	mg/L
Organic / Inorganic Carbon		
Dissolved Organic Carbon	0.5	mg/L

Parameter	LOR	Unit
Total and Dissolved Metals		
Aluminum (Al)	0.003	mg/L
Antimony (Sb)	0.0001	mg/L
Arsenic (As)	0.0001	mg/L
Barium (Ba)	0.0001	mg/L
Beryllium (Be)	0.0001	mg/L
Bismuth (Bi)	0.00005	mg/L
Boron (B)	0.01	mg/L
Cadmium (Cd)	0.000005	mg/L
Calcium (Ca)	0.05	mg/L
Chromium (Cr)	0.0005	mg/L
Cobalt (Co)	0.0001	mg/L
Copper (Cu)	0.0005	mg/L
Iron (Fe)	0.03	mg/L
Lead (Pb)	0.00005	mg/L
Lithium (Li)	0.001	mg/L
Magnesium (Mg)	0.1	mg/L
Manganese (Mn)	0.0001	mg/L
Molybdenum (Mo)	0.00005	mg/L
Nickel (Ni)	0.0005	mg/L
Potassium (K)	0.05	mg/L
Selenium (Se)	0.00005	mg/L
Silicon (Si)	0.1	mg/L
Silver (Ag)	0.00001	mg/L
Sodium (Na)	0.05	mg/L
Strontium (Sr)	0.0002	mg/L
Thallium (Tl)	0.00001	mg/L
Tin (Sn)	0.0001	mg/L
Titanium (Ti)	0.01	mg/L
Uranium (U)	0.00001	mg/L
Vanadium (V)	0.0005	mg/L
Zinc (Zn)	0.003	mg/L
EEM Parameters		
Mercury (Hg)-Total	0.000005	mg/L

Notes: LOR: Limit of Reporting; EEM: Environmental Effects Monitoring

Table 6.4 Surface water monitoring overview

Location	Station Name	EMS Code	Description	Frequency	Depths	Parameters Measured	Guidelines
Mine Site	W1	E225084	Morehead Creek	Quarterly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Mine Site	W4a	E298551	North Dump Creek below Wight Pit Road	Monthly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Mine Site	W5	E208039	Bootjack Creek Above Hazeltine Creek	Monthly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Mine Site	W8	E216743	NE Edney Creek Tributary	Quarterly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Mine Site	W8Z	E223292	SW Edney Creek Tributary	Quarterly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Mine Site	W10	E291209	Lower Edney Creek (upstream of breach impact)	Semi-annually[1]	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Mine Site	W12	E216744	6 km Creek at Road	Quarterly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Mine Site	W20	E297070	W20 Creek Tributary to Bootjack Lake	Semi-annually	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Edney Creek	EDC-01	E303014	Lower Edney Creek (remediated reach)	Semi-annually[1]	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Hazeltine Creek	HAC-10	E303010	Upper Hazeltine Creek at Polley Lake outlet	Monthly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Hazeltine Creek	HAC-13	E304810	End of Reach 1 in Hazeltine Creek	Monthly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Hazeltine Creek	HAC-14	pending	Middle Hazeltine Creek upstream of the canyon	Monthly[2]	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Hazeltine Creek	HAC-05a	E304510	Upper Hazeltine Creek at Gavin Lake FSR Bridge	Monthly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Hazeltine Creek	HAC-08	E303013	Lower Hazeltine Creek at Ditch Road Bridge	Monthly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL

Location	Station Name	EMS Code	Description	Frequency	Depths	Parameters Measured	Guidelines
Hazeltine Creek	HAC-01c	E303953	Lower Hazeltine Creek outflow to Quesnel Lake	Monthly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Bootjack Lake	B1	E207975	Bootjack Lake deepest area at north end	Semi-annually[3]	Surface (0 m), 1 m above thermocline (AT) and 1 m below thermocline (BT) OR mid-depth if no thermocline (MID), bottom (B)	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
				Monthly[4]	Limnological profile	Field parameters - lake	BC WQG - AL
Bootjack Lake	B2	E215897	Bootjack Lake deepest area at south end	Semi-annually[3]	Surface (0 m), 1 m above thermocline (AT) and 1 m below thermocline (BT) OR mid-depth if no thermocline (MID), bottom (B)	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
				Monthly[4]	Limnological profile	Field parameters - lake	BC WQG - AL
				Three times annually [10]	Limnological profile, surface	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Bootjack Lake	B4	E216744	Bootjack Lake (potential zone of influence from seepage from Springer Pit)	For closure only[5]	For closure only[5]	For closure only[5]	-
Polley Lake	P1	E207974	Polley Lake deepest area at north end	Spring overturn, twice in summer, fall overturn, once under ice[6]	Surface (0 m), 1 m above thermocline (AT) and 1 m below thermocline (BT) OR mid-depth if no thermocline (MID), bottom (B)	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
				Monthly[4]	Limnological profile	Field parameters - lake	BC WQG - AL
Polley Lake	P2	E207975	Polley Lake deepest area at south end	Spring overturn, twice in summer, fall overturn, once under ice[6]	Surface (0 m), 1 m above thermocline (AT) and 1 m below thermocline (BT) OR mid-depth if no thermocline (MID), bottom (B)	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
				Monthly[4]	Limnological profile	Field parameters - lake	BC WQG - AL
				Three times annually [10]	Limnological profile, surface	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Quesnel Lake	QUL-58	E304876	Quesnel Lake discharge IDZ	Four times annually[7, 11, 12]	Limnological profile, If plume detected: middle of plume (MP), 5 m above (AP), 5 m below plume (BP) If plume not detected: surface (S), 1 m above thermocline (AT) and 1 m below thermocline (BT) OR mid-depth if no thermocline (MID), bottom (B)	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals, EEM parameter (total mercury)[8]	BC WQG - AL
Quesnel Lake	QUL-57	E304874	Quesnel Lake IDZ	Four times annually[7, 11, 12]	Limnological profile, sample depths as for QUL-58	Field parameters - lake	BC WQG - AL
Quesnel Lake	QUL-59	E304875	Quesnel Lake IDZ	Four times annually[7, 11, 12]	Limnological profile, sample depths as for QUL-58	Field parameters - lake	BC WQG - AL
Quesnel Lake	QUL-18	E303019	Quesnel Lake far-field, downstream of Hazeltine Creek	Four times annually[7, 11]	Limnological profile, 0 m, 20 m, 50 m, 100 m[9]	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Quesnel Lake	QUL-2a	E303020	Quesnel Lake far-field, upstream of Hazeltine Creek (reference)	Four times annually[7, 11]	Limnological profile, 0 m, 20 m, 40 m, 60 m	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals, EEM parameter (total mercury)[8]	BC WQG - AL

Location	Station Name	EMS Code	Description	Frequency	Depths	Parameters Measured	Guidelines
Quesnel Lake	QUL-ZOO-1	E306455	Quesnel Lake in centre of West Basin (zooplankton station)	Three times annually [10, 11]	Limnological profile, surface	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Quesnel Lake	QUL-ZOO-7	E306456	Quesnel Lake near Cariboo Island (reference zooplankton station)	Three times annually [10, 11]	Limnological profile, surface	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL

Notes: [1] In June and October due to access; [2] May to November only due to restricted access in winter; [3] At spring overturn and late summer; [4] Between spring and fall overturn; [5] Monitoring will depend on closure conditions; [6] if ice and weather conditions meet safety requirements; [7] Taken at evenly spaced time series plus or minus one month; [8] Total mercury will be collected at MID or BT for QUL-58 and at 40 m for QUL-2a as part of EEM four times per year (no less than 1 month apart). Parameter only reported to MDMER; [9] QUL-18 is approximately 110 m deep. 100 m sample depth is collected for historical consistency; [10] Taken in conjunction with plankton sampling (see Section 6.14); [11] When sampling is less frequent than monthly, sampling at Quesnel Lake operational surface water monitoring stations (as identified in Table 6.6) will be undertaken when effluent discharge to Quesnel Lake is discharging. In the event of an unexpected shutdown of the water treatment plant, reasonable efforts will be made to re-sample within the timeframe of the quarterly or other specified time period sampling upon restart of effluent discharge to Quesnel Lake; [12] Samples will be taken at HAD-3 on the same day as samples collected from QUL-57, -58, and -59.

DOC: dissolved organic carbon; BC WQG: British Columbia Water Quality Guidelines; AL: aquatic life; FSR: Forest Service Road; EEM: Environmental Effects Monitoring; IDZ: initial dilution zone

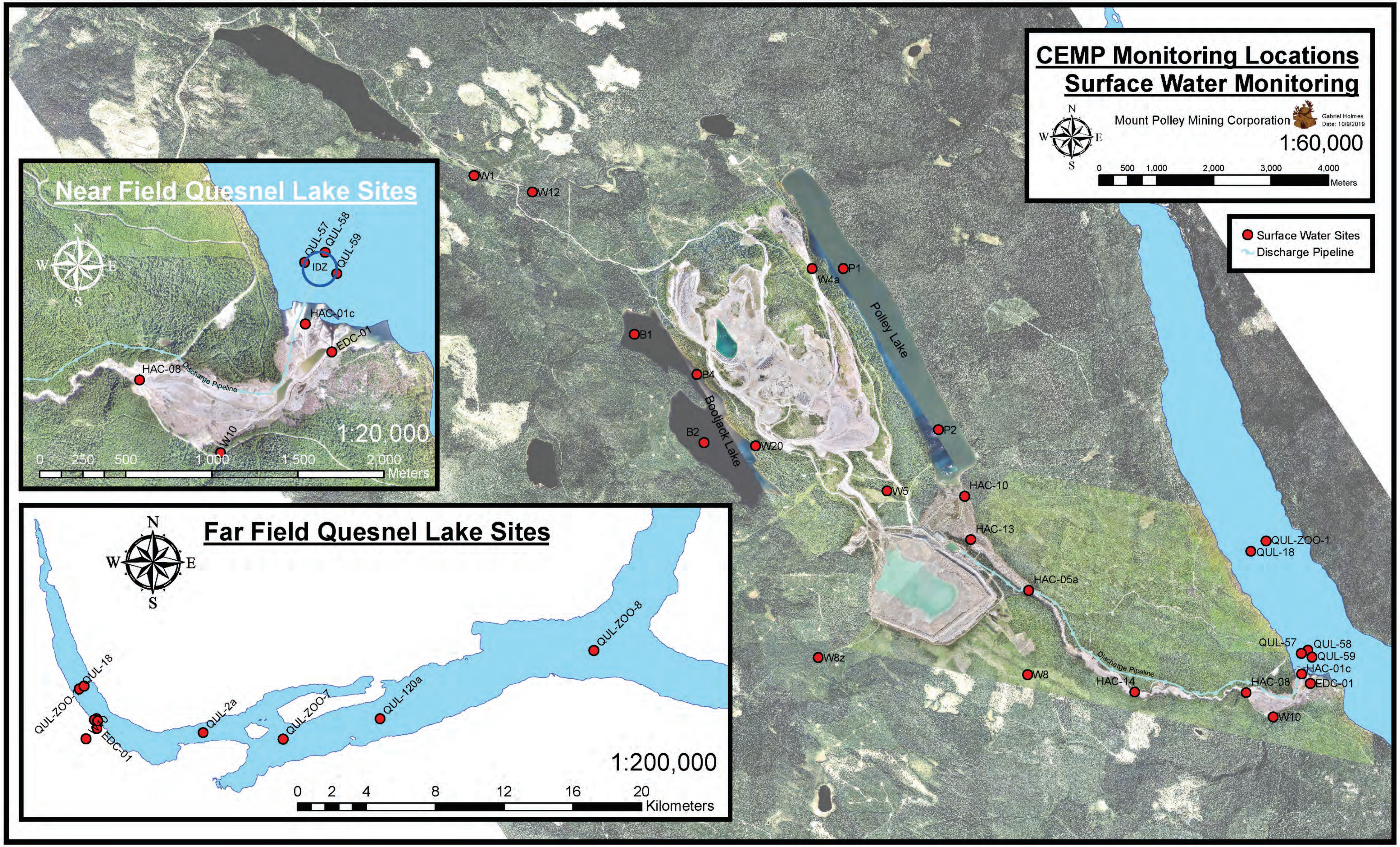


Figure 6.2 CEMP monitoring locations: Surface water monitoring

6.6.4 High-Level Monitoring Design Description

Field parameter collection, sample collection, preparation, and shipping will be conducted following the SOPs and WMs for the associated field meters, Surface Water Quality Monitoring and Lake Water Monitoring, as appropriate as described in the QA/QC Manual. These procedures include use of lab-verified clean or appropriately rinsed sampling bottles and steps to reduce risk of sampling contamination. *In-situ* parameters will be measured when samples for chemistry are collected. Water samples will be analyzed as described in Section 6.6.3. Limnological profiles of field parameters will be conducted where described in Table 6.4.

For the edge of the IDZ sampling, limnological profiles of field parameters (specific conductance, temperature, and turbidity) will be carried out in an attempt to identify the location of the plume from the outfall (i.e., direction of flow). MPMC is committed to spending a reasonable level of effort and time to detect the plume and direction of flow. The reasonable level of effort and time will vary depending on the health and safety risks associated with the weather conditions and season. Vertical profiles of field measurements and water chemistry samples will be taken at the inferred centerline of the plume at the edge of the IDZ (station QUL-58).

A plume dispersion model was developed by Golder for the nearfield (i.e., in the vicinity of the IDZ), and a hydrodynamic model of Quesnel Lake has been developed and calibrated by Tetra Tech EBA to predict effluent transfer throughout the West Basin of Quesnel Lake and potential for buildup (Golder 2015b). Monitoring at the near-field station, along with monitoring of other Quesnel Lake receiving environment stations, will be used to verify the near-field and lake-wide hydrodynamic models. It should be noted that the nearfield and the hydrodynamic models, as described in the Long Term Water Management Plan, serve as the basis for the Trigger Response Plan incorporated into the 2018 ADP.

Table 6.5 is a summary of previous surface water monitoring undertaken and includes recommendations for future monitoring. Further rationale is provided in the following sub-sections, if appropriate, and is referenced in the table where applicable.

Table 6.5 Summary of surface water monitoring

Summary of Monitoring and Findings	Monitoring Objective		
	Operational	Post-Breach	Reclamation
Previous monitoring undertaken	Monitoring included streams adjacent to the mine site to determine if there are any changes in water quality. Bootjack and Polley lakes were monitored as receiving environment of the mine. Bootjack Lake was monitored to evaluate potential for exfiltration from Springer Pit. The monitoring sites in Bootjack Lake were moved to two deeper monitoring locations in 2017, as described in the 2016 AERR. For the discharge receiving environment, Quesnel Lake and Quesnel River were monitored.	Post-breach monitoring overlapped with operational monitoring in Polley Lake, Quesnel Lake, and Quesnel River. Monitoring occurred at sites selected to capture major inputs and mixing of Hazeltine Creek. Supplemental sampling of 3 stations flowing into Hazeltine Creek in the Polley Flats area was undertaken to support a geochemical conceptual model in 2016 (SRK and Minnow 2016).	N/A
Summary of findings	The results for the creeks and lakes from 2016-2017 identified no significant trends. No indication of exfiltration from the Springer Pit was found in Bootjack Lake.	Results from Quesnel River show no indications of further effects post-breach since 2016. The 2016 and 2017 results showed that the lower sedimentation pond was effective at decreasing the TSS concentration of Hazeltine Creek. The modelling concluded that 93 to 99% of copper was organically complexed and generally not bioavailable.	N/A
Recommendations for 2018-2020 monitoring	A summary of all changes from the 2016 CEMP is provided in Section 6.6.4.1.	A summary of changes from the 2016 CEMP is provided in Sections 6.6.4.1 and 6.6.4.2.	N/A

Notes: AERR: Annual Environmental and Reclamation Report; N/A: not applicable; TSS: total suspended solids

6.6.4.1 Operational Monitoring

Table 6.6 summarizes all changes in operational surface water monitoring form the 2016 CEMP.

Table 6.6 Operational monitoring changes since the 2016 CEMP

Sample Site(s)	Change from 2016 CEMP	Purpose/Justification
W1	Reduced frequency from monthly to quarterly	W1 monitors water quality in Morehead Creek, the outflow of Bootjack Lake. As of time of writing, Springer Pit water level is below 990 masl and no indication of exfiltration from the Springer Pit was found in Bootjack Lake. The monitoring frequency will be reviewed by a QP if Bootjack Lake shows any mine-related changes in the future.
W10	Reduced frequency from monthly to semi annually (in June and October)	The monitoring of this site overlaps with Post-Breach Monitoring as it acts as a reference location for the remediated section of Edney Creek. The reduced frequency aligns with frequency of EDC-01 (see Section 6.6.4.2).
W20	Reduced frequency from quarterly to semi-annually	This creek is not directly influenced by mine activities as mine-affected water is diverted away from this creek catchment. Less intense monitoring is required. The frequency will be reviewed by a QP if Bootjack Lake water quality shows any mine-related changes.
QUL-58	Reduced frequency from monthly to 4 times per year (taken at evenly spaced time series plus or minus one month)	Monitoring As per the ADP, QUL-58 monitoring is for model verification.
QUL-57	Reduced frequency from monthly to 4 times per year (taken at evenly spaced time series plus or minus one month)	As per the ADP, QUL-57 monitoring is for model verification.
QUL-59	Reduced frequency from monthly to 4 times per year (taken at evenly spaced time series plus or minus one month)	As per the ADP, QUL-59 monitoring is for model verification.
QUL-18	Reduced frequency from monthly to 4 times per year (taken at evenly spaced time series plus or minus one month)	As per the ADP, QUL-18 monitoring is for model verification.
QUL-2a	Reduced frequency from monthly to 4 times per year (taken at evenly spaced time series plus or minus one month) Considered Quesnel Lake reference site	As per the ADP, QUL-2a monitoring is for model verification and is now considered the Quesnel Lake reference site.

Sample Site(s)	Change from 2016 CEMP	Purpose/Justification
QUL-120a	Reduced from seasonally to semi-annually (taken at evenly spaced time series plus or minus one month) No longer considered Quesnel Lake reference site	As per the ADP, QUL-120a monitoring is for model verification.
QUR-1	Continuous monitoring removed	Continuous monitoring was conducted at this site from August 12, 2014 to May 30, 2016. In consultation with ENV, given the lack of variation in the results, continuous monitoring was deemed to be no longer necessary.
QUR-11	Removed	This site is regularly monitored by the provincial and federal government agencies with financial support from MPMC. An annual side-by-side sample will be collected by MPMC at the request of the regulator.
P1, P2	Reduced sampling from monthly to spring overturn, twice in summer, fall overturn, and once in winter under ice Change in sampling depths	The monitoring of these sites overlap with Post-Breach Monitoring. The reduction in monitoring frequency (both sampling and limnological profiles) is because the water quality in Polley Lake appears to be stable. If changes are observed in water quality reflecting breach- or mine-related impacts, frequency of monitoring will be reviewed by a QP. These sample depths align with pre-breach monitoring as agreed upon with ENV staff biologist.
B1, B2	Reduced monitoring of limnological profile from semi-monthly to monthly Change in sampling depths	The reduction in monitoring frequency is because the water quality in Bootjack Lake appears to be stable. If changes are observed in water quality reflecting mine-related impacts, frequency of monitoring will be reviewed by a QP. These sample depths align with pre-breach monitoring as agreed upon with ENV staff biologist.

Notes: CEMP: Comprehensive Environmental Monitoring Plan; masl: meters above sea level; QP: Qualified Professional; ADP: Annual Discharge Plan

6.6.4.2 POST-BREACH MONITORING

Table 6.7 summarizes all changes in operational surface water monitoring form the 2016 CEMP.

