RED MOUNTAIN UNDERGROUND GOLD PROJECT
VOLUME 3 | CHAPTER 18
FISH AND FISH HABITAT EFFECTS ASSESSMENT

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18 FISH AND FISH HABITAT EFFECTS ASSESSMENT

18.1 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 (BC).

This chapter of the Project's Application for an Environmental Assessment Certificate / Environmental Impact Statement (Application/EIS) presents the effects assessment for the Fish and Fish Habitat valued components (VCs). The purpose of this assessment is to comprehensively evaluate the potential changes to Fish and Fish Habitat that may result from the Project.

The introduction summarizes why Fish and Fish Habitat were selected as VCs, what is encompassed, and linkages to the assessment of other VCs. The remainder of the chapter covers: the scope of the assessment, existing conditions (i.e., baseline data), potential effects, mitigation measures, residual effects and their significance, cumulative effects, follow-up strategy, and conclusions.

Fish and Fish Habitat were selected as VCs based on input and consultation with the Project's technical Working Group, which is composed of Nisga'a Nation, as represented by the Nisga'a Lisims Government (NLG), provincial government, and federal government representatives.

The federal *Fisheries Act* defines fish as 'the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals'. Fish and Fish Habitat were selected as VCs based on the following rationale:

- Fish populations are an important resource to Nisga'a Nation, and changes in Fish and Fish Habitat have the potential to affect Nisga'a Nation Treaty rights;
- Fish are at the top of the foodweb in the freshwater aquatic ecosystem and can provide a link to terrestrial systems as a food source for humans and wildlife;
- The ability to monitor fish populations to detect potential changes resulting from Project activities;
- There is a requirement for fish to be assessed under the *Canadian Environmental Assessment Act, 2012* (CEAA 2012) s.5(1)(a)(i) and CEAA 2012 s.5(1)(c)(iii); and
- Federal and Provincial requirements under the *Fisheries Act* and the Metal Mining Effluent Regulations.

The Fish and Fish Habitat VCs are closely linked to the Aquatic Resources VC, which is represented by benthic invertebrates and periphyton. Benthic invertebrates support the assessment of potential effects on benthivorous fish health and fish habitat. Periphyton supports the assessment of potential effects on fish habitat via effects on benthic invertebrates. Benthic invertebrate success is often based on an abundant and diverse periphyton community. Periphyton is therefore a representative indicator of benthic invertebrate health, and in turn, fish and fish health and habitat integrity.

This chapter describes the fish species and fish habitat in the Project area and focuses on direct mortality and species responses to environmental conditions (e.g., water quality and lethal or sub-lethal effects) and effects on Fish Habitat (e.g., flow and indirect effects on fish). There is overlap between the two VCs as Fish depend on Fish Habitat, and the measurement of Fish Habitat has long been used as a surrogate for fish, as it can be more easily measured and does not risk mortality though fishing.

For this effects assessment, all fish species within the Project area will be represented by the following:

- Dolly Varden (*Salvelinus malma*);
- Bull Trout (*Salvelinus malma*);
- Eulachon (*Thaleichthys pacificus*); and
- Salmonid Species (*Oncorhynchus* spp.)

18.2 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 by the Canadian Environmental Assessment Agency (the Agency) outline the requirements of the Fish and Fish Habitat Effects Assessment to meet both the provincial and federal environmental assessment (EA) requirements under the *BC Environmental Assessment Act* (2002) and CEAA 2012, respectively.

Federal and provincial regulations and policies which guide protection of Fish and Fish Habitat during the mine development process are summarized in Table 18.2-1.

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 by providing scientifically-derived benchmarks for evaluating the potential for observing adverse biological effects in aquatic systems.

Guidelines are not regulatory instruments but can be defined as targets or triggers for action if not met. 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 outlined above, the BC Ministry of Environment’s (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 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 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 18.2-1. Summary of Applicable Legislation, Regulations, and Guidelines for Fish and Fish Habitat Effects Assessment

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 the 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 cubic metres (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.
Species at Risk Act (2002)	Federal	DFO (for Schedule 1 aquatic species)	The *Species at Risk Act* (SARA; 2002) prohibits killing, harming, capturing, or harassing species listed (in schedule 1 of the Act) as endangered, threatened or extirpated and provides protection for habitat that supports these species. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses and identifies species at risk. An activity that affects an aquatic species at risk in a way that is prohibited by the federal SARA requires approval from DFO.
British Columbia Conservation Data Centre (BC MOE, 2010)	Provincial	BC Ministry of Environment (BC MOE)	The CDC assigns species at risk to one of three ranked lists: red-, blue-, and yellow-lists. These lists help to identify species (and ecosystems) that can be considered for designation as Endangered or Threatened either provincially under the BC *Wildlife Act*, or nationally by the COSEWIC. Red-listed species have, or are candidates for, Extirpated, Endangered, or Threatened status in BC. Blue-listed species are considered to be of Special Concern (formerly Vulnerable) in BC. Blue-listed species are at risk, but are not Extirpated, Endangered, or Threatened.

Legislation/Regulation/Policy	Level of Government	Administered by	Description
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 greater than 100 persons. The EMA specifies environmental monitoring requirements for EMA permit holders, which should enable on-going evaluation of waste management performance, receiving environment condition, and evaluation of impact predictions made during the permit application.
Water Sustainability Act (2016)	Provincial	BC Ministry of Forests, Lands and Natural Resource Operations (FLNRO)	The *Water Sustainability Act* (WSA) regulates the diversion and use of water resources. Under the WSA, a license 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.
CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life	Federal	CCME	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.
CCME Canadian Sediment Quality Guidelines for the Protection of Aquatic Life	Federal	CCME	The CCME Sediment Quality Guidelines cover protection of freshwater aquatic life by providing scientific 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.
CCME Canadian Tissue Residue Guidelines for the Protection of Wildlife Consumers of Aquatic Biota	Federal	CCME	The CCME Canadian Tissue Residue Guidelines address those substances for which aquatic food sources are the main route of exposure. The tissue residue guidelines (TRGs) refer to the maximum concentration of a chemical substance in the tissue of aquatic biota that is not expected to result in adverse effects in wildlife. TRGs can apply to any aquatic species consumed by wildlife, including fish, shellfish, other invertebrates, or aquatic plants.

Legislation/Regulation/Policy	Level of Government	Administered by	Description
BC Water Quality Guidelines: • Working Water Quality Guidelines (2015) • Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture (2017)	Provincial	BC MOE	In BC, the definition of water quality includes the sediments, therefore the Approved Water Quality Guidelines also includes sediment quality values for some parameters. These guidelines serve as benchmarks for the protection of benthic 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 SWQG' and an 'Upper SWQG', which are equivalent to CCME's Interim Sediment Quality Guidelines (ISQGs) and Probable Effect Levels (PELs), respectively.

18.3 Scope of the Assessment

18.3.1 Information Sources

The information sources used to assess potential Project effects on Fish and Fish Habitat included baseline reports, the Project Overview (Volume 2, Chapter 1), and the effects assessments for Hydrology (Volume 3, Chapter 12); Surface Water Quality (Volume 3, Chapter 13); Sediment Quality (Volume 3, Chapter 14); and Aquatic Resources (Volume 3, Chapter 17). Information gathered during consultation with NLG as well as meetings and discussion with the Project's Working Group was also incorporated.

Baseline characterization of Fish and Fish Habitat within the Project area is summarized in Section 18.4.4. The baseline studies included detailed review of historical and background information, data gap analysis, and field surveys. Baseline field surveys on Fish and Fish Habitat were conducted in 1993 (Rescan 1994) and from 2014 to 2016. These efforts are detailed in the Baseline Fisheries and Aquatic Resources Report (Volume 8, Appendix 18-A).

Other information sources for Fish and Fish Habitat Effects Assessment are:

- Noble, C.A.J. and Challenger, W. 2015. Nass River Euchalon 2014 Abundance Estimation: Training, Egg and Larvae Monitoring, and Bear River Eulachon Assessment, prepared for Aboriginal Fund for Species at Risk (AFSAR). Nisga'a Fisheries Report No. 14-34;

- Ministry of Forests, Lands and Natural Resource Operations (FLNRO), 2012. Nass South Sustainable Resource Management Plan;

- Cleugh, T.R. 1979. Status of the Environmental Knowledge of the Stewart Estuary. Memorandum Report Habitat Protection Division Fisheries and Oceans; and

- BC Fish Inventory Data Query. Note that this information source was used to conduct baseline work but was not used to inform the effects assessment.

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 NLG's preferences and EAO's and the Agency's direction for comparatively low levels of engagement with the other Aboriginal Groups potentially affected by the Project (TSKLH and MNBC). 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.

18.3.2 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 18.3-1 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 Fish and Fish Habitat.

Table 18.3-1: Consultation Feedback

Topic	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.
Fish Fish Habitat	X				NLG requested a conceptual aquatic effects monitoring program (AEMP) design be included in the Application.	A conceptual AEMP has been included in the Application/EIS.
CRA Fisheries		X			FLRNO requested that the Project's work force be considered as a potential effect on Fish through increased fishing pressure.	The CRA Fisheries effects assessment includes consideration of potential changes to fishing pressure due to the Project's workforce.
CRA Fisheries		X			DFO requested that IDM construct of model of the potential downstream effects of a catastrophic failure of the Tailings Management Facility (TMF).	IDM has conducted a dam breach failure analysis and it is included in the Application/EIS.

Topic	Feedback by*				Consultation Feedback	Response
	NLG	G	P/S	O		
CRA Fisheries Fish	X				NLG requested that the assessment of the Fish VC include the salmon and eulachon in the lower Bear River.	The assessment of potential effects on Bear River salmon and eulachon and their significance will be considered under CRA Fisheries.
Fish		X			FLRNO requested that Dolly Varden and Bull Trout be included as VCs in the Fish effects assessment.	These species have been included as VCs in the Fish effects assessment.
Fish	X	X			NLG and DFO requested that eulachon be included as a VC in the Fish effects assessment.	Eulachon have been included as a VC in the Fish and Fish Habitat effects assessment.
Fish Habitat		X			FLNRO requested that Landforms and Natural Landscapes should be included as an IC for the Fish Habitat effects assessment.	Landforms and Natural Landscapes have been considered in the Fish and Fish Habitat effects assessment.

*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

18.3.3 Valued/Intermediate Components, Assessment Endpoints, and Measurement Indicators

There are several potential pathways through which the Project could result in effects on Fish and Fish Habitat. Potential effects pathways start with Project activities (e.g., mine water discharge, instream works), which can cause changes to the physical and chemical conditions within watercourse. Changes in sediment quality, water quality, or physical habitat conditions (e.g., flow regimes) represent potential stressors which, in turn, could lead to effects on Fish and Fish Habitat. These stressors are also pathways to effects on Aquatic Resources (Chapter 17). Aquatic Resources (benthic invertebrates and periphyton) support the assessment of potential effects on benthivorous fish health and fish habitat. Periphyton supports the assessment of potential effects on fish habitat via effects on benthic invertebrates. Benthic invertebrate success is often based on an abundant and diverse periphyton community. Periphyton is therefore a representative indicator of benthic invertebrate health, and in turn, fish and fish health, and habitat integrity.

The primary measurement indicators for Fish and Fish Habitat are fish species presence or absence, fish population metrics, direct mortality, changes in water quality and sediment quality parameter concentrations, changes in hydrology (flow volumes and timing), and aquatic habitat loss (Table 18.3-2).

Groundwater Quality (Volume 3, Chapter 11), Hydrology (Volume 3, Chapter 12), Surface Water Quality (Volume 3, Chapter 13), Sediment Quality (Volume 3, Chapter 14), and Aquatic Resources (Volume 3, Chapter 17) are pathways of effects to Fish and Fish Habitat.

Intermediate Components (ICs) represent the pathway of potential effect between a Project component or activity and a VC. Groundwater Quality is an IC and is linked to the Fish and Fish Habitat VC via the Surface Water Quality and Sediment Quality VCs.

