RED MOUNTAIN UNDERGROUND GOLD PROJECT
VOLUME 3 | CHAPTER 14
SEDIMENT QUALITY EFFECTS ASSESSMENT

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14 SEDIMENT QUALITY EFFECTS ASSESSMENT

14.1 Introduction

The Red Mountain Underground Gold Project (the Project) is a proposed underground gold mine in the Bitter Creek valley, located near Stewart, in northwest British Columbia.

This Application/EIS chapter presents the effects assessment for the Sediment Quality valued component (VC). The purpose of this assessment is to comprehensively evaluate the potential changes to the quality of sediment that may result from the Project.

The introduction summarizes why Sediment Quality was selected as a VC, what it encompasses, and linkages to other VCs. The remainder of the chapter covers: the scope of the assessment, existing aquatic conditions (i.e., baseline data), potential effects, mitigation measures, residual effects and their significance, cumulative effects, follow-up, and conclusions.

Sediment Quality was selected as a VC in order to assess the potential effects of the proposed Project on the health of aquatic ecosystems. Sediment quality is important for freshwater life as many freshwater organisms live in or on the sediments or feed on benthic organisms. The Canadian Council of Ministers of the Environment (CCME) has established interim guidelines for metal concentrations in sediments to protect freshwater life from acute and chronic toxicity (CCME 2015). Additionally, the particle size composition of sediments is a valuable parameter for predicting the type and variety of resident benthic organisms and for estimating the metal adsorption potential and organic carbon content of the sediments. Fine sediments composed of silt and clay particles tend to have greater metal and organic matter content due to particle surface adsorption, increased deposition rates, and longer residence times and often host distinct biological communities.

Sediment Quality was originally screened for inclusion as an intermediate component, IC, i.e., pathway component; however, through consultation and feedback with the Working Group for the Project, it was changed to a receptor VC. The Sediment Quality VC is closely linked to the Surface Water Quality VC and Groundwater Quality IC, and is also considered a pathway component in the assessment of Aquatic Resources VC and the Fish and Fish Habitat VCs.

14.2 Regulatory and Policy Setting

The Application Information Requirements (AIR) for the Project, approved by the British Columbia (BC) Environmental Assessment Office (EAO) in March 2017 and the Guidelines for the Preparation of an Environmental Impact Statement pursuant to the *Canadian Environmental Assessment Act, 2012*, (the EIS Guidelines) issued for the Project by the Canadian Environmental Assessment Agency (the Agency) in January 2016 outline the requirements of the Sediment Quality Effects Assessment to meet both the provincial and federal environmental assessment (EA) requirements under the *BC Environmental Assessment Act* (2002) and *Canadian Environmental Assessment Act, 2012*, respectively.

Federal and provincial regulations and policies which guide protection to Sediment Quality during the mine development process are summarized in Table 14.2-1.

The Canadian Council of Ministers of Environment (CCME) Water and Sediment Quality Guidelines, and the BC Approved Water Quality Guidelines cover protection of freshwater aquatic life. Guidelines are not regulatory instruments but can be defined as targets or triggers for action if not met and can be used as the basis of regulatory limits. Generally, the BC guidelines are used where BC and CCME guidelines differ, as the BC guidelines are intended to represent more closely the conditions in BC waters, while the CCME (federal) guidelines are more general in nature.

In addition to the guidelines and legislation outlined in Table 14.2-1, BC MOE's Water and Air Baseline Monitoring Guidance Document (BC MOE, 2016) outlines and defines the baseline study requirements for mining projects in BC. Information requirements for water quality (including physical and chemical parameters, aquatic sediments, tissue residues, and aquatic life), fish and fish habitat, and initial environmental impact assessment are included.

The Project is located within the Nass Area and Nass Wildlife Area, as set out in Nisga’a Final Agreement (NFA). Pursuant to the NFA, Nisga’a Nation, as represented by the Nisga’a Lisims Government (NLG), has Treaty rights to the management and harvesting of fish, wildlife, and migratory birds within the Nass Area and Nass Wildlife Area. The Project is also within the asserted traditional territories of Tsetsaut Skii km Lax Ha (TSKLH) and Métis Nation BC (MNBC).

Table 14.2-1: Summary of Applicable Legislation, Regulations, and Guidelines for Sediment Quality, Red Mountain Project

Legislation/Regulation/Policy	Level of Government	Administered by	Description
Fisheries Act (1985)	Federal	Fisheries and Oceans Canada (DFO)	The Fisheries Act prohibits the carrying out of any work, undertaking or activity that results in serious harm to fish that are part of a commercial, recreational, or Aboriginal (CRA) fishery, or to fish that support such a fishery. 'Serious harm' is defined as: "the death of fish or the permanent alteration to, or destruction of, fish habitat". While the act does not directly protect benthic invertebrates and periphyton, these aquatic organisms are afforded protection because they support fish and are a constituent of fish habitat.
Metal Mining Effluent Regulations	Federal	Environment and Climate Change Canada (ECCC)	The Metal Mining Effluent Regulations (MMER) are administered under section 36(3) of the *Fisheries Act*. MMER allows proponents to deposit deleterious substances into waters frequented by fish, if Schedule 2 of the MMER is amended to designate these waters as a Tailings Impoundment Area. In addition, discharge of effluent from metal mines to surface waters is regulated through the MMER. Under MMER, if mine discharge into the receiving environment exceeds 50 m^3 per day the mine shall conduct environmental effects monitoring (EEM) studies of the potential effects of effluent on the fish populations, on fish tissue and on the benthic invertebrate community.
Environmental Management Act (2003)	Provincial	BC MOE	The *Environmental Management Act* (EMA) prohibits pollution of water, land, and air in BC. Mines require authorization under the EMA to discharge mining effluent to receiving waters, and are required to register (or include on the permit) sewage discharges for systems designed for a capacity of greater than 100 persons. The EMA specifies environmental monitoring requirements for EMA permit holders, which should enable ongoing evaluation of waste management performance, receiving environment condition, and evaluation of impact predictions made during the permit application.

<table>
<tr><th>Legislation/Regulation/Policy</th><th>Level of Government</th><th>Administered by</th><th>Description</th></tr>
<tr><td>Water Sustainability Act (2016)</td><td>Provincial</td><td>BC Ministry of Forests, Lands and Natural Resource Operations (BC MFLNRO)</td><td>The Water Sustainability Act (WSA) regulates the diversion and use of water resources. Under the WSA, a licence or use approval is required to make changes in and about a stream. Changes in and about a stream are defined as:
Any modification to the nature of the stream, including any modification of the land, vegetation and natural environment of a stream or the flow of water in a stream, or
Any activity or construction within a stream channel that has or may have an impact on a stream or stream channel.</td></tr>
<tr><td>CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life</td><td>Federal</td><td>CCME</td><td>Water quality guidelines are intended to provide protection of freshwater life from anthropogenic stressors such as chemical inputs or changes to physical components. Guideline values are meant to protect all forms of aquatic life and all aspects of the aquatic life cycles, including the most sensitive stage of the most sensitive species for the long-term.</td></tr>
<tr><td>CCME Canadian Sediment Quality Guidelines for the Protection of Aquatic Life</td><td>Federal</td><td>CCME</td><td>The CCME Sediment Quality Guidelines cover protection of freshwater aquatic life by providing scientifically-derived benchmarks for evaluating the potential for observing adverse biological effects in aquatic systems. CCME’s Interim Sediment Quality Guidelines (ISQGs) and Probable Effect Levels (PELs), are associated with occasional and frequent adverse biological effects, respectively.</td></tr>
<tr><td>BC Water Quality Guidelines:
Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture (2017)
Working Water Quality Guidelines (2015)
Working Sediment Quality Guidelines (2015)</td><td>Provincial</td><td>BC MOE</td><td>In BC, the definition of water quality includes sediments, therefore the Approved Water Quality Guidelines also includes sediment quality values for some parameters. However, for clarity, Approved Water Quality Guidelines will be referred to as BC WQG and Approved Water Quality Guidelines for sediment will be referred to as BC WSG. These guidelines serve as benchmarks for the protection of aquatic life in freshwater and marine environments.

BC MOE (2015) also has Working Water Quality Guidelines (WWQGs), and Working Sediment Quality Guidelines (WSQGs), which provide benchmarks for those substances that have not yet been fully assessed and formally endorsed by BC MOE and are obtained from other jurisdictions, including the CCME. Most WSQGs have a ‘Lower WSQG’ and an ‘Upper WSQG’, which are equivalent to CCME’s Interim Sediment Quality Guidelines (ISQGs) and Probable Effect Levels (PELs), respectively.</td></tr>
</table>

14.3 Scope of the Assessment

14.3.1 Information Sources

The information sources used to assess potential Project effects on Sediment Quality included baseline reports, the Project Overview (Volume 2, Chapter 1), and the effects assessments for Surface Water Quality (Volume 3, Chapter 13), and Groundwater Quality (Volume 3, Chapter 11). Information gathered during consultation with NLG as well as meetings and discussion with the Project's Working Group were also incorporated.

Baseline characterization of Sediment Quality within the Project area is summarized in Section 14.4.4. Sediment characterization was conducted as part of the most recent baseline program, from 2014 to 2016 and is described in the baseline report for Fisheries and Aquatic Resources (Appendix 18-A).

In addition to the baseline sediment sampling, baseline water quality data also informed the effects assessment for Sediment Quality. Baseline characterization for Surface Water Quality, and the information sources, is detailed in Volume 3, Chapter 13.

As outlined in Chapter 6 (Effects Assessment Methodology), IDM has not conducted primary traditional use or traditional ecological knowledge (TEK) surveys in support of the Project due to the preferences of Nisga'a Nation, as represented by NLG, and EAO's and the Agency's direction for comparatively low levels of engagement with the other Aboriginal Groups potentially affected by the Project. IDM has committed to using TEK where that information is publicly available. As no TEK relevant to this effects assessment was publicly available at the time of writing, no TEK has been incorporated.

14.3.2 Input from Consultation

IDM is committed to open and honest dialogue with regulators, Aboriginal Groups, community members, stakeholders, and the public.

IDM conducted consultation with regulators and Aboriginal Groups through the Working Group co-led by EAO and the Agency. Where more detailed and technical discussions were warranted, IDM and Working Group members, including sometimes NLG representatives, held topic-focused discussions, the results of which were brought back to EAO and the Working Group as a whole.

Further consultation with Aboriginal Groups, community members, stakeholders, and the public has been conducted as outlined by the Section 11 Order and EIS Guidelines issued for the Project. More information on IDM's consultation efforts with Aboriginal Groups, community members, stakeholders, and the public can be found in Chapter 3 (Information Distribution and Consultation Overview), Part C (Aboriginal Consultation), Part D (Public Consultation), and Appendices 27-A (Aboriginal Consultation Report) and 28-A (Public Consultation Report). A record of the Working Group's comments and IDM's responses can be found in the comment-tracking table maintained by EAO.

Table 14.3-1 provides a summary of the consultation feedback and input that was received and that was specifically relevant to and affected issues scoping and VC selection for Sediment Quality.

Table 14.3-1: Consultation Feedback

Topic (VC, IC, Sub-Component)	Feedback by*				Consultation Feedback	Response
	NLG	G	P/S	O		
Aquatic Resources Fish Fish Habitat Groundwater Quality Hydrogeology Hydrology Sediment Quality Surface Water Quality	X				NLG requested a conceptual aquatic effects monitoring program (AEMP) design be included in the Application.	A conceptual AEMP has been included in Volume 5, Chapter 29 of the Application/EIS.
Sediment Quality	X				NLG requested a conceptual aquatic effects monitoring program (AEMP) design be included in the Application.	A conceptual aquatic effects monitoring program design has been included in the Application/EIS.
Sediment Quality	X				NLG requested that Sediment Quality be included in the assessment as a VC, rather than an IC.	IDM has included Sediment Quality as a VC in the effects assessment.
Sediment Quality	X				NLG requested that baseline sediment quality conditions be evaluated in Bitter Creek, Goldslide Creek, Otter Creek, Bear River, and American Creek, and that a sufficient number of samples need to be collected in each river system to document variability in sediment chemistry.	Baseline sediment quality conditions were evaluated in Bitter Creek, Goldslide Creek, Otter Creek, Bear River and American Creek. Two sampling events were included in the baseline: 3 replicates at each site in 2014 and 5 replicates at each site in 2016.

*NLG = Nisga’a Lisims Government;
G = Government - Provincial or federal agencies;
P/S = Public/Stakeholder - Local government, interest groups, tenure and license holders, members of the public;
O = Other

14.3.3 Valued Components, Assessment Endpoints, and Measurement Indicators

There are several potential pathways through which the Project could result in effects on Sediment Quality. Potential effects pathways start with Project activities (e.g., mine water discharge, runoff, atmospheric deposition, and instream works), which can cause changes to the chemical and physical nature of sediment. Changes in water quality could lead to eventual changes in sediment quality.

The primary measurement indicators for the Sediment Quality VC are the changes in physical attributes (particle size), and chemical attributes in stream sediments compared to provincial or federal guidelines for aquatic life (Table 14.3-2). Physical changes include the addition of material to sediments and the changes to the composition of sediments. Chemical changes include metals that are adsorbed to sediment particles and changes to concentrations of polycyclic aromatic hydrocarbon compounds.

Groundwater Quality (Volume 3, Chapter 11), Hydrology (Volume 3, Chapter 12), and Surface Water Quality (Volume 3, Chapter 13), are IC pathways of effects to Sediment Quality. Sediment Quality is an effect pathway for the Aquatic Resources and Fish and Fish Habitat VCs.

ICs represent the pathway of potential effect between a Project component or activity and a VC. Groundwater Quality is an IC that is linked to the Sediment Quality VC.

Table 14.3-2: Assessment Endpoints and Measurement Indicators for Sediment Quality

Primary Measurement Indicators	Assessment Endpoint
• Change in parameter concentrations, such as concentration of metal and non-metal constituents in stream sediments, compared to provincial or federal guidelines for freshwater aquatic life. • Change in sediment particle size distribution, sediment loading.	• Maintenance of the quality of sediment in the receiving environment. • Maintenance of other VCs that are influenced by Sediment Quality.

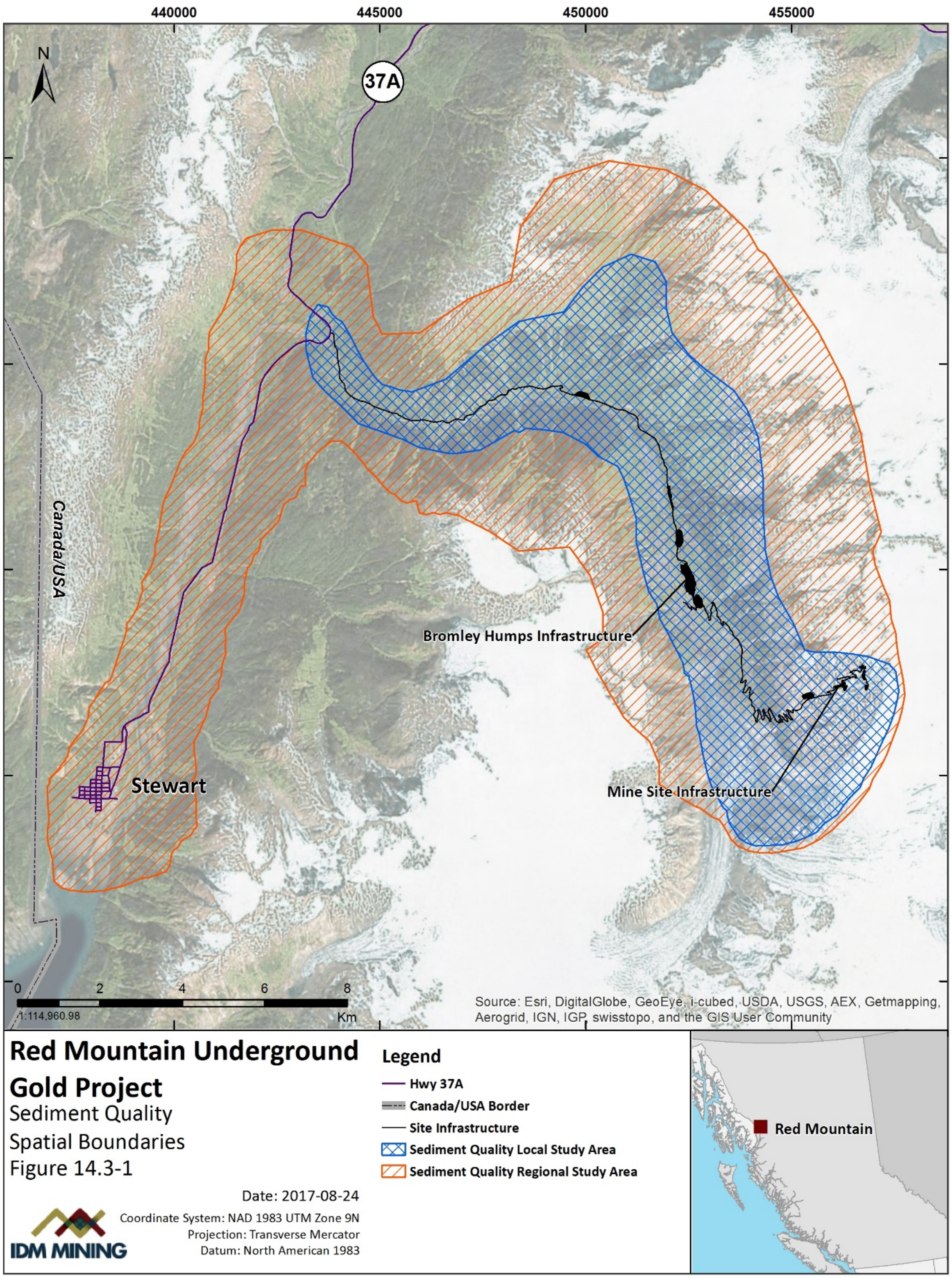
14.3.4 Assessment Boundaries

14.3.4.1 Spatial Boundaries

The spatial boundaries for assessment of the Sediment Quality VC consist of two spatial boundaries: the Local Study Area (LSA) and the Regional Study Area (RSA). The study area boundaries were based on the likely geographic extent of potential direct and indirect effects to Sediment Quality from the Project (Figure 14.3-1). The LSA encompasses the zone of influence of the Project, covering the area within which there is a reasonable potential for adverse Project-specific effects to occur. For Sediment Quality, the LSA includes the Bitter

Creek watershed up to the Bromley Glacier. The RSA is larger, and provides context for the assessment of potential Project effects. The RSA was used for assessment of direct and indirect Project effects and for assessment of potential cumulative effects. The RSA surrounds the LSA, and also contains portions of the Bear River watershed, from American Creek to Stewart and the northern end of the Portland Canal.

Figure 14.3-1: Local and Regional Study Areas for Sediment Quality



14.3.4.2 Temporal Boundaries

The temporal boundaries for Sediment Quality VC have been defined as "Life of Project", which covers the period from Construction through to the Post-Closure Phase of the Project (Table 14.3-3). These temporal boundaries capture the periods within which a reasonable expectation of interaction with components of the freshwater environment can be predicted.