Table 6.7 Post-breach monitoring changes since the 2016 CEMP

Sample Site(s)	Change from 2016 CEMP	Purpose/Justification
HAC-13	Reduced from weekly to monthly	This site used to be upstream of the Hazeltine Creek Discharge and was monitored under the EEM. Currently, this site monitors water quality in Hazeltine Creek after Reach 1. Monitoring frequency has been reduced to align with other Hazeltine Creek samples.
HAC-14	Added	This site was added to monitor effects of remediation activities on Hazeltine Creek water quality. The frequency aligns with other Hazeltine Creek samples.
HAC-12	Removed	In consultation with ENV (C. Danyluk, personal communication, February 8, 2018), this site has been removed as it is no longer necessary with the connection of the pipeline from the WTP to the diffusers.
HAC-01c	Added	This site represents Hazeltine Creek water quality before entering Quesnel Lake. The frequency aligns with other Hazeltine Creek samples.
EDC-01	Reduced from monthly to semi-annually	No significant trends have been identified at EDC-01. Because of reduced site access in winter and stable water quality, sampling frequency has been reduced to semi-annually.

Notes: CEMP: Comprehensive Environmental Monitoring Plan; EEM: Environmental Effects Monitoring; ENV: BC Ministry of Environment and Climate Change Strategy; WTP: Water Treatment Plant

6.6.5 DATA QUALITY CONTROL, OBJECTIVES, AND REVIEW

For water chemistry, QC samples will be collected as a component of the monitoring program as per the MPMC QA/QC Manual. A combined QC schedule for all surface water monitoring (i.e., operational, post-breach, reclamation) is summarized in Table 6.8.

Table 6.8 Water chemistry QC sample frequencies for surface water monitoring

QC Samples	Frequency
Duplicate samples	10% of surface water samples
Equipment blanks	Monthly per piece of equipment (when used)
Trip blanks	Twice per month
Field blanks	Twice per month
Filter blanks	Quarterly
Deionized water blanks	Annually
Laboratory replicate[1]	Annually

Note: [1] Split sample

For results greater than five times the method detection limit (MDL), a relative percent difference (RPD) will be used to identify differences between original and duplicate samples. These data quality objectives (DQOs) are the same as the RPDs used by the lab. If one or both results are less than five times the MDL, a difference between original and duplicate samples greater than two times the MDL is used to identify differences. Blanks in which any parameters exceed the reported MDL will be flagged.

6.6.6 Laboratory Analysis

Samples will be submitted to and processed by a Canadian Association of Laboratory Accreditation (CALA) accredited analytical laboratory, typically ALS Environmental Inc. in Burnaby, BC, where standard testing procedures will be used as specified in the most recent editions of the *BC Environmental Laboratory Manual* (MoE 2015).

Laboratory precision will be assessed on the basis of laboratory duplicate results and laboratory accuracy will be assessed using certified reference materials (CRMs) and matrix spikes. Potential laboratory contamination will be assessed using a DQO of ≤ 2 times the laboratory MDL in laboratory method blank results.

6.6.7 Data Analysis and Reporting

In Hazeltine Creek, data analysis and interpretation for reporting purposes will include calculation of summary statistics (e.g., mean, minimum, maximum, and 95th percentile values over the period of interest) and evaluation of any spatial (e.g., down the creek) and temporal changes or trends. Results will also be compared to the BC aquatic life WQGs.

In the other surface water monitoring sites, statistical analysis will be carried out to compare data to reference sites and to assess trends over time. Results will also be compared to the BC aquatic life WQGs.

6.7 Hydrology Monitoring

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.7.1 Section Authors and Study Design Professionals

This section was written by MPMC, and is guided by Section 3.4 of the Permit (April 7, 2017).

6.7.2 Monitoring Objectives

The objective of hydrological monitoring in Hazeltine Creek is to characterize the hydrology of the Hazeltine Creek system, assess fish habitat (only in reaches accessible to fish), interpret water quality and water balance, and evaluate changes over time as rehabilitation works are carried out and system recovery occurs (e.g., establishment of riparian vegetation).

The objective of hydrological monitoring in Edney Creek is to characterize the hydrology of Edney Creek in the remediated section, asses fish habitat, interpret water quality, and evaluate changes over time as rehabilitation works are carried out and system recovery occurs (e.g., establishment of riparian vegetation).

The objective of the hydrological monitoring of the streams and creeks that run through or adjacent to the mine site is to characterize the hydrology of the drainages, interpret water quality, and evaluate any changes over time.

6.7.3 Monitoring Overview

MPMC maintains eight hydrology stations as required by the Permit. Table 6.9 provides an overview of the hydrology monitoring. No large changes have been made from the 2016 CEMP, but wording has been changed to more align with the wording in Section 3.4 in the Permit. Further details of monitoring sites, including site access descriptions, access or safety concerns, and a brief rationale for monitoring, is provided in the Site Matrix in Appendix D. Figure 6.3 shows monitoring locations of the hydrology monitoring locations.

Staff gauges will be benchmarked (calibrated) once per year between June 15 and August 31, as defined by the Permit. Staff gauge readings will be recorded during water chemistry sampling events at the associated stations and each manual flow measurement. Note that there is currently no staff gauge installed at station W4a (North Dump Creek), as it is a very low flow creek; however, as recommended by WaterSmith Research Inc. (WaterSmith; Appendix K in MPMC 2016e), MPMC will endeavor to install a staff gauge at this location that provides adequate information. Continuous stage monitoring equipment (pressure transducers) will be installed at hydrometric locations specified in Table 6.9 during non-freezing conditions.

Manual flow gaugings will be conducted at all sites during high, moderate, and low flows in non-freezing conditions. These measurements will be conducted at minimum three times per year for validation of the stage-discharge rating curves. If stage-discharge stability is not demonstrated, the frequency of monitoring will be increased to five times per year during the non-freezing period (across the spectrum of high to low flows) to meet Resources Information Standards Committee Grade A standards for hydrometric monitoring (MoE 2009). Due to site characteristics and difficult operating conditions, often the sites meet Grade B/C standards. MPMC will continue to work with a QP to move toward meeting Grade A standards for all hydrological stations. A stage discharge curve that encompasses the non-freezing period flows will be maintained for all hydrological stations with staff gauges.

Table 6.9 Hydrology monitoring overview

Station Name	EMS Code	Description	Frequency	Parameters Measured	Guidelines
H4	-	Upper Hazeltine Creek at Polley Lake outlet	Continuous[1]	Water head pressure, temperature	N/A
			Weekly (daily during high runoff periods)	Stage (staff gauge)	Permit 11678
			Monthly[1]	Manual flow gauging	
H1	-	Upper Hazeltine Creek hydrometric station (at Gavin Lake FSR Bridge)	Continuous[1]	Water head pressure, temperature	Permit 11678
			Monthly[1]	Stage (staff gauge)	
			Monthly[1]	Manual flow gauging	
H2	-	Lower Hazeltine Creek hydrometric station (downstream of the Ditch Road Bridge)	Continuous[1]	Water head pressure, temperature	Permit 11678
			Monthly[1]	Stage (staff gauge)	
			Monthly[1]	Manual flow gauging	
W1b	E291449	Morehead Creek	Water quality sample and when flows are measured[1]	Stage (staff gauge)	Permit 11678
			High, moderate and low flows[1]	Manual flow gauging (3 time/year; 5 times if rating curve stability not demonstrated)	
W4a	E298551	North Dump Creek below Wight Pit Road	Monthly[1]	Manual flow gauging	Permit 11678
W5	E208039	Bootjack Creek Above Hazeltine Creek	Water quality sample and when flows are measured[1]	Stage (staff gauge)	Permit 11678
			High, moderate, and low flows[1]	Manual flow gauging (3 time/year; 5 times if rating curve stability not demonstrated); only when sufficient flow	

Station Name	EMS Code	Description	Frequency	Parameters Measured	Guidelines
W12	E216744	6 km Creek at Road	Water quality sample; when flows are measured[1]	Stage (staff gauge)	Permit 11678
			High, moderate and low flows[1]	Manual flow gauging (3 time/year; 5 times if rating curve stability not demonstrated)	
H3	-	Lower Edney Creek	Continuous[1]	Water head pressure, temperature	N/A
			When flows are measured[1]	Stage (staff gauge)	Permit 11678
			High, moderate and low flows[1]	Manual flow gauging (3 time/year; 5 times if rating curve stability not demonstrated)	

Notes: [1] In non-freezing conditions; N/A: not applicable

Figure 6.3 CEMP monitoring locations: Hydrology monitoring

6.7.4 High-Level Monitoring Design Description

Hydrological monitoring will be conducted as per the SOPs and WMs for Hydrological Monitoring (which includes installing and downloading continuous loggers) and Benchmarking, as well as the specific WM for operating the FlowTracker acoustic Doppler velocity meter.

Note that some streams do not flow year-round; if there is no flow and a sample or measurement cannot be taken as scheduled, the attempt will be documented in the field notebook.

To verify the accuracy of established rating curves (i.e., confirm that the channel morphology at the station and outflow control point have not changed) and, where possible, extend the upper and lower bounds of the curves, manual flow gaugings will be taken according to Table 6.9 in non-freezing conditions. Manual flow monitoring requirements will be re-evaluated each year, following refinement of the stage-discharge rating curves.

Table 6.10 is a summary of previous hydrology monitoring undertaken and includes recommendations for future monitoring. Further rationale is provided in the following sub-sections, if appropriate, and is referenced in the table where applicable.

Table 6.10 Summary of hydrology monitoring and findings

Summary of Monitoring and Findings	**Monitoring Objective**		
	Operational	**Post-Breach**	**Reclamation**
Previous monitoring undertaken	W1b, W5, and W12 were established prior to 2014. W4a was established in 2014. More detail for each site is provided in Section 6.7.4.1.	H1 and H2 hydrology sites were established in 2015, when channeling of Hazeltine Creek was completed. H4 hydrology site was established in 2016 in the remediated section of upper Hazeltine Creek. H3 hydrology site in the remediated section of Edney Creek was established in 2015. More detail of each station is provided in Section 6.7.4.2.	N/A
Summary of findings	Manual measurements were used to confirm and refine rating curves.	Manual measurements confirmed the rating curves for H1, H2, and H3. Increased manual measurements for H4 will confirm the ratings curve.	N/A

Summary of Monitoring and Findings	Monitoring Objective		
	Operational	Post-Breach	Reclamation
Recommendations for 2018-2020 monitoring	Manual measurements will be collected to confirm the rating curves. One hydrology station is not configured for staff gauge and its establishment will be explored.	Continuous monitoring of levels will continue using the established rating curve. Manual measurements will be collected to confirm the rating curves.	N/A

Notes: N/A: not applicable

6.7.4.1 OPERATIONAL MONITORING

Table 6.11 summarizes the operational hydrology sites. Flows around the MPMC site are freshet driven; therefore, many hydrology stations are low flow during the rest of the year and cannot be measured. No continuous monitoring devices are installed at these sites due to the very low flow nature of the creeks.

Table 6.11 Summary of operational hydrology sites

Site	Comment
W1b	Site W1b was established in 2012. Benchmarking of this station has occurred annually. In 2016, WaterSmith made significant changes to the site and a new stage-discharge curve was developed. MPMC will continue to conducted manual measurements to confirm the rating curve.
W4a	Site W4a was established downstream, and replaced site W4 in 2014. Only manual bucket flow measurements are recorded from a constructed pipe weir at this site and will continue until recommendations for installation of a staff gauge are explored.
W5	Site W5 at Bootjack Creek was re-established in 2008. Benchmarking of this station has occurred annually. A new staff gauge was installed in 2016 by WaterSmith and a new stage-discharge curve was developed. MPMC will continue to conducted manual measurements to confirm the curve.
W12	Site W12 was established in 1990. Benchmarking of this station has occurred annually. A new stage-discharge curve was developed in 2016. MPMC will continue to conducted manual measurements to confirm the curve.

Notes: WaterSmith: WaterSmith Research Inc.; MPMC: Mount Polley Mining Corporation

6.7.4.2 POST-BREACH MONITORING

Table 6.12 summarizes the post-breach hydrology sites.

Table 6.12 Summary of post-breach monitoring hydrology sites

Site	Comment
H1	Site H1 was established in upper Hazeltine Creek in 2015. Benchmarking of this station has occurred annually. A new stage-discharge curve was developed in 2016. A continuous monitoring device will be installed at this station to provide continuous water head pressure measurements during non-freezing periods. In addition, MPMC will continue to conducted manual measurements to confirm the rating curve.
H2	Site H2 was established in upper Hazeltine Creek in 2015. Benchmarking of this station has occurred annually. A new stage-discharge curve was developed in 2016. A continuous monitoring device will be installed at this station to provide continuous water head pressure measurements during non-freezing periods. In addition, MPMC will continue to conducted manual measurements to confirm the rating curve.
H3	Site H3 was established in the remediated area of lower Edney Creek in 2015. Benchmarking of this station has occurred annually. A new stage-discharge curve was developed in 2016. A continuous monitoring device will be installed at this station to provide continuous water head pressure measurements during non-freezing periods. In addition, MPMC will continue to conducted manual measurements to confirm the curve.
H4	Site H4 was established in upper Hazeltine Creek at the Polley Lake Weir in 2016. Benchmarking of this station has occurred annually. A new stage-discharge curve was developed in 2016. A continuous monitoring device will be installed at this station to provide continuous water head pressure measurements during non-freezing periods. In addition, MPMC will continue to conducted manual measurements to confirm the curve.

Notes: MPMC: Mount Polley Mining Corporation

6.7.5 Data Quality Control, Objectives, and Review

The FlowTracker has built in error messages associated with measurements that are outside of set QC bounds, and reports an International Standard Calculation error and statistical (US Geological Survey calculation) error output following each discharge measurement as a QC measure.

Benchmarking, as described above and as per the protocol in the QA/QC Manual, will occur annually between June 15 and August 31 as per the Permit, or as described by the Permit.

Routine monitoring includes inspections of equipment, including stilling wells and loggers (e.g., to identify sedimentation inside the stilling well or debris build up in logger ports). Identification of potential station changes or issues also occurs through data analysis when data are inconsistent or unusual in comparison with previously collected data.

6.7.6 Laboratory Analysis

No laboratory analysis is required for hydrology monitoring.

6.7.7 Data Analysis and Reporting

Data analysis will include building and validating the stage-discharge rating curves, as well as production of annual hydrographs. These will be presented in the AERR.

6.8 Groundwater Monitoring

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.8.1 Section Authors and Study Design Professionals

This section was written by MPMC.

6.8.2 Monitoring Objectives

The primary objective of the groundwater monitoring program on the mine site is to determine the direction, volume, and quality of groundwater flow from the mine site and other disturbed areas to receiving environment.

6.8.3 Monitoring Overview

Groundwater monitoring wells around the mine site are installed in the area around the TSF, the Springer Pit, downstream of waste rock dumps and haul roads, and in other areas on or surrounding the mine. The monitoring program was developed on the recommendation of the groundwater program review by Golder conducted in March 2016. This review was submitted to ENV on March 31, 2016. An annual review of the groundwater monitoring program was also conducted by Golder in March 2017 and was submitted as Appendix F in the 2017 AERR (MPMC 2018). Recommendations from the 2017 review have been incorporated into the monitoring program outlined below. Sampling events at times of maximum and minimum hydrologic conditions to account for seasonal variability will be conducted when appropriate (i.e., spring and late summer/fall). Static water level (SWL) of all wells will be monitored on the same day at minimum once annually to allow for comparison across the site.

Groundwater monitoring wells were also installed along the Hazeltine Creek in 2015 and 2016. From Golder (2017), groundwater "was not screened for the terrestrial risk assessment because wildlife do not consume groundwater". Monitoring of surface water in Hazeltine Creek captures the potential effects of groundwater discharged to the Hazeltine Channel system (Golder 2017; see Section 6.6). No further monitoring is planned at these groundwater wells.

Table 6.13 summarizes the parameters analysed for groundwater quality. Table 6.14 provides an overview of the groundwater monitoring. Further details of monitoring sites, including site access descriptions, access or safety concerns, and a brief rationale for monitoring, is provided in the Site Matrix in Appendix D. Figure 6.4 shows monitoring locations of the groundwater sampling locations.

Table 6.13 Groundwater chemistry parameters

Parameter	LOR	Unit
Field Parameters		
pH	-	pH
Conductivity	-	µS/cm
Temperature	-	°C
Physical Tests		
Conductivity	2	µS/cm
Hardness (as $CaCO_3$)	0.5	mg/L
pH	0.1	pH
Turbidity	0.1	NTU
Anions and Nutrients		
Alkalinity, Total (as $CaCO_3$)	1	mg/L
Ammonia, Total (as N)	0.005	mg/L
Chloride (Cl)	0.5	mg/L
Fluoride (F)	0.02	mg/L
Nitrate and Nitrite (as N)	0.003	mg/L
Nitrate (as N)	0.001	mg/L
Nitrite (as N)	0.005	mg/L
Total Nitrogen	0.03	mg/L
Phosphorus (P)-Total Dissolved	0.002	mg/L
Phosphorus (P)-Total	0.002	mg/L
Sulfate (SO_4)	0.3	mg/L

Parameter	LOR	Unit
Dissolved Metals		
Aluminum (Al)	0.003	mg/L
Antimony (Sb)	0.0001	mg/L
Arsenic (As)	0.0001	mg/L
Barium (Ba)	0.0001	mg/L
Beryllium (Be)	0.0001	mg/L
Bismuth (Bi)	0.00005	mg/L
Boron (B)	0.01	mg/L
Cadmium (Cd)	0.000005	mg/L
Calcium (Ca)	0.05	mg/L
Chromium (Cr)	0.0005	mg/L
Cobalt (Co)	0.0001	mg/L
Copper (Cu)	0.0005	mg/L
Iron (Fe)	0.03	mg/L
Lead (Pb)	0.00005	mg/L
Lithium (Li)	0.001	mg/L
Magnesium (Mg)	0.1	mg/L
Manganese (Mn)	0.0001	mg/L
Molybdenum (Mo)	0.00005	mg/L
Nickel (Ni)	0.0005	mg/L
Potassium (K)	0.05	mg/L
Selenium (Se)	0.00005	mg/L
Silicon (Si)	0.1	mg/L
Silver (Ag)	0.00001	mg/L
Sodium (Na)	0.05	mg/L
Strontium (Sr)	0.0002	mg/L
Thallium (Tl)	0.00001	mg/L
Tin (Sn)	0.0001	mg/L
Titanium (Ti)	0.01	mg/L
Uranium (U)	0.00001	mg/L
Vanadium (V)	0.0005	mg/L
Zinc (Zn)	0.003	mg/L