Table 18.3-2: Assessment Endpoints and Measurement Indicators for Fish and Fish Habitat

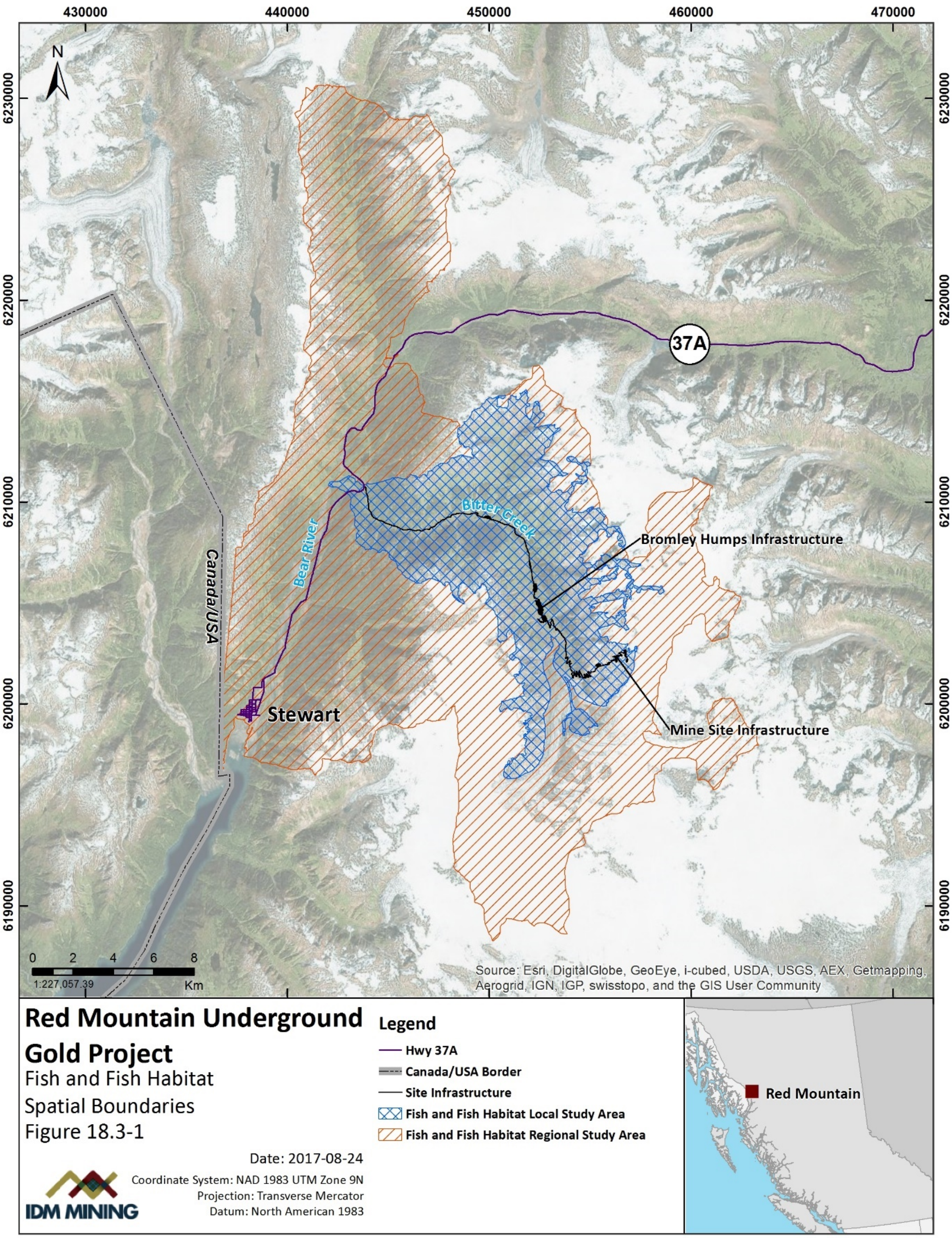
VC	Primary Measurement Indicators	Assessment Endpoint
Fish represented by: • Dolly Varden • Bull Trout • Eulachon • Salmonid Species	• Fish species presence or absence; fish population metrics; and direct mortality. • Habitat loss and alteration (quantity, quality and availability). • Water Quality in fish-bearing watercourses - change in parameter concentrations compared to provincial or federal guidelines for freshwater aquatic life; and comparison of metal concentrations in fish tissues. • Growth, survival, and reproduction of fish, assessed by comparison of predicted concentrations of water and sediment quality to screening values or benchmarks derived from literature-based toxicity tests.	The maintenance of ecological conditions that support populations relative to existing baseline.
Fish Habitat	• Water Quality - change in parameter concentrations compared to provincial or federal guidelines for freshwater aquatic life. • Change in timing, flows, and volume. • Change in sediment parameter concentrations, compared to provincial or federal guidelines for freshwater aquatic life. • Periphyton and Benthic Invertebrate community metrics. • Channel morphology lateral and vertical stability (i.e., bank erosion and scour).	The maintenance of ecological conditions that support populations relative to existing baseline.

18.3.4 Assessment Boundaries

18.3.4.1 Spatial Boundaries

The spatial boundaries for assessment of Fish and Fish Habitat 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 Fish and Fish Habitat from the Project (Figure 18.3-1). 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 Fish and Fish Habitat, 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 18.3-1: Local and Regional Study Areas for Fish and Fish Habitat



18.3.4.2 Temporal Boundaries

The temporal boundaries for Fish and Fish Habitat have been defined as "Life of Project", which covers the period from Construction through to the Post-Closure Phase of the Project, thereby encompassing all periods during which there is a potential for effects on Fish and Fish Habitat (Table 18.3-3). These boundaries capture the time periods within which a reasonable expectation of interaction with components of the freshwater environment can be predicted.

Table 18.3-3: Temporal Boundaries for the Effects Assessment of Fish and Fish Habitat

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, 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 dore 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.

18.3.4.3 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, FLNRO's Skeena Region (Region 6), and the Regional District of Kitimat-Stikine (RDKS).

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 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 TSKLH and 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 Fish and Fish Habitat 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 (Volume 8, Appendix 14-C).

18.4 Existing Conditions

18.4.1 Overview of Existing Conditions

The Project area is characterized by rugged, steep terrain with weather conditions typical of the northern coastal mountains. Temperatures are moderated year-round by the coastal influence. The mean annual air temperature at an elevation of 1,514 metres above sea level (masl) is −0.8°C, with monthly mean values ranging between −6.4°C in December and January and 6.9°C in August (Volume 8, Appendix 12-A). 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 the baseline climate and hydrology report (Appendix 12-A).

A deactivated logging road extends from Highway 37A for approximately 13 kilometres (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 Bromley Glacier. 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 Fish and Fish Habitat evaluation are Otter Creek, Hartley Gulch, Cambria Creek, Roosevelt Creek, and Swarm 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 18.3-1). Bear River flows peak in summer (July/August).

The proposed Project is composed of two main areas with interconnecting roads (Figure 18.4-1): the Mine Site with an underground mine and three portals (Upper Portal, Lower Portal, and Vent Portal) at the upper elevations of Red Mountain (1950 masl; Figure 18.4-2); and Bromley Humps situated in the Bitter Creek valley (500 masl), with a Process Plant and TMF (Figure 18.4-3). The deposit is under the summit of Red Mountain at elevations ranging between 1,600 and 2,000 masl.