Table 14.3-3: Temporal Boundaries for the Effects Assessment of Sediment Quality

Phase	Project Year	Length of Phase	Description of Activities
Construction	Year -2 to Year 1	18 months	Construction activities and construction of: Access Road, Haul Road, Powerline, declines, power supply to the underground, water management features, water treatment facilities, Tailings Management Facility (TMF), Process Plant, ancillary buildings and facilities; underground lateral development and underground dewatering; ore stockpile and ore processing start-up; and receiving environmental monitoring.
Operation	Year 1 to Year 6	6 years	Ramp up to commercial ore production and maintain a steady state of production, underground dewatering, tailings storage, water treatment, gold doré shipping, environmental monitoring, and progressive reclamation.
Closure and Reclamation	Year 7 to Year 11	5 years	Underground decommissioning and flooding; decommissioning of infrastructure at portals, Process Plant, TMF, ancillary buildings and facilities; reclamation, water treatment; removal of water treatment facilities.
Post-Closure	Year 12 - 21	10 years	Receiving environment monitoring to ensure closure objectives are satisfied.

Temporal characteristics of the Sediment Quality VC were considered when defining the temporal boundaries. Given that metals and hydrocarbons can accumulate in sediments over time, the temporal boundaries should capture impacts that occur gradually, as well as cumulative impacts. Different potential sources of sediment contaminants will come about during different phases of the Project, and the response in the sediment chemistry will therefore also vary over extended time scales.

14.3.4.3 Administrative and Technical Boundaries

Administrative boundaries refer to the limitations imposed on the assessment by political, economic, or social constraints, and consider the jurisdiction in which the Project is located. The Project falls within the resource management area boundaries of DFO's Pacific Region, BC MFLNRO's Skeena Region (Region 6), and the Regional District of Kitimat-Stikine.

The Project is located within the Nass Area and Nass Wildlife Area, as set out in Nisga'a Final Agreement (NFA). Pursuant to the NFA, Nisga'a Nation, as represented by the Nisga'a Lisims Government (NLG) has Treaty rights to the management and harvesting of fish, wildlife, and migratory birds within the Nass Area and Nass Wildlife Area. The Project is also within the asserted traditional territories of Tsetsaut Skii km Lax Ha (TSKLH) and Métis Nation BC (MNBC).

Technical boundaries refer to the constraints imposed on the assessment by limitations in the ability to predict the effects of a Project. Technical boundaries for the assessment of potential effects to Sediment Quality include:

- Limitations in current knowledge;
- Limitations imposed by the constraints of the data collection methods, study design, and data coverage; and
- Assumptions required in the predictive models, specifically the Water and Load Balance Model Report (Appendix 14-C).

14.4 Existing Conditions

14.4.1 Overview of Existing Conditions

The Project area is characterized by rugged, steep terrain with weather conditions typical of the northern coastal mountains. The deposit is under the summit of Red Mountain at elevations ranging between 1,600 and 2,000 metres above sea level (masl). Temperatures are moderated year-round by the coastal influence. The mean annual air temperature (MAAT) at an elevation of 1514 metres is −0.8°C, with monthly mean values ranging between −6.4°C in December and January and 6.9°C in August (Appendix 12-A: Baseline Climate and Hydrology Report). Precipitation is significant throughout the year; October is typically the wettest month and there is significant snow accumulation in the winter (JDS 2016). The snowfall, steep terrain, and frequently windy conditions present blizzard and avalanche hazards during the winter (JDS 2016). The climatic conditions at the Project site are described in Appendix 12-A.

A deactivated logging road extends e from Highway 37A for approximately 13 km along the Bitter Creek valley; however, it is currently impassable for heavy equipment due to washouts caused by Bitter Creek, and at other creek crossings (JDS 2016).

The proposed underground mine is situated at the top of the Red Mountain cirque, a short, westerly trending hanging valley above the Bitter Creek valley. The cirque is drained by Goldslide Creek. Goldslide Creek flows southwest into the east side of Bromley Glacier which extends about 1 km to the Bitter Creek headwaters. Flows in Goldslide Creek peak during freshet (typically in June) and Goldslide Creek is not glacially-influenced. Goldslide and Rio Blanco Creeks are the two uppermost tributaries to Bitter Creek. Other Bitter Creek tributaries relevant to the baseline Sediment Quality evaluation are Otter Creek, Roosevelt Creek, and two small unnamed tributaries to Bitter Creek that drain Bromley Humps. Otter Creek is glacially-influenced and its flows peak during summer (typically in July) because of glacial melt. The winter low flow period in Otter Creek is from November to April. Like Otter Creek, Bitter Creek is glacially-influenced and flows peak in summer (typically in July), and are low during November to April. Bitter Creek is a tributary to the Bear River, which flows into the Portland Canal near Stewart (Figure 14.3-1). Flows peak in summer (July/August) in Bear River.

The proposed Project is composed of two main areas with interconnecting access roads (Figure 14.4-1): the Mine Site with an underground mine and three portals (Upper Power, Lower Portal and Vent Portal) at the upper elevations of Red Mountain (1,950 masl; Figure 14.4-2); and Bromley Humps situated in the Bitter Creek valley (500 masl), with a Process Plant and TMF (Figure 14.4-3).

Figure 14.4-1: Project Components – Overview

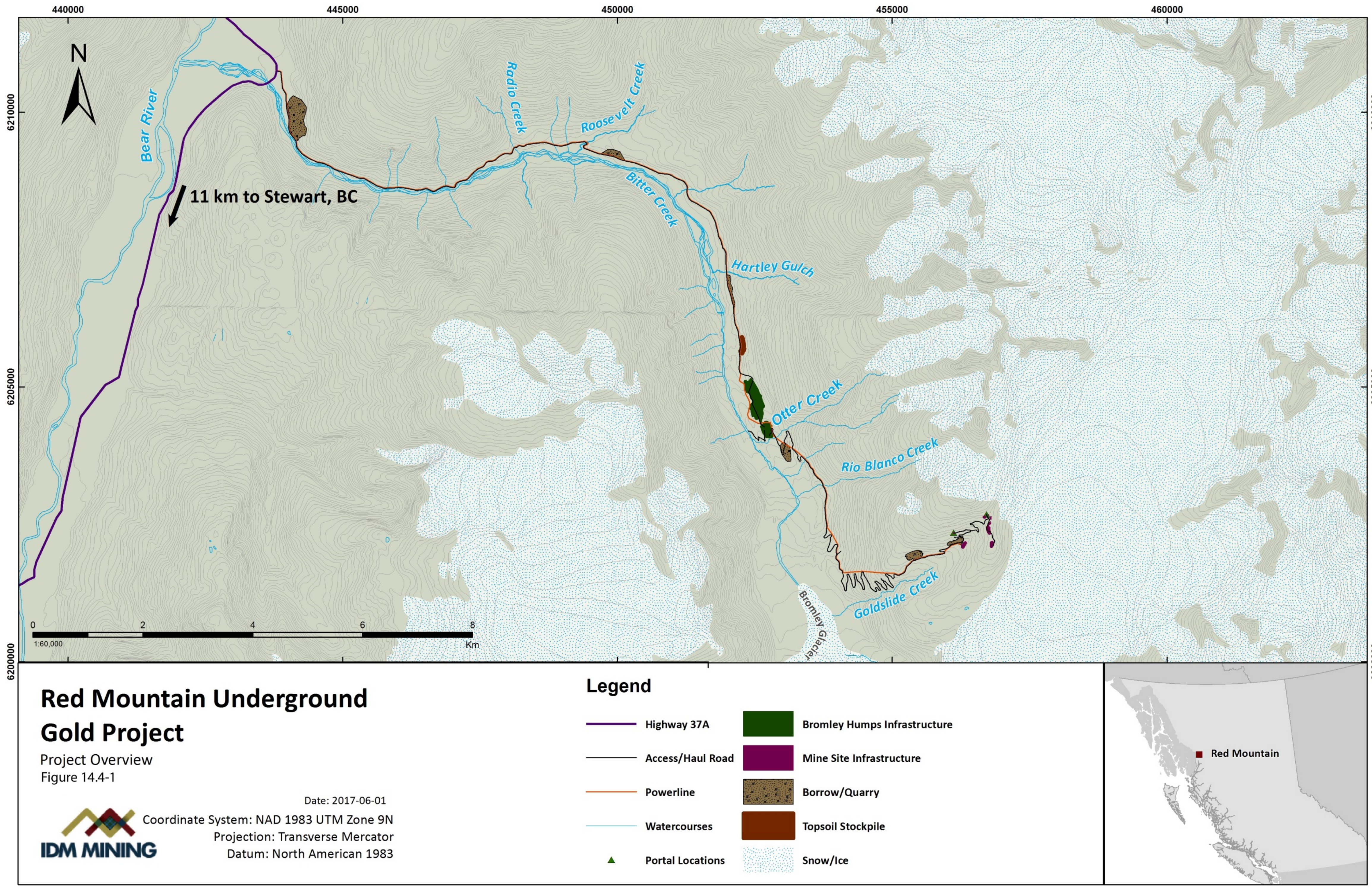


Figure 14.4-2: Project Components – Mine Site

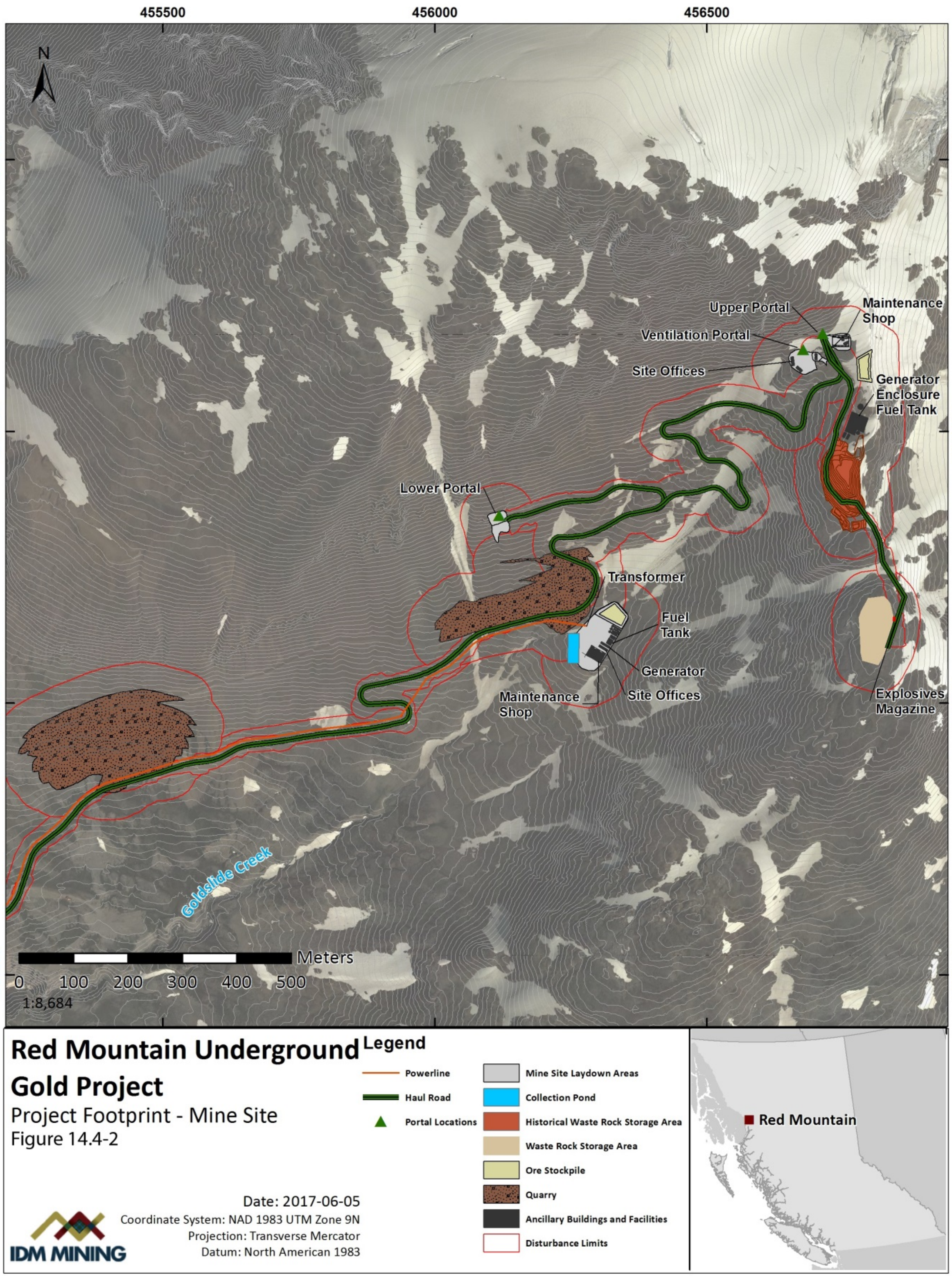
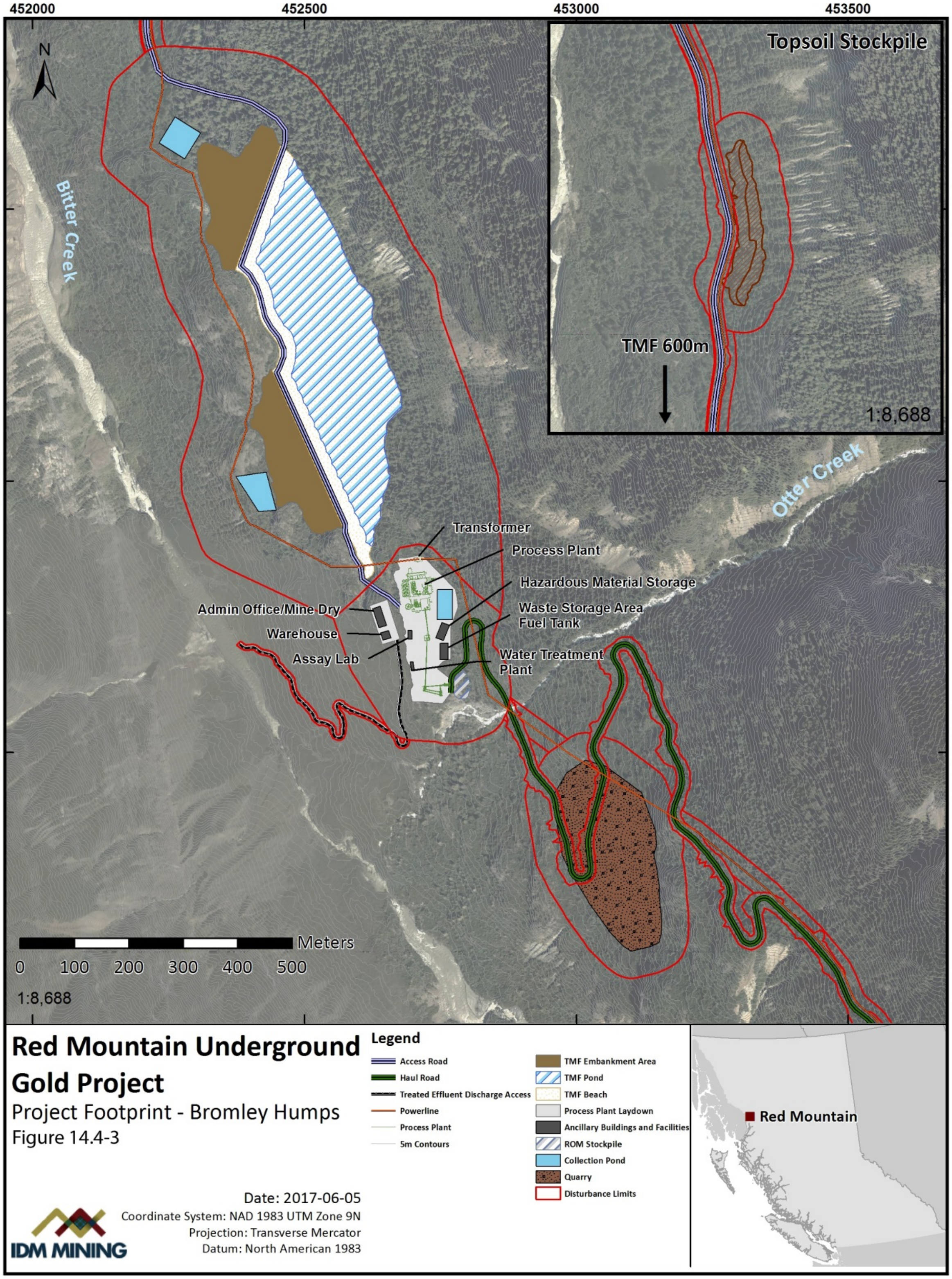


Figure 14.4-3: Project Components – Bromley Humps



14.4.2 Past and Current Projects and Activities

Placer mining commenced in Bitter Creek at the base of Red Mountain at the turn of the 20th century. In 1989, gold mineralization was discovered and surface drilling was conducted from 1991 to 1994.

Existing infrastructure on the site includes an underground decline and drift development that was developed in 1993 and 1994 for bulk sampling the mineralized Marc zone, a 50,000 tonne (t) waste rock pile, a surface tote road network, camp buildings, helipads, and used mobile equipment (JDS 2016).

Current activities include environmental baseline studies in the Bitter Creek watershed. Between 2015 and 2017, a surface and underground drilling program at Red Mountain was launched, which included the dewatering of the underground mine and obtaining material for engineering and resource studies.

Underground dewatering is the only significant anthropogenic activity that may have resulted in a human-caused alteration to the environmental setting of the Project, prior to the proposed Project or other activities in the area. The dewatered volumes were discharged to the Cambria Icefield and followed an assumed eight kilometer pathway prior to entering the headwaters of Bitter Creek, formed by Bromley Glacier meltwater (IDM 2017).

Water quality monitoring during the dewatering program was conducted at BC08 (referred to as "CP2" in the 2016 Dewatering Report [IDM 2017]). The monitoring results indicated that the mine discharge did not affect water quality in Bitter Creek, as laboratory results indicated that concentrations of water quality parameters were within natural variability. It follows that there were no effects on sediment quality from the mine dewatering.

14.4.3 Project-Specific Baseline Studies

As outlined in Chapter 6 (Effects Assessment Methodology), IDM has not conducted primary traditional use or traditional ecological knowledge (TEK) surveys in support of the Project due to the preferences of Nisga'a Nation, as represented by NLG, and EAO's and the Canadian Environmental Assessment Agency's direction for comparatively low levels of engagement with the other Aboriginal Groups potentially affected by the Project. IDM has committed to using TEK where that information is publically available. As no TEK relevant to this effects assessment was publicly available at the time of writing, no TEK has been incorporated.

14.4.3.1 Data Sources

The baseline studies included detailed review of historical and background information, data gap analysis, and field sampling. Initial baseline field studies for various disciplines were conducted in the Project area from the spring of 1993 to the late fall of 1994 by Rescan, however those studies did not include sediment sampling. The current baseline programs to support the Application/EIS were carried out in 2014 and in 2016 (Table 14.4-1; Appendix 18-A).