Notes: LOR: Limit of Reporting

Table 6.14 Groundwater monitoring overview

Station Name	EMS Code	Description	Frequency	Parameters Measured	Guidelines
GW96-2a	E229681	Tailings Impoundment East Well (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW96-2b	E229682	Tailings Impoundment East Well (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW96-3a	E229683	Tailings Impoundment SE Well (deep)	Annually[1]	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
			Quarterly[1]	SWL	N/A
GW96-4a	E229685	Tailings Impoundment SW Well (deep)	Annually[1]	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
			Quarterly[1]	SWL	N/A
GW96-4b	E229686	Tailings Impoundment SW Well (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW96-7	E229690	SE Sed Pond Well	Annually[1]	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
			Quarterly[1]	SWL	N/A
GW00-1a	E242385	Tailings Impoundment West Well (deep)	Annually[1]	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
			Quarterly[1]	SWL	N/A
GW00-1b	E242384	Tailings Impoundment West Well (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW00-2a	E242387	Tailings Impoundment West Well (deep)	Annually[1]	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
			Quarterly[1]	SWL	N/A
GW00-3a	E242389	Tailings Impoundment West Well (deep)	Annually[1]	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
			Quarterly[1]	SWL	N/A
GW00-3b	E242388	Tailings Impoundment West Well (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
95-R-5	E229695	Lower SERDS Well (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW05-01	E258923	Wight Pit/Polley Lake Interface Well	Quarterly[2]	Field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW11-1a	E291210	Below Temporary PAG Dump (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW11-1b	E291211	Below Temporary PAG Dump (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW11-2a	E291212	Below SERDS (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW11-2b	E291213	Below SERDS (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW12-1a	E291969	NW of Temporary PAG Dump (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW12-1b	E291970	NW of Temporary PAG Dump (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW12-2a	E291971	Springer Pit Well (deep)	Quarterly	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
			Continuous	SWL (level logger installed in well)	N/A
GW12-2b	E291972	Springer Pit Well (shallow)	Quarterly	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
			Continuous	SWL (level logger installed in well)	N/A
GW12-3a	E291973	Below Waste Haul Road (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW12-3b	E291974	Below Waste Haul Road (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW12-4a	E291976	Below NEZ Dump (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW12-4b	E291977	Below NEZ Dump (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW12-5a	E291978	Below Wight Pit Road (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW12-5b	E291979	Below Wight Pit Road (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW14-1	E301973	Groundwater well at New Orica Site	Quarterly[2]	Field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW15-1a	E303210	Springer Pit Well North (deep)	Quarterly	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
			Continuous[3]	SWL (level logger installed in well)	N/A
GW15-1b	E303211	Springer Pit Well North (shallow)	Quarterly	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
			Continuous[3]	SWL (level logger installed in well)	N/A
GW15-2a	E303212	Springer Pit Well South (deep)	Quarterly	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
			Weekly	SWL (if required under the Springer Pit Response Plan)	N/A

Station Name	EMS Code	Description	Frequency	Parameters Measured	Guidelines
GW15-2b	E303213	Springer Pit Well South (shallow)	Quarterly	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
			Weekly	SWL (if required under the Springer Pit Response Plan)	N/A
GW16-1a	E308529	Below SERDS (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW16-1b	E308530	Below SERDS (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW16-2a	E308531	Tailings Impoundment North Well (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
			Quarterly	SWL	N/A
GW16-2b	E308532	Tailing Impoundment North Well (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW16-3a	E308533	Tailings Impoundment SE Well (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
			Quarterly	SWL	N/A
GW16-3b	E308534	Tailings Impoundment SE Well (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW16-4a	E308535	Tailings Impoundment S Well (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
			Quarterly	SWL	N/A
GW16-4b	E308536	Tailings Impoundment S Well (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW16-5a	E308537	Tailings Impoundment W Well (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
			Quarterly	SWL	N/A
GW16-5b	E308538	Tailings Impoundment W Well (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW16-6a	E308539	West of Cariboo Pit (deep)	Quarterly	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW16-6b	E308540	West of Cariboo Pit (shallow)	Quarterly	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW16-7	E308541	Between Wight Pit and Polley Lake	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG
GW16-8	E308542	Between Wight Pit and Polley Lake	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals	CSR Schedule 3.2 AL Standards; BC WQG

Notes: [1] Wells show stable chemistry. If an unexpected change in SWL is observed, well water will be sampled; [2] Wells provide domestic water for personnel; BC WQG – British Columbia water quality guideline; SWL: static water level; CSR: Contaminated Sites Regulations; AL: aquatic life; [3] Leveloggers have been removed from GW15-1a and 1b as wells are dry. Leveloggers will be reinstalled once water is above well screen.

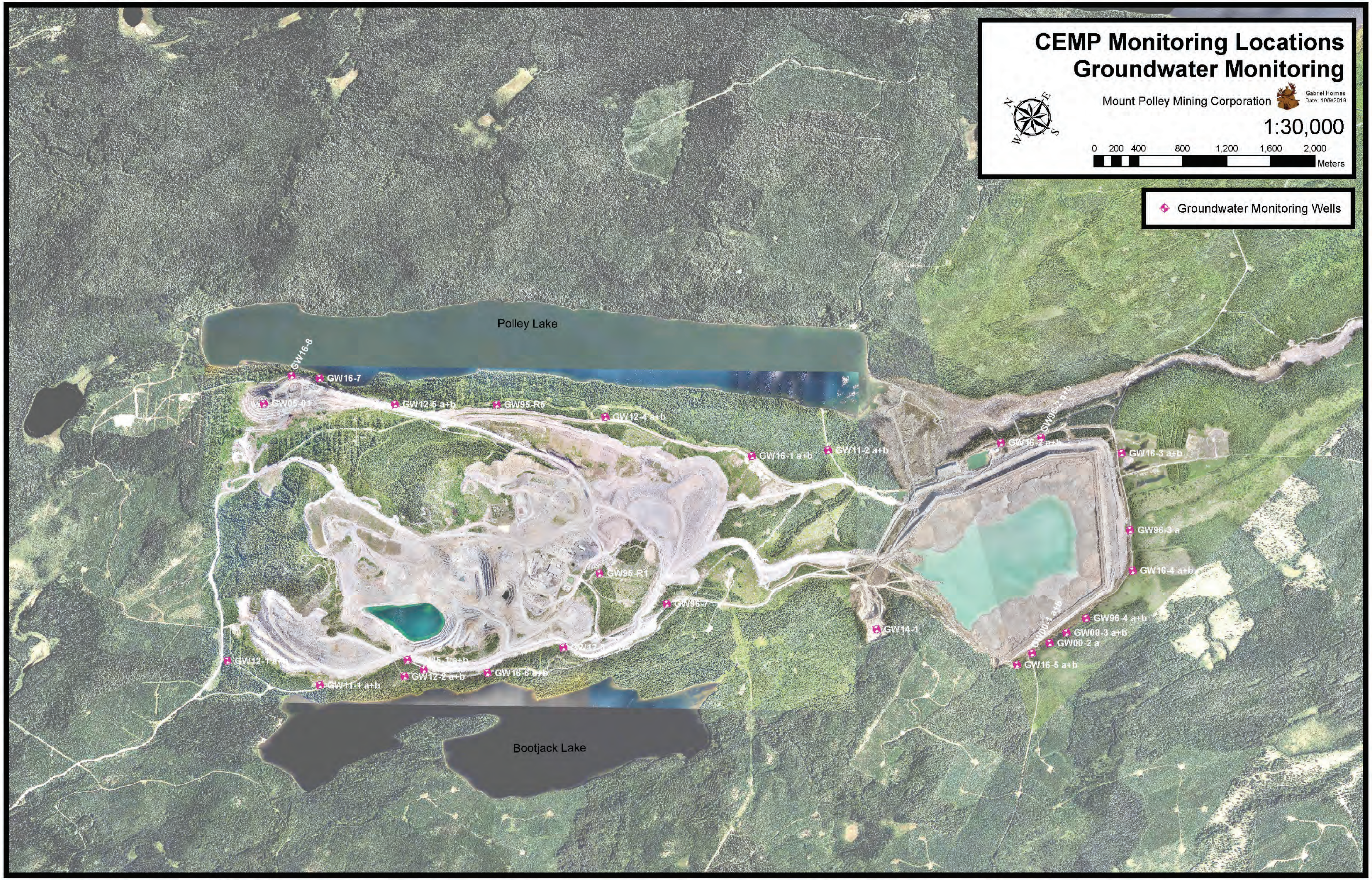


Figure 6.4 CEMP monitoring locations: Groundwater monitoring

6.8.4 High-Level Monitoring Design Description

As outlined in the SOPs, groundwater monitoring involves use of an automated depth to water meter to measure SWL and a submersible pump powered by a generator for sampling. These protocols also require routine inspections of the well housing.

Sample collection, preparation, and shipping will be conducted following the SOPs and WMs for Groundwater Monitoring and use of associated field meters in the QA/QC Manual. These procedures include use of lab-verified clean or appropriately rinsed sampling bottles and steps to reduce risk of sampling contamination. *In-situ* parameters will be measured when samples for chemistry are collected. Water samples will be analyzed as described in Section 6.8.3.

Table 6.15 is a summary of previous groundwater monitoring undertaken and includes recommendations for future monitoring. Further rationale is provided in the following sub-sections, if appropriate, and is referenced in the table where applicable.

Table 6.15 Summary of groundwater monitoring and findings

Summary of Monitoring and Findings	**Monitoring Objective**		
	Operational	**Post-Breach**	**Reclamation**
Previous monitoring undertaken	Groundwater locations in both shallow and deep bedrock downstream of mine activities. Higher frequency monitoring occurred at wells near the Springer Pit in 2015, 2016, and 2017 because the pit water level was above 1025 masl. Dredging of the Springer Pit commenced in 2017, and the water level in the pit is less than 1000 masl at the time of writing.	An updated groundwater program was implemented for the ERA (Golder 2017). Wells installed in 2015 were resampled and additional wells were installed along the creek in 2016. Groundwater was analyzed for dissolved metals, TSS, pH, anions, nutrients, hardness and acidity.	N/A
Summary of findings	Monitoring of the groundwater wells near the Springer Pit showed exfiltration from the Springer Pit towards Bootjack Lake occurred during 2016. This exfiltration was reversed after the Springer Pit was dewatered, which was confirmed by continued monitoring of these wells. No groundwater leakage from Springer Pit to Bootjack Lake in 2107 was inferred based on the levels measured. No significant changes to groundwater quality were identified in the 2017 annual groundwater review (MPMC 2018).	Although copper was the primary metal of concern in the tailings outwash material deposited in Hazeltine Creek, groundwater copper concentrations were lower than the CSR standard. Other substances that exceeded CSR standards are believed to be associated with natural conditions and were not derived from the tailings.	N/A
Recommendations for 2018-2020 monitoring	New groundwater wells were drilled at the end of 2016 as per recommendations in the Groundwater Program Review. These wells were incorporated into the current program in 2017. One pair of wells was removed due to likely contamination and were replaced (see Golder 2016c). See Section 6.8.4.1 for more detail on the recommendations for future monitoring.	No further sampling is planned for groundwater in Hazeltine Creek. If the water quality declines in the creek, monitoring of these wells will be reviewed and considered.	N/A

Notes: masl: metres above sea level; CSR: Contaminated Sites Regulation; ERA: ecological risk assessment; TSS: total suspended solids

6.8.4.1 Operational Monitoring

The monitoring frequencies of the Springer Pit wells were decreased from monthly to quarterly due to the ongoing dewatering at Springer Pit, which has resulted in a significant drop in water levels in some of these wells. For example, dataloggers have been removed from GW15-1a and b as these wells are now dry (J. Foley, personal communication, August 10, 2018). According to J. Foley, "due to the ongoing dewatering at Springer Pit, Golder would consider it acceptable to move to quarterly monitoring, if groundwater is present within the wells." Once dewatering stops and the pit is refilled, consideration to move back to monthly monitoring for a period of time will be given.

A further change to the recommendations put forth in Appendix F of MPMC (2018) is that "quarterly groundwater monitoring should continue at GW16-6 a and b, but semi-annual monitoring can be completed at the remaining GW16 well series. Note that some of the remaining 2016 well series (other than GW16-6 a/b) were monitored one to three times in the 2017 calendar year" (J. Foley, personal communication, August 10, 2018).

6.8.5 Data Quality Control, Objectives, and Review

For water chemistry, QC samples will be collected as a component of the monitoring program as per the MPMC QA/QC Manual. A combined QC schedule for all the groundwater monitoring is summarized in Table 6.16.

Table 6.16 Water chemistry QC sample frequencies for groundwater water monitoring

QC Samples	Frequency
Duplicate samples	10% of groundwater samples
Equipment blanks	Quarterly per piece of equipment (when used)
Trip blanks	Quarterly/semi-annually[1]
Field blanks	Quarterly/semi-annually[1]

Notes: [1] Quarterly for quarterly groundwater samples, semi-annually for semi-annual groundwater samples (i.e., six per year)

For results greater than five times the MDL, an RPD will be used to identify differences between original and duplicate samples. These DQOs are the same as the RPDs used by the lab. If one or both results are less than five times the MDL, a difference between original and duplicate samples greater than two times the MDL is used to identify differences. Blanks in which any parameters exceed the reported MDL will be flagged.

6.8.6 Laboratory Analysis

Samples will be submitted to and processed by a CALA accredited analytical laboratory, typically ALS Environmental Inc. in Burnaby, BC for chemistry samples, where standard testing procedures will be used as specified in the most recent editions of the *BC Environmental Laboratory Manual* (MoE 2015).

Laboratory precision will be assessed on the basis of laboratory duplicate results and laboratory accuracy will be assessed using certified reference materials (CRMs) and matrix spikes. Potential laboratory contamination will be assessed using a DQO of ≤ 2 times the laboratory MDL in laboratory method blank results.

6.8.7 DATA ANALYSIS AND REPORTING

Data analysis and interpretation for reporting purposes will include calculation of summary statistics (e.g., mean, minimum, maximum, and 95th percentile values over the period of interest) and evaluation of water chemistry or water level changes and/or trends. Groundwater chemistry will be compared to the Schedule 3.2, Column 3 (Aquatic Life) standards in the ENV Contaminated Sites Regulation (CSR) under the EMA, and BC WQGs per Technical Guidance 15 (MOE 2017a). These data will also be used by a third party qualified professional for the three-year groundwater monitoring program review, and updates to hydrogeological models, including the Springer Pit groundwater model. Hazeltine Creek groundwater data will be used to support the geochemical characterization of materials in the Hazeltine Creek corridor.

6.9 CONTACT WATER QUALITY MONITORING

Monitoring in this subsection falls under BC *Mines Act* M-200 and is only described here for completeness. Monitoring is summarized and changes will be presented in the CEMP, but changes to this monitoring are subject to BC *Mines Act* Permit M-200 and not Section 7 in the CEMP or Section 5 in the CEMP TOR (Appendix A).

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.9.1 SECTION AUTHORS AND STUDY DESIGN PROFESSIONALS

This section was written by MPMC.

6.9.2 MONITORING OBJECTIVES

The objective is to monitor trends in contact water quality on site, including runoff and mill process water, specifically at locations that represent the WTP source water. These data are applied to understand trends in site water chemistry and inform water management planning, including water discharge strategies.

6.9.3 MONITORING OVERVIEW

Table 6.17 summarizes the parameters analysed for contact water quality. Table 6.18 provides an overview of the contact water monitoring. Figure 6.5 shows monitoring locations of the contact water sampling locations.

Table 6.17 Contact water chemistry parameters

Parameter	LOR	Unit
Field Parameters - General		
pH	-	pH
Conductivity	-	µS/cm
Temperature	-	°C
Turbidity	-	NTU
Physical Tests		
Conductivity	2	µS/cm
Hardness (as $CaCO_3$)	0.5	mg/L
pH	0.1	pH
Total Suspended Solids	1	mg/L
Total Dissolved Solids	10	mg/L
Turbidity	0.1	NTU
Anions and Nutrients		
Alkalinity, Total (as $CaCO_3$)	1	mg/L
Ammonia, Total (as N)	0.005	mg/L
Chloride (Cl)	0.5	mg/L
Fluoride (F)	0.02	mg/L
Nitrate and Nitrite (as N)	0.003	mg/L
Nitrate (as N)	0.001	mg/L
Nitrite (as N)	0.005	mg/L
Total Nitrogen	0.03	mg/L
Orthophosphate-Dissolved (as P)	0.001	mg/L
Phosphorus (P)-Total Dissolved	0.002	mg/L
Phosphorus (P)-Total	0.002	mg/L
Sulfate (SO_4)	0.3	mg/L
Organic / Inorganic Carbon		
Dissolved Organic Carbon	0.5	mg/L

Parameter	LOR	Unit
Total and Dissolved Metals		
Aluminum (Al)	0.003	mg/L
Antimony (Sb)	0.0001	mg/L
Arsenic (As)	0.0001	mg/L
Barium (Ba)	0.0001	mg/L
Beryllium (Be)	0.0001	mg/L
Bismuth (Bi)	0.00005	mg/L
Boron (B)	0.01	mg/L
Cadmium (Cd)	0.000005	mg/L
Calcium (Ca)	0.05	mg/L
Chromium (Cr)	0.0005	mg/L
Cobalt (Co)	0.0001	mg/L
Copper (Cu)	0.0005	mg/L
Iron (Fe)	0.03	mg/L
Lead (Pb)	0.00005	mg/L
Lithium (Li)	0.001	mg/L
Magnesium (Mg)	0.1	mg/L
Manganese (Mn)	0.0001	mg/L
Molybdenum (Mo)	0.00005	mg/L
Nickel (Ni)	0.0005	mg/L
Potassium (K)	0.05	mg/L
Selenium (Se)	0.00005	mg/L
Silicon (Si)	0.1	mg/L
Silver (Ag)	0.00001	mg/L
Sodium (Na)	0.05	mg/L
Strontium (Sr)	0.0002	mg/L
Thallium (Tl)	0.00001	mg/L
Tin (Sn)	0.0001	mg/L
Titanium (Ti)	0.01	mg/L
Uranium (U)	0.00001	mg/L
Vanadium (V)	0.0005	mg/L
Zinc (Zn)	0.003	mg/L

Notes: LOR: Limit of Reporting

Table 6.18 Contact water monitoring overview

Station Name	EMS Code	Description	Drainage	Inspection Frequency	Sample Frequency	Parameters Measured	Guidelines	Permit[1]
E1a	E225309	TSF Supernatant	Tailings slurry, seepage collection ponds	Daily	Quarterly[2]	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
Long Ditch	-	Long Ditch	East RDS, NEZ Dump, SERDS, Wight Pit dewatering	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
SERDS Ditch	-	SERDS Ditch	SERDS, West Ditch, MDC Sump	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
E13	-	NW Sump	Temporary NW PAG Stockpile	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
E14	-	Mine Drainage Creek Sump	Upper Mine Drainage Creek, West Ditch	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
E15	-	Bootjack Creek Culvert Sump	TSF Haul Road, Upper Bootjack Creek	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
E17	-	9km Sump	Temporary NW PAG Stockpile	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
E4	-	Main Embankment Seepage Collection Pond	MTD, STD, Main Embankment foundation drains	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
E18	-	Central Collection Sump	Long Ditch, SERDS Ditch	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
East MTD	-	East Main Toe Drain	East TSF Main Embankment toe drain	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
West MTD	-	West Main Toe Drain	West TSF Main Embankment toe drain	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
STD	-	South Toe Drain	TSF South Embankment toe drain	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
Gavin's Ditch	-	-	Undisturbed area east of Polley Mountain	Semi-annually	Semi-annually[3]	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	Permit 11678[4]
TSF Clean Water Diversion	-	-	Undisturbed area west of TSF	Semi-annually	Semi-annually[3]	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	Permit 11678[4]
Wight Pit Clean Water Diversion	-	-	Undisturbed area north of Wight Pit	Semi-annually	Semi-annually[3]	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	Permit 11678[4]

Notes: [1] Permit regulating the sample; [2] When reclaim water is sourced from TSF; [3] In spring and fall, coinciding with ditch inspections; [4] Under Section 2.4.1 of Permit 11678, surface runoff from undisturbed areas must be diverted away from mine workings. These clean water ditches are monitored to ensure water quality is maintained; N/A: not applicable; TSF: Tailings Storage Facility; PAG: potentially acid generating

Figure 6.5 CEMP monitoring locations: Contact water monitoring

6.9.4 HIGH-LEVEL MONITORING DESIGN DESCRIPTION

Sample collection, preparation, and shipping will be conducted following the SOPs and WMs for Surface Water Quality Monitoring, and use of associated field meters in the QA/QC Manual. These procedures include use of lab-verified clean or appropriately rinsed sampling bottles and steps to reduce risk of sampling contamination. *In-situ* parameters will be measured when samples for chemistry are collected. Water samples will be analyzed as described in Section 6.9.3.