Figure 18.4-1: Project Components – Overview

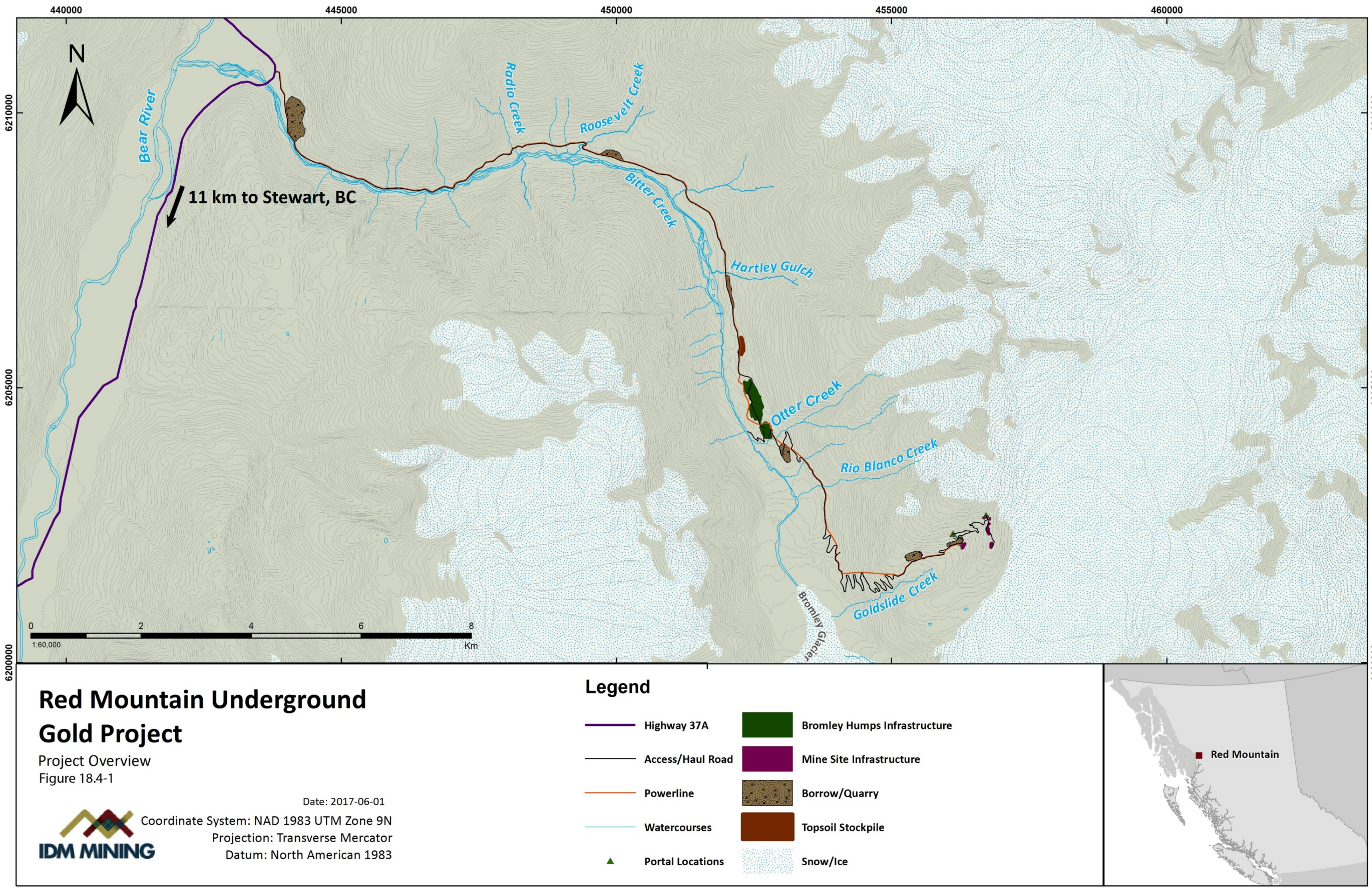


Figure 18.4-2: Project Components – Mine Site

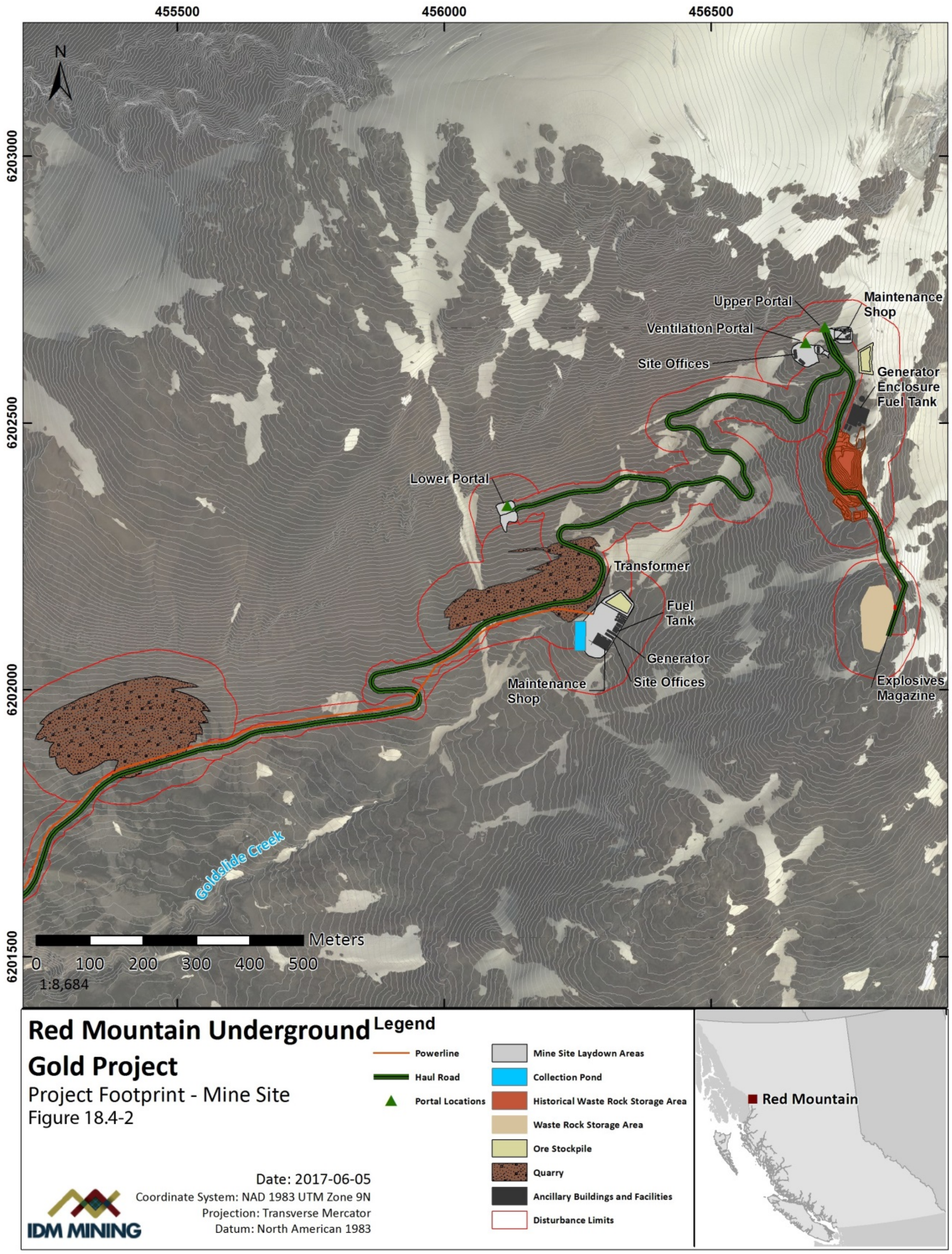
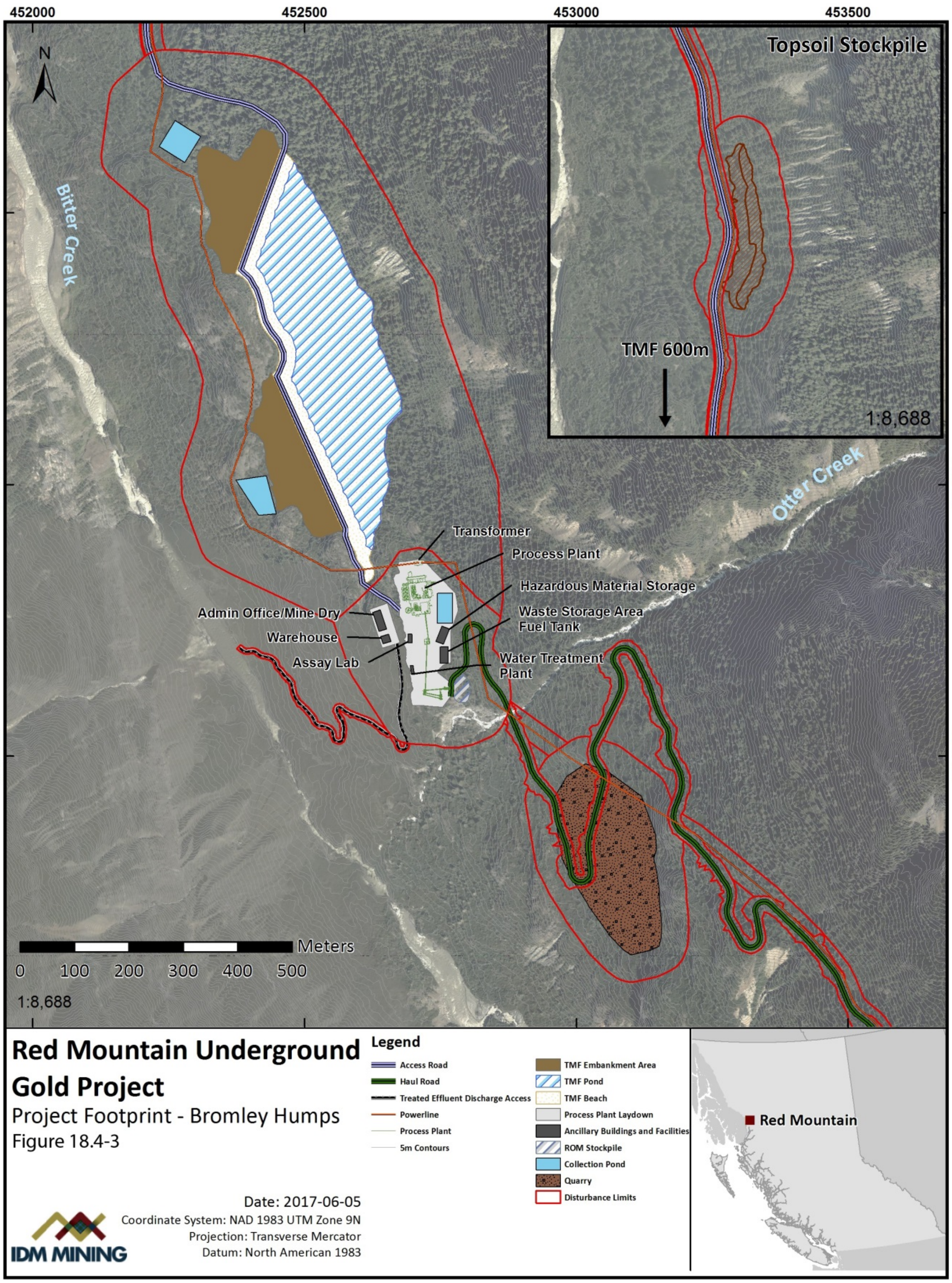


Figure 18.4-3: Project Components – Bromley Humps



18.4.2 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 estimate studies.

The dewatering program 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 changes that may occur as a result of the proposed Project or other projects and/or activities in the area.

The discharge water from dewatering was pumped to the Cambria Icefield and followed an 8 km pathway before potentially 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 2016 Dewatering Report (IDM, 2017)). The monitoring results indicated that the mine discharge did not affect water quality in Bitter Creek, as there were no fluctuations in water quality parameters that were outside of natural variability. Given this, and that the closest fish-bearing habitat is approximately 5 km downstream of BC08, it follows that there were no effects on Fish Habitat or Fish from the dewatering of the adit.

18.4.3 Project-Specific Baseline Studies

18.4.3.1 Data Sources

The baseline studies included detailed review of historical and background information, data gap analysis, and field surveys. Initial baseline field surveys for Fish and Fish Habitat were conducted in 1993 to 1994 (Rescan, 1994). The recent baseline programs to support the Application/EIS were carried out from 2014 to 2016, as described in Appendix 18-A. Baseline sampling programs are summarized in Table 18.4-1 and Table 18.4-2.

Table 18.4-1: Fish Community Sampling for the Red Mountain Project, 1990-2017

Year	1993	1994	2014	2015	2016
Season	Summer Fall	Winter Fall	Summer (August)	Summer (August) Fall (September)	Spring (May)
Sampling Agency	Rescan	Rescan	Northlink Consultants LP	Northlink Consultants LP	Northlink Consultants LP
Streams Sampled/ Site/Timing	*Bitter Creek* F1, F2, F3 (Summer and Fall) F4 (Summer) F4-B, F8, F10, F11 (Fall) *Roosevelt Creek* F6, F7 (Summer and Fall) F6-B (Fall) *Bear River* F5 (Summer and Fall) (Note: Sites with "-B" are replacement sites which were sampled because low discharge precluded sampling at the original site)	*Bitter Creek* F2, F3, F8 (Winter) F10, F11 (Fall) *Roosevelt Creek* F6-B (Winter) *Hartley Gulch* F9 (Winter) (Note: Sites with "-B" are replacement sites which were sampled because low discharge precluded sampling at the original site)	*Bitter Creek* BC01, BC04, BC07, BC08, BC09N, BC09S, BC10, BC11, CA01 *Roosevelt Creek* RC01, RC02 *Goldslide Creek* GC01, GC02, *Otter Creek* OC01 *Rio Bianco Creek* RBC01 *Bear River* BR01, BR08 *American Creek* AC01	*Bitter Creek* BC02, BC03, BC04, BC05, BC07, BC08, BC09, BC10 *Roosevelt Creek* RC02 *Bear River* BR02, BR03, BR04, BR08, BR09, BR-T-01 American Creek AC01	*Bitter Creek* BC09, BC10, GN01, GN02, BN02, GN03, BN03, BN04 *Roosevelt Creek* RC02
Sampling and Data Collection Summary	Electrofishing, minnow trapping Fish stomach content Fish tissue (metals)	Electrofishing Fish stomach content Fish tissue (metals)	Electrofishing, minnow trapping, Fish tissue (metals)	Electrofishing, minnow trapping	Bongo net, gill net, electrofishing, minnow trapping

Year	1993	1994	2014	2015	2016
Data Analysis	Relative abundance, distribution, fish biometrics (length, weight, age), condition factor, Fish tissue metal concentrations, Benthic taxonomy for stomach contents		Relative abundance, distribution; fish biometrics (length, weight, age class), fish tissue metal concentrations		
Laboratory (Metals analysis)	Elemental Research Inc., Vancouver		Maxxam Analytical Lab		

Table 18.4-2: Fish Habitat Field Data Collection for the Red Mountain Project, 1990-2017

Year	1993 - 1994	2014 - 2016
Season	Summer and Fall (1993) Winter (1994)	Summer (August 2015 and 2016) Spring (May 2016)
Sampling Agency	Rescan	Northlink Consultants LP
Sites Assessed	*Bitter Creek* F2, F3 (Summer, Fall and Winter) F1, F4 (Summer and Fall) F8 (Fall and Winter) F4-B, Reaches (R1-R4) (Fall) *Roosevelt Creek* F6, F7 (Summer and Fall) F6-B (Fall) *Hartley Gulch* F9 (Winter) *Bear River* F5 (Summer and Fall)	*Bitter Creek* Reach 1-6 and associated tributaries *Bear River* Bear River and associated tributaries
Sampling Methods	Fish habitat Assessment (Nielsen and Johnson 1989)	Fish habitat assessment using protocols and guidelines outlined in the RISC's Reconnaissance 1:20,000 Fish and Fish Habitat Inventory Procedures and the Forest Practices Code Fish-stream Identification Guidebook Helicopter overflight surveys assessing coarse habitat features
Sampling Parameters	Gradient, wetted length, wetted width, percent habitat unit composition, substrate composition, percent cover of large organic debris, overstream vegetation, boulders and pools	Gradient, channel width, wetted width, pool depth, cover, woody debris, instream vegetation, overstream vegetation, substrate composition

18.4.3.2 Primary Data Collection and Analysis Methods

1993-1994 Sampling Locations

The 1993-1994 fisheries sampling program covered Bitter Creek (seven sites, two of which were relocated), Roosevelt Creek (two sites, one of which was relocated), Hartley Gulch (one site) and Bear River (one site) (Table 18.4-3; Figure 18.4-4). Sites F10 and F11 were located within non-fish bearing areas on mainstem Bitter Creek, and were sampled to confirm fish absence. The most downstream fish bearing site on Bitter Creek (F4) was located immediately below the Highway 37A crossing, and the most upstream fish bearing site (F8) was located just downstream of Hartley Gulch. The 2014-2016 sites are not co-located with the 1993-1994 sites.