Table 14.4-1: Summary of Sediment Quality Sampling for the Red Mountain Project, 1993-2016

Year	2014	2016
Sampling Agency	SNC-Lavalin	Northlink
Sampling Purpose	Baseline Monitoring for Red Mountain	Baseline Monitoring for Red Mountain
Analytical Lab	Maxxam laboratories (Burnaby, BC)	AGAT Laboratories (Burnaby, BC)
Parameters Analyzed	Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Lithium, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Phosphorus, Potassium, Selenium, Silver, Sodium, Strontium, Thallium, Tin, Titanium, Uranium, Vanadium, Zinc, Zirconium	Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Lead, Mercury, Molybdenum, Nickel, Selenium, Silver, Thallium, Tin, Vanadium, Zinc
Streams Sampled	Bitter Creek, Goldslide Creek, Otter Creek, Bear River, American Creek	Bitter Creek, Goldslide Creek, Otter Creek, Bear River, American Creek
Sites Sampled	BC02, BC04, BC08, BC13.4, GSC05, OC04, BR06, BR08, AC02	BC02, BC08, BC13.4, GSC02, OC04, BC02, BR06, BR08, AC02

14.4.3.2 Primary Data Collection and Analysis Methods

14.4.3.2.1 Sampling Locations

Monitoring locations in the LSA (Table 14.4-2; Figure 14.4-4) included: BC02, BC04, BC013.4, and BC08 (Bitter Creek); GSC02 and GSC05 (Goldslide Creek); and OC04 (Otter Creek). Additional monitoring in the RSA included: BR08 and BR06 (Bear River); and AC02 (American Creek). Table 14.4-2 lists Sediment Quality monitoring sites and rationale for choice.

Table 14.4-2: Baseline Sediment Quality Sampling Sites and Descriptions

Watershed	Site	Description of Monitoring Location	Rationale for Inclusion
Bitter Creek	BC02	Lower Bitter Creek, near the Highway 37A bridge	Receiving watershed
	BC04	Middle Bitter Creek, upstream of the Roosevelt Creek confluence	Receiving watershed
	BC13.4	Middle Bitter Creek, downstream of the Otter Creek confluence	Receiving watershed
	BC08	Upper Bitter Creek, downstream of the Goldslide Creek confluence and the Bromley Glacier	Receiving watershed
Goldslide Creek	GSC02	Lower Goldslide Creek, below the existing exploration camp and above the Bromley Glacier on the steep slope	Receiving watershed
	GSC05	Middle Goldslide Creek, near the existing exploration camp	Receiving watershed
Otter Creek	OC04	Upper Otter Creek, southern branch of creek	Upstream reference location for receiving watershed
Bear River	BR06	Bear River, downstream of the Bitter Creek confluence	Receiving watershed Monitoring far downstream effects
	BR08	Bear River, upstream of the Bitter Creek confluence	Upstream reference location for receiving watershed
American Creek	AC02	Lower American Creek	Reference watershed for fisheries and aquatics

Sediment quality sampling locations cover all areas that could be affected by the proposed construction, operations, and closure activities of the mine, including downstream of potential mine influences, as well as locations farther afield where downstream and/or cumulative effects could be assessed. The receiving watersheds in the monitoring program are Goldslide Creek, Bitter Creek, and Bear River, and the control watersheds are (upper) Otter Creek and American Creek.

Where possible, baseline sediment sampling was co-located with water quality and aquatic resources sampling. Sites were named according to their associated water quality sampling location. The one exception is BC13.4, which is near water quality site BC06 but is approximately 200 m upstream of BC06 (and 13.4 km upstream on Bitter Creek) due to the lack of suitable substrate conditions for sediment sampling at BC06. Sediment sampling locations within each site were chosen based on the abundance of fine-grained sediments (i.e., silts and clays). Baseline sampling was not conducted on two small unnamed non-fish bearing tributaries to Bitter Creek that drain Bromley Humps where the TMF is proposed. At the time of baseline sampling, the TMF was proposed at a different location, within the Red Mountain cirque, above the Bitter Creek valley.

Listed below are the watercourses and associated sampling locations and reference sampling locations. Figure 14.4-4 shows the Sediment Quality sampling sites in relation to the Project.

14.4.3.2.2 Bitter Creek

Bitter Creek monitoring locations (BC02, BC04, BC13.4, and BC08) are all downstream of the proposed mining facilities. There are no monitoring locations on Bitter Creek upstream of the Goldslide Creek confluence and thus no upstream reference location, because the creek is overlain by Bromley Glacier at, and upstream of, Bitter Creek's confluence with Goldslide Creek.

14.4.3.2.3 Goldslide Creek

Goldslide Creek, the uppermost tributary of Bitter Creek, drains the cirque in which the Project will be located. The two Goldslide Creek monitoring locations (GSC02 and GSC05) are both downstream of the proposed mining facilities. There are no monitoring locations on Goldslide Creek upstream of the mine, because mine infrastructure (portals) are located within the headwaters of Goldslide Creek and there is no defined channel upstream of the Upper Portal.

14.4.3.2.4 Otter Creek

Otter Creek is a right bank tributary of Bitter Creek. The site on Otter Creek (OC04) is upstream of Bromley Humps where the TMF and Process Plant are proposed.

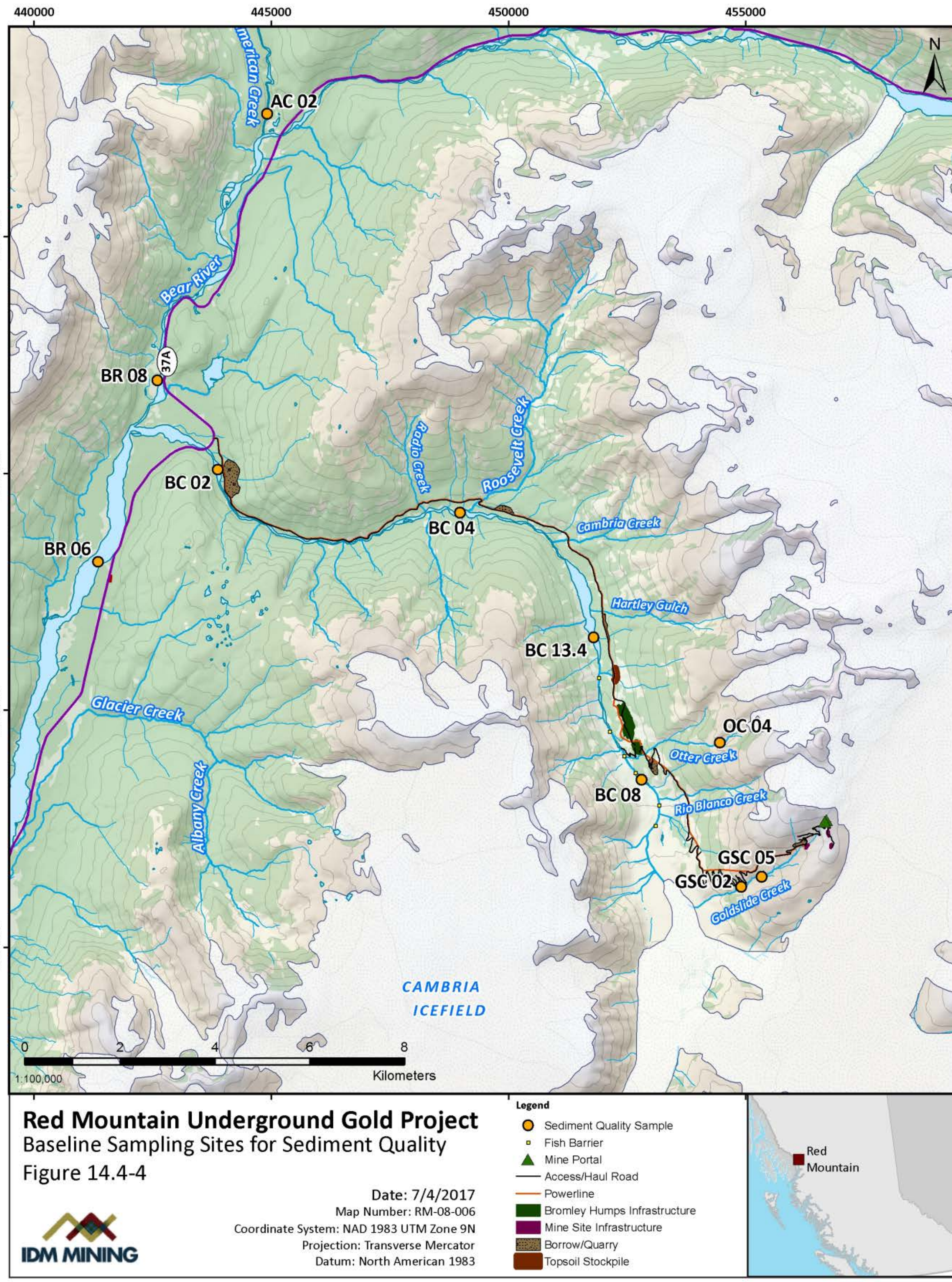
14.4.3.2.5 Bear River

Bitter Creek flows into the Bear River. Bear River has one monitoring site upstream of the confluence with Bitter Creek (BR08) and one monitoring location downstream of the confluence (BR06).

14.4.3.2.6 American Creek

There is one reference monitoring location on American Creek (AC02), which flows into the Bear River upstream and north of Bitter Creek.

Figure 14.4-4: Sediment Quality Sampling Sites



14.4.3.3 Field Sampling Methods

Sediment sampling was conducted in late September of 2014, and in early September of 2016. Sediment sampling followed the Water and Air Baseline Monitoring Guidance for Mine Proponents and Operators (BC MOE, 2016) and applicable Resource Inventory Standard Committee (RISC) guidance documents to the extent allowed by conditions at the time. The sediment sampling design included comparison of split samples for QA/QC: 50% of sediments samples included a split replicate sample. At each site, replicate samples were collected from depositional zones of fine-grained sediments and stored in 250 mL glass jars. Generally, 3 replicate samples were collected at each site in 2014, while 5 replicate samples were collected at each site in 2016. All sampling was conducted by qualified personnel, with a minimum of one crew member having significant sediment quality sampling experience. Nitrile gloves were worn throughout sampling. A non-corrosive metal scoop was used when collecting sediments for Polycyclic Aromatic Hydrocarbons (PAHs), grain size, total organic carbon (TOC), and moisture analysis; a plastic scoop was used when collecting sediments for metal and sulphur analysis. Field observations were recorded in the field on waterproof paper. All field notes were scanned and transcribed as needed into the final report.

14.4.3.4 Laboratory Analyses

During the two-year sediment quality baseline study (2014 and 2016), 68 samples were analyzed using industry-standard techniques at Maxxam Laboratories in Burnaby, BC in 2014, and AGAT Laboratories in Burnaby, BC, in 2016; both facilities are Canadian Association for Laboratory Accreditation (CALA) accredited environmental laboratories. Samples were transported to the lab using receiving laboratory best practices to maintain sample quality.

Samples were analyzed for moisture, pH, particle size, and PAHs. In 2016 analysis of metals, total organic carbon (TOC) and sulphur were conducted on the fraction of each sample that passed through a <63 µm sieve, in accordance with BC MOE (2016). In 2014 the sediment fraction used in the chemical analysis came from the <2 mm sieve (Appendix 18-A).

14.4.3.5 Relevant Guidelines and Data Analysis

Where applicable, sediment concentrations of the various parameters were compared with federal and provincial sediment quality guidelines, including: BC Provincial Ambient Water Quality Criteria for Polycyclic Aromatic Hydrocarbons (PAHs; BC MOE 1993), and the Canadian Council of Ministers of the Environment Interim Sediment Quality Guidelines for PAHs and inorganic metals (CCME 2001). These guidelines are only available for a limited number of metal concentrations (total) in sediments. Currently, ISQGs and PELs are recommended for 31 chemicals or substances (7 metals: arsenic, cadmium, chromium, copper, lead, mercury and zinc; 13 PAHs and 11 organochlorine compounds). Definitions for these numerical guidelines for the protection of aquatic life are as follows (CCME 1999):

- Interim Sediment Quality Guidelines (ISQG): generally reflective of threshold effect levels (TELs), which are the concentrations below which there are unlikely to be any adverse biological effects

- Probable Effects Level (PEL): concentration above which adverse effects are expected to frequently occur

All analytical data received from the laboratories were compiled into Microsoft Excel. Full summary statistics (mean, median, maximum, minimum, and standard deviation) were calculated based on analytical results and can be found in Appendix 18-A. Relevant BC MOE and CCME sediment quality guidelines are outlined in Table 14.4-3.

Table 14.4-3: Summary of Sediment Quality Guidelines

Parameter	Units	CCME PEL (a)	CCME ISQG (b)	BC WSG (c)
2-Methylnaphthalene	mg/kg	0.20	0.02	n/a
Acenaphthene	mg/kg	0.89	0.01	0.15
Acenaphthylene	mg/kg	0.13	0.01	n/a
Anthracene	mg/kg	0.25	0.05	0.6
Benzo(a)anthracene	mg/kg	0.39	0.03	0.2
Benzo(a)pyrene	mg/kg	0.78	0.03	0.06
Chrysene	mg/kg	0.86	0.06	n/a
Dibenzo(a,h)anthracene	mg/kg	0.14	0.01	n/a
Fluoranthene	mg/kg	2.36	0.11	2
Fluorene	mg/kg	0.14	0.02	0.2
Naphthalene	mg/kg	0.39	0.03	0.01
Phenanthrene	mg/kg	0.52	0.04	0.04
Pyrene	mg/kg	0.88	0.05	n/a
Arsenic	mg/kg	17	5.9	n/a
Cadmium	mg/kg	3.5	0.6	n/a
Chromium	mg/kg	90	37.3	n/a
Copper	mg/kg	197	35.7	n/a
Lead	mg/kg	91.3	35	n/a
Mercury	mg/kg	0.486	0.17	n/a
Selenium	mg/kg	n/a	n/a	2.0
Zinc	mg/kg	315	123	n/a

Notes:
(a) Probable Effects Level (PEL) defines the level above which adverse effects are expected to occur frequently
(b) Interim Sediment Quality Guidelines (ISQG) correspond to threshold level effects below which adverse biological effects are not expected
(c) British Columbia Sediment Quality Guidelines (BC WSG) standard for maximum approved concentrations in freshwater aquatic sediment
(d) ‘n/a’ indicates that no approved guideline is available

14.4.4 Baseline Characterization

The complete Sediment Quality baseline can be found in in Appendix 18-A. Summary statistics for sediment quality parameters are provided by watercourse in the following sections. Table 14.4-10 summarizes guideline exceedances and Table 14.4-9 summarizes the sites and parameters which were statistically different than their respective reference sites under baseline conditions, i.e. sites and parameters for which a difference from reference occurs under existing conditions.

14.4.4.1 Goldslide Creek (GSC05 and GSC02)

Sediment quality analysis for samples collected for Goldslide Creek was completed in 2014 and 2016, and summarized in Table 14.4-4. All samples were collected at the GSC05 site. Seven sediment samples were collected between 2014 and 2016: one sample in 2014 (*i.e.,* no replication), and six replicate samples in 2016. Results from 2016 were averaged for each of the parameters to provide mean values. Sediment samples were sand dominate with composition relatively consistent between years (2014 = 86 %, 2016 mean = 85.8 %). Total organic carbon (TOC) had a wide range for the samples collected in 2016 (2,000-8,700 milligrams per kilogram (mg/kg)) with the 2014 sample falling at the lower end of that range (2,100 mg/kg).

Concentrations of four metals exceeded the ISQG in the 2014 sample: arsenic, cadmium, copper, and zinc. Of the four ISQG exceedances, three exceeded PEL guidelines in 2014: arsenic, copper, and zinc. PEL guidelines and ISQG for arsenic are 17.9 and 5.9 mg/kg respectively, with sample concentrations 5 and 15 times the guideline values in 2014. PEL and guidelines for copper are 197 and 35.7 mg/kg respectively with sample concentrations 2 and 12 times guideline values in 2014. PEL and ISQG guidelines for zinc are 197 and 35.7 mg/kg respectively with sample concentrations 2 and 12 times guideline values in 2014. All Goldslide Creek sites contained selenium concentration above BC WSG of 2.0 mg/kg with mean concentration of 7.73 mg/kg in 2014.

Mean concentrations of four metals exceeded of the ISQG in the 2016 samples: arsenic, cadmium, copper, and zinc. Of the four ISQG exceedances, all exceeded PEL guidelines in 2016. Sample PEL guidelines and ISQG exceedances in 2016 were 4 and 13 times the guideline values for arsenic, 6 and 34 times the guideline values for copper and 2 and 12 times guideline values for zinc respectively. PEL guidelines and ISQG for cadmium are 3.5 and 0.6 mg/kg with 2016 mean sediment sample concentrations 1.3 times PEL and 7.5 times ISQG values. All Goldslide Creek sites contained selenium concentration above BC WSG of 2.0 mg/kg with mean concentration of 12.2 mg/kg in 2016.

Table 14.4-4: Sediment Quality Summary Statistics for Goldslide Creek (GSC05 and GSC02)

Parameter	Units	Min		Mean		Max	
		2014	2016	2014	2016	2014	2016
% Gravel	%	5.8	N/A	5.8	N/A	5.8	N/A
%Sand	%	86	83	86	85.8	86	89
%Silt	%	4.4	8	4.4	10.8	4.4	13
%Clay	%	3.4	3	3.4	3.3	3.4	4
TOC	mg/kg	2100	2000	2100	3850	2100	8700
2-Methylnaphthalene	mg/kg	<0.02	<0.01	<0.02	<0.01	<0.02	<0.01
Acenaphthene	mg/kg	<0.005	<0.01	<0.005	<0.01	<0.005	<0.01
Acenaphthylene	mg/kg	<0.005	<0.01	<0.005	<0.01	<0.005	<0.01
Anthracene	mg/kg	<0.004	<0.02	<0.004	<0.02	<0.004	<0.02
Benzo(a)anthracene	mg/kg	n/a	<0.02	n/a	<0.02	n/a	<0.02
Benzo(a)pyrene	mg/kg	n/a	<0.02	n/a	<0.02	n/a	<0.02
Chrysene	mg/kg	n/a	<0.02	n/a	<0.02	n/a	<0.02
Fluoranthene	mg/kg	n/a	<0.02	n/a	<0.02	n/a	<0.02
Fluorene	mg/kg	n/a	<0.02	n/a	<0.02	n/a	<0.02
Naphthalene	mg/kg	n/a	<0.02	n/a	<0.02	n/a	<0.02
Phenanthrene	mg/kg	n/a	<0.02	n/a	<0.02	n/a	<0.02
Pyrene	mg/kg	n/a	<0.02	n/a	<0.02	n/a	<0.02
Antimony	mg/kg	8.47	4.1	8.47	5.7	8.47	7.9
Arsenic	mg/kg	***92.0***	***49.7***	***92.0***	***79.1***	***92.0***	***99.6***
Cadmium	mg/kg	3.03	2.78	3.03	***4.51***	3.03	***5.86***
Chromium	mg/kg	26.3	16	26.30	34.33	26.3	44
Copper	mg/kg	***457***	***813***	***457***	***1216***	***457***	***1540***
Lead	mg/kg	29.9	16.8	29.9	25.5	29.9	34
Mercury	mg/kg	0.05	0.02	0.05	0.03	0.05	0.04
Selenium	mg/kg	7.73*	7.9*	7.73*	12.2*	7.73*	14.9*
Silver	mg/kg	1.1	0.70	1.1	1.0	1.1	1.3
Zinc	mg/kg	***443***	296	***443***	***440***	***443***	***554***

1. ‘n/a' indicates that no concentration or analysis value is available
2. Results of 2014 sediment quality data are based on the sediment fraction of < 2 mm; 2016 a sediment fraction of < 63 µm was used for chemical analysis
3. Highlighted values indicate an exceedance of ISGQ sediment quality guideline
4. Bold Italic values indicate an exceedance of PEL sediment quality guideline
5. (*) indicates the value exceeds the BC sediment quality guideline
6. RDL = Reported Detection Limit
7. < Non-Detectable

14.4.4.2 Otter Creek (OC04)

Sediment quality analysis for samples collected for Otter Creek was completed in 2014 and 2016, and is summarized in Table 14.4-5. All samples were collected at the OC04 site. Eight sediment samples were collected between 2014 and 2016: three replicate samples in 2014, and five replicate samples in 2016. Sediment samples were sand-dominant in both 2014 and 2016 (2014 mean = 76%, 2016 mean = 92.2%) with silt as the subdominant substrate (2014 mean = 18.3%, 2016 mean = 5.75%). Mean sediment total organic carbon (TOC) concentrations in 2014 were 1,900 mg/kg and 1,440 mg/kg in 2016.