Table 6.19 is a summary of previous contact water monitoring undertaken and includes recommendations for future monitoring. Further rationale is provided in the following sub-sections, if appropriate, and is referenced in the table where applicable.

Table 6.19 Summary of contact water monitoring and findings

Summary of Monitoring and Findings	**Monitoring Objective**		
	Operational	**Post-Breach**	**Reclamation**
Previous monitoring undertaken	Sumps that collect and temporarily store water as well as ditches that convey water from many different sources were monitored.	N/A	N/A
Summary of findings	There were no notable trends in 2017 contact water monitoring that suggested the monitoring program needs to be changed.	N/A	N/A
Recommendations for 2018-2020 monitoring	The Springer Pit Sump (E11) is no longer representative of the pit lake water quality and has not been the source of influent for the WTP since 2016. Tailings supernatant (E1a) is also not the source for the WTP. Therefore, these sites has been removed from monitoring under the Permit; E11 continues to be monitored under the *Mines Act* Permit M-200 (see Section 6.10).	N/A	N/A

Notes: N/A: not applicable; WTP: Water Treatment Plant

6.9.5 DATA QUALITY CONTROL, OBJECTIVES, AND REVIEW

For water chemistry, QC samples will be collected as a component of the monitoring program as per the MPMC QA/QC Manual. A combined QC schedule for all contact water monitoring is summarized in Table 6.20. For results greater than five times the MDL, an RPD will be used to identify differences between original and duplicate samples. These DQOs are the same as the RPDs used by the lab. If one or both results are less than five times the MDL, a difference between original and duplicate samples greater than two times the MDL is used to identify differences. Blanks in which any parameters exceed the reported MDL will be flagged.

Table 6.20 Water chemistry QC sample frequencies for contact water monitoring

QC Samples	Frequency
Duplicate samples	10% of contact water samples
Trip blanks	Combined with surface water QC schedule
Field blanks	Combined with surface water QC schedule

6.9.6 Laboratory Analysis

Samples will be submitted to and processed by a CALA accredited analytical laboratory, typically ALS Environmental Inc. in Burnaby, BC, where standard testing procedures will be used as specified in the most recent editions of the *BC Environmental Laboratory Manual* (MoE 2015).

Laboratory precision will be assessed on the basis of laboratory duplicate results and laboratory accuracy will be assessed using certified reference materials (CRMs) and matrix spikes. Potential laboratory contamination will be assessed using a DQO of ≤ 2 times the laboratory MDL in laboratory method blank results.

6.9.7 Data Management and Analysis

Data analysis and interpretation for reporting purposes will include calculation of summary statistics (e.g., mean, minimum, maximum, and 95th percentile values over the period of interest). These data, including spatial and temporal trends in relation to mine features and their geochemistry, will be used in long-term water management planning (Section 5.1).

6.10 Seep Monitoring

Monitoring included in this subsection fall under BC *Mines Act* Permit M-200 and is only described here for completeness. Monitoring is summarized and changes will be presented in the CEMP, but changes to this monitoring are subject to BC *Mines Act* Permit M-200 and not Section 7 in the CEMP or Section 5 in the CEMP TOR (Appendix A).

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.10.1 Section Authors and Study Design Professionals

This section was written by MPMC.

6.10.2 Monitoring Objectives

An important component in determining and monitoring long-term chemical stability of drainage from the pits and waste rock dumps is water quality monitoring. The seep sampling is conducted under the BC *Mines Act* Permit M-200.

6.10.3 Monitoring Overview

Under the BC *Mines Act* Permit M-200 seepage monitoring program, monitoring of waste rock dump seepages is conducted under a bi-annual seep survey program of all waste rock dumps on site, with representative seeps being monitored more frequently when possible (numerous seeps stop flowing during dry periods). Table 6.21 summarizes the parameters analysed for seepage water quality. A list of dumps and pits that are sampled, along with the representative sample locations, is provided in Table 6.22 and Table 6.23, respectively. Figure 6.6 shows monitoring locations of the seepage sampling locations.

Table 6.21 Seepage water chemistry parameters

Parameter	LOR	Unit
Field Parameters - General		
pH	-	pH
Conductivity	-	µS/cm
Temperature	-	°C
Turbidity	-	NTU
Physical Tests		
Conductivity	2	µS/cm
Hardness (as $CaCO_3$)	0.5	mg/L
pH	0.1	pH
Total Suspended Solids	1	mg/L
Total Dissolved Solids	10	mg/L
Turbidity	0.1	NTU
Anions and Nutrients		
Alkalinity, Total (as $CaCO_3$)	1	mg/L
Ammonia, Total (as N)	0.005	mg/L
Chloride (Cl)	0.5	mg/L
Fluoride (F)	0.02	mg/L
Nitrate and Nitrite (as N)	0.003	mg/L
Nitrate (as N)	0.001	mg/L
Nitrite (as N)	0.005	mg/L
Total Nitrogen	0.03	mg/L
Orthophosphate-Dissolved (as P)	0.001	mg/L
Phosphorus (P)-Total Dissolved	0.002	mg/L
Phosphorus (P)-Total	0.002	mg/L
Sulfate (SO_4)	0.3	mg/L
Organic / Inorganic Carbon		
Dissolved Organic Carbon	0.5	mg/L

Parameter	LOR	Unit
Total and Dissolved Metals		
Aluminum (Al)	0.003	mg/L
Antimony (Sb)	0.0001	mg/L
Arsenic (As)	0.0001	mg/L
Barium (Ba)	0.0001	mg/L
Beryllium (Be)	0.0001	mg/L
Bismuth (Bi)	0.00005	mg/L
Boron (B)	0.01	mg/L
Cadmium (Cd)	0.000005	mg/L
Calcium (Ca)	0.05	mg/L
Chromium (Cr)	0.0005	mg/L
Cobalt (Co)	0.0001	mg/L
Copper (Cu)	0.0005	mg/L
Iron (Fe)	0.03	mg/L
Lead (Pb)	0.00005	mg/L
Lithium (Li)	0.001	mg/L
Magnesium (Mg)	0.1	mg/L
Manganese (Mn)	0.0001	mg/L
Molybdenum (Mo)	0.00005	mg/L
Nickel (Ni)	0.0005	mg/L
Potassium (K)	0.05	mg/L
Selenium (Se)	0.00005	mg/L
Silicon (Si)	0.1	mg/L
Silver (Ag)	0.00001	mg/L
Sodium (Na)	0.05	mg/L
Strontium (Sr)	0.0002	mg/L
Thallium (Tl)	0.00001	mg/L
Tin (Sn)	0.0001	mg/L
Titanium (Ti)	0.01	mg/L
Uranium (U)	0.00001	mg/L
Vanadium (V)	0.0005	mg/L
Zinc (Zn)	0.003	mg/L

Notes: LOR: Limit of Reporting

Table 6.22 Seep monitoring overview

Waste Rock Dump	Representative Sample	Representative Sample Frequency	Parameters Measured	Guidelines
North Bell Dump	Joe's Creek Pipe	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
Boundary Dump	Boundary Seep 2	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
East RDS	-	-	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
NEZ Dump	NEZ Seep 1	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
Waste Haul Road	Mine Drainage Creek Culvert	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
Temporary NW PAG Dump	PAG Seep 15	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
TSF Haul Road	-	-	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
SERDS	SERD Seep 13	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A

Table 6.23 Pit seepage monitoring overview

Pit	Station Name	Sample Frequency	Parameters Measured	Guidelines
Cariboo Pit	E8	Semi-annually[1]	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
Wight Pit	E10	Semi-annually[1]	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
Springer Pit	E11	Semi-annually[1]	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
Boundary Pit	Boundary Pit	Semi-annually[1]	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A

Notes: [1] When pit is not storing water from other sources on site

Figure 6.6 CEMP monitoring locations: Seep monitoring

6.10.4 High-Level Monitoring Design Description

Sample collection, preparation, and shipping will be conducted following the SOPs and WMs for Surface Water Quality Monitoring, and use of associated field meters in the QA/QC Manual. These procedures include use of lab-verified clean or appropriately rinsed sampling bottles and steps to reduce risk of sampling contamination. *In-situ* parameters will be measured when samples for chemistry are collected. Water samples will be analyzed as described in Section 6.10.3.

Table 6.24 is a summary of previous seep monitoring undertaken and includes recommendations for future monitoring. Further rationale is provided in the following sub-sections, if appropriate, and is referenced in the table where applicable.

Table 6.24 Summary of seep monitoring and findings

Summary of Monitoring and Findings	**Monitoring Objective**		
	Operational	**Post-Breach**	**Reclamation**
Previous monitoring undertaken	N/A	N/A	Seeps were sampled at the toe of waste rock piles and from pits that are not storing water from other locations.
Summary of findings	N/A	N/A	The results are used to inform long-term planning for reclamation and closure. It has been identified that two seeps from the NEZ Dump have elevated metal concentrations. See Section 6.10.4.1 for more detail.
Recommendations for 2018-2020 monitoring	N/A	N/A	The program will continue unchanged because bi-annual monitoring (i.e., in spring and fall) captures representative conditions.

Notes: N/A: not applicable; NEZ: North-East Zone

6.10.4.1 Reclamation and Closure Monitoring

NEZ Seep 1 and NEZ Seep 2 have elevated metal concentrations compared to other seeps on site. To address this, research into the source of the elevated metals has been launched, as well as possible treatment options. A new collection system for these two seeps has been constructed to isolate the water from the mine site collection infrastructure; this water will be pumped to the mill for the short-term while the research is conducted.

6.10.5 Data Quality Control, Objectives, and Review

For water chemistry, QC samples will be collected as a component of the monitoring program as per the MPMC QA/QC Manual. A combined QC schedule for all seep monitoring is summarized in Table 6.25.

Table 6.25 Water chemistry QC sample frequencies for seep monitoring

QC Samples	Frequency
Duplicate samples	10% of seep monitoring samples
Trip blanks	Quarterly/Semi-annually[1]
Field blanks	Quarterly/Semi-annually[1]

Notes: [1] Quarterly for quarterly sampling events; semi-annually for semi-annual sampling events

For results greater than five times the MDL, an RPD will be used to identify differences between original and duplicate samples. These DQOs are the same as the RPDs used by the lab. If one or both results are less than five times the MDL, a difference between original and duplicate samples greater than two times the MDL is used to identify differences. Blanks in which any parameters exceed the reported MDL will be flagged.

6.10.6 Laboratory Analysis

Samples will be submitted to and processed by a CALA accredited analytical laboratory, typically ALS Environmental Inc. in Burnaby, BC, where standard testing procedures will be used as specified in the most recent editions of the *BC Environmental Laboratory Manual* (MoE 2015).

Laboratory precision will be assessed on the basis of laboratory duplicate results and laboratory accuracy will be assessed using certified reference materials (CRMs) and matrix spikes. Potential laboratory contamination will be assessed using a DQO of ≤ 2 times the laboratory MDL in laboratory method blank results.

6.10.7 Data Analysis and Reporting

Collection of this data is used in long-term effluent water quality predictions. These results are presented in the AERR and are applied to understand long-term ML/ARD potential, develop site source terms, and inform water management planning.

6.11 Effluent Monitoring

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.11.1 Section Authors and Study Design Professionals

This section was written by MPMC.

6.11.2 Monitoring Objectives

The objective of the effluent monitoring program is to verify the water chemistry complies with the applicable regulatory limits at the point of discharge (MDMER Schedule 4 and the Permit limits in Table 6.26; see Section 1.2.3 in the Permit), and that the discharge flow rate does not exceed the permitted rates of a maximum of 52,000 m^3/day and an annual average of 29,000 m^3/day (see Section 1.2.1 in the Permit). The influent is also sampled to allow for analysis of treatment efficacy.

6.11.3 Monitoring Overview

The flow rate, temperature, and TSS of the effluent will be continuously monitored and recorded in the Veolia WTP HMI. MPMC may consider less frequent sampling (MDMER minimum is quarterly) if the monthly mean concentrations of parameters are <10% of the MDMER guidelines for 12 months, as described Section 13 (1) of the MDMER. To make this change if these conditions are met, MPMC will follow the process outlined in Section 7. Table 6.27 summarizes the parameters analysed for effluent quality and Table 6.28 provides an overview of the effluent monitoring. Further details of monitoring sites, including site access descriptions, access or safety concerns, and a brief rationale for monitoring, is provided in the Site Matrix in Appendix D. Figure 6.7 shows monitoring locations of the effluent sampling locations. Reporting of the monitoring data is outlined in Section 9.

Table 6.26 Permit 11678 and MDMER Schedule 4 treated effluent compliance limits for direct discharge to Quesnel Lake

		Permit Limit		MDMER Schedule 4: Authorized Limits	
Constituent	**Units**	**Interim [1]**	**Final [2]**	**MAX Monthly Mean**	**MAX Grab Sample**
Non-Metal Constituents					
pH	pH	6.0 - 9.5	6.0 - 9.5	6.0 - 9.5	6.0 - 9.5
Total Suspended Solids	mg/L	15 (mean)/30 (max)		15	30
Total Sulphate	mg/L	720	1,100	-	-
Total Ammonia	mg/L (as N)	0.41	1.21	-	-
Total Nitrate	mg/L (as N)	9.7	34	-	-
Total Nitrite	mg/L (as N)	0.78		-	-
Total Phosphorus	mg/L	0.09		-	-
Fluoride	mg/L	17			
Cyanide [3]	mg/L	-		1	2
Radium 226 [4]	Bq/L	-		0.37	1.11
Total Metals					
Arsenic	mg/L	0.0034	0.028	0.5	1
Chromium	mg/L	0.0011	0.004	-	-
Copper	mg/L	0.012	0.033	0.3	0.6
Iron	mg/L	1		-	-
Lead	mg/L	-		0.2	0.4
Manganese	mg/L	3.4		-	-
Molybdenum	mg/L	0.36		-	-
Selenium	mg/L	0.06	0.075	-	-
Silver	mg/L	0.00024		-	-
Zinc	mg/L	0.059		-	-
Dissolved Metals					
Aluminum	mg/L	0.75		-	-
Cadmium	mg/L	0.00034		-	-
Iron	mg/L	0.35		-	-
Acute Toxicity Testing Results					
96h LC50 Rainbow Trout	Mortality in 100% effluent	50%		-	LC50 >100%
48h LC50 *D. magna*		50%		-	LC50 >100%

Notes: [1] Maximum discharge limits until toxicity testing on final effluent concentrations is conducted; [2] Maximum discharge limits applicable after ENV is satisfied that toxicity testing demonstrates that the final effluent will not cause mixture toxicity. This requirement has been met; [3] MDMER requirement only; if cyanide is not used in the mining/milling process, then it does not have to be analysed. Since cyanide is not used in the mining/milling process at Mount Polley, the effluent is not analysed for cyanide; [4] MDMER requirement only; if 10 consecutive samples show radium 226 as less than 0.037 Bq/l then frequency of sampling for radium 226 can be reduced to once a quarter. This has been satisfied, and radium 226 analysis is currently conducted quarterly.

Table 6.27 Effluent chemistry parameters

Parameter	LOR	Unit
Field Parameters - General		
pH	-	pH
Conductivity	-	µS/cm
Temperature	-	°C
Turbidity	-	NTU
Physical Tests		
Conductivity	2	µS/cm
Hardness (as $CaCO_3$)	0.5	mg/L
pH	0.1	pH
Total Suspended Solids	1	mg/L
Total Dissolved Solids	10	mg/L
Turbidity	0.1	NTU
Anions and Nutrients		
Alkalinity, Total (as $CaCO_3$)	1	mg/L
Ammonia, Total (as N)	0.005	mg/L
Chloride (Cl)	0.5	mg/L
Fluoride (F)	0.02	mg/L
Nitrate and Nitrite (as N)	0.003	mg/L
Nitrate (as N)	0.001	mg/L
Nitrite (as N)	0.005	mg/L
Total Nitrogen	0.03	mg/L
Orthophosphate-Dissolved (as P)	0.001	mg/L
Phosphorus (P)-Total Dissolved	0.002	mg/L
Phosphorus (P)-Total	0.002	mg/L
Sulfate (SO_4)	0.3	mg/L
Organic / Inorganic Carbon		
Dissolved Organic Carbon	0.5	mg/L

Notes: LOR: Limit of Reporting

Parameter	LOR	Unit
Total and Dissolved Metals		
Aluminum (Al)	0.003	mg/L
Antimony (Sb)	0.0001	mg/L
Arsenic (As)	0.0001	mg/L
Barium (Ba)	0.0001	mg/L
Beryllium (Be)	0.0001	mg/L
Bismuth (Bi)	0.00005	mg/L
Boron (B)	0.01	mg/L
Cadmium (Cd)	0.000005	mg/L
Calcium (Ca)	0.05	mg/L
Chromium (Cr)	0.0005	mg/L
Cobalt (Co)	0.0001	mg/L
Copper (Cu)	0.0005	mg/L
Iron (Fe)	0.03	mg/L
Lead (Pb)	0.00005	mg/L
Lithium (Li)	0.001	mg/L
Magnesium (Mg)	0.1	mg/L
Manganese (Mn)	0.0001	mg/L
Molybdenum (Mo)	0.00005	mg/L
Nickel (Ni)	0.0005	mg/L
Potassium (K)	0.05	mg/L
Selenium (Se)	0.00005	mg/L
Silicon (Si)	0.1	mg/L
Silver (Ag)	0.00001	mg/L
Sodium (Na)	0.05	mg/L
Strontium (Sr)	0.0002	mg/L
Thallium (Tl)	0.00001	mg/L
Tin (Sn)	0.0001	mg/L
Titanium (Ti)	0.01	mg/L
Uranium (U)	0.00001	mg/L
Vanadium (V)	0.0005	mg/L
Zinc (Zn)	0.003	mg/L

Table 6.28 Effluent monitoring overview

<table>
<tr><th>Station Name</th><th>EMS Code</th><th>Description</th><th>Frequency</th><th>Parameters Measured</th><th>Guidelines</th></tr>
<tr><td>E19</td><td>E305050</td><td>WTP influent</td><td>Weekly[1]</td><td>Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals</td><td>N/A</td></tr>
<tr><td rowspan="4">HAD-3</td><td rowspan="4">E304230</td><td rowspan="4">WTP treated effluent</td><td>Continuous[1]</td><td>TSS (calculated), temperature, flow rate</td><td>Permit 11678</td></tr>
<tr><td>Weekly[1]</td><td>Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals, radium 226[2], total mercury[3]</td><td>Permit 11678; MDMER; EEM</td></tr>
<tr><td>Monthly</td><td>Acute toxicity tests:
- Rainbow trout: Biological Test Method: Reference Method for Determining Acute Lethality of Effluents to Rainbow Trout (Reference Method EPS1/RM/13)
- Daphnia Magna: Biological Test Method: Reference Method for Determining Acute Lethality of Effluents to Daphnia magna (Reference Method EPS1/RM/14)
- or most recent methods, as per MDMER</td><td>Permit 11678; MDMER[4]</td></tr>
<tr><td>Semi-annually[5]</td><td>Chronic toxicity tests:
- Biological Test Method: Toxicity Tests Using Early Life Stages of Salmonid Fish (Rainbow Trout) (Reference Method EPS 1/RM/28)
- Invertebrate species: Biological Test Method: Test of Reproduction and Survival Using the Cladoceran Ceriodaphnia dubia (Report EPS 1/RM/21)
- Plant species: Biological Test Method: Test for Measuring the Inhibition of Growth Using the Freshwater Macrophyte, Lemna minor (Reference Method EPS 1/RM/37)
- Algal species: Biological Test Method: Growth Inhibition Test Using Freshwater Alga Selenastrum capricornutum (Report Method EPS 1/RM/25)</td><td>MDMER</td></tr>
</table>

Notes: [1] Only when discharging; [2] MDMER requirement only; if 10 consecutive samples show radium 226 as less than 0.037 Bq/l then frequency of sampling for radium 226 can be reduced to once a quarter. This has been satisfied and radium 226 analysis is currently conducted quarterly; [3] EEM requirement only; can be discontinued if concentration is less than 0.10 µg/L in 12 consecutive samples. This has been satisfied and mercury analysis has been discontinued; [4] MDMER June 2018 Part 2 Division 2 16 (1): frequency may be reduced to quarterly if discharge is determined not to be acutely lethal for 12 consecutive months; [5] Chronic/sub-lethal toxicity tests are conducted semi-annually for 3 years. MDMER June 2018 Schedule 5, 6 (1-3): after 3 years, frequency will be increased to once per calendar quarter on the sub lethal species whose results of sub lethal tests produce the lowest geometric mean, taking into account the inhibition concentration that produces a 25% effect or effective concentration of 25%; N/A: not applicable; TSS: total suspended solids; DOC: dissolved organic carbon; MDMER: Metal and Diamond Mining Effluent Regulations; EEM: Environmental Effects Monitoring

Figure 6.7 CEMP monitoring locations: Effluent monitoring

6.11.4 HIGH-LEVEL MONITORING DESIGN DESCRIPTION

Sample collection, preparation, and shipping will be conducted following the SOPs and WMs for Surface Water Quality Monitoring, and use of associated field meters in the QA/QC Manual. These procedures include use of lab-verified clean or appropriately rinsed sampling bottles and steps to reduce risk of sampling contamination. *In-situ* parameters will be measured when samples for chemistry are collected. Water samples will be analyzed for the parameters described in Section 6.11.3.