Table 18.4-3: Fisheries Sampling Sites, 1993-1994

Watercourse	Site Name	Site Description	Location
Bitter Creek	F1	Spring Fed Channel	Approximately 400 m upstream of Roosevelt Creek confluence
Bitter Creek	F2	Spring Fed Creek	Approximately 500 m downstream of Radio Creek confluence
Bitter Creek	F3	Mainstem Edgewater	Approximately 3 km downstream of Roosevelt Creek
Bitter Creek	F4, F4-B	Side Channel	Downstream of Highway 37A bridge
Bear River	F5	Side Channel	Approximately 1.4 km downstream from Bitter Creek confluence
Roosevelt Creek	F6, F6-B	Side Channel	Approximately 250 m upstream from Bitter Creek
Roosevelt Creek	F7	Mainstem Edgewater	Approximately 1.3 km upstream from Bitter Creek
Bitter Creek	F8	Spring Fed Channel	Approximately 200 m downstream of Hartley Gulch confluence, on north side of Bitter Creek
Hartley Gulch	F9	Side Channel	Lower Hartley Gulch
Bitter Creek	F10	Mainstem	Within non-fish bearing section of Bitter Creek
Bitter Creek	F11	Mainstem	Within non-fish bearing section of Bitter Creek

2014-2016 Sampling Locations

2014-2016 fisheries sampling in the LSA (Table 18.4-4; Figure 18.4-4) covered Bitter Creek (ten sites), Goldslide Creek (two sites), Rio Blanco Creek (one site), Otter Creek (one site), Hartley Gulch (one site), Cambria Creek (three sites located near the confluence with Bitter Creek), Roosevelt Creek (two sites), and Swarm Creek (site near mouth, at Bitter Creek). Fish sampling in the RSA covered Bear River (13 sites) and American Creek (one site). Four of the Bear River sites were tributary sites.

Two sites on mainstem Bitter Creek above the fish barrier (BC08 and BC11), as well as sites on Goldslide Creek, Rio Blanco Creek and Otter Creek, and were sampled to confirm fish absence. The most downstream fish bearing site on Bitter Creek (BC03) was located immediately upstream of Bear River, and the most upstream fish bearing site (BC10) was located at the Hartley Gulch confluence. The sites are not co-located with the 1993-1994 sites.

Table 18.4-4: Fisheries Sampling Sites, Bitter Creek Watershed, 2014-2016

Watercourse	Site Name	Location	Fish Bearing	Closest 1993 site(s)
Bitter Creek	BC08	Most upstream site on Bitter Creek mainstem	N	F10 and F11
	BC11	Unnamed tributary to Bitter Creek, near confluence with mainstem Bitter Creek	N	F10 and F11
	BC04	Mainstem Bitter Creek (2014) Side channel of Bitter Creek (2015)	Y	F1 (upstream)
	BC07	Lowermost 50 m of a tributary, known as Swarm Creek (*i.e.* immediately above Bitter Creek)	Y	F2 (downstream)
	CA01	Bitter Creek, where a tributary (known as Cable Creek) flows in.	Y	F3 (downstream)
	BC01	Bitter Creek upstream of Highway 37A bridge	Y	F4, F4-B (downstream)
	BC02	Bitter Creek immediately upstream of Highway 37A bridge	Y	F4, F4-B (downstream)
	BC05	Bitter Creek downstream of Highway 37A bridge	Y	F4, F4-B (upstream)
	BC03	Bitter Creek at confluence with Bear River (*i.e.* most downstream site)	Y	F4, F4-B (upstream), F5 (downstream, on Bear River)
Goldslide Creek	GS02	Goldslide Creek approximately halfway been point of origin and confluence with Bromley Glacier	N	n/a
	GC01	Goldslide Creek immediately upstream of the Bromley Glacier	N	n/a
Rio Blanco Creek	RBC01	Rio Blanco Creek just upstream of Bitter Creek	N	n/a
Otter Creek	OC01	Otter Creek upstream of confluence with Bitter Creek	N	n/a
Hartley Gulch	BC10	Hartley Gulch where it enters Bitter Creek	Y	F9 (upstream), F8 (downstream)
Cambria Creek	BC09, BC09N, BC09S,	Cambria Creek where it enters Bitter Creek. BC09 and BC09N are on the north fork of Cambria Creek, BC09S is on the south fork.	Y	n/a

Watercourse	Site Name	Location	Fish Bearing	Closest 1993 site(s)
Roosevelt Creek	RC01	Upper Roosevelt Creek; 3.7 km upstream from Bitter Creek, falls below site.	N	n/a
	RC02	Lower Roosevelt Creek	Y	F6, F6-B, F7

Note:
Bitter Creek tributaries are listed from upstream to downstream, and sites in each watercourse are listed from upstream to downstream.

Table 18.4-5: Fisheries Sampling Sites, Bear River Watershed, 2014-2016

Watercourse	Site Name	Location
American Creek	AC01	American Creek, approximately 1.3 km upstream from confluence with Bear River
Bear River	BR-T-01	Tributary to Bear River (just upstream from Bear River), approximately 8 km upstream from Bitter Creek
	BR09	Bear River mainstem, approximately 6 km upstream from Bitter Creek
	BR04	Tributary to Bear River (close to confluence with mainstem Bear River), approximately 5.8 km upstream from Bitter Creek
	BR08	Bear River, approximately 1.5 km upstream from Bitter Creek
	BR01	Bear River, approximately 3 km downstream from Bitter Creek
	BN04	Bear River, approximately 3 km downstream from Bitter Creek
	GN02	Bear River, approximately 3.4 km downstream from Bitter Creek
	BN02	
	BR03	Tributary to Bear River (just upstream from Bear River), approximately 4.8 km downstream from Bitter Creek
	BR02	
	GN01	Mainstem Bear River, approximately 6.4 km downstream from Bitter Creek
	GN03	Mainstem Bear River, approximately 7.3 km downstream from Bitter Creek
	BN03	Mainstem Bear River, approximately 7.3 km downstream from Bitter Creek

Note:
Sites are listed from upstream to downstream, all sites are fish bearing

The 2014-2016 sites cover areas that could be affected by the proposed construction, operation, and closure of the Project. Sites were established upstream and downstream of potential mine influences, and at far-field locations where downstream and/or cumulative effects could be assessed.

In addition to the named streams listed in Table 18.4-4, there are two small unnamed watercourses, located within Bromley Humps where the TMF is proposed. Both watercourses drain into Bitter Creek. There are no baseline sampling sites for fish and fish habitat located on those watercourses. Both watercourses are non-fish bearing. The larger of the two watercourses has a series of drop and chutes in the lower reach which prohibit fish passage. The smaller watercourse is confluent with Bitter Creek above the fish barrier on Bitter Creek. Listed below are the watercourses and associated sampling locations from the 2014 to 2016 baseline program.

Bitter Creek

Bitter Creek flows for 18.1 km from the toe of the Bromley Glacier to its confluence with the Bear River. There are nine fisheries sites on Bitter Creek, distributed along the length of the creek. Three of the nine sites are located where tributary streams enter Bitter Creek.

Rio Blanco Creek

Rio Blanco Creek is a right bank, headwater tributary of Bitter Creek, downstream of the Bromley Glacier, within the non-fish bearing section of Bitter Creek. There is one fisheries site on Rio Blanco Creek (RBC01) which was sampled to confirm fish absence.

Goldslide Creek

Goldslide Creek drains the Mine Site cirque in which the Project will be located. The creek is confluent with the right margin of the Bromley Glacier, out of which Bitter Creek flows. There are two fisheries sites on Goldslide Creek (GSC02, GSC01) which were sampled to confirm fish absence.

Otter Creek

Otter Creek is a right bank tributary of Bitter Creek, within the non-fish bearing section. The site on Otter Creek (OC01) is downstream of Bromley Humps area where the TMF and Process Plant are proposed.

Hartley Gulch

Hartley Gulch is another right bank tributary of Bitter Creek, downstream of Otter Creek. Hartley Gulch enters Bitter Creek within the fish-bearing section. Mine infrastructure is not proposed within the area drained by this watercourse. There is one fisheries site on Hartley Gulch (BC10), near the confluence with Bitter Creek.

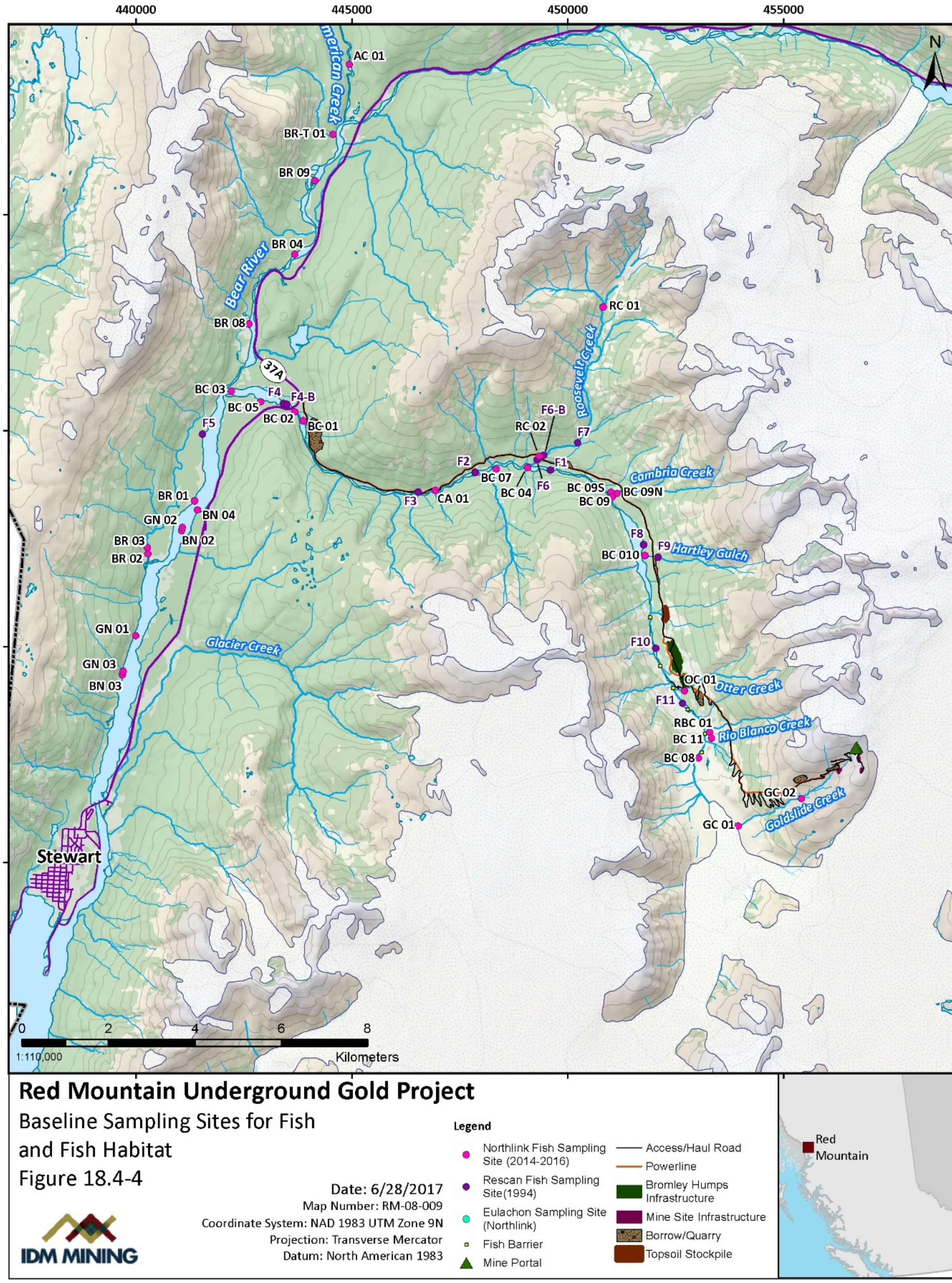
Bear River

Bitter Creek flows into the Bear River. Bear River has four fisheries sites upstream of the confluence with Bitter Creek and nine sites downstream of the confluence.