Mean concentrations of three metals exceeded the ISQG in the 2014 samples: arsenic, cadmium, and copper. No parameter values exceeded PEL guidelines for the 2014 samples. Mean sediment sample concentration of arsenic in 2014 was 9.4 mg/kg, exceeding the ISQG of 5.9 mg/kg. Mean sediment sample concentration of cadmium in 2014 was 7.3 mg/kg, exceeding the ISQG of 0.6 mg/kg. Mean sediment sample concentration of copper in 2014 was 43 mg/kg, exceeding the ISQG of 35.7 mg/kg.

Mean concentrations of three metals exceeded the ISQG in the 2016 samples: arsenic, cadmium, and copper. Of the three parameters that exceeded ISQG in 2016, arsenic also exceeded PEL guidelines in 2016. Mean sediment sample concentration of arsenic in 2016 was 18.1 mg/kg, exceeding the ISQG of 5.9 mg/kg and the PEL guidelines of 17.9 mg/L. Mean sediment sample concentration of cadmium in 2016 was 1.10 mg/kg, exceeding the ISQG of 0.6 mg/kg. Mean sediment sample concentration of copper in 2016 was 87.6 mg/kg, exceeding the ISQG of 35.7 mg/kg. Although mean concentrations for the sites were below the guidelines, one Otter Creek sample exceeded ISQG for chromium concentrations, two Otter Creek samples exceeded ISQG for zinc concentrations, and one Otter Creek sample exceeded BC SQG concentrations for selenium in 2016.

Table 14.4-5: Sediment Quality Summary Statistics for Otter Creek (OC04)

Parameter	Units	Min		Mean		Max	
		2014	2016	2014	2016	2014	2016
% Gravel	%	1.7	N/A	1.9	N/A	2.2	N/A
%Sand	%	70	87	76	92.2	80	97
%Silt	%	13	2	18.3	5.75	25	10
%Clay	%	3.1	3	3.8	3.2	5.3	4
TOC	mg/kg	1700	800	1900	1440	2100	2200
2-Methylnaphthalene	mg/kg	n/a	<0.02	n/a	<0.02	n/a	<0.02
Acenaphthene	mg/kg	n/a	<0.01	n/a	<0.01	n/a	<0.01
Acenaphthylene	mg/kg	n/a	<0.01	n/a	<0.01	n/a	<0.01
Anthracene	mg/kg	n/a	<0.02	n/a	<0.02	n/a	<0.02
Benzo(a)anthracene	mg/kg	n/a	<0.02	n/a	<0.02	n/a	<0.02

Parameter	Units	Min		Mean		Max	
		2014	2016	2014	2016	2014	2016
Benzo(a)pyrene	mg/kg	n/a	<0.02	n/a	<0.02	n/a	<0.02
Chrysene	mg/kg	n/a	<0.02	n/a	<0.02	n/a	<0.02
Fluoranthene	mg/kg	n/a	<0.02	n/a	<0.02	n/a	<0.02
Fluorene	mg/kg	n/a	<0.02	n/a	<0.02	n/a	<0.02
Naphthalene	mg/kg	n/a	<0.01	n/a	<0.01	n/a	<0.01
Phenanthrene	mg/kg	n/a	<0.02	n/a	<0.02	n/a	<0.02
Pyrene	mg/kg	n/a	<0.02	n/a	<0.02	n/a	<0.02
Arsenic	mg/kg	9.4	14.0	9.9	***18.1***	10.6	***23.5***
Cadmium	mg/kg	0.73	0.88	0.83	1.10	0.89	1.38
Chromium	mg/kg	15.7	23	17.7	30.4	19.5	42
Copper	mg/kg	43	63.2	48.6	87.6	52.7	121
Lead	mg/kg	13.3	20.9	14.6	22.5	15.8	26
Mercury	mg/kg	0.05	0.01	0.05	0.02	0.05	0.02
Selenium	mg/kg	0.6	0.5	0.9	1.2	1.1	2.3*
Silver	mg/kg	0.34	0.50	0.37	0.62	0.39	1.0
Zinc	mg/kg	104	93	108	114	110	137

Notes:
1. ‘n/a' indicates that no concentration or analysis value is available
2. Results of 2014 sediment quality data are based on the sediment fraction of < 2 mm; 2016 a sediment fraction of < 63 µm was used for chemical analysis
3. Highlighted values indicate an exceedance of ISGQ sediment quality guideline
4. Bold Italic values indicate an exceedance of PEL sediment quality guideline
5. (*) indicates the value exceeds the BC sediment quality guideline
6. RDL = Reported Detection Limit
7. < Non-Detectable

14.4.4.3 Bitter Creek (BC02, BC04, BC13.4 and BC08)

Sediment quality analysis for samples collected for Bitter Creek was completed in 2014 and 2016, and is summarized in Table 14.4-6. Samples were collected at four sites: BC02, BC04, BC13.4, and BC08. Eleven sediment samples were collected in2014: three replicates each at BC02, BC04, and BC13.4 and two replicates at BC08. Sixteen samples were collected in 2016: 5 replicates each at BC02, BC13.4, and BC08 plus an additional replicate at BC13.4. BC04 was not sampled in 2016. Results are available from across all sites, for each year, to provide mean values. Sediment samples were sand-dominant in both 2014 and 2016 (2014 mean = 67.1 %, 2016 mean = 86.6 %) with silt as the subdominant substrate (2014 mean = 27.5 %, 2016 mean = 9.0%). Mean sediment total organic carbon (TOC) concentrations in 2014 were 3,873 mg/kg and 2,369 mg/kg in 2016.

Mean concentrations of five metals exceeded the ISQG in the 2014 samples: arsenic, cadmium, copper, lead, and zinc. Of the five ISQG exceedances, arsenic also exceeded PEL guidelines in 2014. Mean sediment sample concentration of arsenic in 2014 was 72.5 mg/kg, exceeding the ISQG of 5.9 mg/kg and the PEL guidelines of 17.9 mg/L. All Bitter Creek sites contained selenium concentrations above BC SQG of 2.0 mg/kg with mean concentration of 4.91 mg/kg in 2014.

Mean concentrations of six metals exceeded the ISQG in the 2016 samples: arsenic, cadmium, chromium, copper, lead, and zinc. Of the six ISQG exceedances, arsenic also exceeded PEL guidelines in 2016. Mean sediment sample concentration of arsenic in 2016 was 122.8 mg/kg, exceeding the ISQG of 5.9 mg/kg and the PEL guidelines of 17.9 mg/L. Although the means for the sites were below the guidelines, one Bitter Creek sample exceeded PEL guidelines for lead concentrations in 2014, and three Bitter Creek samples exceeded PEL guidelines for lead concentrations in 2016. All Bitter Creek sites contained selenium concentration above BC SQG of 2.0 mg/kg with mean concentration of 7.69 mg/kg in 2016.

Table 14.4-6: Sediment Quality Summary Statistics for Bitter Creek (BC02, BC04, BC13.4, BC08)

Parameter	Units	Min		Mean		Max	
		2014	2016	2014	2016	2014	2016
% Gravel	%	0.0	N/A	0.5	N/A	4.5	N/A
%Sand	%	46.0	65.0	67.1	86.6	89.0	95.0
%Silt	%	7.0	2.0	27.5	9.0	46.0	30.0
%Clay	%	0.5	3.0	5.0	4.4	8.6	9.0
TOC	mg/kg	3300	1600	3873	2369	4300	3500
2-Methylnaphthalene	mg/kg	<0.02	<0.01	<0.02	<0.01	<0.02	<0.01
Acenaphthene	mg/kg	<0.005	<0.01	<0.005	<0.01	<0.005	<0.01
Acenaphthylene	mg/kg	<0.005	<0.01	<0.005	<0.01	<0.005	<0.01
Anthracene	mg/kg	<0.004	<0.02	<0.004	<0.02	<0.004	<0.02
Benzo(a)anthracene	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo(a)pyrene	mg/kg	<0.02	<0.05	<0.02	<0.05	<0.02	<0.05
Chrysene	mg/kg	<0.02	<0.05	<0.02	<0.05	<0.02	<0.05
Dibenzo(a,h)anthracene	mg/kg	<0.05	N/A	<0.05	N/A	<0.05	N/A
Fluoranthene	mg/kg	<0.02	<0.05	<0.02	<0.05	<0.02	<0.05
Fluorene	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenanthrene	mg/kg	<0.01	<0.02	<0.01	<0.02	<0.01	<0.02
Pyrene	mg/kg	<0.05	<0.01	<0.05	<0.02	<0.05	<0.02
Arsenic	mg/kg	***43.7***	***43.7***	***72.5***	***122.8***	***167.0***	***232.0***

Parameter	Units	Min		Mean		Max	
		2014	2016	2014	2016	2014	2016
Cadmium	mg/kg	1.28	1.49	1.59	1.90	1.91	3.49
Chromium	mg/kg	24.8	34.0	31.8	53.3	36.9	87.0
Copper	mg/kg	79.2	119	88.5	147.5	111	***210***
Lead	mg/kg	17.3	20.9	35.7	59.5	***95.7***	***222***
Mercury	mg/kg	0.05	0.02	0.05	0.05	0.05	0.08
Selenium	mg/kg	3.0 *	4.3 *	4.9*	7.7*	9.2*	12.9*
Silver	mg/kg	0.71	0.70	1.1	1.3	1.8	3.2
Zinc	mg/kg	107	147	146	176	183	286

Notes:

1. 'n/a' indicates that no concentration or analysis value is available
2. Results of 2014 sediment quality data are based on the sediment fraction of < 2 mm; 2016 a sediment fraction of < 63 µm was used for chemical analysis
3. Highlighted values indicate an exceedance of ISGQ sediment quality guideline
4. ***Bold Italic*** values indicate an exceedance of PEL sediment quality guideline
5. (*) indicates the value exceeds the BC sediment quality guideline
6. RDL = Reported Detection Limit
7. < Non-Detectable

14.4.4.4 Bear River (BR06 and BR08)

Sediment quality analysis for samples collected for Bear River was completed in 2014 and 2016, and summarized in Table 14.4-7. Seventeen sediment samples were collected between 2014 and 2016: 6 samples in 2014 (3 replicates each at BR06 and BR08), and 11 samples in 2016 (five replicates each at BR06 and BR08, plus one additional replicate sample at BR06). Sediment samples were sand- and silt-dominant in 2014 with mean percent composition at 50.3% and 43.0% respectively. In 2016, sediment samples were sand dominant (2016 mean = 88.6%) with silt subdominant (2016 mean=7.6%). Mean sediment total organic carbon (TOC) concentrations in 2014 were 2,900 mg/kg and 1,873 mg/kg in 2016.

Mean concentrations of five metals exceeded the ISQG in the 2014 sample: arsenic, cadmium, copper, lead, and zinc. Of the five ISQG exceedances, arsenic also exceeded PEL guidelines in 2014. Mean sediment sample concentration of arsenic in 2014 was 31.5 mg/kg, exceeding the ISQG of 5.9 mg/kg and the PEL guidelines of 17.9 mg/L. Although the means for the sites were below the guidelines, one Bear River sample exceeded BC SQG of 2.0 mg/kg for selenium in 2014.

Mean concentrations of five metals exceeded the ISQG in the 2016 samples: arsenic, cadmium, copper, lead, and zinc. Of the five ISQG exceedances, arsenic also exceeded PEL guidelines in 2016. Mean sediment sample concentration of arsenic in 2016 was 62.1 mg/kg, exceeding the ISQG of 5.9 mg/kg and the PEL guidelines of 17.9 mg/L. Mean sediment sample concentration of selenium in 2016 was 3.94 mg/kg, exceeding the BC SQG of 2.0 mg/kg.

Table 14.4-7: Sediment Quality Summary Statistics for Bear River (BR06 and BR08)

Parameter	Units	Min		Mean		Max	
		2014	2016	2014	2016	2014	2016
% Gravel	%	0.0	N/A	0.1	N/A	0.2	N/A
%Sand	%	36.0	67.0	50.3	88.6	64.0	95.0
%Silt	%	33.0	2.0	43.0	7.6	58.0	26.0
%Clay	%	3.9	3.0	6.9	3.7	9.8	7.0
TOC	mg/kg	1500	800	2900	1873	5000	2600
2-Methylnaphthalene	mg/kg	<0.02	<0.01	<0.02	<0.01	<0.02	<0.01
Acenaphthene	mg/kg	<0.005	<0.01	<0.005	<0.01	<0.005	<0.01
Acenaphthylene	mg/kg	<0.005	<0.01	<0.005	<0.01	<0.005	<0.01
Anthracene	mg/kg	<0.004	<0.02	<0.004	<0.02	<0.004	<0.02
Benzo(a)anthracene	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo(a)pyrene	mg/kg	<0.02	<0.05	<0.02	<0.05	<0.02	<0.05
Chrysene	mg/kg	<0.02	<0.05	<0.02	<0.05	<0.02	<0.05
Dibenzo(a,h)anthracene	mg/kg	<0.05	N/A	<0.05	N/A	<0.05	N/A
Fluoranthene	mg/kg	<0.02	<0.05	<0.02	<0.05	<0.02	<0.05
Fluorene	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenanthrene	mg/kg	<0.01	<0.02	<0.01	<0.02	<0.01	<0.02
Pyrene	mg/kg	<0.05	<0.02	<0.05	<0.02	<0.05	<0.05
Arsenic	mg/kg	***22.4***	***30.8***	***31.5***	***62.1***	***44.8***	***96.0***
Cadmium	mg/kg	1.21	1.5	1.42	1.75	1.67	2.1
Chromium	mg/kg	7.8	17	11.8	23.4	22.9	31
Copper	mg/kg	41.9	63.3	53.0	90.0	73.4	122
Lead	mg/kg	31.3	34.8	39.2	44.8	51	66
Mercury	mg/kg	0.05	0.05	0.07	0.07	0.08	0.08
Selenium	mg/kg	1.1	1.4	1.8	3.9*	2.9*	6.8*
Silver	mg/kg	0.63	0.60	0.75	0.95	1.0	1.4
Zinc	mg/kg	151	160	192	202	241	274

Notes:

1. 'n/a' indicates that no concentration or analysis value is available
2. Results of 2014 sediment quality data are based on the sediment fraction of < 2 mm; 2016 a sediment fraction of < 63 µm was used for chemical analysis
3. Highlighted values indicate an exceedance of ISGQ sediment quality guideline
4. ***Bold Italic*** values indicate an exceedance of PEL sediment quality guideline

5. (*) indicates the value exceeds the BC sediment quality guideline
6. RDL = Reported Detection Limit
7. < Non-Detectable

14.4.4.5 American Creek (AC02)

Sediment quality analysis for samples collected for American Creek was completed in 2014 and 2016, and summarized in Table 14.4-8. All samples were collected at site AC02. Nine sediment samples were collected between 2014 and 2016: 3 samples in 2014 and six samples in 2016. Sediment samples were sand-dominate with composition relatively consistent between years (2014 = 77.7%, 2016 mean = 85.3%). Total organic carbon (TOC) levels were relatively low compared to other sites with a concentration of 585 mg/kg in 2014 and 833 mg/kg in 2016.

Mean concentrations of four metals exceeded the ISQG in the 2014 samples: arsenic, cadmium, copper, and zinc. Of the four ISQG exceedances, no parameters exceeded PEL guidelines in 2014. All American Creek sites contained selenium concentration above BC SQG of 2.0 mg/kg with mean concentration of 2.47 mg/kg in 2014.

Mean concentrations of five metals exceeded the ISQG in the 2016 samples: arsenic, cadmium, copper, lead and zinc. Of the five ISQG exceedances, arsenic also exceeded PEL guidelines in 2016. Mean sediment sample concentration of arsenic in 2016 was 33.2 mg/kg, exceeding the ISQG of 5.9 mg/kg and the PEL guidelines of 17.9 mg/L. All American Creek sites contained selenium concentration above BC SQG of 2.0 mg/kg with mean concentration of 6.3 mg/kg in 2016.