Table 6.29 is a summary of previous effluent monitoring undertaken and includes recommendations for future monitoring. Further rationale is provided in the following sub-sections, if appropriate, and is referenced in the table where applicable.

Table 6.29 Summary of effluent monitoring and findings

Summary of Monitoring and Findings	**Monitoring Objective**		
	Operational	**Post-Breach**	**Reclamation**
Previous monitoring undertaken	Discharge monitoring included the influent and treated effluent.	N/A	N/A
Summary of findings	All samples were at or below permit limits for the treated effluent in 2017; in 2016, the majority of samples were at or below the permit limits. When samples did not meet permit limits, ENV was notified and an investigation into the cause was undertaken. Comparing the influent concentrations to treated effluent concentrations verified reduction in parameters interest. See Section 6.11.4.1 for more details.	N/A	N/A
Recommendations for 2018-2020 monitoring	Monitoring of the influent (E19) will be increased from monthly to weekly to align with monitoring of HAD-03 for better efficiency analysis of the WTP.	N/A	N/A

Notes: N/A: not applicable; ENV: Ministry of Environment and Climate Change Strategy; WTP: water treatment plant

Should there be an extreme weather event or equipment failure in the WTP that could affect water quality in the effluent, MPMC has the ability to request rush analysis from the analytical lab (ALS). MPMC maintains an Emergency Response Plan for the effluent discharge as required by the MDMER and the Permit.

6.11.4.1 OPERATIONAL MONITORING

Figure 6.8 shows total copper concentrations and Figure 6.9 shows TSS in the influent (E19) and effluent (HAD-03) in 2017. No exceedances were recorded in 2017 in the effluent.

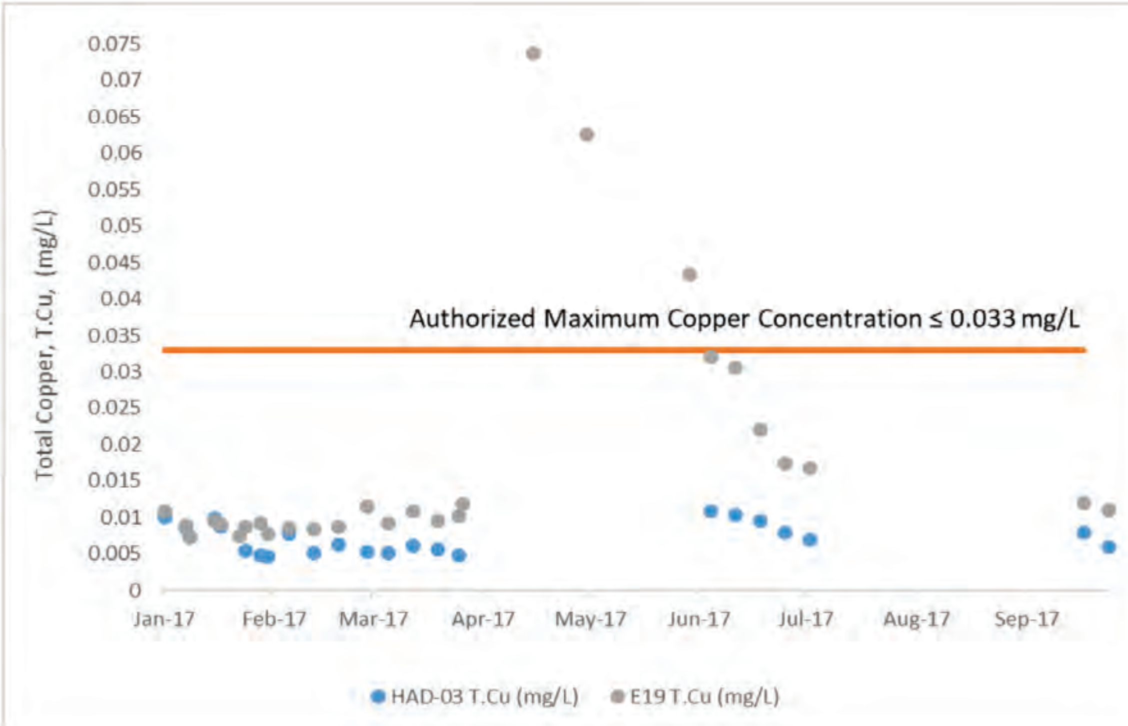


Figure 6.8 Total suspended solids concentrations in influent (E19) and effluent (HAD-03) in 2017

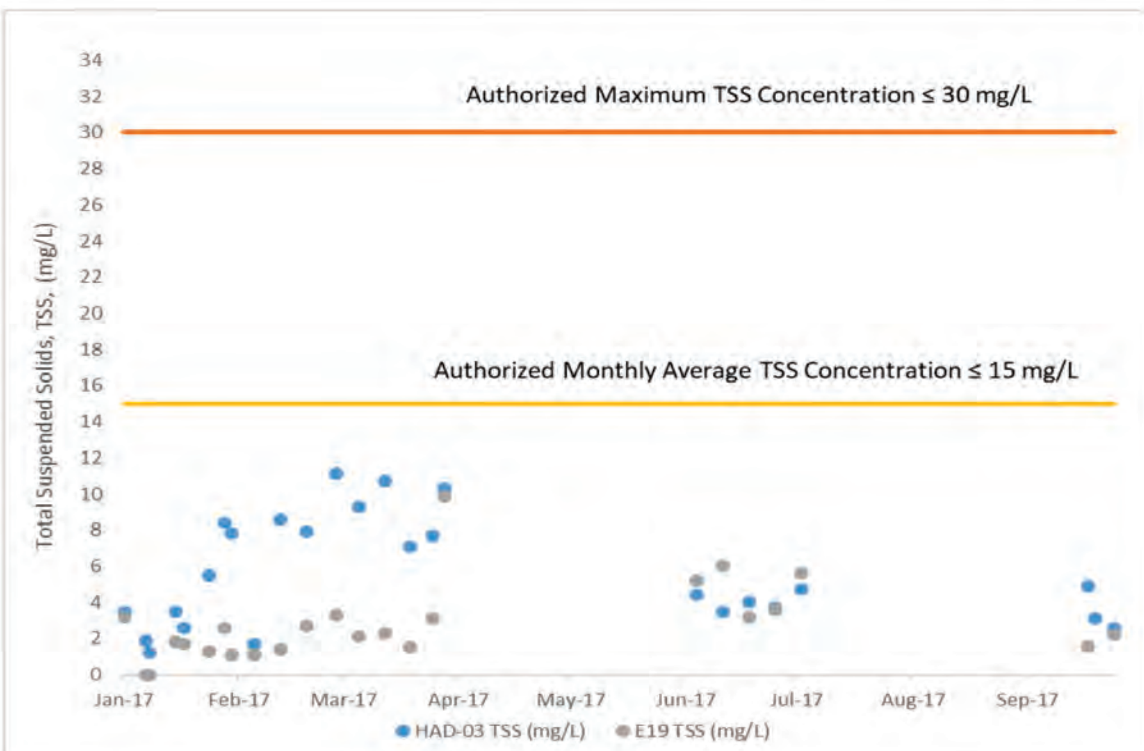


Figure 6.9 Total copper concentrations in influent (E19) and effluent (HAD-03) in 2017

MPMC conducts acute toxicity tests monthly for LC50 Rainbow trout and LC50 *Daphnia magna*. Under the new MDMER, *D. magna* is now a compliance parameter. MPMC will continue to conduct these acute lethality tests as required.

MDMER has changed the frequency of acute toxicity tests for effluent discharge. In accordance with Part 2, Division 2, paragraph 16 (1), acute lethality tests at the final discharge point (HAD-3) will become quarterly if the effluent is determined to be non-lethal for 12 consecutive months (Government of Canada 2018). Effluent at HAD-3 since discharge has started (December 2015) has been shown to be non-lethal.

MPMC has conducted chronic toxicity tests on the effluent discharge since December 7, 2015 on a quarterly and semi-annual basis. Under MDMER requirements, after three years (after December 2018 at HAD-3), the chronic toxicity tests results will be reviewed by a QP and will be streamlined to one test only. This test will be based on the most sensitive organism to the effluent according to historical geometric means and will be tested quarterly. The reduction of frequency from the 2016 CEMP for the chronic toxicity tests, as described in Table 6.28, aligns with the MDMER, as no actionable effects have been recorded at HAD-03 and the MDMER protocol is established to characterise the impacts on the most sensitive aquatic life.

6.11.5 Data Quality Control, Objectives, and Review

For water chemistry, QC samples will be collected as a component of the monitoring program as per the MPMC QA/QC Manual. Effluent monitoring samples are combined in the surface water QC schedule (see Section 6.6.5), as laid out in Table 6.8.

6.11.6 Laboratory Analysis

Samples will be submitted to and processed by a CALA accredited analytical laboratory, typically ALS Environmental Inc. in Burnaby, BC for chemistry samples and Nautilus Environmental in Burnaby, BC for toxicity testing, where standard testing procedures will be used as specified in the most recent editions of the *BC Environmental Laboratory Manual* (MoE 2015) and the MDMER (where applicable; i.e., discharge water toxicity testing).

Laboratory precision will be assessed on the basis of laboratory duplicate results and laboratory accuracy will be assessed using certified reference materials (CRMs) and matrix spikes. Potential laboratory contamination will be assessed using a DQO of ≤ 2 times the laboratory MDL in laboratory method blank results.

QC monitoring for toxicity testing will be carried out at the laboratory, as per the test methods, with requirements to meet criteria such as test organism health history, and control acceptability. Uncertainty associated with test results will be described by the standard deviation around the mean and/or the confidence limits around the point estimate.

6.11.7 Data Analysis and Reporting

Data analysis and interpretation for reporting purposes will include calculation of summary statistics (e.g., mean, minimum, max, and 95th percentile values over the period of interest) and screening of results against applicable regulatory benchmarks (see Table 6.26). Screening will include evaluation of results at the treated effluent discharge against MDMER and the Permit limits. Alerts are set up in the MP-5 database so that MPMC Environmental Department staff receives an email if specified benchmarks are exceeded.

6.12 Sediment Quality Monitoring

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.12.1 Section Authors and Study Design Professionals

This section was written by MPMC, and is a summary of the study design provided by Minnow Environmental Inc. (Minnow). The detailed study design is provided in Appendix B.1. Golder prepared the study design for selecting an alternate reference lake for Polley Lake (Appendix B.7).

6.12.2 Monitoring Objectives

As outlined in Appendix B.1, the objectives of sediment quality monitoring are to:

- "Evaluate the influence of mine activities on the receiving environments (e.g., Hazeltine Creek, Polley Lake, and Quesnel Lake) in comparison to baseline and/or reference conditions";
- "Determine potential implications to aquatic life by applying a variety of interpretive tools";
- "Provide data to support exposure assessment as part of the ERA and HHRA";
- "Provide supporting information for benthic invertebrate community monitoring"; and,
- "Advance technical understanding of the stability or mobility and potential bioavailability of metals and metalloids in lake sediments affected by the TSF Breach".

6.12.3 Monitoring Overview

Sediment quality monitoring under the CEMP is proposed to meet the combined needs of:

1) Operational monitoring (including the discharge of treated effluent to Quesnel Lake);
2) Monitoring of the impact of the 2014 perimeter embankment failure; and
3) Monitoring of response to reclamation activity following the perimeter embankment failure.

An overview of the proposed sediment quality monitoring program is provided in Table 2 and Figures 5 and 6 of Appendix B.1. Sediment quality monitoring is focused on Polley Lake, Hazeltine Creek, and Quesnel Lake, with reference areas identified for each mine-influenced sampling area (i.e., Bootjack Lake for Polley Lake, unaffected areas of Quesnel Lake for impacted areas of Quesnel Lake). Table 3 in Appendix B.1 summarizes the analytes and laboratory reporting limits for the sediment quality monitoring program.

The monitoring program is divided into lake monitoring and creek monitoring and will include physical and chemical characterisation of deposited sediments. Sediment quality sampling will be supported by measurements of temperature, dissolved oxygen, pH, and specific conductance near the sediment-water interface at all sampling stations. Some additional monitoring of the stability and potential bioavailability of metals associated with sediments impacted by the TSF Breach may be undertaken (e.g., deployment of Diffusive Gradients in Thin Films [DGT] devices to monitor labile metal concentrations; toxicity testing using *Hyalella azteca*). More detail is provided in Appendix B.1.

6.12.4 High-Level Monitoring Design Description

Appendix B.1 provides a summary of sediment monitoring history previously conducted in the vicinity of the mine in the surrounding lakes and creeks, including baseline, and pre- and post-breach monitoring. The sample collection methods are also summarized in Appendix B.1 for lake sediment sampling, creek sediment sampling, and DGT sampling. A study design for evaluating alternate reference lakes for Polley Lake is provided in Appendix B.7.

6.12.5 Data Quality Control, Objectives, and Review

Appendix B.1 summarizes the QAQC program for the sediment monitoring plan. It includes specific QA/QC protocols, including collection of QC samples and collection of replicate samples to allow for statistical calculations and to capture within-area variability. As described in Appendix B.1, "comparisons between duplicate samples will be made by calculating the RPD between concentrations of paired duplicates. If the RPD <40% for concentrations that are >5 times the detection limit, then the duplicate sample results will be considered acceptable. Analyte concentrations in laboratory blank samples will be evaluated in relation to their respective detection limits." See Appendix B.1 for more details.

6.12.6 Laboratory Analysis

Chemical analyses will be completed at a CALA accredited analytical laboratory and will include moisture content, pH, particle size distribution, total organic carbon (TOC), total nitrogen, total sulphur, and total metal concentrations, as summarized in Table 3 in Appendix B.1.

Toxicity testing will be conducted at a CALA accredited testing laboratory using a 10 day test of the survival and growth of *Chironomus dilutus.* DGT analysis is described in detail in Appendix B.1 in Section 4.3.

6.12.7 Data Analysis and Reporting

As described in Appendix B.1, data will be provided to the QP and summarized by calculating mean, median, standard deviation, standard error, minimum, maximum, 5th percentile, and 95th percentile for each analyte for all replicated data. Appendix B.1 describes how "sediment quality data will then be evaluated in comparison to British Columbia Working Sediment Quality Guidelines for the protection of aquatic life (WSQGs; MOE 2017b) and reference concentrations. Reference 95th percentile values will be used to screen exposed-area mean concentrations to efficiently identify analytes with concentrations that are beyond the range of reference.

"The overall interpretation of sediment quality data will include integration of a weight-of-evidence that includes other components of the MPMC CEMP (e.g., benthic invertebrate community data). Thus, within the CEMP, sediment quality data interpretation will specifically include the integration of data on sediment quality, the results of specialized evaluations (e.g., DGT results), and the results of bio-assessment (e.g., sediment toxicity testing and benthic invertebrate communities).

"An interpretive report based on the sediment quality data will be prepared to be integrated into the AERR for the Mount Polley Mine that is prepared annually by MPMC (see Section 9.3). The interpretive report will provide all data in an Appendix and will include the data quality review, the results of the screening against BCWSQG, and the results of temporal and spatial comparisons. All data interpretation will be summarized in clear text form supported by tables and data plots."

6.13 Benthic Invertebrate Monitoring

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.13.1 Section Authors and Study Design Professionals

This section was written by MPMC, and is a summary of the study design provided by Minnow. The detailed study design is provided in Appendix B.2. Golder prepared a study design for selecting an alternate reference lake for Polley Lake (Appendix B.7).

6.13.2 Monitoring Objectives

As outlined in Appendix B.2, the objectives of benthic invertebrate monitoring are to:

- "Evaluate the influence of Mount Polley Mine activities on benthic invertebrate communities, productivity, and tissue quality in receiving environments (e.g., Polley Lake, Hazeltine Creek, Edney Creek, and Quesnel Lake) in comparison to baseline and/or reference conditions";
- "Determine potential implications to aquatic life (e.g., through assessment of benthic invertebrate community and productivity endpoints, and comparison of benthic tissue quality results to available guidelines; MoE 2014) and to aquatic ecosystem health by providing supporting information for the assessment of potential effects to higher trophic levels (e.g., fish and fish habitat quality; Section 6.16)"; and,
- "Provide data to support exposure assessment as part of the ERA and HHRA."

Benthic invertebrate community monitoring is also required as part of EEM under the MDMER. The objective of the MDMER EEM benthic invertebrate monitoring identified in Appendix B.2 is to "evaluate whether there are effects to benthic invertebrate community characteristics between the area of Quesnel Lake exposed to Mount Polley mine effluent and a reference area (Environment Canada 2012)."

6.13.3 Monitoring Overview

Benthic invertebrate monitoring under the CEMP is designed to meet the combined needs of:

1) Operational monitoring (including the discharge of treated effluent to Quesnel Lake);
2) Monitoring of the impact of the 2014 TSF embankment breach; and
3) Monitoring of the response to reclamation activity following the TSF embankment breach.

An overview of the proposed benthic invertebrate monitoring program is provided in Table 3 of Appendix B.2, and includes benthic invertebrate community, productivity, and tissue quality. Benthic invertebrate monitoring is focused on Polley Lake, Hazeltine Creek, lower Edney Creek, Quesnel Lake, and associated reference areas (Figures 6 and 7 of Appendix B.2). Table 4 in Appendix B.2 summarizes the analytes and laboratory reporting limits for the benthic invertebrate monitoring program. The sampling frequency at this time is once every three years.

6.13.4 High-Level Monitoring Design Description

Appendix B.2 provides a summary of benthic invertebrate monitoring history previously conducted in the vicinity of the mine in the surrounding lakes and creeks, including baseline, and pre- and post-breach monitoring. The sample collection methods are also summarized in Appendix B.2 for community and productivity sampling, and tissue quality sampling. A study design for evaluating alternate reference lakes for Polley Lake is provided in Appendix B.7.

6.13.5 Data Quality Control, Objectives, and Review

Appendix B.2 summarizes the QAQC program for the benthic invertebrate monitoring plan. It includes specific QA/QC protocols, including collection of QC samples and collection of replicate samples to allow for statistical calculations and to capture within-area variability. As stated in Appendix B.2, "for benthic invertebrate tissue quality samples, comparisons between duplicate samples will be made by calculating the RPD between concentrations of paired duplicates. If the RPD <25% for concentrations that are >5 times the detection limit, then the duplicate sample results will be considered acceptable. Analyte concentrations in laboratory blank samples will be evaluated in relation to their respective detection limits.