American Creek

American Creek flows into the Bear River upstream (north) of Bitter Creek. There is one fisheries site on American Creek (AC01).

Figure 18.4-4: Fisheries Sampling Sites, 1993-1994, and 2014-2016



18.4.3.3 Field Sampling Methods

The methods used to conduct fish and fish habitat studies are summarized in this section. Details of fish sampling and habitat assessment methods are available in Appendix 18-A for the 2014-2016 sampling program, and in the 1994 Environmental Setting Report (Rescan 1994) for the 1993-1994 sampling program.

There are limitations and assumptions to all of the fish and fish habitat sampling methodologies. Each method tends to provide a snapshot in time of fish use of habitats in the Project area. Sub-sampling and extrapolation to broader habitat areas is a limitation of most fish studies. However, the baseline program was designed to provide a comprehensive overview of aquatic conditions, with complementary data collected at the same stations (for example, sediment quality, benthic invertebrates, periphyton and fish community). This provides a reasonably accurate portrayal of fisheries resources in the Project area. The availability of baseline information from the same Project area in the early 1990s provides further confidence in the accuracy of the fish and fish habitat assessment.

18.4.3.3.1 1993-1994 Sampling Program

The 1993-1994 fisheries surveys were conducted in the Bitter Creek watershed and Bear River during summer (June 28 to July 3, 1993), fall (September 24 to October 1, 1993), and winter (January 29 to 31, 1994). Fish species presence/absence sampling was also conducted in the upper watershed (Sites F10 and F11) during November 1993 and October 1994. Rescan used the similar methods to those employed in 2014-2016 surveys (Appendix 18-A).

Fish Habitat Assessment

To assess fish habitat, standard biophysical parameters were measured at each site during all surveys, including reach gradient, wetted length, wetted width, percent habitat unit composition (pool, riffle, glide, cascade), substrate composition, percent cover of large organic debris, overstream vegetation, boulders and pools. The Bitter Creek mainstem was divided into reaches (R1-R4), primarily on the basis of stream gradient and similar biophysical parameters. These reaches do not completely correspond to the reach numbers used in the baseline surveys from 2014-2106 (Appendix 18-A), primarily due to the receded Bromley Glacier. This meant that Reach 6 as delineated in 2014, was still under ice during surveys of the mainstem Bitter Creek in 1993-1994. Reach 1 was the same for both surveys in 1993-1994, and 2014-2016. Reach 2 as delineated in 1993-1994 corresponds to approximately 60% of the 2014-2016 Reach 2. Reach 3 as defined in 1993-1994 comprises of 100% of reaches 3 and 4, 40% of Reach 2, and 10% of Reach 5 as delineated in 2014-2016. Reach 4 as defined in 1993-1994 corresponds to 90% of Reach 5 in 2014-2016.

Fish Community Sampling

Fisheries sampling sites were selected on the basis of habitat potential to support known or suspected species and life stages of salmonids, particularly Dolly Varden char, chum salmon (*Oncorhynchus keta*), pink salmon (*O. gorbuscha*), and coho salmon (*O. kisutch*). Due to high turbidity and water velocity and a general absence of fish and edgewater habitat, only three sites were located on the Bitter Creek mainstem. All other fish sampling sites were located on reach-specific, representative side channels, spring-fed channels, and Roosevelt Creek.

Fish presence/absence at each site in the Bitter Creek watershed was determined by electrofishing with a Smith Root Model 15A backpack electrofisher. Prior to electrofishing, stop nets were positioned at the upstream and downstream ends of the sample section to prohibit fish migration during sampling. All fisheries stations were electrofished thoroughly (1-3 passes) until all fish had been removed (0 catch/pass). Spot electrofishing was conducted at sites F10 and F11 in November 1993, and again at site F10 in October 1994, to confirm fish absence upstream of the probable impasse on Bitter Creek.

Gee-type minnow traps were also deployed during the summer and fall surveys in Bitter Creek. Minnow trapping in high quality habitat attempted to increase fish capture probability and confirm presence/absence and relative abundance.

Monofilament gill nets were drifted for 125 to 200 m in Bitter Creek mainstem, downstream of the Roosevelt Creek confluence (1 drift), and approximately 400 m upstream of the Bitter Creek bridge on Highway 37A (2 drifts) during the fall sampling period.

Captured fish were identified to species and counted in the field. Fish lengths and weights were also recorded for a subsample of captured fish.

A subset of fish were lethally sampled for analyzing diet (stomach contents), age (scales and otoliths), and metals concentrations in tissues.

18.4.3.3.2 2014-2016 Sampling Program

Fish habitat assessment and fish sampling was conducted in three years (2014, 2015, and 2016), and two seasons (spring and summer). Two methods were used for fish sampling: Electrofishing and minnow trapping. Gill and bongo nets were also used in Bear River in May, 2016.

Fish sampling and habitat assessment methods followed:

- *British Columbia Fish Collection Methods and Standards* published by the *Resource Inventory Standards Committee* (RISC) (RISC 1997);
- *British Columbia Field Sampling Manual* (Clark 2002); and
- Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures (RISC 2001).

Fish Habitat Assessment

An aerial assessment (overflight) of the watercourses within the LSA was undertaken, prior to on-the-ground fisheries surveys, to identify habitat features such as steep gradients, obvious barriers (e.g. falls), extensive meso-habitats (e.g. heavy riffles or large pools), and instream debris accumulations. The findings of the aerial assessment, as well as background review, informed the delineation of reach breaks, and site selection for ground surveys.

Field forms guided the standardized collection of primary physical habitat characteristics reconcilable to qualitative assessment of fish habitat with respect to rearing, spawning, overwintering, and migratory fish habitat.

Habitat data collection included gradient, channel width, wetted width, pool depth, cover, woody debris, instream vegetation, overstream vegetation, and substrate composition at each of the sites.

Fish Community Sampling

Fish sampling programs were conducted in summer 2014 (August 16 to 26), summer and early fall of 2015 (August 11 to 13, September 8 to 9, and September 13), and spring of 2016 (May 10 to 11).

The 2014 and 2015 fisheries sampling events covered sites on Bitter Creek and its tributaries, Bear River, and American Creek. Electrofishing was the primary method used for sampling. Minnow traps were set at some sites, where conditions permitted. Details of effort (electrofishing seconds, and minnow trap soak times) are provided in Appendix 18-A.

The 2016 fisheries sampling event covered Bitter Creek tributary sites (Roosevelt Creek, Cambria Creek, and Hartley Gulch), and Bear River. Electrofishing and/or minnow trapping was conducted at the Bitter Creek tributary sites. Sampling on Bear River in 2016 targeted Eulachon, using bongo and gill nets. Details of effort (electrofishing seconds, minnow trap soak times, net soak times) are provided in Appendix 18-A.

Minnow or G-Traps, were used on a limited basis given the hydrological characteristics of the target watercourses in the study area. Baited traps were deployed and permitted to soak through one dusk-to-dawn cycle prior to retrieval.

Gill nets were also employed, specifically to target adult eulachon in the mainstem of the Bear River where water depth and velocity determined sample site location. Bongo nets were also deployed in the Bear River mainstem to target eulachon larvae.

Fish were identified to species and counted in the field. Fish lengths and weights were also recorded for a subsample of captured fish.

In 2014, a sub-set of captured fish (Dolly Varden), were sampled for tissue (for metals analysis) and aging structures (otoliths, fin rays, and scales). Tissue and aging structures were sampled from fish at seven sites: two Bear River sites, one upstream (BR08) and the other downstream (BR01) of the confluence with Bitter Creek; three sites along Bitter Creek (BC01, CA01, and BC04); one site on Roosevelt Creek (RC02) and one site on American Creek (AC01).

18.4.3.4 Laboratory and Data Analyses

18.4.3.4.1 1993-1994 Sampling Program

Fish Habitat

Qualitative description and evaluation of habitat in the Bitter Creek and Bear River watersheds were reported, based on three field surveys conducted in 1993 and early 1994. Reach- and site- specific fish habitat descriptions were provided for Bitter Creek.

Fish Community

Fish relative abundance estimates were reported as fish/m^2 for electrofishing, based on the total number of fish captured within a discrete stream area isolated with upstream and downstream stop nets.

Minnow trap catch values were reported as fish/trap-hour to allow relative abundance comparisons to be made between and within sites.

Condition Factor (K), a measure of fish fitness, was calculated from fish biometric data (length and weight).

Fish scales, collected for fish aging, were analyzed by a qualified specialist using methods consistent with those described by Bilton (1973). Otoliths were also removed for fish aging and analyzed by methods consistent with Sjolund (1974).

Fish stomach contents analysis was carried out, in accordance with established guidelines for benthic invertebrate sample handling. Each fish stomach was opened and the contents rinsed in a 150 µm Nitex sieve to remove the preservative (10% formalin solution). Organisms were identified to the species level, where possible, and counted.

Fish tissue samples were analyzed by Elemental Research Inc., North Vancouver, by inductively coupled plasma mass spectrophotometry (ICP-MS).

18.4.3.4.2 2014-2016 Sampling Program

Fish Habitat

Fish habitat was described for Bitter Creek and Bear River watersheds (mainstem and tributaries), based on fish habitat assessment field data. Reach breaks and fish barriers on Bitter Creek were identified. Habitat descriptions also included discussion of fish sampling results, and habitat suitability for the various life stages of fish present.

Habitat was classified qualitatively as: poor/marginal, fair/moderate, or good; based on the physical habitat data, fish species and life stages present, and professional judgement.

Fish Community

Fish communities were assessed by species reconciled to the watershed from which they were sampled.

Relative fish abundance in the study area was determined using a catch per unit effort CPUE index, defined as the number of fish caught per second of electrofishing effort, or number of fish caught per trap per hour. CPUE was calculated for Bitter Creek, Bear River, and American Creek.

Condition Factor (K), a measure of fish fitness, was calculated from fish biometric data (length and weight).

Fish tissue samples were submitted to Maxxam Analytical lab on September 4, 2014. Samples were analyzed for total metal concentrations in mg/kg of wet tissue, using Coupled Plasma-Mass Spectroscopy (ICP-MS). Percent moisture content of the samples was analyzed using gravimetry (dried at 105°C). The mean and standard deviation of each metal concentration were reported for each watercourse (Bitter Creek, Roosevelt Creek, Bear River, and American Creek). Mean concentrations compared to guidelines for the protection of aquatic and piscivorous wildlife, as well as to Health Canada standards for mercury levels in fish. Guidelines for selenium in tissue are based on dry weight concentrations, and mean metal concentrations for selenium were therefore converted to dry weight using percent moisture:

$$dry\ weight = \frac{wet\ weight}{100 - (\%\ moisture)} \times 100$$

Fish otoliths were submitted to a qualified specialist for fish aging. Otoliths were cleaned of debris and organic tissue, dried, and then cleaved in half with a razor blade. The specimens were then heated with an alcohol-fuelled Bunsen burner to carbonize the otolith. Once burnt, the otoliths were embedded in plasticine, exposing the burnt, cut surface and then placed under a tri-ocular stereoscope with a mounted digital camera. The otoliths were then coated with canola oil to enhance the annuli, photographed, and recorded. The digital photos were subsequently downloaded and labelled, and the annulus aging was labelled and recorded in a summary sheet.