Table 14.4-8: Sediment Quality Summary Statistics for American Creek (AC02)

Parameter	Units			Min		Mean		Max	
				2014	2016	2014	2016	2014	2016
% Gravel	%			0.0	N/A	0.2	N/A	0.6	N/A
%Sand	%			75.0	72.0	77.7	85.3	83.0	92.0
%Silt	%			15.0	4.0	19.3	11.0	22.0	24.0
%Clay	%			2.4	3.0	3.0	3.7	4.0	4.0
TOC	mg/kg			580	600	585	833	590	1200
2-Methylnaphthalene	mg/kg			0.02	0.01	0.02	0.01	0.02	0.01
Acenaphthene	mg/kg			0.005	0.01	0.005	0.01	0.005	0.01
Acenaphthylene	mg/kg			0.005	0.01	0.005	0.01	0.005	0.01
Anthracene	mg/kg			0.004	0.01	0.004	0.01	0.004	0.01
Benzo(a)anthracene	mg/kg			0.02	0.02	0.02	0.02	0.02	0.02
Benzo(a)pyrene	mg/kg			0.02	0.05	0.02	0.05	0.02	0.05
Chrysene	mg/kg			0.02	0.05	0.02	0.05	0.02	0.05
Dibenzo(a,h)anthracene	mg/kg			0.05	N/A	0.05	N/A	0.05	N/A
Fluoranthene	mg/kg			0.02	0.05	0.02	0.05	0.02	0.05

Parameter	Units			Min		Mean		Max	
				2014	2016	2014	2016	2014	2016
Fluorene	mg/kg			0.02	0.02	0.02	0.02	0.02	0.01
Naphthalene	mg/kg			0.01	0.01	0.01	0.01	0.01	0.01
Phenanthrene	mg/kg			0.01	0.02	0.01	0.02	0.01	0.02
Pyrene	mg/kg			0.02	0.02	0.02	0.02	0.02	0.02
Arsenic	mg/kg			15.7	***29.6***	16.6	***33.2***	***17.6***	***36.5***
Cadmium	mg/kg			0.742	1.28	0.92	1.43	1.16	1.57
Chromium	mg/kg			4.2	8	4.20	10.17	4.2	15
Copper	mg/kg			45.5	81.4	50.7	93.6	59.8	113
Lead	mg/kg			15.7	32.2	17.2	36.8	19.7	39.8
Mercury	mg/kg			0.05	0.09	0.06	0.10	0.065	0.11
Selenium	mg/kg			2.1*	5.5*	2.5*	6.3*	2.7*	7.3*
Silver	mg/kg			0.34	0.50	0.39	0.67	0.43	0.80
Zinc	mg/kg			128	153	137	169	154	182

Notes:

1. 'n/a' indicates that no concentration or analysis value is available
2. Results of 2014 sediment quality data are based on the sediment fraction of < 2 mm; 2016 a sediment fraction of < 63 µm was used for chemical analysis
3. Highlighted values indicate an exceedance of ISGQ sediment quality guideline
4. ***Bold Italic*** values indicate an exceedance of PEL sediment quality guideline
5. (*) indicates the value exceeds the BC sediment quality guideline
6. RDL = Reported Detection Limit
7. All PAHs were non-detectable; the detection limit value was reported in the table

Table 14.4-9: Sites and Parameters which were Statistically Different than their Respective Reference Sites Under Baseline Conditions

COPC	BC 02	BC 13.4	BC 08	BR 06	GSC 02
Arsenic		×	×	×	×
Cadmium		×			×
Chromium	×	×	×	×	
Copper	×	×	×	×	×
Lead				×	
Mercury	×	×	×	×	×
Selenium				×	×
Zinc				×	×

× = concentration of parameter at site was statistically different than the concentration at the respective reference site

Table 14.4-10: Exceedance of Guidelines for All Sites and Samples

Parameter	GSC02			GSC05			OC04			BC02			BC04		
	ISQG	PEL	BC SQG	ISQG	PEL	BC SQG	ISQG	PEL	BC SQG	ISQG	PEL	BC SQG	ISQG	PEL	BC SQG
Arsenic	6 of 6	6 of 6	n/a	1 of 1	1 of 1	n/a	8 of 8	2 of 8	n/a	8 of 8	8 of 8	n/a	3 of 3	3 of 3	n/a
Cadmium	6 of 6	5 of 6	n/a	1 of 1	0 of 1	n/a	8 of 8	0 of 8	n/a	8 of 8	0 of 8	n/a	3 of 3	0 of 3	n/a
Chromium	4 of 6	0 of 6	n/a	0 of 1	0 of 1	n/a	1 of 8	0 of 8	n/a	4 of 8	0 of 8	n/a	0 of 3	0 of 3	n/a
Copper	6 of 6	6 of 6	n/a	1 of 1	1 of 1	n/a	8 of 8	0 of 8	n/a	8 of 8	0 of 8	n/a	3 of 3	0 of 3	n/a
Lead	0 of 6	0 of 6	n/a	0 of 1	0 of 1	n/a	0 of 8	0 of 8	n/a	3 of 8	0 of 8	n/a	1 of 3	0 of 3	n/a
Selenium	n/a	n/a	6 of 6	n/a	n/a	1 of 1	n/a	n/a	1 of 8	n/a	n/a	8 of 8	n/a	n/a	3 of 3
Mercury	0 of 6	0 of 6	n/a	0 of 1	0 of 1	n/a	0 of 8	0 of 8	n/a	0 of 8	0 of 8	n/a	0 of 3	0 of 3	n/a
Zinc	6 of 6	5 of 6	n/a	1 of 1	1 of 1	n/a	2 of 8	0 of 8	n/a	7 of 8	0 of 8	n/a	3 of 3	0 of 3	n/a
Parameter	**BC08**			**BC013.4**			**BR06**			**BR08**			**AC02**		
Arsenic	7 of 7	7 of 7	n/a	9 of 9	9 of 9	n/a	7 of 7	7 of 7	n/a	8 of 8	8 of 8	n/a	9 of 9	7 of 9	n/a
Cadmium	7 of 7	0 of 7	n/a	9 of 9	0 of 9	n/a	7 of 7	0 of 7	n/a	8 of 8	0 of 8	n/a	9 of 9	0 of 9	n/a
Chromium	5 of 7	0 of 7	n/a	6 of 9	0 of 9	n/a	0 of 7	0 of 7	n/a	0 of 8	0 of 8	n/a	0 of 9	0 of 9	n/a
Copper	7 of 7	0 of 7	n/a	9 of 9	1 of 9	n/a	7 of 7	0 of 7	n/a	8 of 8	0 of 8	n/a	9 of 9	0 of 9	n/a
Lead	4 of 7	1 of 7	n/a	6 of 9	3 of 9	n/a	5 of 7	0 of 7	n/a	8 of 8	0 of 8	n/a	4 of 9	0 of 9	n/a
Selenium	n/a	n/a	7 of 7	n/a	n/a	9 of 9	n/a	n/a	7 of 7	n/a	n/a	1 of 8	n/a	n/a	9 of 9
Mercury	0 of 7	0 of 7	n/a	0 of 9	0 of 9	n/a	0 of 7	0 of 7	n/a	0 of 8	0 of 8	n/a	0 of 9	0 of 9	n/a
Zinc	7 of 7	0 of 7	n/a	9 of 9	0 of 9	n/a	7 of 7	0 of 7	n/a	8 of 8	0 of 8	n/a	9 of 9	0 of 9	n/a

Notes:

1. Probable Effects Level (PEL) defines the level above which adverse effects are expected to occur frequently.
2. Interim Sediment Quality Guidelines (ISQG) correspond to threshold level effects below which adverse biological effects are not expected
3. British Columbia Sediment Quality Guideline (BC SQG) standard for maximum approved concentrations of selenium in freshwater aquatic sediment

14.5 Potential Effects

14.5.1 Methods

Activities associated with the Project have the potential to cause adverse effects to Sediment Quality in the immediate and downstream aquatic environments. Effects were assessed in relation to planned discharges, runoff, atmospheric deposition, and instream works for all mine components using project interaction matrices (Section 14.5.2). Once links between mine components and project interactions were identified, key potential effects were discussed in terms of potential pathways of effects to Sediment Quality (Section 14.5.3). Potential effects from indirect interactions are presented in the context of potential effects on Surface Water Quality as these two VCs are closely linked.

This effects assessment for Sediment Quality assumes that all Project activities will occur within the designed scope of the Project. Any potential risk due to spills, equipment malfunctions, emergencies, or accidents are assessed in Accidents and Malfunctions (Volume 3, Chapter 23), and are not discussed further in this assessment.

14.5.2 Project Interactions

The physical works and activities to be implemented during the Project have the potential to interact with and lead to effects on the Sediment Quality VC. Evaluation of the interaction matrix (Table 14.5-1) led to identification of potential effects. Project interactions and potential effects associated with Sediment Quality are presented below. IDM's identification of interactions and potential Project effects on Sediment Quality have been informed by the conceptual site model (CSM) and Screening Level Ecological Risk Assessment (SLEcoRA) conducted for the Project.

Table 14.5-1: Potential Project Interactions, Sediment Quality

Project Component/Activity	Potential Effect / Pathway of Interaction with Sediment Quality
Construction Phase	
Construct Access Road and Haul Road from Hwy 37A to the Upper Portal	Changes to Sediment Quality from erosion and sedimentation, ML / ARD, blasting, and dust deposition
Install Powerline from substation tie-in to the Lower Portal laydown area	Changes to Sediment Quality as a result of erosion and sedimentation, dust deposition
Excavate and secure Lower Portal entrance and access tunnel	Changes to Sediment Quality from erosion and sedimentation, dust deposition, ML / ARD and/or blasting
Construct Mine Site water management infrastructure including talus quarries and the portal collection pond, dewatering systems, and water diversion, collection and discharge ditches and swales.	Changes to Sediment Quality from ML / ARD, discharges, erosion and sedimentation and/or dust deposition
Install and fill fuel tanks at the Mine Site	Changes Sediment Quality as result of the storage, handling, and use of chemicals and fuels at the Mine Site, Access Road, and Haul Road; changes to Sediment Quality as a result of erosion and sedimentation and dust deposition

Project Component/Activity	Potential Effect / Pathway of Interaction with Sediment Quality
Construct Explosives Magazine	Changes to Sediment Quality as a result of the manufacture, storage and use of explosives; changes to Sediment Quality as a result of erosion and sedimentation and dust deposition
Construct other Mine Site ancillary buildings and facilities	Changes to Sediment Quality as a result of erosion and sedimentation, and/or dust deposition
Discharge of water from underground workings at the Mine Site	Changes to Sediment Quality as a result of mine water discharge
Initiate underground lateral development and cave gallery excavation	Changes to Sediment Quality as a result of ML/ARD, blasting, and groundwater interaction
Temporarily stockpile ore at the Mine Site	Changes to Sediment Quality as a result of erosion and sedimentation, ML/ARD and dust deposition
Transport and deposit waste rock to the Waste Rock Storage Area(s)	Changes to Sediment Quality as a result of dust deposition
Clear and prepare the TMF basin and Process Plant pad	Changes to Sediment Quality as a result of erosion/sedimentation and dust deposition
Excavate rock and till from the TMF basin and local borrows / quarries for construction activities (e.g. dam construction for the TMF)	Changes to Sediment Quality from erosion and sedimentation, ML / ARD and dust deposition
Establish water management facilities including diversion ditches for the TMF and Process Plant	Changes to Sediment Quality as a result of ML/ARD, discharges, erosion and sedimentation, and dust deposition
Construct the TMF	Changes to Sediment Quality resulting as a result of erosion and sedimentation, and dust deposition
Construct the Process Plant and Run of Mine Stockpile location	Changes to Sediment Quality as a result of erosion and sedimentation, ML / ARD and dust deposition
Construct water treatment facilities at Bromley Humps	Changes to Sediment Quality as a result of erosion/sedimentation, and dust deposition
Construct Bromley Humps ancillary buildings and facilities	Changes to Sediment Quality as a result of from erosion, sedimentation, and dust deposition
Commence milling to ramp up to full production	Changes to Sediment Quality as a result of dust deposition
Operation Phase	
Use Access Road for personnel transport, haulage, and delivery of goods	Changes to Sediment Quality as a result of erosion, sedimentation, and dust deposition
Maintain Access Road and Haul Road, including grading and plowing as necessary	Changes to Sediment Quality as a result of erosion and sedimentation and dust deposition
Maintain Powerline right-of-way from substation tie-in to portal entrance, including brushing activities as necessary	Changes to Sediment Quality as a result of erosion, sedimentation, and dust deposition
Continue underground lateral development, including dewatering	Changes to Sediment Quality as a result of ML / ARD, blasting, and dewatering
Discharge of water from underground facilities	Changes to Sediment Quality resulting from discharges

Project Component/Activity	Potential Effect / Pathway of Interaction with Sediment Quality
Haul waste rock from the portals to the Waste Rock Storage Area for disposal (waste rock transport and storage)	Changes to Sediment Quality as a result of erosion and sedimentation, ML / ARD and dust deposition
Extract ore from the underground and transport to Bromley Humps to Run of Mine Stockpile (ore transport and storage)	Changes to Sediment Quality as a result of ML / ARD and dust deposition
Treat and discharge, as necessary, excess water from the TMF	Changes to Sediment Quality as a result of discharge
Temporarily store hazardous substances including fuel, explosives, and mine supplies	Changes to Sediment Quality as a result of a potential spill
Progressively reclaim disturbed areas no longer required for the Project	Changes to Sediment Quality as a result of erosion and sedimentation, and dust deposition
Closure and Reclamation Phase	
Use and maintain Access Road for personnel transport, haulage, and removal of decommissioned components until road is decommissioned and reclaimed.	Changes to Sediment Quality as a result of erosion, sedimentation, and dust deposition
Decommission underground infrastructure	Changes to Sediment Quality as a result of erosion and sedimentation
Flood underground	Changes to Sediment Quality as a result of ML / ARD and groundwater interaction
Decommission and reclaim Lower Portal Area and Powerline	Changes to Sediment Quality as a result of erosion and sedimentation and dust deposition
Decommission and reclaim Haul Road	Changes to Sediment Quality as a result of erosion and sedimentation and dust deposition
Decommission and reclaim all remaining mine infrastructure (Mine Site and Bromley Humps, except TMF) in accordance with Closure Plan	Changes to Sediment Quality as a result of erosion and sedimentation and dust deposition
Construct the closure spillway	Changes to Sediment Quality as a result of erosion and sedimentation and dust deposition
Treat and discharge water from the TMF	Changes to Sediment Quality as a result of discharge, erosion and sedimentation, and dust deposition
Conduct maintenance of mine drainage, seepage, and discharge	Changes to Sediment Quality as a result of discharges
Remove discharge water line and water treatment plant	Changes to Sediment Quality as a result of groundwater interaction and removal of discharge
Decommission and reclaim Access Road	Changes to Sediment Quality as a result of erosion and sedimentation and dust deposition
Post-Closure Phase	
Flood underground	Changes to Sediment Quality as a result of ML/ARD and groundwater interaction

14.5.3 Discussion of Potential Effects

The overall effect from the Project to the Sediment Quality VC is the potential for change to sediment quality. A change can be physical (e.g., particle size distribution) or chemical (e.g., sediment metal concentrations). For the purposes of this assessment, the potential effects were classified under the following categories, which represent all the possible pathways that could lead to a change in sediment quality. Furthermore, these categories draw on predictive analyses conducted for other VCs, such as Surface Water Quality, to provide quantitative predictions of potential changes to sediment quality. The categories are:

- Physical changes:
  - Change in sediment quality due to non-contact water runoff (direct effect);
  - Change sediment quality from direct inputs of soil/sediments (e.g., fill from road and embankments) (direct effect); and
  - Change in sediment quality due to aerial deposition of dust (direct effect).
- Chemical changes:
  - Change in sediment quality due to a change in water quality (indirect effect).

14.5.3.1 Physical Changes to Sediment Quality

14.5.3.1.1 Non-contact Water Runoff

Bromley Humps

During TMF construction, erosion and sedimentation is expected from overburden clearing in preparation for the TMF basin and Process Plant pad, and excavation of rock and till from the TMF basin and local borrows for construction activities. Runoff from disturbed areas can carry increased sediment loads to watercourses. The lower reaches of two unnamed tributaries, in Bromley Humps that flow into Bitter Creek, will be most susceptible to increased sediment loads and high TSS. Physical alteration of sediment through this pathway includes changes in particle size distribution, and increased sedimentation in the benthic zone of downstream watercourses.

During operations, non-contact water runoff will be directed away from developed areas by means of natural or man-made diversion channels and routed to the watercourses, which already drain those areas under baseline (natural) conditions. There will be minimal changes to the existing drainage patterns that could alter sediment inputs to Bitter Creek, thus the change to sediment quality is expected to be negligible.

Mine Site

During the Construction Phase, some erosion and sedimentation is expected from land-clearing activities including the construction of mine portal facilities and water management infrastructure. Closure and reclamation will similarly result in the disturbance, transport and relocation of surficial materials. Sediment control ponds will be constructed prior to major clearing activities during construction, and remain until closure and reclamation, in all areas where sediment could enter receiving environments, such as Goldslide Creek.

Access Roads

The Access/Haul Road from Highway 37A to the mine portal entrance will be built early in the Construction Phase.

Construction activities will require vegetation clearing and grubbing, the installation of culverts and bridges, and can produce excess sedimentation into nearby creeks at road crossings. The use of any heavy machinery required for construction within the stream channel can lead to erosion thereby causing the addition of material to sediments and modification of the composition of sediments.

Quarries and Borrow Areas

There are two talus quarries located at the Mine Site, and an additional four borrow and quarry areas located along the Access and Haul Roads: Otter Creek Quarry, Roosevelt Borrow, Hartley Gulch Borrow; and Highway 37A Quarry. Suspended sediments transported from these areas can change the composition of sediments (siltation).

14.5.3.2 Direct Sediment Inputs

Direct inputs of soil and sediments into watercourses may occur from road infilling or placement of earth embankments, along sections of the road that are below the Bitter Creek high water mark, and at road crossings. However, sediment loading from this source is likely to be minimal or negligible because material placed instream will be coarse (e.g., rip rap or clear crush) or stabilized such that the risk of releasing sediment is low.

14.5.3.3 Aerial Deposition (Dustfall)

Dustfall, or total particulate matter, is generated mainly from blasting (for portal and road construction), ore conveying, crushing and hauling, and traffic and equipment use along roadways. Potential changes to sediment quality from increased dustfall include changes to particle size distribution, with a higher proportion of finer sediments, as well as increased sediment loading. Downstream effects may include increased TSS, homogenization of stream bed features, and reduced pool depths, ultimately leading to decreased habitat quality and quantity for periphyton and benthic invertebrate communities.

Using an air dispersion model, CALPUFF, annual maximum dustfall rates (milligrams per square decimeter per day; $mg/dm^2/day$) from Project sources, at Sediment Quality sampling sites, were predicted to occur during operations in Year 3. Predicted increases in dustfall rates compared with background levels were typically small (0 to 7% increase), an exception was site GSC02, where the predicted maximum annual dustfall represented an increase of 32% of background. However, predicted maximum annual dustfall at all sites are below the historical provincial annual air quality standard of 1.7 $mg/dm^2/day$, and therefore potential effects of dustfall on TSS levels in the LSA are expected to be minor, if not negligible.

14.5.3.4 Chemical Changes in Sediment Quality

14.5.3.4.1 Changes in Surface Water Quality

Potential changes to Sediment Quality chemical parameters, from changes in Water Quality, are discussed here.

The following pathways to changes to water quality are described in the effects assessment for the Surface Water Quality (Volume 3, Chapter 13), and are discussed here in the context of potential effects to sediment chemistry:

- Mine discharge;
- TMF discharge;
- Road runoff;
- Non-contact water runoff; and
- Aerial deposition.

The above pathways can contribute to changes in water quality, including changes in metal concentrations, nutrient loading, acidity (pH), and water hardness. Each of these components of Surface Water Quality, and the interaction with Sediment Quality, are summarized in Table 14.5-2. A discussion of each pathway follows.

Table 14.5-2: Water Quality Components and Interactions with Sediment Quality

Water Quality Component	Description	Project Activity/Pathway	Interaction with Sediment Quality
pH	Acid-base balance of water, this can be altered by inputs of nitrogen oxides and sulphur dioxides. These compounds are released into the atmosphere from burning fossil fuels, and mix with water, increasing its acidity. Sulfates derived from oxidation of metal sulfides are the main cause of acidification at metal mine sites.	Discharge, runoff, aerial deposition	The solubility and bioavailability of some metals, and their adsorption to and release from sediments, are influenced by the pH of sediment pore water and the overlying surface water.
Metals	Metals suspended or dissolved in water. Examples include arsenic, cadmium, chromium, copper, lead, zinc, selenium, and mercury. Metals occur naturally in the environment but can be released through mining activities.	Discharge, runoff, aerial deposition	Interactions with Sediment Quality include adsorption of dissolved metals from the water column into stream sediments, dissolved metals precipitating or forming colloids and settling into sediment, and the direct loading of particulate-bound metals into sediments (Manahan 1984; Campbell et al. 2006).

Water Quality Component	Description	Project Activity/Pathway	Interaction with Sediment Quality
Nutrients	Chemical compounds that are taken up by periphyton for growth. The primary bioavailable nutrients in surface water and sediment pore water are soluble forms of nitrogen and phosphorus. These chemicals stimulate the growth of all types of aquatic plants, including periphyton (microscopic algae), although other chemicals (e.g., silica) may limit growth when other nutrients are available in abundance.	Blasting residues, runoff, discharge, aerial deposition	Moderate increases in concentrations of nutrients in sediment can increase periphyton growth and food supply for benthic invertebrates. Overabundance of nutrients and resultant periphyton and plant growth can upset the balance of the aquatic environment, degrade physical habitat and have cascading effects through the food web.
Hydrocarbons	Polycyclic aromatic hydrocarbons (PAHs) are formed during combustion processes. Sources include vehicular exhaust, crude oil, wood preservatives, and petroleum.	Discharge, runoff, aerial deposition	PAHs have low water solubility and preferentially partition into, and therefore accumulate in, sediments. Several PAHs have been identified as carcinogens or mutagens and can be acutely or chronically toxic to aquatic organisms.