"For benthic invertebrate community samples, reanalysis for quality control endpoints (organism sorting efficiency, subsampling precision and accuracy error, and taxonomic identification error) will be performed on 10% of samples, and results of quality control measures will be evaluated relative to pre-established DQOs." See Appendix B.2 for more details.

6.13.6 Laboratory Analysis

As described in Appendix B.2, "taxonomic identification of benthic invertebrate community samples will be completed by a qualified laboratory certified under the Taxonomic Certification Program of the Society for Freshwater Science (SFS). Benthic invertebrate tissue quality samples will remain frozen until overnight shipment on ice with completed COCs to ALS Environmental, Burnaby BC, which is an analytical laboratory accredited by the CALA."

6.13.7 DATA ANALYSIS AND REPORTING

As described in Appendix B.2, data will be provided to the QP and summarized by calculating mean, median, standard deviation, standard error, minimum, maximum, 5th percentile, and 95th percentile for each endpoint for all replicated data. Data analysis will be completed for each monitoring component (community, productivity, and tissue quality). More detail for each monitoring component is provided in Section 4.5 of Appendix B.2.

As stated in Appendix B.2, "an interpretive report based on the benthic invertebrate data will be prepared to be integrated into the AERR for the Mount Polley Mine that is prepared annually by MPMC (see Section 9.3). The interpretive report will provide all data in an appendix and will include the date quality review, the results of the screening against BCWQG, and the results of temporal and spatial comparisons. All data interpretation will be summarized in clear text form supported by tables and data plots."

6.14 PLANKTON AND CHLOROPHYLL *A* MONITORING

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.14.1 SECTION AUTHORS AND STUDY DESIGN PROFESSIONALS

This section was written by MPMC.

6.14.2 MONITORING OBJECTIVES

The objective of phytoplankton and zooplankton monitoring at lake stations is to assess potential changes in plankton community abundance and diversity, as well as temporal and special changes in zooplankton metal concentrations. Chlorophyll *a* sampling will be conducted and analyzed to provide support data that can be interpreted with other biological monitoring and water chemistry data in a broader analysis of lake productivity.

This monitoring will be conducted to aid in assessing lake productivity following the TSF embankment breach (Post-Breach Monitoring: Polley Lake and Quesnel Lake) and to identify any changes related to the chemistry of the discharged treated effluent (Operational Monitoring: Quesnel Lake).

6.14.3 MONITORING OVERVIEW

Table 6.30 summarizes the parameters analysed for plankton and chlorophyll *a* monitoring. Chlorophyll *a*, phytoplankton taxonomy and biomass, and zooplankton taxonomy and metal tissue samples will continue to be collected concurrently with water chemistry samples (including field parameters) three times per year to capture early and late growing seasons as outlined in Table 6.31. Growing seasons were determined after monthly sampling was conducted in 2015; data analysis of zooplankton community is presented in Golder (2016d). Further details of monitoring sites, including site access descriptions, access or safety concerns, and a brief rationale for monitoring, is provided in the Site Matrix in Appendix D. Figure 6.10 shows monitoring locations of the plankton and chlorophyll *a* sampling locations.

Table 6.30 Plankton and chlorophyll *a* parameters

Parameter	LOR	Unit
Taxonomy		
Phytoplankton	-	-
Zooplankton	-	-
Total Metals in Tissue		
Aluminum (Al)	2	mg/kg
Antimony (Sb)	0.01	mg/kg
Arsenic (As)	0.02	mg/kg
Barium (Ba)	0.05	mg/kg
Beryllium (Be)	0.01	mg/kg
Bismuth (Bi)	0.01	mg/kg
Boron (B)	1	mg/kg
Cadmium (Cd)	0.005	mg/kg
Calcium (Ca)	20	mg/kg
Chromium (Cr)	0.005	mg/kg
Cobalt (Co)	0.05	mg/kg
Copper (Cu)	0.02	mg/kg
Iron (Fe)	0.1	mg/kg
Lead (Pb)	3	mg/kg
Lithium (Li)	0.02	mg/kg
Magnesium (Mg)	0.5	mg/kg
Manganese (Mn)	2	mg/kg
Molybdenum (Mo)	0.05	mg/kg
Nickel (Ni)	0.02	mg/kg
Potassium (K)	0.2	mg/kg
Selenium (Se)	10	mg/kg
Silicon (Si)	20	mg/kg
Silver (Ag)	0.05	mg/kg
Sodium (Na)	0.05	mg/kg
Strontium (Sr)	20	mg/kg
Thallium (Tl)	0.05	mg/kg
Tin (Sn)	0.02	mg/kg
Titanium (Ti)	0.002	mg/kg
Uranium (U)	0.1	mg/kg
Vanadium (V)	0.002	mg/kg
Zinc (Zn)	0.1	mg/kg
Plant Pigments (Water)		
Chlorophyll *a*	0.01	µg

Notes: LOR: Limit of Reporting

Table 6.31 Plankton and chlorophyll *a* monitoring overview

Station Name	EMS Code	Description	Frequency	Parameters Measured	Guidelines
P2	E307975	Polley Lake deepest area at south end	Three times between June 15 and September 15, at least 30 days apart	Chlorophyll *a*, Phytoplankton taxonomy and biomass Zooplankton metals, taxonomy, and biomass	N/A
B2	E215897	Bootjack Lake deepest area at south end	Three times between June 15 and September 15, at least 30 days apart	Chlorophyll *a*, Phytoplankton taxonomy and biomass Zooplankton metals, taxonomy, and biomass	N/A
QUL-ZOO-1	E306455	Quesnel Lake zooplankton station at Hazeltine	Three times between June 15 and September 15, at least 30 days apart	Chlorophyll *a*, Phytoplankton taxonomy and biomass Zooplankton metals, taxonomy, and biomass	N/A
QUL-ZOO-7	E306456	Quesnel Lake zooplankton station at Horsefly	Three times between June 15 and September 15, at least 30 days apart	Chlorophyll *a*, Phytoplankton taxonomy and biomass Zooplankton metals, taxonomy, and biomass	N/A

Notes: N/A: not applicable; IDZ: initial dilution zone

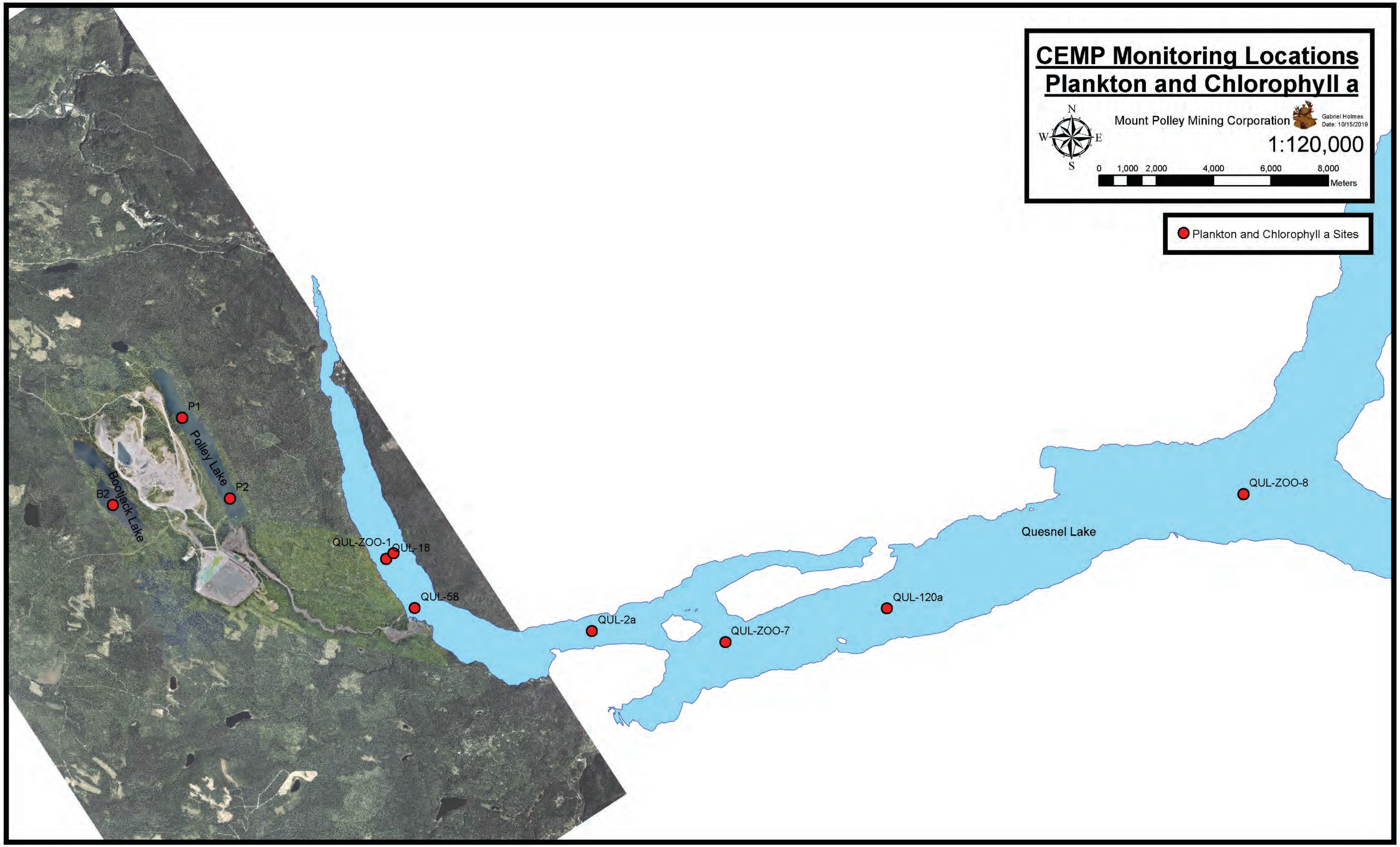


Figure 6.10 CEMP monitoring locations: Plankton and chlorophyll *a* monitoring

6.14.4 High-Level Monitoring Design Description

Sample collection, preparation, and shipping will be conducted following procedures outlined in the SOPs and WMs on Lake Water Monitoring and Zooplankton Sampling in the MPMC QA/QC Manual.

In brief, sampling at all stations will be conducted as follows:

- Zooplankton samples:
    - will be collected using 50 µm mesh nets with a mouth diameter ≥0.5 m, and equipped with a flow meter. In 2019, for stations previously sampled with a 150-µm mesh net, samples will be collected with both a 50- and a 150-µm mesh net to enable an assessment of the difference between the two net mesh sizes and to facilitate comparison with historical data.
    - will be collected using a modified horizontal tow.
    - for taxonomy/biomass will be transferred to a Nalgene container and preserved with buffered formalin.
    - for tissue chemistry will consist of a composite of multiple tows to achieve a minimum required tissue mass for analysis (i.e., 1.5 g).
- Phytoplankton samples
    - will be collected as a depth-integrated sample. Water will be collected from at least four discrete depths at each station (surface, one-third Secchi depth, two-thirds Secchi depth, total Secchi depth), with a grab sampler (e.g., Kemmerer, Van Dorn) or with a length of flexible tubing modified for this purpose, with or without a peristaltic pump.
    - will be collected as surface and depth-integrated samples in 2019 to allow for an assessment of the difference between the two methods and to facilitate comparison with historical data.
    - for Chlorophyll *a* analysis will be transferred to a container wrapped in aluminum foil.
    - for taxonomy/biomass will be preserved with Lugol's solution

One replicate will be collected in each of June and August, and five replicates will be collected during the July sampling event, and samples for zooplankton and phytoplankton will be collected on the same day for each lake. Secchi depth and *in situ* water-chemistry supporting data will be collected concurrently at each station.

Table 6.32 is a summary of previous plankton and chlorophyll *a* monitoring undertaken and includes recommendations for future monitoring. Further rationale is provided in the following sub-sections, if appropriate, and is referenced in the table where applicable. Monitoring for plankton and chlorophyll *a* overlaps with operational monitoring in Quesnel Lake, as described in Section 6.14.2.

Table 6.32 Summary of plankton and chlorophyll *a* monitoring and findings

Summary of Monitoring and Findings	Monitoring Objective		
	Operational	Post-Breach	Reclamation
Previous monitoring undertaken	Plankton (phyto and zoo) taxonomy and chlorophyll *a* sampling frequency was semi-annually in 2016 and 2017 (June/July and August) at two stations in Polley Lake and three stations in Quesnel Lake. Some sampling events were missed in 2017 due to safety concerns.		N/A
Summary of findings	Zooplankton and phytoplankton results will be analysed in the three-year interpretive report (see Section 9.4) and recommendations for changes may be made, if required, in this report. Some chlorophyll *a* data were collected prior to the TSF breach. Results from 2013 – 2017 are shown in Section 6.14.4.1.		N/A
Recommendations for 2017-2020 monitoring	The sampling program outlined in Table 6.31 will be repeated annually.		N/A

Notes: N/A: not applicable

6.14.4.1 POST-BREACH MONITORING

Figure 6.11 shows chlorophyll *a* data collected from Polley Lake from 2013 – 2017. Data from P2 will continue to be collected to analyse potential trends.

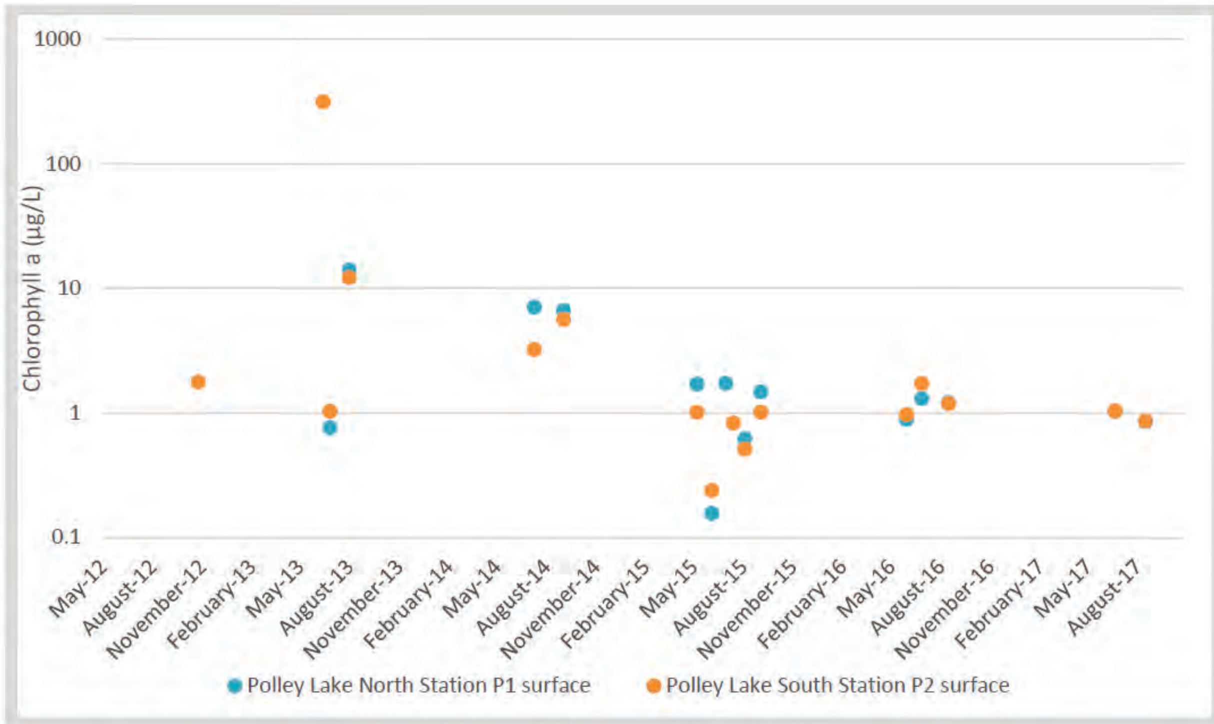


Figure 6.11 Chlorophyll *a* data collected from Polley Lake from 2013 - 2017

6.14.5 Data Quality Control, Objectives, and Review

QA/QC procedures will consist of re-analysis of 10% of phytoplankton and zooplankton taxonomy samples, and analysis of a duplicate metals sample for tissue chemistry once annually. For taxonomy, replicate counts should meet the DQO of within 20% of the original count. For metals, the RPD data quality of greater than 40% for concentrations greater than or equal to five times the MDL will be used to identify differences between original and duplicate samples for metals.

6.14.6 Laboratory Analysis

Plankton taxonomy samples will be shipped to the following laboratories for processing[2]:

- Biologica environmental Services Ltd., Victoria, BC: plankton taxonomy.
- ALS Environmental Inc., Burnaby, BC[3] – chlorophyll *a* and zooplankton tissue chemistry.

6.14.7 Data Analysis and Reporting

Statistical analysis will be carried out to evaluate trends over time by comparing results with data collected annually. In Quesnel Lake, near-field data will be compared with far-field and reference data to evaluate

[2] No accreditation program exists for plankton taxonomy

[3] Accredited by the Canadian Association of Laboratory Accreditation (CALA)

potential mine impact and spatial trends. These data will also be used to assess implications for lake productivity and fish populations.

6.15 Periphyton Monitoring

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.15.1 Section Authors and Study Design Professionals

This section was written by MPMC, and is a summary of the study design provided by Minnow. The detailed study design is provided in Appendix B.3.

6.15.2 Monitoring Objectives

As outlined in Appendix B.3, the objectives of periphyton monitoring are to:

- "Evaluate the influence of mine activities (related to mine operations, the TSF breach, and/or rehabilitation activities) on Hazeltine Creek (the creek receiving environment directly influenced by mine activity) and lower Edney Creek (a creek environment directly influenced by the TSF breach)";
- "Serve as supporting information for the determination of potential effects to aquatic life at higher trophic levels (benthic invertebrates and fish; Sections 6.13 and 6.16, respectively)";
- "Provide supporting information for the assessment of benthic invertebrate tissue quality, benthic invertebrate community condition, and fish habitat productivity"; and,
- "Provide data to support exposure assessment as part of the ERA and HHRA".

Periphyton monitoring will include assessment of productivity, community composition, and tissue quality, with comparison to previous and/or reference conditions, to applicable guidelines (i.e., chlorophyll *a*; MoE 2018), and to literature-based criteria (or classification ranges) for productivity.

6.15.3 Monitoring Overview

Periphyton monitoring under the CEMP is proposed to meet the combined needs of:

1) Operational monitoring (including the previous discharge of treated effluent to Hazeltine Creek);
2) Monitoring of the impact of the 2014 TSF breach; and
3) Monitoring of the response to reclamation activity following the TSF breach.

An overview of the proposed periphyton monitoring program is provided in Table 1 and Figure 4 of Appendix B.3. Periphyton monitoring is focused on Hazeltine Creek and lower Edney Creek with reference areas identified for each mine-influenced sampling area (i.e., upper Edney Creek and Frypan Creek for upper Hazeltine Creek, and an unaffected area of lower Edney Creek for rehabilitated areas of lower Edney Creek and lower Hazeltine Creek). Table 2 in Appendix B.3 summarizes the analytes and laboratory reporting limits or the periphyton monitoring program.

6.15.4 High-Level Monitoring Design Description

Appendix B.3 provides a summary of periphyton monitoring history previously conducted in the vicinity of the mine in the surrounding creeks, including pre- and post-breach monitoring. The sample collection methods are also summarized in Appendix B.3 for biomass and chlorophyll *a* sampling, community sampling, and tissue quality sampling.