18.4.4 Baseline Characterization

18.4.4.1 Fish Habitat

Fish habitat characteristics for the LSA (Bitter Creek Watershed) and RSA (Bear River and American Creek) are based on the most recent fisheries community and habitat assessments conducted from 2014 to 2016.

18.4.4.1.1 Bitter Creek Watershed

Bitter Creek is a confined, heavily turbid mainstem comprising of predominantly strong riffle habitat through steep valleys. The entire length of Bitter Creek extends from its confluence with Bear River at 87 masl upstream 18.1 km to the toe of Bromley Glacier at 750 masl. The mainstem channel spans six primary reaches, with seven physical barriers limiting upstream fish migration within Reach 5 (). Key habitat characteristics of Bitter Creek homogenous reaches, and tributary reaches, are provided in Table 18.4-6. Representative photographs of Bitter Creek reaches are shown in Figure 18.4-5 and fish bearing status is shown in Figure 18.4-6

Figure 18.4-5: Photographs of Bitter Creek Reaches

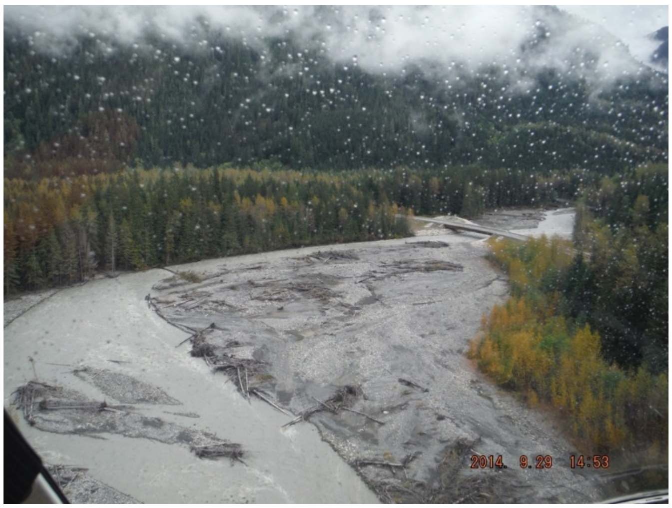


Figure 18.4 5a: Bitter Creek Reach 1

Figure 18.4 5b: Bitter Creek Reach 2

Figure 18.4 5c: Bitter Creek Reach 3

Figure 18.4 5d: Bitter Creek Reach 4

Figure 18.4 5e: Bitter Creek Reach 5

Figure 18.4 5f: Bitter Creek Reach 6

Table 18.4-6: Fish Habitat in the fish-bearing watercourses of the Red Mountain Project LSA

Watercourse	Reach # / Section	Length (m)	Mean Bankful Width* (m)	Mean Bankful Depth* (m)	Riparian Vegetation	Dominant Substrate	Description
Bitter Creek	1 (fish bearing)	1,600	164 (±43)	1.0	Mixed forest	Cobble	Wide, low gradient depositional
	2 (fish bearing)	9,460	75 (±46)	2.0	Mixed forest	Cobble	Steep walled, narrow, 100% riffle
	3 (fish bearing)	1,590	171 (±45)	1.6	Shrub	Gravel	Wide, low gradient, N-S aspect
	4 (fish bearing)	1,150	36 (±32)	-	Mixed forest	Cobble	Steep walled, narrow, 100% riffle
	5 (non-fish bearing)	3,680	26 (±18)	-	Mixed forest	Cobble	Moderate gradient, 7 barriers
	6 (non-fish bearing)	390	40 (±13)	-	Shrub	Boulder	Homogenous channel, headwaters
Hartley Gulch	Lowermost (fish bearing)	393	~ 30	~ 1.0	young seral stage deciduous saplings	Boulder	High gradient
Cambria Creek	Lowermost (fish bearing)	384	~ 7 (North fork) ~ 14 (South fork)	~ 0.11 (North fork) ~ 0.17 (South fork)	young mixed deciduous forest	Cobble	The main channel of Cambria Creek splits into a north and south fork about 300 m upstream from Bitter Creek
Roosevelt Creek	Lowermost (fish bearing)	544	~ 40	~ 2.0	deciduous shrubs and young seral stage hardwoods	Boulder	Moderate gradient, lower gradient near confluence with Bitter Creek

*Note: mean bankful widths and depths based on site cards from baseline report (Appendix 18-A), with the exception of Bitter Creek mean bankful widths which were measured from aerial imagery using ArcGIS software.
Dashes (-) indicates no information available.

Bitter Creek experiences unlimited sediment supply to most of its upper four reaches. Sediment transport is highly dynamic and presumably forms a homogenous bedload for most its length. Seasonal freshets result in extreme increases in discharge volumes which tend to out-transport any woody debris introduced to the channel via debris torrents and frequent avalanches. As a result, habitat complexity is low and instream features that could provide sediment and debris storage lending to habitat and channel complexity, are transitory at best. Woody debris recruitment potential is high due to the frequency of tributary borne events. High turbidity persists from the headwaters of the mainstem downstream to the confluence with Bear River with the exceptions of small areas at and immediately downstream of clear tributary confluences.

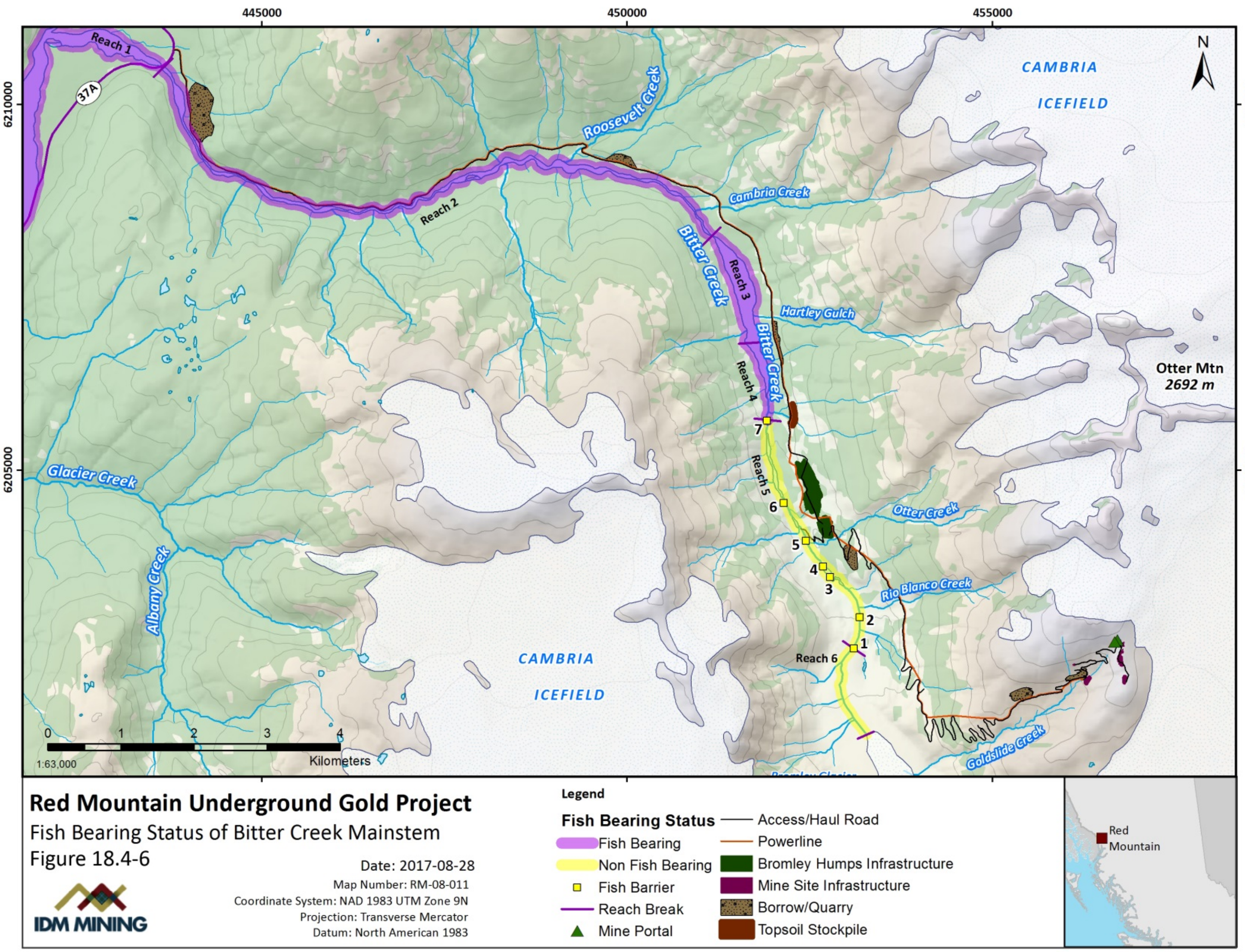
Channel morphology in Bitter Creek is primarily riffle throughout and extends through each of the channel's six defined reaches. The proportion of riffle habitat to glide or run type habitat declines slightly during late summer and fall as discharge and wetted channel widths decline. The Bitter Creek thalweg comprises riffle for the length of the mainstem channel; however, channel margins in a few isolated zones during low flow periods transition to run-type habitat on the declining hydrograph. Pool habitat within the mainstem channel of Bitter Creek is not apparent under any flow conditions but occasional small secondary and tertiary pools associated with side channel or tributary tail-outs were noted during the late summer and autumn sampling visits.

Barriers to Fish Passage

Channel gradients through the length of the Bitter Creek mainstem are considered low to moderate with respect to Fish Habitat and access. Reach 5 of this system, however, is a steeper and narrowly confined, bedrock controlled section that presents seven permanent physical barriers to fish passage. Four of these seven features represent falls that present vertical drops that are greater than approximately 1.5 m, and in excess of resident species' ability to negotiate. The remaining three barriers are situated at the narrowest of the pinch-points in the bedrock margins and constrict flows to less than 3 m where water velocities and cascades are considered insurmountable to upstream migrants.

Despite high turbidity, extensive riffle, and marginal usable fish habitat, Bitter Creek is fish bearing to the upper extent of Reach 4 where Reach 5 begins with the most downstream of the noted barriers. Reach 5 comprises the length of the mainstem channel hosting the seven barriers, and Reach 6, a short 390 m section upstream of the uppermost barrier, with no possibility of fish access, is also considered to be non-fish bearing.

Figure 18.4-6: Fish Bearing Status of Bitter Creek Mainstem



Bitter Creek Tributaries

The Bitter Creek mainstem channel receives tributary input from several right and left bank streams along most of its length. Of these tributaries, seven are named right bank streams, three of which are confluent with Bitter Creek upstream of fish barriers in Reach 5. These include Goldslide, Rio Blanco, and Otter creeks from upstream to downstream, respectively. The remaining right bank tributaries include Hartley Gulch, Cambria, Roosevelt, and Radio creeks. The left bank tributaries are all high gradient (18-68%), non-fish bearing creeks, that provide clean, clear water to Bitter Creek. Representative photographs of Bitter Creek tributaries are shown in Figure 18.4-7.