Mine Discharge

Water from the underground mine may be potentially affected by underground water management, drilling, blasting, excavation and backfilling activities.

During Construction, water from the underground workings will be discharged in accordance with permit conditions, via the Upper Portal into the Cambria Icefield as per the discharge activities during exploration. From the discharge point, the natural drainage path is approximately 8 km to Bitter Creek, via Lost Valley and the Bromley Glacier. Based on the ongoing monitoring results, potential effects on Sediment Quality from discharge to the Cambria Icefield during construction are not expected, and this interaction is not carried forward in the assessment.

During Operation, this water will continue to be pumped to the Cambria Icefield for the first 1.5 years of production until the Lower Portal is commissioned. Water would then be pumped to surface and will combine with other mine contact water in the Portal Collection Pond, within the cirque, before being discharged to the receiving environment. The Portal Collection Pond receives the discharge from underground mine dewatering during construction and operations, as well as runoff from the stockpile and laydown areas. Goldslide Creek receives discharges from the Portal Collection Pond as well as discharge from the sediment ponds servicing two talus quarries.

Discharge to Goldslide Creek during operations would also include all surface contact water, i.e., any drainage or stormwater water that has interacted with mining areas, ore stockpiles, waste rock, and excavated rock. Drainage that contacts site infrastructure, particularly from ore stockpiles, has the potential to contain dissolved metals. As such, all contact water will be intercepted, contained (e.g., collection ponds or sumps), analyzed, and treated if required, before discharge to the receiving environment.

Discharge to Goldslide Creek could lead to potential effects on Sediment Quality by contributing metals from mine contact water, nutrients from the blasting residues, and hydrocarbons from the use of fuel, oil and grease.

In Goldslide Creek, mean sediment concentrations for arsenic, copper, and zinc exceeded the PEL guideline in both baseline sampling years, and cadmium exceeded the PEL in 2014. Exceedances for arsenic were approximately five times the guideline value. Exceedances for the other metals were typically less severe (up to two times the guideline value), except for copper, which was six times the guideline value in 2016. Selenium exceeded the BC SQG for sediment in both years (there is no CCME guidelines for selenium in sediment), with the largest exceedance occurring in 2016 (six times the BC SQG value).

Some metal particles may enter stream sediments within Goldslide Creek, and may be transferred to aquatic life through surface contact or ingestion. This will include particulate metals, as well as dissolved metals that become complexed with silt/colloidal particles or organic matter and enter stream sediments. However, the incidence of dissolved metals entering stream sediments at adverse levels is predicted to be low based on the lack of fine substrates including clays and organic matter, and relatively high flow rates, both of which would minimize deposition into stream sediments in Goldslide Creek.

Discharge entering Goldslide Creek will flow directly into Bromley Glacier, which currently extends about 1 km before forming the headwaters of Bitter Creek. It is anticipated that most metals entering Goldslide Creek will be in the dissolved form because discharge will be treated to meet MMER requirements, and this will include settling. Dissolved metals will mostly remain in the water column as they are flushed downstream.

TMF Discharge

During the Operation Phase, process water, runoff from the Process Plant area, runoff from the tailings beaches, and water used in heavy equipment and truck washing facilities will be directed to the TMF. Discharge of excess TMF water to Bitter Creek will be required at certain times of year, to manage the impounded volume behind the TMF. The discharge will be treated prior to release into Bitter Creek, i.e. there will be no direct discharge from the TMF under normal operating conditions.

TMF discharge is a sediment pathway as it involves potential changes in sediment metal concentrations. Pathways to changing Sediment Quality include adsorption of dissolved metals from the water column into stream sediments, dissolved metals precipitating or forming colloids and settling into sediment, and the direct loading of particulate-bound metals into sediments (Manahan 1984; Campbell et al. 2006). Fine materials such as clay, silt, or organic matter are more likely to bind to dissolved metal particles, thus incorporating them into stream sediments (Manahan 1984). Other physico-chemical properties such as pH, water hardness, and the presence of iron and manganese complexes can also act to alter metal bioavailability (Salomons et al. 1987). Potential effects to Sediment Quality will occur over time (years) and would not likely be discernable during operations. It is anticipated that most metals entering Bitter Creek will be in the dissolved form due to the TMF acting as a settling pond, MMER discharge requirements for TSS, and seepage being filtered through subsurface materials before entering the receiving environment. Dissolved metals will mostly remain in the water column as they are flushed downstream, and will be diluted by each successive tributary and stream entering the drainage.

However, some metal particles may enter stream sediments within Bitter Creek, and may be transferred to aquatic life through surface contact or ingestion. This will include particulate metals that enter the creek via TMF spillway flow during the Closure Phase (until the TMF supernatant is drained), as well as dissolved metals that become complexed with silt/colloidal particles or organic matter and enter stream sediments. However, the incidence of dissolved metals entering stream sediments at adverse levels is predicted to be low based on the lack of fine substrates including clays and organic matter, and relatively high flow rates, both of which would minimize deposition into stream sediments in Bitter Creek.

During the Post-Closure Phase of the Project, discharge of water from the decommissioned TMF to Bitter Creek may continue.

Blasting Residues

Ammonium Nitrate Fuel Oil (ANFO) will be used during construction and operation of the mine. Blasting is anticipated to occur on a daily basis during construction and temporary explosives magazines will be stored at Bromley Humps, as well as at various locations along the road, during construction.

Underground mining and mine development, including excavation of the Lower Portal entrance and access tunnel, construction of the TMF and construction of the access and haul roads, will require blasting. Blasting residues contain nitrogen compounds that will remain on the surface of excavated rock and be available for transport to the aquatic environment via runoff. Water-soluble nitrogen compounds such as ammonia and nitrate are bioavailable, meaning they are metabolized by organisms for growth. Ammonia can be toxic to aquatic biota at elevated concentrations, and guidelines (CCME) are in place that define thresholds for protection of aquatic life. Several factors such as pH, temperature, dissolved oxygen concentration, and ionic strength affects ammonia toxicity.

Blasting residues have the potential to leach from excavated rock to access road watersheds. The proposed road alignment along the north/northeast bank of Bitter Creek follows a deactivated logging road at the toe of a steep hillside on the north side of Bitter Creek. To avoid destabilizing sensitive slopes and putting road users and workers in an unsafe position, sections of the access road will encroach on the High Water Line (HWL) of Bitter Creek. Blasting to construct cuts may be required within some of these sections. However, the vast majority of the explosives will be used for blasting ore at the Mine Site. It is expected that nitrogen loading from the excavated rock along the access roads will be minimal.

During operations, blasting residues from the mine area will be collected and directed to the Portal Collection Pond for settling prior to discharge into Goldslide Creek. Blasting residues from Bromley Humps, including runoff from ore stockpiles, will be captured and diverted to the TMF for eventual treatment prior to discharge into Bitter Creek. Seepage from the TMF during operations will be collected in the seepage collection ponds downstream of the TMF embankment and pumped back to the TMF; therefore no impacts to Surface Water Quality in Bitter Creek, resulting from nitrogen loading, are expected during the Operation Phase.

Road Runoff

Runoff from the Access and Haul Roads has potential to contribute metals and other contaminants (e.g., blasting residues, PAHs, road salts from de-icing) to the receiving aquatic environment. Additional sources of contaminants that can be transported via road runoff include the quarries and borrow areas adjacent to the road. There are four borrow and quarry areas located along the roads: Otter Creek Quarry, Roosevelt Borrow, Hartley Gulch Borrow, and Highway 37A Quarry. Materials transported from these areas via runoff can increase sediment contaminant concentrations.

The potential effects from blasting and dust associated with quarries and borrow pits are assessed separately.

Aerial Deposition (Acid Deposition)

Acid deposition forms when nitrogen oxides (NOx) and sulphur dioxides (SOx) are emitted from burning fossil fuels. Alkalinity, which determines the buffering capacity of water against acidic inputs, is low in Bitter Creek and Goldslide Creek (Appendix 14-A). Acidification conditions (lower pH) can alter the abundance and community composition of periphyton and benthic invertebrate communities. Acid deposition could occur if levels of NOx and SOx were predicted to be consistently high (i.e., above guideline) and wide-spread, and effects of such deposition on the ecological environment would also need to consider the tolerance capacity of the existing environment.

For the Air Quality assessment, the air dispersion model CALPUFF was used to assess potential effects to the IC Air Quality, and predictions were generated for annual maximum concentrations of SOx, NOx (micrograms per cubic metre of air; $\mu g/m^3$). Maximum annual concentrations of SOx and NOx are predicted to remain well below the ambient air quality objectives. Based on this, acid deposition from these sources is considered negligible.

14.6 Mitigation Measures

14.6.1 Key Mitigation Approaches

Results from the review of best management practices, guidance documents, and mitigation measures conducted for similar projects, as well as professional judgment for the Project-specific effects and most suitable management measures, were considered in determining the mitigation measures. The approach to the identification of mitigation measures subscribed to the mitigation hierarchy, as described in the Environmental Mitigation Policy for British Columbia (http://www.env.gov.bc.ca/emop/). Technical and economic feasibility constraints dictated the highest level on the hierarchy that could be achieved for each potential effect and the identification of mitigation measures for managing these effects.

Potential Project-related effects to Sediment Quality will be reduced through mitigation measures, management plans, and adaptive management. If mitigation measures were considered entirely effective, potential Project-related effects to the Sediment Quality VC were not identified as residual effects.

Specific mitigation measures were identified and compiled for each category of potential effect on Sediment Quality and presented in this section. For the purposes of this assessment, mitigation measures included any action or project design feature that will reduce or eliminate effects to Sediment Quality. Key approaches include:

- Design Mitigation;
- Regulatory Requirements;
- Best Management Practices (BMPs); and
- Monitoring.

One key mitigation measure applicable to all potential effects on Sediment Quality is the implementation of an Aquatic Effects Management and Response Plan (AEMRP; Volume 5, Chapter 29). This plan outlines the management and response measures to be implemented during all phases of the Project. The AEMRP will include the following:

- Monitoring streams at locations potentially affected by the Project, and at reference areas well away from Project activities;
- Monitoring surface water quality, sediment quality, and aquatic biology;
- Monitoring fish populations and fish tissues; and
- If effluent (as defined in MMER regulations) is proposed for discharge to the environment, then additional sampling per MMER requirements may be conducted (effluent characterization, acute toxicity testing; site characterization studies [including hydrology], sublethal toxicity testing).

The following subsection describes primary measures to mitigate the following potential Project effects on the Sediment Quality VC:

- Physical changes in sediment quality from non-contact water runoff and direct inputs of sediment;
- Physical changes in sediment quality from aerial deposition; and
- Chemical changes in sediment quality from changes in surface water quality.

14.6.1.1 Mitigation Measures for Physical Changes in Sediment Quality from Non-Contact Water Runoff and Direct Inputs of Sediment

The primary mitigation measure to reduce inputs of suspended sediments from non-contact water runoff is to minimize the potential for erosion and the transport of material in runoff. Diversion ditches will be established around Bromley Humps and the Mine Site to route non-contact water to the natural catchment during the Operation Phase.

Effects on sediment quality associated with sedimentation and erosion caused by runoff of non-contact water will be minimized through adherence to Best Management Practices and management plans found Volume 5, Chapter 29 including, Site Water Management Plan, and Erosion and Sediment Control Plan.

Mitigation measures are provided in Table 14.6-1. Employing these mitigation measures, including monitoring and adaptive management, are predicted to result in no residual effects to Sediment Quality from non-contact water runoff and direct inputs of sediment.

14.6.1.2 Mitigation Measures for Physical Changes to Sediment Quality from Aerial Deposition

Effects on sediment quality from acid deposition and dustfall will be minimized through adherence to Best Management Practices as outlined in the Air Quality and Dust Management Plan (Volume 5, Chapter 29). Specifically, dust suppression measures during construction activities, proper management of stockpiles to minimize dust, and the tailings disposal methods to ensure beaches are saturated will greatly reduce potential for aerial deposition into nearby watercourses. Proper maintenance of equipment and vehicles and underground mining will contribute to significant reductions in Project emissions.

A complete list of mitigation measures to avoid and mitigate effects to changes in sediment quality from dustfall can be found in the effects assessment for Air Quality Effects Assessment (Volume 3, Chapter 7). Employing these mitigation measures, including monitoring and adaptive management, are predicted to result in no residual effects to Sediment Quality from dustfall.

14.6.1.3 Mitigation Measures for Chemical Changes in Sediment Quality from Changes in Surface Water Quality

The primary measure to mitigate potential changes to Sediment Quality from changes in Surface Water Quality will be to sequester all mine and TMF discharges and site contact water prior to entering the aquatic environment. Mine discharge and contact water will be directed to collection ponds for settling before discharge into Goldslide Creek. At Bromley Humps, excess TMF supernatant and all contact water will be treated to meet MMER requirements, prior to discharge into Bitter Creek. Groundwater seepage from the TMF will be collected in two seepage collection ponds and pumped back to the TMF. Project-activities related fuels, oils and other hydrocarbons will employ BMPs for machinery operation, maintenance, refueling, and secondary containment systems.

Management plans in Volume 5, Chapter 29 will include: Explosives Management Plan, Hazardous Materials Management Plan, Material Handling & ML/ARD Management Plan, Site Water Management Plan, Tailings Management Plan, and a Spill Contingency Plan.

A complete list of mitigation measures to avoid and mitigate effects to sediment quality from changes in water quality can be found in the effects assessment for the Surface Water Quality Effects Assessment (Volume 3, Chapter 13). However, with these mitigation measures in place, there would still be a potential for residual effects on sediment quality.

14.6.2 Environmental Management and Monitoring Plans

In addition to mitigation measures, the following environmental management and monitoring plans will be designed and implemented to monitor water quality, aquatic habitat and aquatic communities in the LSA.

- Access Management Plan;
- Air Quality and Dust Management Plan;
- Aquatic Effects Management and Response Plan;
- Erosion and Sediment Control Plan;
- Material Handling & ML/ARD Management Plan;
- Spill Contingency Plan; and
- Site Water Management Plan.

14.6.3 Effectiveness of Mitigation Measures

The anticipated effectiveness of mitigation measures to minimize the potential for significant adverse effects is evaluated and classified as follows within this section:

- Low effectiveness: Proposed measure is experimental, or has not been applied in similar circumstances.

- Moderate effectiveness: Proposed measure has been successfully implemented, but perhaps not in a directly comparable situation.

- High effectiveness: Proposed measure has been successfully applied in similar situations.

- Unknown effectiveness: Proposed measure has unknown effectiveness because it has not been implemented elsewhere in a comparable project or environment.

The key measures proposed for mitigating potential effects on the Sediment Quality VC from non-contact water runoff, direct sediment inputs, aerial deposition, and from changes to surface water quality, along with mitigation effectiveness and uncertainty are outlined in Table 14.6-1. This table also identifies the residual effects that will be carried forward for residual effects characterization and significance determination.

The timing of effectiveness of the mitigation measures varies depending on the type of mitigation. Mitigation measures that are part of the project design or that rely on avoidance or prevention of effect through BMPs or Regulatory Requirements are effective immediately. Mitigation measures that are based on monitoring are dependent on the monitoring schedule. The implementation of all the mitigation measures as a whole will generally provide close to immediate effectiveness.

The proposed mitigation measures include standard measures that are known to be effective (based on relevant/applicable experience with other mining projects), and therefore the certainty associated with their use is high. Any uncertainty associated with the effectiveness of the proposed mitigation measures will be addressed through the AEMRP, Site Water Management Plan and Air Quality and Dust Management Plan (Volume 5, Chapter 29). If monitoring indicates that effectiveness of mitigation measures is lower than predicted, further mitigation may be required as per adaptive management strategies outlined in these plans.

Table 14.6-1: Proposed Mitigation Measures and Their Effectiveness

IC/VC	Potential Effects	Primary Mitigation Measures	Rationale	Applicable Phase(s)[1]	Effectiveness[2]	Uncertainty[3]	Residual Effect
Sediment Quality	Changes to sediment quality from non-contact water runoff and direct inputs of sediment	Establish diversion ditches around Bromley Humps and the Mine Site to route non-contact water to the natural catchment.	Reduces inputs of suspended sediment from non-contact water runoff	C,O,CR	High	Low	N
		Regular inspections will be conducted to ensure drainage, erosion, and sediment control measures are effective and functioning properly; all necessary repairs and adjustments will be conducted in a timely manner.	Regular inspections allows for proactive solutions to be implemented.		High	Low	
		Sediment loading in runoff will be minimized by the application of measures to intercept total suspended solids before it reaches the freshwater environment.	Erosion and sediment control measures (e.g., well-placed and -maintained silt fencing) are standard industry practice.		High	Low	
		The area of landscape disturbance will be minimized and ecosystem-based revegetation and progressive reclamation will occur promptly to minimize erosion potential, introduction of invasive plants, and to facilitate initiation of successional ecological processes.	Reduction in surface footprint minimizes potential effects to surface water.		High	Low	
	Changes to sediment quality from aerial deposition (dustfall)	Road design and ore/waste transport plans have been optimized to minimize the distance travelled, which will reduce dust and emissions.	Reduces the direct release of ambient criteria air contaminants (from point or equipment sources).	C,O,CR	High	Low	N
		Use of emission control measures on point source and crusher transfer point emissions (e.g., scrubbers, dust collectors)			Moderate	Low	
	Changes to sediment quality from changes to surface water quality	All implemented mitigation measures for Surface Water Quality will serve as mitigation for Sediment Quality relative to this effect (Chapter 13, Section 13.6).					Y

[1]Applicable Phase: C - construction; O = operation; CR = closure and reclamation; PC = post-closure
[2]Effectiveness: Low = measure unlikely to result in effect reduction; Moderate = measure has a proven track record of partially reducing effects; High = measure has documented success (e.g., industry standard; use in similar projects) in substantial effect reduction
[3]Uncertainty: High = proposed measure is experimental, or has not been applied in similar circumstances; Moderate = proposed measure has been successfully implemented, but perhaps not in a directly comparable situation; Low = proposed measure has been successfully applied in similar situations

14.7 Residual Effects Characterization

14.7.1 Summary of Residual Effects

The chemical changes to sediment quality from changes in water quality are reduced by the proposed mitigation (water treatment, BMPs, etc.), however the water quality model predictions indicate that concentrations of some contaminants will still exceed guideline or background levels in the receiving environment. Therefore, a residual effect on Sediment Quality from changes in Surface Water Quality is carried forward, and characterized in this section.

Physical changes to sediment quality from non-contact water runoff is not being carried forward as a residual effect, because the proposed mitigation measures will effectively reduce or eliminate the potential for a measurable change in sediment quality from this source. Project impacts on sediment quality from minor increases in erosion and sedimentation are considered negligible as aquatic habitat in the LSA experiences a naturally wide range of TSS, particularly during peak flows. Baseline water quality sampling results for median TSS during the high flow period (June and July), were: 1.5 mg/L in Goldslide Creek, 258 mg/L at BC08, and 520 mg/L at BC02 (Appendix 14-A).