6.15.5 Data Quality Control, Objectives, and Review

Appendix B.3 summarizes the QAQC program for the periphyton monitoring plan. It includes specific QA/QC protocols, including collection of QC samples and collection of replicate samples to allow for statistical calculations and to capture within-area variability. As stated in Appendix B.3, "comparisons between duplicate samples will be made by calculating the RPD between concentrations of paired duplicates. If the RPD < 25% for concentrations that are > 5 times the detection limit, then the duplicate sample results will be considered acceptable. Analyte concentrations in laboratory blank samples will be evaluated in relation to their respective detection limits. Specific QC sampling and associated reporting will for tissue quality and periphyton productivity endpoints be requested of the analytical laboratory, including reagent blank results, laboratory replicate results, and laboratory accuracy results (i.e., matrix spikes, laboratory control samples, and/or certified reference materials). QC reporting will also be requested of the laboratory performing taxonomic analysis of the periphyton community samples, including organism enumeration checks for a minimum of 10% of samples." See Appendix B.3 for more details.

6.15.6 Laboratory Analysis

The laboratory responsible for the physical or chemical analyses will be accredited by the CALA for these analyses.

6.15.7 Data Analysis and Reporting

For all replicated data (typically based on a sample size of five or eight stations per area), data will be provided to the QP and summarized by calculating mean, median, standard deviation, minimum, and maximum for each analyte. Data analysis will be completed for each monitoring component (productivity, community, and tissue quality). More detail for each monitoring component is provided in Section 4.5 of Appendix B.3.

As outlined in Appendix B.3, "an interpretive report based on the periphyton monitoring data will be prepared to be integrated into the AERR for the Mount Polley Mine that is prepared annually by MPMC (see Section 9.3). The interpretive report will provide all data in an appendix and will include the data quality review, the results of the screening against BCWSQG and other guidelines or classification schemes, and the results of temporal and spatial comparisons. All data interpretation will be summarized in clear text form supported by tables and data plots."

6.16 Fish Monitoring

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.16.1 Section Authors and Study Design Professionals

This section was written by MPMC, and is a summary of the study design provided by Minnow. The detailed study design is provided in Appendix B.4.

6.16.2 Monitoring Objectives

As outlined in Appendix B.4, the objectives of fish monitoring are to:

- "Evaluate the influence of Mount Polley Mine activities on fish communities, populations, and tissue quality in receiving environments (Hazeltine Creek, Polley Lake, and Quesnel Lake) in comparison to baseline and/or reference conditions";
- "Determine potential implications to aquatic ecosystem health and human health (e.g., relative to available fish tissue quality guidelines [MoE 2014; CFIA 2015])";
- "Provide data to support exposure assessment as part of the ERA and HHRA"; and,
- "Document fish habitat utilization in creek and lake areas that were physically impacted by the TSF breach (most notably Hazeltine Creek and the lower segment of Edney Creek), thereby documenting the effectiveness of fish habitat rehabilitation efforts".

From Appendix B.4, the objective of the MDMER EEM fish monitoring is to "evaluate whether there are differences in population endpoints (survival, growth, and reproduction) of sentinel fish species between the area of Quesnel Lake exposed to Mount Polley mine effluent and a reference area (Environment Canada 2012)." Evaluation of selenium in fish tissues is also triggered under the MDMER on the basis of current selenium concentrations in effluent.

6.16.3 Monitoring Overview

Fish monitoring under the CEMP is designed to meet the combined needs of:

1) Operational monitoring (including the discharge of treated effluent to Quesnel Lake);
2) Monitoring of the impact of the 2014 TSF embankment breach; and
3) Monitoring of the response to remediation following the TSF embankment breach.

As previously indicated, fish monitoring includes fish tissue quality monitoring, sentinel fish population monitoring, fish habitat characterization and fish usage monitoring, and fish community monitoring. An overview of the proposed fish monitoring program is provided in Table 8 and Figures 5 and 6 of Appendix B.4. Table 9 in Appendix B.4 summarizes the fish tissue analytes and laboratory reporting limits for the fish monitoring program.

6.16.4 High-Level Monitoring Design Description

Appendix B.4 provides a summary of fish monitoring history previously conducted in the vicinity of the mine in the surrounding creeks, including baseline monitoring, and pre- and post-breach monitoring. The sample collection methods and monitoring are also summarized in Appendix B.4 for tissue sampling, sentinel fish population monitoring, fish community monitoring, and fish habitat characterization and usage monitoring.

In addition to the monitoring outlined in Appendix B.4, visual spawning surveys of upper Hazeltine Creek to evaluate the success of re-introduction of spawning access by Polley Lake rainbow trout, and at the mouth of Hazeltine/Edney Creek to confirm access to that stream reach following a monitoring program developed in conjunction with the Habitat Remediation Working Group (HRWG). The surveys consisted of two field staff walking the bank of the creek channel and documenting visual observations of species, life stage, and behaviour of fish in the creek, and in lower Hazeltine/Edney, the presence of redds was noted. In upper Hazeltine Creek 25 surveys were conducted through the 2018 ice-free period and in the Hazeltine/Edney Creek mouth, 12 surveys were conducted. Spawning surveys were conducted in Hazeltine/Edney again in 2019.

6.16.5 Data Quality Control, Objectives, and Review

Appendix B.4 summarizes the QAQC program for the fish monitoring plan. It includes specific QA/QC protocols, including collection of QC samples and collection of replicate samples to allow for statistical calculations and to capture within-area variability. For fish tissue samples, comparisons between duplicate samples will be made by calculating the RPD between concentrations of paired duplicates. If the RPD <25% for concentrations that are >5 times the detection limit, then the duplicate sample results will be considered acceptable. Specific QC samples will include laboratory blanks, laboratory replicates, and laboratory accuracy samples (i.e., matrix spikes, laboratory control samples, and/or certified reference materials). The QC sample results will be assessed as part of the data quality review. See Appendix B.4 for more details.

6.16.6 Laboratory Analysis

All chemical analyses will be completed by a laboratory that is accredited by CALA, and will be required to include specific QC samples and report associated results.

6.16.7 Data Analysis and Reporting

Catch-per-unit-effort and summary statistics for meristic measurements taken in the field will be calculated. Although community and population data is collected during every phase or component of the fish monitoring program, the sample size will be defined by the study objectives and may be insufficient to address corollary questions. For example, the sample size required for tissue quality analyses (n = 8) is not large enough to support formal contrasts of population endpoints. To this end, evaluation of fish community data will rely on qualitative comparisons, and conclusions regarding fish populations will be supported by non-lethal measurements and sampling under the MDMER EEM (with larger sample size), as described in Appendix B.4. Analysis methods for the MDMER EEM fish population data, as described in Appendix B.4 will be "consistent with EEM technical guidance (Environment Canada 2012). Summary statistics, including mean, median, minimum, maximum, standard deviation, standard error, and sample size, will be calculated for fish age, fork length, total length, body weight, condition, liver weight, gonad weight, and fecundity; calculations will be completed according to species and area. All data sets will be assessed for normality and equality of variance in order to determine the suitability of parametric statistical procedures. An effect on the fish population will be evaluated for each of these measures and is defined as a statistically significant difference between the effluent-exposed area and the reference area (Environment Canada 2012). For each endpoint, statistically significant differences between effluent-exposed and reference areas (by species and sex) will be assessed using ANOVA, Analysis of Covariance (ANCOVA), or non-parametric equivalents, as appropriate, following technical guidance (Environment Canada 2012).

"For the fish tissue data sets, statistical comparisons of age, length, weight, and concentrations of metals in fish tissues (n = 8) will be completed among years and locations. The sample size, mean, median, standard deviation, standard error, minimum, maximum, 5th percentile, and 95th percentile will be calculated for each analyte. Means will be calculated using the Kaplan-Meier (K-M) method. The standard deviation and the median for each analyte will also be calculated using the K-M method. When a standard deviation cannot be estimated (i.e., when an analyte has a high proportion of censored values), it will be reported as "not calculated".

"Results of the fish habitat characterizations for Upper Hazeltine, Lower Hazeltine, and Lower Edney creeks will be summarized, along with fish usage results, according to season (spring, summer, and fall) and year. Fish habitat characterization measures will be summarized by season, reach, and area (rehabilitated and reference), with summary statistics (mean and standard deviation) calculated for all numerical parameters."

More detail for each monitoring component is provided in Section 4.5 of Appendix B.4.

An interpretive report based on the fish monitoring data was prepared to be integrated into the AERR for the Mount Polley Mine that is prepared annually by MPMC (see Section 9.3). The interpretive report will provide all data in an appendix and will include the data quality review, the results of the screening against BCWQGs, and the results of temporal and spatial comparisons. All data interpretation will be summarized in clear text form supported by tables and data plots.

With respect to the spawning surveys, rainbow trout were observed spawning in upper Hazeltine Creek, confirming that the fish were successfully re-introduced to the reconstructed channel. A majority of spawning activity occurring from May 10 to 25, 2018, when 488 rainbow trout redds were counted, and emergence of young-of-year trout began in late June (Minnow 2019). In 2018, rainbow trout, longnose sucker and redside shiner were observed lower Hazeltine/Edney (Minnow 2019) and in fall 2019, sockeye salmon were observed using the reconstructed habitat (data will be reported in 2020).

6.17 Wildlife Monitoring

Wildlife monitoring described below includes observational monitoring and monitoring using wildlife cameras. A study design for wildlife monitoring in the Hazeltine Creek corridor will be provided in 2020. This subsection will be updated accordingly.

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.17.1 Section Authors and Study Design Professionals

This section was written by MPMC (wildlife observations) and Golder (tissue collection and food chain model – related to follow up tasks for the ERA).

6.17.2 Monitoring Objectives

The current objective of the wildlife monitoring is to document the presence of mammals and birds using or migrating through the mine site and adjacent areas. This information is used for land use planning and to monitor the potential for effects of mine-related activities on animals in the area.

The study design concept in Appendix B.5 focuses on reducing the sources of uncertainty from the terrestrial ERA (Golder 2017).

6.17.3 Monitoring Overview

Operational Monitoring - Wildlife occurrences will be recorded throughout the year by MPMC Environmental Department staff, and by other MPMC employees and contractors, when possible. Observations will include wildlife sightings and evidence of wildlife, such as tracks and droppings. Documentation will include the date, initials of the observer, location of the observation, wildlife observed, and comments (such as size of group, sex, or activity of an animal).

Data files from wildlife cameras installed in three locations (Hazeltine Creek, Mine Site, Reference site) are downloaded and reviewed monthly. Any changes to the location of the cameras are documented. Details including frequency of use by wildlife near each camera and variety of wildlife are documented. These details will be included in the AERR.

Supplemental Tasks - A tiered approach was been recommended, as outlined in Appendix B.5. Only Tasks 1A, 2A, 2B and 3 will be undertaken as part of the current CEMP. If risks are found to be unacceptable at the end of Step 2, further investigation following the proposed tiered approach described in Appendix B.5 will be conducted, which may include a development of a study design.

6.17.4 High-Level Monitoring Design Description

Table 6.33 is a summary of previous wildlife monitoring undertaken and includes recommendations for future monitoring. Further rationale is provided in the following sub-sections, if appropriate, and is referenced in the table where applicable.

Table 6.33 Summary of wildlife monitoring and findings

Summary of Monitoring and Findings	Monitoring Objective		
	Operational	**Post-Breach**	**Reclamation**
Previous monitoring undertaken	General wildlife observations (animals, scat, and tracks) documented.	N/A	N/A
Summary of findings	734 observations of wildlife were documented in 2017.	N/A	N/A
Recommendations for 2018-2020 monitoring	General wildlife observations will continue to be made per Permit requirements. A study design for wildlife monitoring in the Hazeltine Creek corridor will be provided in 2020.	Reconnaissance-level field surveys to support updated food chain modelling for potential bioaccumulation in wildlife.	N/A

Notes: N/A: not applicable

6.17.4.1 Operational Monitoring

This section will be updated when a study design is submitted in 2020.

6.17.4.2 Post-Breach Monitoring

In 2018, a reconnaissance-level survey was undertaken to support an update of the food chain model first presented in the ERA. Soil sampling is presented in Section 6.19, soil invertebrate sampling in Section 6.20, and vegetation monitoring in Section 6.21. An additional component considered in the food chain model was flying insects.

Samples of flying invertebrates (bees/wasps [order Hymenoptera], moths [order Lepidoptera], and crickets/grasshoppers [order Orthoptera]) were collected from the impacted area and background areas. Information about the tissue chemistry of this important food item for insectivorous birds and bats was not previously available in Golder (2017). The samples were collected through a combination of manual foraging and trapping. Manual foraging generally involved surveying flowering plants for bees or the ground surface for grasshoppers and using a sweep net to capture target invertebrates. Moths were predominantly collected using black light traps. Terrestrial invertebrate trapping was conducted using methods adapted from the RISC guidelines for terrestrial arthropod inventory (RIC 1998), guidance from the Biological Survey of Canada (Marshall et al. 1994; Danks 1996) and the US Department of Agriculture (Schauff 1998). Terrestrial invertebrate trapping methods employed on the Site included malaise traps, black light traps, pan/window traps and Berlese funnels.

Irrespective of the specific capture method, the following steps consistent with the *BC Field Sampling Manual* (BC ENV 2013) were followed to process the flying invertebrate samples:

- Samples were collected using nitrile gloves and transferred to clean Ziploc bags.
- Flying invertebrates of the same order from a single sample location (limited to 25 meters squared [m2]) were composited.
- Flying invertebrates were left in sample containers stored at ambient temperature overnight to allow samples to depurate.
- Flying invertebrate samples were rinsed using DI water and blotted dry with lint-free wipes before being transferred to clean Ziploc bags.
- Samples were transferred to a freezer to kill the invertebrates.
- Samples were kept frozen until they were submitted to the laboratory for analysis.

The invertebrate tissue samples were submitted for analysis of metals and moisture content, and the data were used, with other data collected as part of the reconnaissance survey, to update the food chain model developed to evaluate the potential for bioaccumulation of metals in wildlife. The food chain model update is described in Section 6.17.7.

6.17.5 Data Quality Control, Objectives, and Review

Wildlife observations data will undergo a QC screening prior to upload to the network.

Twelve duplicate flying invertebrate samples were collected and laboratory QC samples consisted of duplicates, method and equipment blanks, and certified reference materials. RPDs exceeded DQOs for most metals in at least one duplicate sample. A higher variability in flying invertebrate samples is expected because the field duplicates are not splits of a composite—they are two composites of different individual organisms. In terms of copper, RPDs of 58 and 86% were noted in two of twelve duplicate pairs for wet weight concentrations and in one of twelve (RPD = 50%) of dry weight concentrations For vanadium, RPDs of 65 to 126% were noted in three of twelve duplicate sample pairs for wet weight concentrations and in zero of twelve duplicate sample pairs for dry weight. The data were considered reliable and suitable for there intended purpose

6.17.6 Laboratory Analysis

Laboratory analyses of the invertebrate tissue samples were undertaken by a CALA-accredited laboratory.

6.17.7 Data Analysis and Reporting

Number of wildlife observations will be tabulated and reported in the AERR.

The flying insect chemistry data (Golder 2019a) and updated food chain model (Golder 2019b) were submitted to ENV as an attachment to the 2018 Annual Report.

The wildlife food chain model presented in the ERA (Golder 2017) provided screening-level risk estimates for receptors exposed to copper and vanadium (the only contaminants of concern identified in the ERA), which were based on calculated area-weighted hazard quotients (HQs) of <1 to 2.8, and a maximum HQ of 5.1 (for masked shrew in the Polley Flats area). Although the HQs were considered not to represent an unacceptable risk to wildlife, the food chain model was refined in 2018 by:

- Adding bats (*Myotis* sp.) as a receptor.
- Improving the quality of information with respect to tissue concentrations in invertebrates and plants by expanding the existing bioaccumulation sampling (as part of the reconnaissance-level survey conducted in 2018).
- Replacing the conservative assumption that flying insects have the same tissue concentrations as soil-dwelling insects by collecting site-specific data (as part of the reconnaissance-level survey conducted in 2018).
- Refining the toxicity reference values (i.e., the denominator in the HQ) to consider more than a highly conservative threshold

Revised screening-level risk estimates resulted in lower HQs. Screening-level HQs were <1 for all receptors except robin, shrew, and bat exposed to copper. The aggregate area-weighted HQs for those three receptors ranged from 1.0 to 1.7, and the maximum observed HQ for a sub-area was 2.1 for robin in the Polley Flats area. When a refined TRV was used to provide an additional level of protection to listed species, no HQs greater than 1 were identified and therefore, risks to wildlife associated with copper and vanadium in soils at the site are considered to be acceptable.

6.18 Amphibian and Reptile Monitoring

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.18.1 Section Authors and Study Design Professionals

This section was written by Golder. The detailed study design concept is provided in Appendix B.6. Note that Appendix B.6 is a study design concept; a study design may be submitted at a later date depending on results of a preliminary review (Steps 1 and 2 as outlined in Figure 1 in Appendix B.6).

6.18.2 Monitoring Objectives

The study design concept in Appendix B.6 focuses on reducing the sources of uncertainty from the terrestrial ERA (Golder 2017). As outlined in Appendix B.6, the objectives of amphibian monitoring will be to "continue the risk assessment process by proceeding through tiers to the point needed to support an informed risk management decision". More detail is provided in Appendix B.6.

6.18.3 Monitoring Overview

A tiered approach has been recommended, as outlined in Appendix B.6. Only Steps 1 and 2 will be completed as part of the current CEMP, with Step 1 undertaken in 2018. If risks are found to be unacceptable at the end of Step 2, further investigation following the proposed tiered approach described in Appendix B.6 will be conducted, which may include a development of a study design.

6.18.4 High-Level Monitoring Design Description

In 2018, Step 1 of the study design concept was undertaken, specifically, a hazard evaluation. Existing soil, sediment and surface water chemistry data were screened for different habitat units against a conservative amphibian-specific screening value, as follows:

1. Review of existing guidelines: the purpose of the review was to determine if existing guidelines, criteria or standards contained sufficient amphibian-specific data to allow their use as a screening value for this assessment.
2. Derivation of screening values: the existing guidelines were determined to be unsuitable for the amphibian hazard assessment, and therefore screening values were developed through the review of scientific literature. Toxicity testing data were compiled, an uncertainty analysis was conducted on the compiled data, and safety factors were applied as applicable to mitigated identified uncertainties.
3. Application of derived screening values to site data: site monitoring data for water, sediment and soils were compared to the screening values for water and hydric soils/sediment.

6.18.5 Data Quality Control, Objectives, and Review

The study was a desktop review of guideline derivation documents and scientific literature.

6.18.6 Laboratory Analysis

No laboratory analysis were undertaken as part of the amphibian hazard assessment.

6.18.7 Data Analysis and Reporting

The amphibian hazard assessment (Golder 2019c) was submitted to ENV as an attachment to the 2018 Environmental and Reclamation Report (the "2018 Annual Report"), prepared in fulfillment of *Mines Act* permit M-200, and *Environmental Management Act* permit 11678. In summary, a toxicity reference value of 0.018 mg/L dissolved copper was derived for evaluating hazards associated with surface water, and 800 mg/kg copper for evaluating hazards associated with hydric soils or sediment. The available surface water and soil data for the Mount Polley site were compared to these conservative screening values, and overall, there was no evidence that environmental concentrations were routinely or notably higher than those screening value on a site-wide basis. Hazards to amphibians as a result of exposure to soil or surface water are considered to be low under these circumstances.

6.19 Soil Monitoring

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description;

data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.19.1 Section Authors and Study Design Professionals

This section was written by Golder, and the detailed study design concept is provided in Appendix B.5.

6.19.2 Monitoring Objectives

The study design concept in Appendix B.5 focuses on reducing the sources of uncertainty from the terrestrial ERA (Golder 2017). As outlined in Appendix B.5, the objective of soil monitoring will be to "refine site-specific relationships between copper concentrations in soil and copper concentrations in various soil invertebrate and plant tissues". More detail is provided in Appendix B.5.