Figure 18.4-7: Photographs of Bitter Creek Tributaries

Figure 18.4 7a: Goldslide Creek

Figure 18.4 7b: Rio Blanco Creek

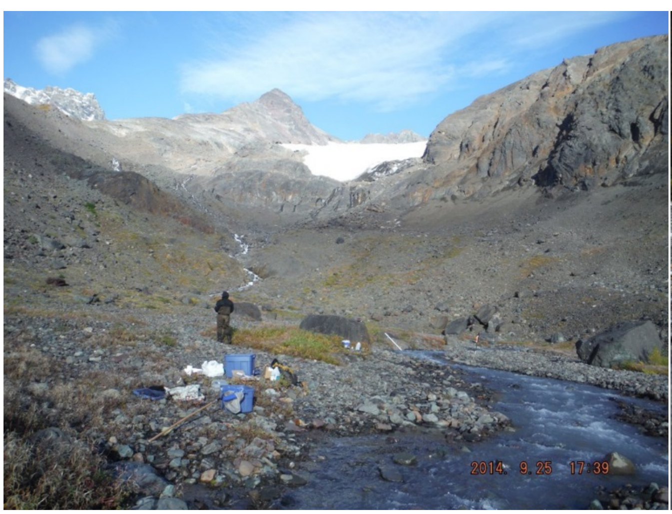


Figure 18.4 7c: Otter Creek

Figure 18.4 7d: Hartley Gulch (at Bitter Creek flats)

Figure 18.4 7e: Cambria Creek

Figure 18.4 7f: Roosevelt Creek

18.4.4.1.2 Bear River Watershed – Regional Study Area

The Bear River watershed, within the confines of the RSA, extends 24 km from the estuary at Stewart to a short distance above the American Creek confluence. Within this distance, the channel width varies between 30 m to approximately 470 m, with the valley flat measuring close to 1,300 m at its widest point downstream of the Bitter Creek confluence.

The mainstem of Bear River is a wide, shallow channel that exhibits braiding and anastomosing on the ascending and descending shoulders of the hydrograph. Similar to Bitter Creek, Bear River experiences relatively high turbidity as a consequence of its glacial origins, frequency of torrent, avalanche, and mass wasting events. American and Bitter creeks represent the two most significant tributaries contributing perennial flows to Bear River.

The Bear River mainstem receives inflow from many tributaries along its length from the outlet of Bear Lake downstream to its mouth and estuary at the top of Portland Canal. Its right bank along the western side has a high density of tributaries draining that range, with American Creek being the most significant. The left bank tributaries are fewer in number; however, Bitter Creek, its most significant tributary, drains from the east.

18.4.4.2 Fish Communities

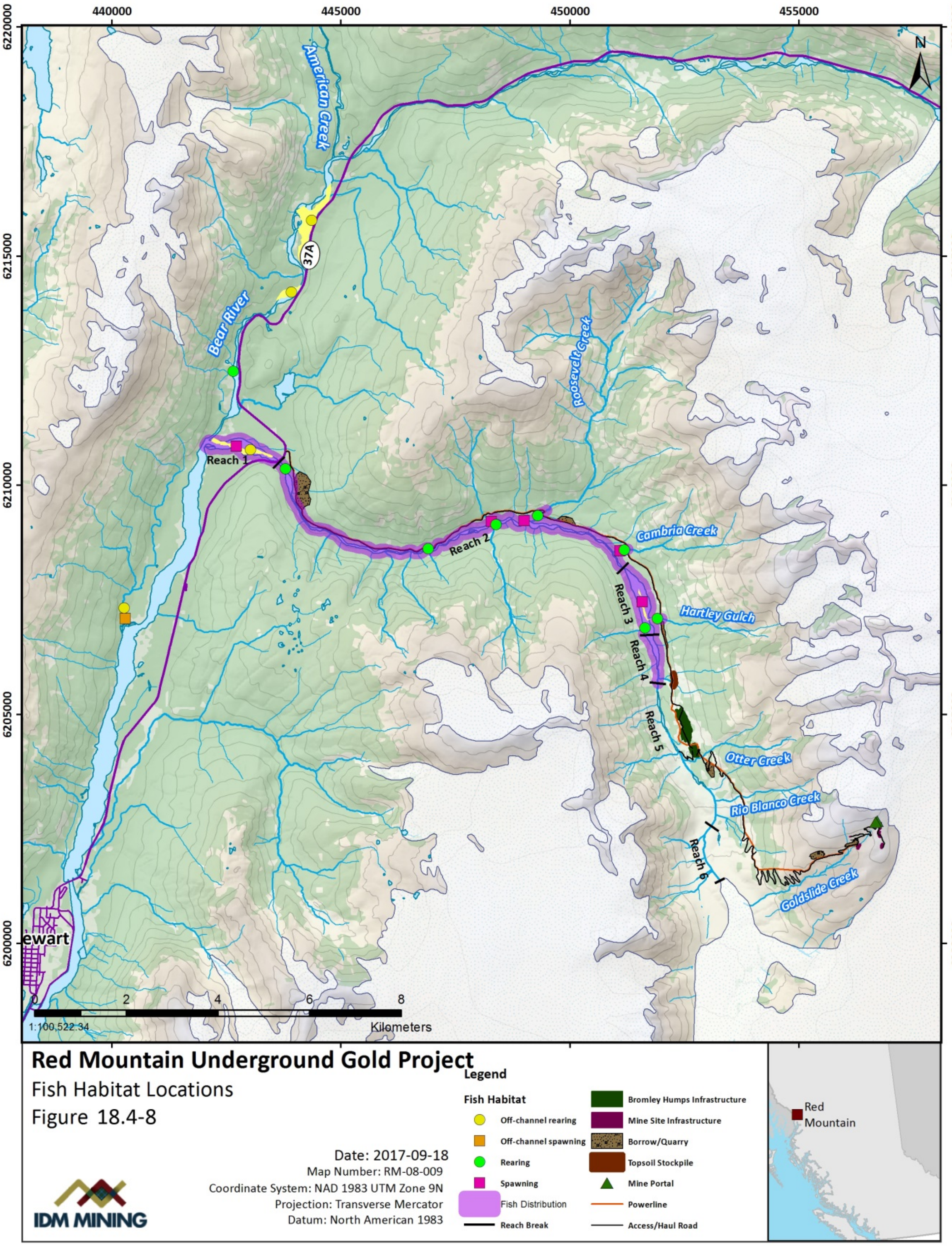
Fish known to be presence in the Project area are present in Table 18.4-1 and fish habitat utilization is in Figure 18.4-8.

Table 18.4-1: Fish Species Documented in the Red Mountain Project Area

Fish Common Name	Fish Latin Name	Presence	LSA/RSA	CRA Fishery?
Dolly Varden	*Salvelinus malma*	Observed in Bear River, Bitter Creek	LSA/RSA	Yes
Coho Salmon	*Oncorhynchus kisutch*	Observed in Bear River	RSA	Yes
Chinook Salmon	*O. tshawytscha*	Observed in Bear River	RSA	Yes
Chum Salmon	*O. keta*	Documented in Bear River	RSA	Yes
Pink Salmon	*O. gorbuscha*	Documented in Bear River	RSA	Yes
Steelhead	*O. mykiss*	Documented in Bear River	RSA	Yes
Rainbow Trout	*O. mykiss*	Documented in Bear River	RSA	Yes
Eulachon	*Thaleichthys pacificus*	Documented in Bear River	RSA	Yes
Coastrange Sculpin	Cottus aleuticus	Observed in Bear River, Bitter Creek	LSA/RSA	No

Although not documented in the provincial fisheries database, Eulachon were reported in the upper estuary of Bear River, and the lower mainstem downstream of the Highway 37A bridge by Cleugh (1979) and Noble *et al.* (2015), respectively. In a report to the Harbours Board, Cleugh (1979) reported recovering adult Eulachon at three sampling locations in the upper estuary of the Bear River. In the Bear River Eulachon Assessment, undertaken jointly by LGL Ltd. and Nisga'a Fisheries (Noble *et al.* 2015), the occurrence of adult spawners downstream of the highway bridge is reported. Anecdotal information suggests Eulachon runs were large up until the mid-2000's but had declined significantly in the past decade with gravel extraction and beaver activity believed to be the cause for the decreases on the Bear River (Noble *et al.* 2015).

Figure 18.4-8: Overview of Fish Habitat Utilization



18.4.4.2.1 Bitter Creek – Dolly Varden Habitat Utilization

Dolly Varden reside throughout the fish bearing areas of Bitter Creek. Habitat utilization for spawning, rearing, overwintering, and migration, is discussed in Appendix 18-A, for specific areas with the Bitter Creek watershed (e.g. where tributary inflows occur), and is summarized here for the habitat descriptions provided in Section 18.4.3.4.1.

Spawning

Dolly Varden spawning habitat is typically characterized by perennial groundwater springs which provide adequate oxygen and suitable temperatures for adult and juvenile survival, and egg incubation during the cold winter months (COSEWIC, 2011).

In Bitter Creek, adult Dolly Varden spawn in October/November. Spawning areas identified during baseline studies are located where the tributaries (namely Hartley Gulch, Roosevelt Creek, and Cambria Creek) enter Bitter Creek. The tributaries provide clear water to the Bitter Creek, which improves the suitability of these areas for spawning. Spawning habitat downstream of the mouth of Hartley Gulch, in the flat section along Bitter Creek's right bank was noted as excellent based on substrate composition (gravel/cobble) and the flushing influence of the clear water from Hartley Gulch. Spawning areas were also noted in lower Bitter Creek, downstream of the Highway 37A Bridge.

Rearing

Juvenile Dolly Varden rear seek out shallow slower-moving areas with clearer water and adequate cover (COSEWIC, 2011). They feed primarily on aquatic insect larvae (COSEWIC, 2011). In Bitter Creek, moderate rearing opportunities are present downstream of the mouth of Hartley Gulch, in the flat section along Bitter Creek's right bank, during low flows in Bitter Creek.

The north fork of Cambria Creek was noted as providing excellent rearing habitat, in the form of a sinuous, small cobble-dominated, step-pool stream, with substantial and complex in-stream and riparian cover. However, access to this area is limited during low flows.

Good rearing habitat was also noted near the confluence of Roosevelt Creek with Bitter Creek, where gradients are relaxed, finer spawning sediments exist, and woody debris and riparian vegetation provide cover.

Overwintering

Overwintering habitat is limiting in the Bitter Creek watershed and was characterized as poor to absent throughout. As for spawning, Dolly Varden overwintering habitat is typically associated with perennial groundwater upwelling (COSEWIC, 2011).

18.4.4.2.2 Fish Species Composition, Abundance and Distribution

Bitter Creek

Fish sampling in Bitter Creek during 1993-1994 and 2014-2016 detected only two fish species in Bitter Creek: Dolly Varden and Coastrange Sculpin. Within Bitter Creek, Dolly Varden distribution extends from its confluence upstream to the most downstream of the seven barriers in Reach 5 with abundance relatively constant between summer and fall months, decreasing to almost zero during winter. Sculpins were noted during one sampling event (2015) in the lower section of Bitter Creek's first reach immediately adjacent to the mainstem of the Bear River.

Although the Bitter Creek valley is steep-sided, a few of its tributaries can provide short lower sections with channel gradients accessible to Dolly Varden. Hartley Gulch and Roosevelt and Cambria creeks are the most notable of these. Fishing data suggests a late summer emigration of Dolly Varden from Roosevelt Creek followed by a late fall immigration. The absence of mature fish during fall and winter suggests that little to no spawning activity occurs in Roosevelt Creek. The other creeks that directly connect to Bitter Creek but are otherwise inaccessible to fish, provide clear water to the Bitter Creek mainstem at their confluence where Dolly Varden were observed. The majority of Bitter Creek fish were found in the tributaries or in Bitter Creek's channel margins directly under the influence of tributary flow where water was clear or sediment loads were significantly less than those observed in the Bitter Creek mainstem channel. The Bitter Creek mainstem channel provides limited habitat due to its elevated turbidity, high current velocities, and negligible refugia.