Changes to sediment quality from dustfall is not being carried forward as a residual effect, based on the predictions of the air quality model. The air dispersion model CALPUFF was used to predict dustfall rates, for the mitigated scenario, during construction and operations. The model predicted the annual maximum dustfall rates (milligrams per square decimetre per day; $mg/dm^2/day$) from Project sources (e.g., road use, material handling), at the sediment sampling site locations. Predicted maximum annual dustfall at the sites range from 0.561 $mg/dm^2/day$ at both Bear River sites, to 0.738 $mg/dm^2/day$ at GSC02 in Goldslide Creek. The values are below the BC annual air quality standard of 1.7 to 2.9 $mg/dm^2/day$, and therefore potential effects of dustfall on TSS levels, and overall sediment quality, in Goldslide Creek and Bitter Creek are expected to be minor, if not negligible.

14.7.2 Methods

Significance of residual effects was evaluated based on several criteria including: magnitude, duration, frequency, reversibility, context, and probability of occurrence, as defined for the Sediment Quality VC (Table 14.7-1).

14.7.2.1 Residual Effects Criteria

Table 14.7-1: Characterization of Residual Effects on Sediment Quality

Criteria	Characterization for Sediment Quality
Magnitude	• **Negligible (N):** no detectable change in predicted sediment quality concentrations from average baseline concentrations. • **Low (L):** effect is detectable, and sediment quality predictions exceed BC / CCME Sediment Quality Guidelines, or average baseline concentrations (for parameters without guidelines) by less than 5 times. • **Moderate (M):** effect is detectable and sediment quality predictions exceed BC / CCME Sediment Quality Guidelines, or average baseline concentrations (for parameters without guidelines) by more than 5 times. • **High (H):** effect is detectable and sediment quality predictions exceed BC / CCME Sediment Quality Guidelines, or average baseline concentrations (for parameters without guidelines) by more than 10 times.
Geographical Extent	• **Discrete (D):** Effect is limited to the immediate receiving environment in Goldslide Creek watershed (Mine Site) or the immediate freshwater environment in Bitter Creek (TMF area, Access Road). • **Local (L):** Effect extends beyond the immediate receiving environment of Goldslide Creek and Bitter Creek near the TMF to the entire Bitter Creek watershed. Effects do not extend into the RSA. • **Regional (R):** Effect extends across the RSA. • **Beyond Regional (BR):** Effect extends beyond the RSA and beyond the province (transboundary effects).
Duration	• **Short-term (ST):** Effect lasts less than 18 months (during the Construction Phase of the Project). • **Long-term (LT):** Effect lasts greater than 18 months and less than 22 years (encompassing Operation, Closure and Reclamation, and Post-Closure Phases). • **Permanent (P):** Effect lasts more than 22 years.
Frequency	• **One time (O)**: effect is confined to one discrete event. • **Sporadic (S)**: effect occurs rarely and at sporadic intervals. • **Regular (R)**: effect occurs on a regular basis. • **Continuous (C)**: effect occurs constantly.
Reversibility	• **Reversible (R):** Effect can be reversed. • **Partially reversible (PR):** Effect can be partially reversed. • **Irreversible (I):** Effect cannot be reversed, is of permanent duration.

Criteria	Characterization for Sediment Quality
Context	• **High (H):** the receiving environment has a high natural resilience to imposed stresses, and can respond and adapt to the effect. • **Neutral (N):** the receiving environment has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect. • **Low (L):** the receiving environment has a low resilience to imposed stresses, and will not easily adapt to the effect.

14.7.2.2 Analytical Assessment Techniques for Sediment Quality

14.7.2.2.1 Water Quality Model

A water and load balance model developed in GoldSim for predictions of receiving environment water quality in Goldslide Creek (GSC02), Rio Blanco Creek (RBC02), Bitter Creek (BC08, BC06, and BC02), and Bear River (BR06).

The model (Appendix 14-C) was used to assess the Project's residual effects of changes to Surface Water Quality caused by the Project over the duration of the mine life, from construction through post-closure. All inputs to the model were on either a monthly or an annual basis. All outputs of the model (flow and water quality predictions) were monthly averages.

14.7.2.3 Assessment of Likelihood

Likelihood is determined per the attributes listed in the Application/EIS Methodology Chapter (Volume 3, Chapter 6).

14.7.2.4 Significance Determination

The evaluation of significance was completed by comparing predicted residual effects against thresholds, standards, trends, or objectives relevant to ecosystems, as defined below.

- Not significant: Residual effects have negligible, low or moderate magnitude; local to regional geographic extent; short- or long-term duration; could occur at any frequency, and are reversible or partially reversible in either the short- or long-term. Sediment Quality for the majority of parameters is maintained within natural variability in the Project receiving environment over the life of the Project.

- Significant: Residual effects have high magnitude; regional or beyond regional geographic extent; duration is permanent; and can occur at all frequencies. Residual effects on Sediment Quality are consequential (i.e., structural and functional changes in VCs that are influenced by Sediment Quality) and are irreversible.

14.7.2.5 Confidence and Risk

Confidence definitions for the Application/EIS are provided in Volume 3, Chapter 6.

14.7.3 Potential Residual Effects Assessment

The results of the residual effects assessment are presented here, by sub-component as applicable, and then by effect.

14.7.3.1 Changes in Sediment Quality from Changes in Surface Water Quality

14.7.3.1.1 Residual Effect Analysis

Residual effects on Sediment Quality from changes in Surface Water Quality are expected, based on the Water and Load Balance Model (Appendix 14-C) which, for the mitigated scenario, predicts that some water quality parameters will exceed CCME or BC WQGs.

The Water and Load Balance Model (Appendix 14-C) predicted the maximum monthly concentrations of water quality parameters in Goldslide Creek, Bitter Creek, Rio Blanco Creek and Bear River, for operations (Years 1 to 6) and closure/post-closure (Years 7 to 21). Water and Load Balance Model predictions are summarized in the Surface Water Quality Effects Assessment (Volume 3: Chapter 13). Potential contaminants of concern (COPCs) for Surface Water Quality were identified as those parameters predicted to exceed water quality guidelines (CCME or BC MOE), in the expected case (P50). The following contaminants of potential concern were identified, which are discussed below in relation to residual effects on Sediment Quality: antimony, cadmium, copper, selenium, silver, and zinc.

- Goldslide Creek
  - Operation Phase: antimony, cadmium, selenium, and zinc
  - Post-Closure Phase: cadmium, copper, selenium, silver, and zinc

- Rio Blanco
  - Post-Closure Phase: cadmium, silver, and zinc

- Bitter Creek
  - Operation Phase: selenium
  - Post-Closure Phase: cadmium, selenium, silver, and zinc

Sediment chemistry tends to reflect long-term contaminant levels in comparison to water chemistry, as contaminants are integrated into sediments over time, and are more likely to capture periodic or storm-based contamination events. Long-term accumulated contaminant levels may be incorporated into the aquatic food web if sediments become re-suspended or are bioavailable.

The mechanisms by which changes in water concentrations of parameters cause a change in sediment chemistry include adsorption of dissolved metals from the water column into stream sediments, dissolved metals precipitating or forming colloids and settling into sediment, and the direct loading of particulate-bound metals into sediments (Manahan 1984; Campbell et al. 2006). Fine materials such as clay, silt, or organic matter are more likely to bind to dissolved metal particles, thus incorporating them into stream sediments (Manahan 1984). Other physico-chemical properties such as pH, water hardness, and the presence of iron and manganese complexes can also act to alter metal bioavailability (Salomons et al. 1987). Goldslide Creek, Rio Blanco Creek and Bitter Creek are both dominated by coarser substrate (e.g., cobble and gravel), and have relatively high flow rates, both of which would minimize integration of contaminants from the water column into the sediment. Seasonal flushing flows during peak flow periods, limit the accumulation of finer sediments by out-transporting sediment. Flows in Goldslide Creek peak during freshet (typically in June). Bitter Creek is glacially-influenced and its flows peak in summer (typically in July). As such, increases in water column concentrations of the contaminants of concern, which are relatively small, or occur during the winter months only, are considered unlikely to impart measurable change on sediment chemistry.

Predictions of sediment concentrations were completed in a semi-quantified manner, where the partial/potential influences of Surface Water Quality concentrations represent the key driver to changes in Sediment Quality. Table 14.7-2, Table 14.7-3, and Table 14.7-4 show the Sediment Quality guidelines, alongside baseline sediment concentrations for the COPCs at each creek. Also shown are the Surface Water Quality exceedances as a factor of the guideline and background values.

Table 14.7-2: Sediment Quality Guidelines, Baseline, and Predicted Surface Water Quality for Goldslide Creek

Parameter	Units	Sediment Quality Guidelines			Mean Baseline		Magnitude of Predicted Surface Water Quality Exceedance		
		CCME PEL (a)	CCME ISQG (b)	BC SQG (c)	2014	2016	BC WQG	CCME	BG
Antimony	mg/kg	n/a	n/a	n/a	8.5	5.7	1.6	n/a	141
Cadmium	mg/kg	3.5	0.6	n/a	3.0	***4.5***	2 - 3.5	2.4 - 4.6	5.1 - 5.7
Copper	mg/kg	197	35.7	n/a	***457***	***1216***	1.2	2.0	5.7
Selenium	mg/kg	n/a	n/a	2.0	7.7*	12.2*	2.1 - 2.2	4.1 - 4.4	1.9 - 2.0
Silver	mg/kg	n/a	n/a	n/a	1.1	1.0	1.5	Below	36
Zinc	mg/kg	315	123	n/a	***443***	***440***	Below to 2.5	1.1 - 1.6	3.0 - 4.2

1. ‘n/a' indicates that no concentration or analysis value is available
2. Results of 2014 sediment quality data are based on the sediment fraction of < 2 mm; 2016 a sediment fraction of < 63 µm was used for chemical analysis
3. Highlighted values indicate an exceedance of ISGQ sediment quality guideline
4. Bold Italic values indicate an exceedance of PEL sediment quality guideline
5. (*) indicates the value exceeds the BC sediment quality guideline

Table 14.7-3: Sediment Quality Guidelines and Predicted Surface Water Quality for Rio Blanco Creek

Parameter	Units	Sediment Quality Guidelines			Magnitude of Predicted Surface Water Quality Exceedance		
		CCME PEL (a)	CCME ISQG (b)	BC SQG (c)	BC WQG	CCME	BG
Cadmium	mg/kg	3.5	0.6	n/a	1.4	1.8	4.4
Silver	n/a	n/a	n/a	n/a	1.2	Below	15
Zinc	mg/kg	315	123	n/a	1.7	Below	4.8

1. 'n/a' indicates that no concentration or analysis value is available
2. Results of 2014 sediment quality data are based on the sediment fraction of < 2 mm; 2016 a sediment fraction of < 63 µm was used for chemical analysis
3. Highlighted values indicate an exceedance of ISGQ sediment quality guideline
4. Bold Italic values indicate an exceedance of PEL sediment quality guideline
5. (*) indicates the value exceeds the BC sediment quality guideline

Table 14.7-4: Sediment Quality Guidelines, Baseline, and Predicted Surface Water Quality for Bitter Creek (BC08, BC06 and BC02)

Parameter	Units	Sediment Quality Guidelines			Mean Baseline		Magnitude of Predicted Surface Water Quality Exceedance		
		CCME PEL (a)	CCME ISQG (b)	BC SQG (c)	2014	2016	BC WQG	CCME	BG
Cadmium	mg/kg	3.5	0.6	n/a	1.6	1.9	Below to 1.2	1.6 - 1.7	1.8 - 5.9
Selenium	mg/kg	n/a	n/a	2.0	4.9*	7.7*	1.2 - 2.1	2.7 - 4.1	1.1 - 1.6
Silver	mg/kg	n/a	n/a	n/a	1.1	1.3	Below	1.8	3.0 - 4.4
Zinc	mg/kg	315	123	n/a	146	176	1.4	Below	1.9 - 2.1

1. 'n/a' indicates that no concentration or analysis value is available
2. Results of 2014 sediment quality data are based on the sediment fraction of < 2 mm; 2016 a sediment fraction of < 63 µm was used for chemical analysis
3. Highlighted values indicate an exceedance of ISGQ sediment quality guideline
4. Bold Italic values indicate an exceedance of PEL sediment quality guideline
5. (*) indicates the value exceeds the BC sediment quality guideline

Goldslide Creek (Operation Phase)

Antimony exceeds the BC Working WQG (0.009 mg/L) during Operation in Goldslide Creek. The maximum concentration is 0.014 mg/L (all months), which is about 1.6 times higher than the working guideline.

Background sediment concentrations are between 5.7 mg/kg and 8.5 mg/kg; however, there is no CCME or BC Sediment Quality guideline for antimony. While there is a Working WQG for antimony in the water column, Working WQGs have not yet been approved, i.e., it has not yet been fully assessed and formally endorsed by BC MOE.

While the predicted change in Surface Water Quality concentration will be relatively large (141 times), and the subsequent change in Sediment Quality may also be similar, an exceedance of the BC Working WQG will be just 1.6 times.

Cadmium

Goldslide Creek (Operation and Post-Closure Phases)

During Operation and Post-Closure, the maximum Surface Water Quality concentration of cadmium in Goldslide Creek is predicted to exceed both BC and CCME WQG.

The frequency (all months and both Project phases), and magnitude (particularly in Post-Closure), of the predicted exceedances are likely to result in a long-term change to sediment cadmium concentrations in Goldslide Creek. Although sediment cadmium concentrations will likely be elevated relative to background, the potential for integration of water column cadmium into the sediment will fluctuate as the maximum cadmium concentrations will change by month/year and by project phase.

Background sediment cadmium concentrations are between 3.0 and 4.5 mg/kg (mean), which is comparably similar to the CCME PEL sediment guideline of 3.5 mg/kg. The change in water concentration will be between 5.1 and 5.7 times background. If sediment concentration increased by the same factors, predicted Sediment Quality concentrations will be between 15.5 mg/kg and 25.7 mg/kg. Actual change would likely be less than the change in water concentration due to the mechanisms of which changes in water concentrations cause a change in sediment chemistry.

Rio Blanco Creek (Post-Closure Phase)

During Post-Closure, the maximum cadmium concentration in Rio Blanco Creek is predicted to be 0.00044 mg/L (February), which is about 1.4, 1.8, and 4.4 times the BC WQG, CCME WQG, and background concentrations respectively. Based on these predictions, sediment cadmium concentrations in Rio Blanco are also predicted to rise above background levels during Post-Closure.

Bitter Creek (Post-Closure Phase)

During Post-Closure, the predicted monthly maximum Surface Water Quality concentrations of cadmium are predicted to exceed either or both the BC and CCME WQG. Exceedances occur during spring/summer when hardness is also low.

Background sediment cadmium concentrations are between 1.6 mg/kg and 1.9 mg/kg, which are well below the CCME PEL guideline of 3.5 mg/kg. The change in water concentration will be between 1.8 and 5.9 times background. If sediment concentration increased by the same factors, predicted Sediment Quality concentrations will be between

2.9 mg/kg and 11.2 mg/kg. Actual change would likely be less than the change in water concentration due to the mechanisms of which changes in water concentrations cause a change in sediment chemistry.

Copper

Goldslide Creek (Post-Closure Phase)

During Post-Closure, the monthly maximum Surface Water Quality concentrations of copper in Goldslide Creek are predicted to exceed both BC and CCME WQGs.

Background sediment copper concentrations in Goldslide Creek are between 457 mg/kg and 1,216 mg/kg in 2014 and 2016, respectively. These baseline concentrations exceed the CCME PEL sediment quality guideline of 197 mg/kg. The change in water concentration will be 5.7 times background. If sediment concentrations increase by the same factors, predicted Sediment Quality concentrations will be between 2,605 mg/kg and 6,929 mg/kg. The baseline concentrations indicate that sediment copper concentrations in Bitter Creek exhibit a wide range and are naturally elevated.

Selenium

Goldslide Creek (Operation and Post-Closure Phases)

During Operation and Post-Closure, the maximum Surface Water Quality concentration of selenium in Goldslide Creek is predicted to exceed both BC and CCME WQGs.

Background sediment selenium concentrations in Goldslide Creek are between 7.7 mg/kg and 12.2 mg/kg and were about four to six times higher than the BC SQG (2.0 mg/kg). This indicates that the benthic community is adapted to elevated sediment selenium concentrations, as Goldslide Creek supports high benthic invertebrate abundance. During the life of the Project, water column selenium concentrations are not more than two times the background. If sediment concentration increased by the same factors, predicted Sediment Quality concentrations will be between 15 mg/kg and 24 mg/kg.

Bitter Creek (Operation and Post-Closure Phases)

During Operation and Post-Closure, the maximum Surface Water Quality concentration of selenium in Bitter Creek is predicted to exceed both BC and CCME WQGs.

Background sediment selenium concentrations in Bitter Creek are between 4.9 mg/kg and 7.7 mg/kg and were about two to four times higher than the BC SQG (2.0 mg/kg). During the life of the Project, water column selenium concentrations are not more than 1.6 times the background. If sediment concentrations increase by the same factors, predicted Sediment Quality concentrations will be between 7.8 mg/kg and 12.3 mg/kg.

The maximum concentration at BC02 during both phases equates to about 1.2 times the background. At BC08 and BC06, the maximum concentrations are 1.6 and 1.2 times background during Operations and Post-Closure respectively. These increases from background concentrations in Bitter Creek are small, and unlikely to impart measurable change in sediment selenium concentrations, which are naturally elevated.

Silver

Goldslide Creek (Post-Closure Phase)

During post-closure, the maximum Surface Water Quality concentration of silver is predicted to exceed the BC WQG, but not the CCME WQG, in Goldslide Creek.

There is no CCME or BC sediment guideline for silver. Baseline sediment samples from Goldslide Creek are approximately 1 mg/kg on average. Given that the maximum water concentration is 36 times higher than the background, a change in sediment silver concentrations is likely.

Rio Blanco (Post-Closure Phase)

During post-closure, the maximum Surface Water Quality concentration of silver is predicted to exceed the BC WQG, but not the CCME WQG, in Rio Blanco Creek.

There is no CCME or BC sediment guideline for silver, and there is no baseline data for sediment silver concentrations in Rio Blanco Creek. As a result, the degree to which changes in water column silver concentrations will affect sediment quality in Rio Blanco Creek cannot be estimated with confidence. However, given that the maximum water concentration is 15 times higher than the background, a change in sediment silver concentrations is likely.

Bitter Creek (Post-Closure Phase)

During Post-Closure, the maximum Surface Water Quality concentration of silver is predicted to exceed the CCME WQG, but not the BC WQG, in Bitter Creek.

There is no CCME or BC sediment guideline for silver. Baseline sediment samples from Bitter Creek were between 1.1 mg/kg and 1.3 mg/kg silver. The potential for an adverse effect on Sediment Quality from increases in water column silver concentrations is low, because silver in the water column remains below the BC WQG guideline, and the maximum increase above the CCME and background is relatively small and decreases with distance downstream.

Zinc

Goldslide Creek (Operation and Post-Closure Phase)

During Operation, the predicted monthly maximum Surface Water Quality concentration of zinc in Goldslide Creek is predicted to be below BC WQG but above CCME WQGs. During Post-Closure, both WQGs are exceeded.