6.19.3 Monitoring Overview

Monitoring of soil stockpiles on the mine site for reclamation and closure is outlined in the Soil Management Plan included in the RCP. It is covered under BC *Mines Act* Permit M-200.

In 2018, Task 1A of the study design concept was undertaken, specifically, a reconnaissance-level sampling program.

6.19.4 High-Level Monitoring Design Description

Operational Sampling - Monitoring of soil stockpiles on the mine site for reclamation and closure is outlined in the Soil Management Plan included in the RCP. It is covered under BC *Mines Act* Permit M-200.

Supplemental Sampling - Soil samples were collected from 69 locations (co-located with tissue samples – described in Sections 6.20 and 6.21) to refine the exposure estimate for post-breach rehabilitated areas. The soil chemistry data were used, with other data collected as part of the reconnaissance survey, to update the food chain model developed to evaluate the potential for bioaccumulation of metals in wildlife. The food chain model update is described in Section 6.17.

Each sample was a composite of three aliquots of soil collected from within a 5 m radius of the tissue sample. The aliquots were collected from the top 20 cm of soil using a hand shovel, and then homogenized in a stainless-steel bowl prior to transfer to clean, laboratory-supplied 125-mL, glass sample jars with Teflon™ lined lids. Samples were kept on ice in a cooler after collection and kept cool until submitted to ALS for analysis of metals and pH.

6.19.5 Data Quality Control, Objectives, and Review

Supplemental soil sampling was undertaken using methods consistent with those used for the HHRA and ERA. Eight field duplicates were collected and laboratory QC consisted of duplicates, method blanks and matrix spike recovery. Copper and vanadium (the metals of interest for the food chain model) met the field DQOs. The soil sample results met the laboratory DQOs for precision, accuracy, method blanks, duplicate sample analysis and matrix spike recovery, with the exception of a method blank that had a detected concentration of copper. This could be a potential bias in samples that are near the limit of reporting but was not an issue in the current samples because all copper results were substantially higher than detection limits. Overall, the data were considered representative and suitable for their intended use.

6.19.6 Laboratory Analysis

Laboratory analyses were undertaken by a CALA-accredited laboratory.

6.19.7 Data Analysis and Reporting

The results of the reconnaissance survey (Golder 2019a) were submitted to ENV as an attachment to the 2018 Annual Report. Data from the 2018 soil sampling were integrated with the relevant historical data to update the soil concentrations used in the food chain model. All samples were compared to the applicable CSR standards, and an overview of those findings is provided below for each of the different rehabilitated areas that were sampled in Tables 1 through 3. Overall, the results of the soil chemistry were consistent with results from previous sampling in those areas and no new contaminants of concern were identified. The use of the soil chemistry data is further discussed in Section 17 (vis-à-vis the food chain model update).

6.20 Soil Invertebrate Monitoring

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.20.1 Section Authors and Study Design Professionals

This section was written by Golder, and the detailed study design concept is provided in Appendix B.5.

6.20.2 Monitoring Objectives

The study design concept in Appendix B.5 focuses on reducing the sources of uncertainty from the terrestrial ERA (Golder 2017). As outlined in Appendix B.5, the objectives of soil invertebrate monitoring will be to:

- "Focus on establishing a long-term trend analysis of soil invertebrate community rather than to support a multitude of pair-wise comparisons that would have limited value for making site management decisions";
- "Refine site-specific relationships between copper concentrations in soil and copper concentrations in various soil invertebrate tissues"; and,
- "Improve the quality of data with respect to tissue concentrations in invertebrates, particularly for flying insects."

6.20.3 Monitoring Overview

In 2018, Task 2A of the study design concept was undertaken, specifically, a reconnaissance-level sampling program.

6.20.4 High-Level Monitoring Design Description

Additional sampling was conducted to improve the spatial coverage of soil invertebrate samples, and to obtain sufficient samples of each main invertebrate type from the range of soil concentrations present at the site. Invertebrate (i.e., ants, beetles, spiders and worm) samples were collected through a combination of manual foraging and trapping. Manual foraging involved surveying the ground surface and searching below woody debris. Sampling was conducted if sufficient volume of soil invertebrates were noted or if a larger soil invertebrate (e.g., a large beetle) was found.

Terrestrial invertebrate trapping was conducted using methods adapted from the RISC guidelines for terrestrial arthropod inventory (RIC 1998), guidance from the Biological Survey of Canada (Marshall et al. 1994; Danks 1996) and the US Department of Agriculture (Schauff 1998). These documents guided the selection of the trapping method, locations of samples, sampling design and trapping protocols. Terrestrial invertebrate trapping methods employed on the Site included pitfall traps and Berlese funnels. Irrespective of the specific capture method, the following steps consistent with the *BC Field Sampling Manual* (BC ENV 2013) were followed to process the soil invertebrate samples:

- Samples were collected using nitrile gloves and transferred to either clean, laboratory supplied glass jars or clean Ziploc bags.
- Invertebrates of the same order from a single sample location (limited to 25 m^2) were composited.
- Soil invertebrates were left in partially open sample containers stored at ambient temperature overnight to allow samples to depurate.
- Invertebrate samples were rinsed using DI water and blotted dry with lint-free wipes before being transferred to clean Ziploc bags.
- Samples were transferred to a freezer to kill the invertebrates.
- Samples were kept frozen until they were submitted to the laboratory for analysis.

The soil invertebrate tissue samples were submitted for analysis of metals and moisture content, and the data were used, with other data collected as part of the reconnaissance survey, to update the food chain model developed to evaluate the potential for bioaccumulation of metals in wildlife. The food chain model update is described in Section 6.17.

6.20.5 Data Quality Control, Objectives, and Review

Soil invertebrate sampling were undertaken using methods consistent with those used for the HHRA and ERA. Eight field duplicates were collected and laboratory QC consisted of duplicates, method blanks and certified reference materials. RPDs were greater than 50% for most metals in at least one duplicate sample. A higher variability in soil invertebrate samples is expected because the field duplicates are not splits of a composite—they are two composites of different individual organisms. In terms of copper, an RPD of 65% was noted for the wet weight concentration in one duplicate pair, but the dry weight data had an acceptable RPD (48%). There was less variability in copper results than most other metals, and Golder concludes that the data are reliable and suitable for its intended purpose. RPDs of 55 to 106% were noted in four of eight duplicate sample pairs for wet weight concentrations and in two of eight duplicate sample pairs for dry weight with respect to vanadium. However, this variability does not impact the overall conclusion that vanadium bioaccumulation is limited, nor does it change the conclusion that vanadium risks to wildlife from consumption of dietary items was low. The tissue samples met the laboratory DQOs with respect to copper and vanadium (the parameters of interest for the food chain model).

6.20.6 Laboratory Analysis

Laboratory analyses were undertaken by a CALA-accredited laboratory.

6.20.7 Data Analysis and Reporting

The results of the reconnaissance survey (Golder 2019a) were submitted to ENV as an attachment to the 2018 Annual Report. The use of the soil chemistry data is further discussed in Section 17 (vis-à-vis the food chain model update).

6.21 Vegetation Monitoring

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.21.1 Section Authors and Study Design Professionals

This section was written by MPMC, and is a summary of the study design concept provided by Golder. The detailed study design concept is provided in Appendix B.5. Note that Appendix B.5 is a study design concept; a study design will be submitted in Q1 2019 after completion of tasks outlined in Figure 2 in Appendix B.5.

6.21.2 Monitoring Objectives

The study design concept in Appendix B.5 focuses on reducing the sources of uncertainty from the terrestrial ERA (Golder 2017). As outlined in Appendix B.5, the objectives of vegetation monitoring will be to:

- "Focus on establishing a long-term trend analysis of plant community rather than to support a multitude of pair-wise comparisons that would have limited value for making site management decisions"; and,
- "Refine site-specific relationships between copper concentrations in soil and copper concentrations in various plant tissues."

More detail is provided in Appendix B.5.

6.21.3 Monitoring Overview

In 2018, Task 2A of the study design concept was undertaken, specifically, a reconnaissance-level sampling program.

6.21.4 High-Level Monitoring Design Description

Samples of the edible portions of plants (were collected following the same approach used in 2015 and 2016. The focus of plant sampling was on rehabilitated areas to increase sample density in these areas and to provide more information about plants growing in soils that have lower copper concentrations than the non-reclaimed areas. The following plant tissue samples were collected in 2018:

- Berry—Berry samples were collected from raspberry [*Rubus occidentalis]*, high bush cranberry [*Viburnum trilobum*], and thimbleberry [*Rubus parviflorus*]) plants that were rooted in soil.
- Leaf—Willow (*Salix* sp.) and alder (*Alnus crispa*) leaf samples were collected from shrubs planted in the impacted area. Only shrubs planted in the floodplain before spring 2016 were sampled. Plants sampled included willow planted in lower Hazeltine Channel in early 2015, above the canyon in late 2015, and in upper Hazeltine Channel late 2015 (near Gavin Lake Bridge).
- Grass— Slender wheatgrass *(Elymus trachycaulus*) samples were collected from a variety of areas. The objective of the sampling was to reduce the uncertainty in the existing soil-to-grass bioaccumulation relationship, and therefore, sampling was limited to a single species which was commonly found across the entire site. Only the edible, above-ground portion of grass was collected.

Sampling methods were consistent with the *BC Field Sampling Manual* (MoE 2013) and consisted of the following steps:

- Plant tissue was hand-picked by field staff using nitrile gloves from an area of 25 m^2 or less. Plant tissue was composited from multiple plants within the area if sufficient volume could not be collected from one plant.
- Plant samples were rinsed using DI water and blotted dry with lint-free wipes before being transferred to clean Ziploc bags.
- Samples were placed in a cooler containing ice until they could be transferred to a freezer for storage prior to shipping to the laboratory for analysis.

The plant tissue samples were submitted for analysis of metals and moisture content, and the data were used, with other data collected as part of the reconnaissance survey, to update the food chain model developed to evaluate the potential for bioaccumulation of metals in wildlife. The food chain model update is described in Section 6.17.

6.21.5 Data Quality Control, Objectives, and Review

Vegetation sampling was undertaken using methods consistent with those used for the HHRA and ERA. Five replicate plant samples were collected and laboratory QC consisted of duplicates, method blanks and certified reference materials. Data quality objectives were met for copper and vanadium (the parameters of interest for the food chain model) in vegetation samples for both field and laboratory QC samples.

6.21.6 Laboratory Analysis

Laboratory analyses were undertaken by a CALA-accredited laboratory.

6.21.7 Data Analysis and Reporting

The results of the reconnaissance survey (Golder 2019a) were submitted to ENV as an attachment to the 2018 Annual Report. The use of the soil chemistry data is further discussed in Section 17 (vis-à-vis the food chain model update).

6.22 Biosolids Monitoring

MPMC is in possession of an EMA permit (15968) for the use of biosolids. This permit requires that MPMC retain the services of a qualified professional to develop a monitoring plan for the biosolids application program. MPMC will submit this plan to ENV and EMPR prior to receiving any additional shipments of biosolids to the mine site.

7 CEMP UPDATES AND REVISIONS

When possible, MPMC will provide written notice of planned changes to the CEMP to the ENV Director a minimum of 30 days prior to implementation to allow for review and feedback on the revision. Proposed changes will be shared with First Nations and stakeholders, as per MPMC's Communication Plan (MPMC 2016d). Additionally, changes that occur but are unplanned, such as the collection of additional samples, will be discussed with the ENV Director as soon as possible after the sampling occurs. When changes are made to the monitoring, this amended plan (or relevant replacement pages) will be resubmitted to the Director.

Given the dynamic nature of environmental investigation, rehabilitation, and water management plan development at Mount Polley Mine, it is anticipated that the CEMP will evolve in alignment with site activities and findings, as described in Section 2.3, and will be updated as required. It is anticipated that larger CEMP revisions in response to these activities and findings will be made with consideration of maintaining continuity in spatial and temporal coverage to meet the global objectives of the CEMP, as described in Section 1.1.

As required by the Permit, following the three-year detailed monitoring program interpretive report to the Director, MPMC will submit a summary of proposed changes to the CEMP to the Director by April 30 of that year (one month following the interpretive report deadline). In order to incorporate recommended changes in a timely fashion, MPMC would appreciate feedback on the proposed changes from the ENV by May 31 of that year.

8 RECLAMATION AND REMEDIATION

Rehabilitation of the aquatic and terrestrial receiving environments that were impacted by the TSF embankment breach and associated remediation activities is continuing as outlined in the Rehabilitation Strategy (November 2015 update; MPMC 2015f), as required by the PAO 107461. Under this broader Rehabilitation Strategy:

- Terrestrial rehabilitation works are being conducted as per the *Planning Concepts for Rehabilitation of Terrestrial Ecosystems at Mount Polley* technical memorandum prepared by Golder (2015e). The reclamation and monitoring steps described in this memorandum are based on the TSF embankment breach environmental impact assessment results to date.
- Rehabilitation of aquatic systems is being conducted under guidance of the Habitat Remediation Working Group, which includes representatives of DFO, ENV, the BC Ministry of Forest, Lands and Natural Resource Operations, the SCIB, and the WLIB. This group provides recommendations and feedback on aquatic ecosystem rehabilitation plans developed by MPMC's consultants.

Monitoring associated with the Hazeltine Creek channel rehabilitation construction activity is undertaken under the *Post-Breach Rehabilitation Work Environmental Management Plan* (Golder 2015f), which pertains to monitoring of any construction works and associated construction specifications. While the lower reaches of Hazeltine Creek remain non-fish bearing (with the exception of the lower sedimentation pond), the *MPMC Fish Exclusion and Response Plan* (MPMC 2015f) is in effect. MPMC will conduct monthly visual inspections for fish in the non-fish bearing areas of the creek when the creek is free of snow and ice (in case any fish have evaded the barriers), as well as weekly inspections of fish exclusion structures. The plan outlines response actions in the event that fish are observed.

As Hazeltine Creek is rehabilitated and returned to fish-bearing status, this environmental management plan will be phased out and be replaced by routine monitoring for evaluating performance of the works as a component of the CEMP.

The Habitat Remediation Working Group made up of provincial and federal regulators, qualified professionals and First Nations representatives, agreed upon a monitoring plan for the return of rainbow trout in Hazeltine Creek in 2018. This plan includes week fish surveys, detailed habitat usage surveys, benthic, sediment, water (quality and quantity), and fish tissue sampling. Reporting on these results will be included in the AERR.

The steps in the aforementioned terrestrial rehabilitation plan include establishment of permanent monitoring plots for ongoing assessment, feedback (to inform adaptive management) and demonstration. As terrestrial rehabilitation works progress, monitoring to this end will be implemented.

A Conceptual Remediation Plan (CRP) was submitted to ENV on January 31, 2018 (Golder 2018) and following receipt of comments on the CRP, a Remediation Plan submitted on March 29, 2019 (Golder 2019d). The Remediation Plan identifies remedial options for the sites impacted by the TSF breach, including creek habitats, lake habitats, and terrestrial habitats, as well as proposed monitoring components to verify the success of the planned remediation. The Remediation Plan was approved by ENV on July 3, 2019.

9 REPORTING

9.1 MONTHLY REPORTING

As required by Section 3.9 in the Permit (April 7, 2017) a monthly report will be submitted to the Director in each month that discharge occurs. The report will summarize the volume of treated effluent discharged, a summary of continuous turbidity readings of the treated effluent discharged, and the most recently available water quality results for the effluent discharged, including a summary of acute and/or chronic toxicity testing results.

9.2 QUARTERLY REPORTING

All data and information collected under the CEMP will be provided to the Director, in electronic format, on a quarterly basis or as required by the Permit.

Under the most recent version of PAO 107461 (June 9, 2017) Section 6.0, a quarterly report detailing the implementation status of requirements of the order, a summary of communications with stakeholders and public relating to the breach, and any remediation activities undertaken in Hazeltine Creek, Polley Lake and Quesnel Lake for the previous and upcoming three months must be submitted to the director.

9.3 ANNUAL REPORTING

As required by the Permit Section 3.9, MPMC will continue to submit an AERR on or before March 31 of each year. This report is combined with the Annual Reclamation Report prepared for the EMPR, with the combined document submitted to both agencies. These reports will include the details required by the permit, as well as an analysis of the linkages between program components, where appropriate. MPMC will refer to *Technical Guidance 4, Environmental Monitoring under the Environmental Management Act* such that the ENV's expectations for reporting are achieved.

The AERR will continue to be in a format suitable for public release and will be deposited at the Cariboo Regional District Library as well as submitted to the SCIB and WLIB within 30 days of being submitted to the ENV.

As required by the Permit (April 7, 2017) Section 2.5, MPMC will continue to submit an annual Environmental Emergency Response Plan and will include updated procedures and notification protocols. MPMC will also continue to submit an Annual Discharge Plan on or before April 15 of each year and include the details required by the Permit Section 2.7.

9.4 THREE-YEAR REPORTS

Under the Permit, a detailed monitoring program interpretive report is required every three years with the first report due on March 31, 2019 and every three years thereafter. The March 2019 interpretive report will include data collected in 2016, 2017, and 2018. This report will be completed by one or more qualified professionals and will be more comprehensive than the synoptic review of data presented in the annual reports. It will include recommendations for changes to the CEMP.

In addition, a groundwater monitoring program review including, but not limited to, sampling, well locations, site water balance, interpretation of data trends, and suitable recommendations is required every three years, with the first presented in March 2016. The next report will be submitted on March 31, 2019. Monitoring data and the analysis of those data presented in the report will be reviewed by a third party qualified professional.

10 FUTURE OUTLOOK

This CEMP represents a unique and specialized variation of a typical mine environmental monitoring plan. This plan seeks to integrate all environmental monitoring programs that are carried out on the Mount Polley mine site and in the local area related to:

(a) Ongoing mine operations (including EMA and *Mines Acts* permit requirements and MDMER requirements of the *Fisheries Act*);
(b) TSF embankment breach-related impacts and remediation; and,
(c) Reclamation and closure planning (*Mines Act* permit requirement).

The overall goals of this CEMP are to provide science-based evidence: for evaluation of environmental impacts of mine operations; for evaluation of the effects of any ongoing impacts of, and remediation measures undertaken in response to, the TSF embankment breach; and to inform ongoing reclamation and closure planning. These goals are guided by an intent to return the impacted areas of the mine site and its surroundings to viable and diverse ecosystems that reflect pre-breach land uses, or those identified by Communities of Interest as representing values of importance. These values of importance are identified through ongoing consultation with local Communities of Interest.

Mount Polley fosters a culture of research and innovation. In addition to the extensive monitoring and research work that was undertaken as part of the impact and risk assessments of the TSF embankment breach, there are a number of research projects underway (and several recently completed) that the mine has supported. The results of these projects may contribute directly to improving the mine's understanding of breach impacts (Cuervo et al, 2017; Garris et al, 2018; Byrne et al, 2018), new approaches to remediation, reclamation and closure (McMahen, PhD in progress, UBC; Litke MASc in progress, UBC), and to mitigating environmental impacts of ongoing operations.

With respect to mitigating environmental impacts of ongoing operations and planning for reclamation and closure, Mount Polley is embarking on passive water treatment research and pilot projects to test the suitability of constructed wetland water treatment systems for dispersed water treatment and discharge on the mine site. These research projects will include lab and site testing, monitoring of water quality, vegetation, and microbial communities, and will be reported annually in the AERR or in a technical memo.

As the results of monitoring programs and environmental research projects are generated, analyzed, and interpreted, this CEMP will be reviewed and updated where warranted. MPMC will aim to review the requirements of the CEMP on a quarterly basis and will submit a list of proposed changes based on the review to the Director within 45 days from the end of the quarter.

11 REFERENCES

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