Background sediment zinc concentrations in Goldslide Creek are between 440 mg/kg and 443 mg/kg and were about 1.4 times higher than the CCME PEL (315 mg/kg). During the life of the Project, water column selenium concentrations are not more than 4.2 times the background. If sediment concentrations increase by the same factors, predicted Sediment Quality concentrations will be between 1,848 mg/kg and 1,861 mg/kg.

Rio Blanco (Post-Closure Phase)

During Post-Closure, the maximum concentration in Rio Blanco Creek is 0.024 mg/L (February), which does not exceed guidelines. The BC WQG is hardness dependent and in May to August guideline exceedances occur. Of these months, the highest concentration is 0.024 mg/L (July), which is about 1.7 times the guideline, lower than the CCME WQG and about 4.8 times background concentrations. Based on these predictions, sediment zinc concentrations in Rio Blanco are also predicted to rise above background levels during Post-Closure.

Bitter Creek (Post-Closure Phase)

During Post-Closure, the predicted monthly maximum Surface Water Quality concentration of zinc in Bitter Creek is predicted to be below the CCME WQG but above the BC WQG.

Background sediment zinc concentrations in Bitter Creek are between 143 mg/kg and 176 mg/kg and are below the CCME PEL (315 mg/kg). During the life of the Project, water column selenium concentrations are not more than 2.1 times the background. If sediment concentrations increase by the same factors, predicted Sediment Quality concentrations will be between 307 mg/kg and 370 mg/kg, which would be just 1.2 times the CCME PEL for the upper value.

14.7.3.1.2 Characterization of Residual Effect

The residual effect will be a potential change in concentrations of those COPCs in the sediment, in Goldslide Creek (antimony, cadmium, selenium, silver and zinc), Rio Blanco Creek (cadmium, silver, and zinc), and in Bitter Creek (cadmium, selenium, silver, and zinc). The Sediment Quality changes are expected to be small, and unlikely to affect the capacity of the sediment to support benthic organisms.

The residual effect on Sediment Quality from changes in Surface Water Quality concentrations as follows:

- Magnitude is Low; change in Sediment Quality is detectable, and when the full suite of parameters is considered, overall baseline conditions / guidelines are not exceeded by more than five times.
- Geographical extent is Local; the effect on Sediment Quality extends beyond the immediate receiving environment of Goldslide Creek and Bitter Creek near the TMF to the entire Bitter Creek watershed (BC02). Effects do not extend into the RSA.
- Duration is Permanent; Sediment Quality will be changed for more than 22 years (beyond Post-Closure).
- Frequency is Continuous; sediments will integrate and accumulate metals loading from mine discharges and groundwater during the mine life and beyond Post-Closure.

- Reversibility is irreversible; it is expected that complete reversibility of the Surface Water Quality in the receiving watercourses is unlikely and therefore, Sediment Quality conditions will be expected to also follow this trend.

- Context is High; the receiving watercourses in the Project LSA (Goldslide Creek, Rio Blanco Creek and Bitter Creek) are dominated by coarser substrate (e.g. cobble and gravel), and have relatively high flow rates, both of which would minimize integration of contaminants from the water column into the sediment. Seasonal flushing flows during peak flow periods, limit the accumulation of finer sediments by out-transporting sediment. As such, Sediment Quality in the Project LSA has naturally high resilience to changes in water chemistry and any changes in water column concentrations are unlikely to impart measurable change on Sediment Quality.

14.7.3.1.3 Likelihood

The likelihood of a residual effect on Sediment Quality from Changes in Surface Water Quality is determined to be moderate, i.e., the effect has a 40 to 80% chance of occurring. This is based on the confidence in the predictions of the Water Quality Model (Appendix 14-C), and also takes into consideration the uncertainty in using those predictions to make inferences about changes in sediment quality. In addition, changes in Sediment Quality concentrations, potentially resulting from changes in water concentrations, will vary widely along the stream channel due to fluvial processes including variable deposition and scouring.

14.7.3.1.4 Significance

Although there will be minor changes to the Surface Water Quality of the receiving environment, only a very small subset of parameters will increase above guidelines/background levels and therefore only those parameters will indirectly affect Sediment Quality. The effect is low in magnitude, localized, continuous, and reversible. This residual effect is considered not significant. Maintenance of the quality of sediment in Goldslide Creek and Bitter Creek, as well as the maintenance of other VCs that are influenced by Sediment Quality, are maintained after the Project ceases.

14.7.3.1.5 Confidence and Risk

The level of confidence associated with the predicted residual effect on Sediment Quality from changes in Surface Water Quality is considered moderate. This is based on the inherent nature of uncertainties associated with water quality modelling and the dependencies on numerous input sources. In addition, the mechanisms through which changes to Surface Water Quality lead to changes in Sediment Quality are not fully understood. Changes in Sediment Quality concentrations, potentially resulting from changes in water concentrations, will vary widely along the stream channel due to fluvial processes including variable deposition and scouring. This uncertainty may affect the likelihood or significance of the predicted residual effect.

Where there were uncertainties in the water quality model input assumptions, reasonably conservative assumptions were made to address those uncertainties and thereby reduce risk. Further details on the assumptions, uncertainty, and conservatism in the water quality model are provided in Appendix 14-C. To address uncertainty in predicting how the changes in Surface Water Quality would affect change in Sediment Quality, the residual effect analysis considered factors such as flow rates, substrate, and baseline sediment chemistry (i.e., existing conditions), as well as discharge timing, and magnitude of predicted water concentrations of contaminants. Understanding how these variables could influence sediment chemistry during the mine life allowed for a higher level of confidence in predicting the residual effect. Based on the confidence in the water quality predictions, and the adequacy of sediment baseline data coverage, it was determined that additional risk analysis was not required for the residual effect.

To reduce uncertainty and maintain the quality of sediment in the receiving environment, as well as other VCs that are influenced by Sediment Quality, monitoring and adaptive management strategies for water quality will be implemented, as described in the AEMRP (Volume 5, Chapter 29) and the Adaptive Management Plan (Volume 5, Chapter 29). These management plans have been designed to mitigate the risk related to a residual effect on sediment quality. The objectives of the AEMRP is to minimize the risk of effects to the aquatic environment through Project design, monitoring and adaptive management. The AEMRP includes an Aquatics Effects Monitoring Program (AEMP) that will provide feedback via the receiving environment on the performance of IDM's management and mitigation during Construction, Operation, Closure and Reclamation, and Post-Closure phases of the Project. The AEMRP also includes management response measures (additional assessment, monitoring and mitigation measures) that would be implemented in response to an unanticipated effect on Sediment Quality.

14.7.4 Summary of Residual Effects Assessment

Residual effects and the selected mitigation measures, characterization criteria, likelihood, significance determination, and confidence evaluations are summarized in Table 14.7-5 for the residual effect on sediment quality.

Table 14.7-5: Summary of the Residual Effects Assessment

Residual Effect	Project Phase(s)	Mitigation Measures	Summary of Residual Effects Characterization Criteria *(context, magnitude, geographic extent, duration, frequency, reversibility)*	Likelihood *(High, Moderate, Low)*	Significance *(Significant, Not Significant)*	Confidence* *(High, Moderate, Low)*
Change in Sediment Quality from change in Surface Water Quality	Operation	Surface Water Quality mitigation measures, Project design mitigations, BMPs, Management Plans.	**Magnitude:** Low **Geographic extent**: Local **Duration**: Permanent **Frequency:** Continuous **Reversibility:** irreversible **Context:** High	Moderate	Not Significant	Moderate

*Confidence estimates allow the decision-maker to evaluate risk associated with the Project.

14.8 Cumulative Effects Assessment

Cumulative effects are the result of Project residual effects on Sediment Quality interacting with residual effects of other physical activities (i.e., anthropogenic developments, projects, or activities) that have been or will be carried out (Agency 2014a).

Guidance documents specific to the cumulative effects methodology are identified below:

- Reference Guide: Addressing Cumulative Environmental Effects (Agency 1994a);
- Practitioners Glossary for the Environmental Assessment of Designated Projects under the *Canadian Environmental Assessment Act, 2012* (Agency 2013);
- Guidelines for the Selection of Valued Components and Assessment of Potential Effects. British Columbia Environmental Assessment Office: Victoria, BC. (EAO. 2013);
- Assessing Cumulative Environmental Effects under the *Canadian Environmental Assessment Act, 2012*, Operational Policy Statement (Agency 2014a); and
- Draft Technical Guidance for Assessing Cumulative Environmental Effects under the *Canadian Environmental Assessment Act, 2012* (Agency, 2014b).

14.8.1 Review Residual Effects

The residual effect after application of mitigation measures is:

- Changes in Sediment Quality from Changes in Surface Water Quality.

14.8.2 Cumulative Effects Assessment Boundaries

Similar to the Project effects assessment, the cumulative effects assessment boundaries are defined as the maximum spatial and temporal scales over which there is a potential for residual Project effects on Sediment Quality to interact with the residual effects of other past, present, and future projects and activities.

14.8.2.1 Spatial Boundaries

The spatial boundaries for the cumulative effects assessment on the Sediment Quality VC are restricted to areas that are hydrologically linked to the residual effects of the Project. Given that the residual effects to Sediment Quality are not predicted to extend beyond the LSA of the Project, it is reasonable to define the cumulative effects assessment boundary as the RSA, which surrounds the LSA, and also includes the Bear River watershed, from American Creek to Stewart and the northern end of the Portland Canal.

14.8.2.2 Temporal Boundaries

The following temporal boundaries are evaluated as part of the cumulative effects assessment:

1. Past: 1988 to 2014;
2. Present: 2014 to 2017, from the start of the Red Mountain Underground Gold Project's detailed baseline studies to the completion of the effects assessment; and
3. Foreseeable Future: the cut-off date for incorporating any new future developments in the cumulative effects assessment in the Application/EIS is 2029. This represents the final anticipated year of the mine life after the Closure and Reclamation Phase is complete.

14.8.3 Identifying Past, Present, or Reasonably Foreseeable Projects and/or Activities

The list of past, present, and reasonably foreseeable projects and/or activities for consideration in the cumulative effects assessment was compiled from a variety of information sources, including municipal, regional, provincial, and federal government agencies and company websites. This list was reviewed to determine which projects and activities that have potential to interact with residual effects on Sediment Quality. Projects and activities with potential to interact with Sediment Quality residual effects are shown in Table 14.8-1.

Table 14.8-1: List of Projects and Activities with Potential to Interact within the Sediment Quality Residual Effects

Project/Activity	Project Life	Location	Proponent
Bitter Creek Hydro Project	Proposed	15 km northeast of Stewart	Bridge Power
Stewart Bulk Terminal	Currently Operating	Stewart	Stewart Bulk Terminals Ltd.
Mineral exploration	Ongoing	Regional	Various
Commercial recreations	Ongoing	Regional	Various
Fishing	Ongoing	Regional	Various
Forestry	Ongoing	Regional	Various
Guide outfitting	Ongoing	Regional	Various
Transportation	Ongoing	Regional	Various
Trapping	Ongoing	Regional	Various

14.8.4 Potential Cumulative Effects and Mitigation Measures

14.8.4.1 Changes in Sediment Quality

The land use activities outlined in Table 14.8-1 have the potential to interact with residual effects on Sediment Quality because of increased road use: mineral exploration, commercial recreations (e.g., river rafting, guided mountaineering), fishing, guide outfitting, transportation, and trapping. Increased road use represents a pathway to a potential cumulative effect, as there is increased potential for runoff, sediment runoff (TSS), and dust deposition along the Access Road adjacent to Bitter Creek and at ford crossings.

The Hydroelectric Project could result in increased rates of sediment transport and deposition, as well as changes in particle size distribution.

These potential effects would add to the inputs already being received from the road use during Construction, Operation, and Closure and Reclamation of the Project.

14.8.4.2 Additional Mitigation Measures

Proposed Mitigation Measures of the Red Mountain Project are outlined in Section 14.6.

Additional mitigation measures for cumulative effects involves taking further action, where possible, to avoid or minimize cumulative effects on the Sediment Quality VC.

It is assumed that proponents of proposed development projects will adhere to their own developed mitigation plans, including sediment and erosion mitigation around construction activities and access roads. In conjunction with mitigation plans implemented by the Project, areas of spatial and temporal overlap between projects will be monitored and mitigated where necessary. IDM and other project proponents could also share monitoring data to help in the detection of unanticipated cumulative effects. No other additional mitigation measures were identified for the Project for mitigating cumulative effects

The permitting and monitoring of run-of-river hydroelectric projects has additional mitigation built into its regulatory infrastructure. Applicable guidelines include:

- Long-term Aquatic Monitoring Protocols for New and Upgraded Hydroelectric Projects (DFO, 2012; Lewis et al., 2011); and
- Flow Ramping Guidelines for Hydroelectric Projects: Developing, Testing, and Compliance Monitoring (Lewis et al., 2013).

14.8.5 Cumulative Effects Interaction Matrix

Potential cumulative effects on Sediment Quality are based on the potential for interaction between the Sediment Quality residual effects with the projects and activities identified in Table 14.8-1. The interaction with effects of reasonably foreseeable future projects and activities are shown in Table 14.8-2.

Table 14.8-2: Interaction with Effects of Reasonably Foreseeable Future Projects and Activities

Residual Effects of this Project on Sediment Quality	Current and Ongoing Projects and Activities								Future Projects and Activities
	Mineral Exploration	Commercial Recreation	Fishing	Forestry	Guide Outfitting	Transportation	Trapping	Stewart Bulk Terminal	Bitter Creek Hydro Project
Change in Sediment Quality from Change in Surface Water Quality	N	N	N	N	N	N	N	N	Y

Notes:
Y = Yes, interaction exists between the residual effect of the Project and the other past, current, or future project/activity
N = No, interaction does not exist between the residual effect of the Project and the other past, current, or future project/activity

The interaction matrix identified the Bitter Creek Hydroelectric Project as the only project with potential to interact with the residual effects on Sediment Quality. The others were determined as not having an interaction due to the following reasons:

- The Stewart Bulk Terminal is located in the RSA, where no Sediment Quality residual effects have been determined.
- While there are mineral exploration claims within the RSA, there are no projects that have entered the approval process and thus it is unknown whether any future projects could potentially add to the proposed Project residual effects, i.e., act cumulatively with the Project.
- The remaining land use activities listed in Table 14.8-2 have the potential to interact with residual effects on Sediment Quality because of increased road use. Increased road use represents a pathway to a potential cumulative effect, as there is increased potential for sediment runoff into Bitter Creek. Currently, use of the Bitter Creek valley for these activities is limited:
  - There is a single commercial recreation licence, for a heli-ski operation, which does not require road use.
  - In the Stewart area, recreational fishing is limited to the upper reaches of Portland Canal and mouth of the Bear River. According to comments received during consultation with NLG, Nisga'a citizens are not known to fish in Bitter Creek (Volume 3, Chapter 19; Economic Effects Assessment).
  - There is single guider outfitter that uses the area, and one trapline.

- Use of the access road will be tightly controlled for safety reasons (including a gate at the entrance), and unauthorized use will not be permitted. IDM will also enforce a no-hunting / no-fishing policy for the Project workforce. At Closure and Reclamation, Project roads will be decommissioned and reclaimed. As such, the potential for these activities to cause an increase in road use that would interact cumulatively with residual effects on Sediment Quality is considered negligible and is not carried forward in the cumulative effects assessment.

14.8.6 Cumulative Effects Characterization

14.8.6.1 Changes in Sediment Quality from Changes in Surface Water Quality

Flow reductions in the diversion reach of the Bitter Creek Hydroelectric Project have the potential to exacerbate changes in water quality in Bitter Creek from mine and TMF discharge, because there will be lower dilution through that reach.

The intake structure (e.g., gallery or weir) may backwater the channel upstream as a headpond, which is typically within the high water perimeter for these types of projects. Reduced stream velocities in the headpond will alter substrate composition such that there is a higher proportion of finer sediments.

Fine sediments are more likely to bind to dissolved metal particles, thus incorporating them into stream sediments (Manahan 1984). Changes in sediment chemistry from mine discharge combined with the increased potential for sediment deposition with the headpond and diversion reach of the hydroelectric project, represents a potential cumulative effect on Sediment Quality. A summary of the cumulative effects assessment is presented below.

14.8.7 Summary of Cumulative Effects Assessment

Table 14.8-3: Summary of Residual Cumulative Effects Assessment

Project Phase	VC	Residual Cumulative Effect	Characterization Criteria *(context, magnitude, geographic extent, duration, frequency, reversibility)*	Likelihood *(High, Moderate, Low)*	Significance *(Significant, Not Significant)*	Confidence* *(High, Moderate, Low)*
C, O, CR, PC	Sediment Quality	Changes in Sediment Quality from Changes in Water Quality	Magnitude: Low Geographic extent: Discrete Duration: Long-term Frequency: Sporadic Reversibility: Reversible Context: High	Moderate	Not Significant	High

*Confidence estimates allow the decision-maker to evaluate risk associated with the Project.

14.9 Follow-up Strategy

IDM has identified a follow-up strategy to evaluate the accuracy of effects predictions and effectiveness of proposed mitigation measures in regards to the Sediment Quality VC. The strategy focuses on implementation of the AEMRP (Volume 5, Chapter 29). The purpose of the AEMRP is to minimize the effects of the Project's activities on the aquatic environment, monitor the results of mitigation to ensure effectiveness, and adaptively manage for any unanticipated effects resulting from the Project. The AEMRP also provides guidance to protect and limit disturbances to the aquatic environment from Project activities.

An Aquatic Effects Monitoring Program (AEMP) with a Before/After/Control/Impact (BACI) study design is proposed as part of the AEMRP. This study design allows comparison of baseline and Project conditions during the Construction, Operation, and Post-Closure Phases, as well as exposure and reference sites. The results of the AEMP will then be compared with the predictions made in the effects assessment, to evaluate their accuracy. For example, water and sediment quality monitoring results will be compared with predictions of the Water and Load Balance Model, and predicted residual effects on sediment quality, respectively.

Adaptive management will require consideration of AEMP results, management reviews, incident investigations, shared traditional, cultural, or local knowledge, new or improved scientific methods, regulatory changes, or other Project-related changes. Mitigation and monitoring strategies for Sediment Quality will be updated to maintain consistency with action plans, management plans, and BMPs that may become available during the life of the Project. Key stakeholders, Aboriginal Groups, and government agencies will be involved, as necessary, in developing effective strategies and additional mitigation.

14.10 Conclusion

No significant change in Sediment Quality concentrations compared to provincial/federal guidelines are predicted to occur at a local or regional scale due to the Project. Likewise, cumulative effects are not anticipated. The maintenance of the quality of sediment in the receiving environment, as well as the maintenance of other VCs that are influenced by Sediment Quality, is therefore not anticipated.

All residual effects were considered non-significant due to the local geographical extent and low magnitude of the anticipated effects. The assessment of significance is contingent on the successful implementation of mitigation measures. The results of this assessment have been carried forward to inform the effects assessments for Aquatic Resources (Chapter 17), and Fish and Fish Habitat (Chapter 18).

The additional mitigation measures for potential cumulative effects on Sediment Quality are expected to reduce the potential for a cumulative effect to a low or negligible level, i.e., measures will be fully effective. Residual cumulative effects that would compromise the maintenance of the quality of sediment in the receiving environment, as well as the maintenance of other VCs that are influenced by Sediment Quality, are therefore not anticipated.

14.11 References

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