Bear River Watershed

Fish species in the Bear River watershed include Dolly Varden, Coho, Chum, Pink, Sockeye and Chinook salmon, Steelhead, Eulachon, and Coastrange Sculpin. In 2014-2016, upstream of the RSA in the Bear mainstem, Coho and Dolly Varden were documented. Other species documented as occurring within the RSA included Rainbow Trout and Steelhead, whose presence is noted a short distance downstream of the American Creek confluence with Bear River as well as in the Bear River estuary at the terminal end of Portland Canal south of Stewart. The provincial Fisheries Inventory Summary System (FISS) records also indicate the presence of Chum and Pink salmon in the lower Bear River adjacent to the Stewart airport and upstream about 5 km along the left bank adjacent to Highway 37A. Given the spawning behaviour of both these species, it is reasonable to assume they may be present as far upstream as the mouth of American Creek, as river patterns and flow change little between their most upstream recorded distribution and this location. Above American Creek, the Bear mainstem narrows considerably and current velocity may preclude these species from ascending further. Coho and Dolly Varden are present in American Creek. The absence of barriers and unchanging river morphology and flow patterns immediately upstream of the sample points suggest that these species are able to ascend further in this system.

Below American Creek, Dolly Varden, Coho, Coastrange Sculpin, and Chinook were all observed at various locations during 2014-2016 sampling. Chinook were observed in the lowest numbers, although similar habitat was noted above its most upstream observed location, and therefore its presence should also be assumed at least to the American Creek confluence. Coastrange Sculpin exhibit a wide range of habitat preferences and despite their reported high site fidelity, it is reasonable to assume that their distribution in this system extends beyond the limits of the RSA within the Bear River mainstem. Dolly Varden, Coho and Coastrange Sculpin were also all observed at various locations during 1993-1994 sampling. Dolly Varden and Coho were observed during summer and fall sampling with highest abundance for both species occurring during the summer. Coastrange Sculpin were only observed during summer sampling.

Sample sites for Eulachon spawners and larvae were established in May 2016. Eulachon were not observed from sampling efforts in the mainstem of the Bear River in 2016 nor were Eulachons of any life stage observed while crews were on-site.

18.4.4.2.3 Size, Age and Condition

Bitter Creek

Dolly Varden captured in the Bitter Creek from the 1993-1994 surveys ranged from 0+ to 4+ years old. Condition factors for most fish fell within the normal range of 0.7 to 1.5, a healthy shape for salmonids. Age class of Dolly Varden captured in the Bitter Creek from the 2014-2016 surveys ranged from the 1 to 4 years with no apparent difference in size and weight compared to fish captured in Bear River.

Bear River Watershed

Coho and pink salmon juveniles captured in the Bear River from the 1993-1994 surveys were all 1+ years old and were likely migrating seaward. Average size for Coho was 7.6 cm and 4.9 g with condition factors indicating that the juveniles were in healthy shape. Age class of Dolly Varden captured in the Bitter Creek from the 2014-2016 surveys ranged from the 1 to 5 years with no apparent difference in size and weight compared to fish captured in Bitter Creek.

18.4.4.2.4 Tissue Metal Concentration

Dolly Varden tissues at seven sites in 2014 were analyzed for select metal concentrations. For all Dolly Varden tissue samples, mean estimated methylmercury concentrations calculated using a conservative estimate of 100% conversion, were well below the guideline for the protection of piscivorous wildlife for all sample sites. Total mercury guidelines were not exceeded by any Dolly Varden tissue samples. Total mercury tissue concentrations were also well below Health Canada mercury guidelines, which ranged from 0.2 mg/kg for subsistence consumers to 0.5 mg/kg. Mean selenium concentrations in Dolly Varden tissues at all samples sites fell well below the selenium guidelines for the protection of freshwater aquatic life, which were updated in spring 2014 (BC MOE 2014). The mean tissue selenium concentrations also did not surpass the human health guidelines for selenium for any sample site, and no sample exceeded health selenium guidelines for high, medium and low fish diets.

Bitter Creek

Selected metal concentrations in Dolly Varden tissues were collected in 2014 at three sites along Bitter Creek (BR01, CA01 and BR04), one site along Roosevelt Creek (RC02) and one site along American Creek (AC01). Mean metal concentrations for the aforementioned sites are summarized in Fish Habitat Field Data Collection for the Red Mountain Project, 1990-2017 Table 18.4-2. Bitter Creek Dolly Varden tissue metals concentration was also sampled in 1994.

Overall, Bitter Creek BC01 site, the furthest downstream of the three sites along Bitter Creek, had the highest mean concentrations for four analytes: antimony, arsenic, cobalt and nickel. The Bitter Creek CA01 site had the highest mean concentrations of calcium and selenium. Bitter Creek BC04 site, the most upstream of the three sites on Bitter Creek, had the highest concentrations of molybdenum and sodium. The 2014 Bitter Creek sample concentrations for selected metals were in the range of values observed in 1994. The Roosevelt Creek (RC02) site had the highest mean concentrations for tin, and the American Creek site (AC01) demonstrated the highest overall mean tissue metal concentrations for only a single analyte, potassium.

Table 18.4-2: Selected Total Metal Concentrations in Dolly Varden Muscle tissue, Bitter Creek Watershed, Red Mountain Project, 2014.

Analyte	Units	Bitter Creek						Roosevelt Creek		American Creek	
		BC01 (n=8)		CA01 (n=8)		BC04 (n=8)		RC02 (n=8)		AC01 (n=8)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Moisture	% wet	74.5	1.1	75.7	0.7	75.4	1.8	74.4	0.9	75.8	1.1
Aluminum	mg/kg	24.3	19.6	8.4	8.3	12.1	13.1	21.5	32.3	38.0	35.6
Antimony	mg/kg	0.044	0.043	0.007	0.007	0.011	0.008	0.009	0.006	0.009	0.006
Arsenic	mg/kg	1.859	3.483	0.101	0.059	0.136	0.064	0.086	0.033	0.160	0.104
Barium	mg/kg	1.54	0.66	0.96	0.38	0.72	0.36	2.00	0.77	4.49	2.60
Beryllium	mg/kg	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.000
Bismuth	mg/kg	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00
Boron	mg/kg	0.05	0.0	0.05	0.0	0.05	0.0	0.05	0.0	0.2	0.1
Cadmium	mg/kg	0.167	0.069	0.077	0.027	0.597	0.361	0.128	0.038	0.086	0.055
Calcium	mg/kg	4913	1368	6303	3050	4536	2370	3618	1224	4528	1556
Chromium	mg/kg	0.06	0.03	0.03	0.02	0.05	0.03	0.10	0.13	0.03	0.02
Cobalt	mg/kg	0.271	0.119	0.171	0.040	0.128	0.040	0.106	0.039	0.156	0.077
Copper	mg/kg	1.22	0.44	1.06	0.33	1.22	0.60	1.16	0.30	1.38	0.56
Iron	mg/kg	116	95	43	29	56	40	73	79	158	127
Lead	mg/kg	0.223	0.344	0.038	0.028	0.031	0.024	0.070	0.038	0.094	0.069
Magnesium	mg/kg	293	22	296	49	287	31	283	25	301	34
Manganese	mg/kg	4.69	1.85	2.93	1.16	2.63	1.36	4.84	1.99	6.78	3.27
Mercury	mg/kg	0.007	0.001	0.007	0.001	0.007	0.003	0.009	0.001	0.011	0.002
Methylmercury[a]	mg/kg	0.007	0.001	0.007	0.001	0.007	0.003	0.009	0.001	0.011	0.002
Molybdenum	mg/kg	0.03	0.01	0.02	0.01	0.10	0.20	0.02	0.01	0.04	0.04

Analyte	Units	Bitter Creek						Roosevelt Creek		American Creek	
		BC01 (n=8)		CA01 (n=8)		BC04 (n=8)		RC02 (n=8)		AC01 (n=8)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Nickel	mg/kg	0.19	0.18	0.07	0.03	0.13	0.07	0.06	0.06	0.04	0.02
Phosphorus	mg/kg	4439	625	5079	1583	4268	1118	3975	588	4594	855
Potassium	mg/kg	3530	191	3619	234	3639	134	3843	160	3875	141
Selenium[b]	mg/kg	1.58	0.28	2.35	0.88	2.21	0.27	1.12	0.26	0.91	0.12
Silver	mg/kg	0.005	0.00	0.005	0.00	0.005	0.00	0.005	0.00	0.005	0.00
Sodium	mg/kg	767	40	818	128	891	124	780	29	866	74
Strontium	mg/kg	4.64	1.22	5.63	2.70	4.14	2.26	3.46	1.21	4.51	1.61
Thallium	mg/kg	0.011	0.001	0.011	0.003	0.020	0.008	0.012	0.002	0.006	0.001
Tin	mg/kg	0.01	0.00	0.01	0.00	0.01	0.00	0.03	0.01	0.01	0.00
Titanium	mg/kg	0.95	0.63	0.46	0.25	0.42	0.26	0.49	0.22	1.25	0.76
Uranium	mg/kg	0.007	0.010	0.0005	0.000	0.002	0.001	0.002	0.001	0.004	0.002
Vanadium	mg/kg	0.12	0.09	0.05	0.03	0.09	0.07	0.09	0.13	0.15	0.13
Zinc	mg/kg	29.3	7.3	30.9	5.5	30.0	7.9	22.9	3.3	26.7	4.2

Notes:
All units are mg/kg wet weight unless otherwise specified
SD=Standard deviation, sample size (n) = 8, * Reference sites
Health Canada mercury guidelines range from 0.2-0.5 for subsistence consumers (Health and Welfare Canada 1979) and maximum allowable level for sale (Canadian Food Inspection Agency 2011), respectively
Canadian Council of Ministers of the Environment tissue residue guideline (CCME 2000) to protect piscivorous wildlife from methylmercury toxicity is 0.033 mg/L.
British Columbia Ministry of Environment aquatic life (whole-body) selenium guideline (BC MOE 2014) for the protection of freshwater aquatic life is 4.0 mg/kg dry weight.
British Columbia Ministry of Environment human consumption selenium screening values for low (0.03 kg/day), medium (0.11 kg/day), and high (0.22 kg/day) fish intake (BC MOE 2014)
[a]Methylmercury is estimated based on 100% of total mercury (Bloom 1992)
[d]Selenium is reported in mg/kg dry weight

Bear River Watershed

Selected metal concentrations in Dolly Varden tissues were collected in 2014 at two Bear River sites (BR08 and BR01). Mean metal concentrations for Bear River are summarized in Table 18.4-3.

Overall, the Bear River BR08 site demonstrated the highest overall mean tissue metal concentrations for 13 analytes: aluminum, barium, beryllium, cadmium, iron, lead, manganese, mercury, silver, thallium, titanium, uranium, and vanadium. The Bear River BR 01 site had the highest mean tissue metal concentrations for five analytes: copper, magnesium, phosphorus, strontium, and zinc.

Table 18.4-3: Selected Total Metal Concentrations in Dolly Varden Muscle Tissue, Bear River Watershed, Red Mountain Project, 2014.

Analyte	Units	Bear River			
		BR01 (n=8)		BR08 (n=8)	
		Mean	SD	Mean	SD
Moisture	% wet	76.0	1.0	76.3	1.6
Aluminum	mg/kg	48.2	59.3	104.9	183.0
Antimony	mg/kg	0.016	0.018	0.032	0.048
Arsenic	mg/kg	0.600	0.365	0.511	0.605
Barium	mg/kg	2.38	1.27	6.80	10.26
Beryllium	mg/kg	0.001	0.000	0.004	0.006
Bismuth	mg/kg	0.01	0.00	0.01	0.00
Boron	mg/kg	0.05	0.0	0.2	0.1
Cadmium	mg/kg	0.167	0.097	0.714	0.652
Calcium	mg/kg	6020	2925	3504	1782
Chromium	mg/kg	0.10	0.12	0.10	0.14
Cobalt	mg/kg	0.164	0.091	0.256	0.270
Copper	mg/kg	1.67	0.55	1.10	0.81
Iron	mg/kg	143	157	389	670
Lead	mg/kg	0.109	0.134	0.737	0.907
Magnesium	mg/kg	353.5	72	327	111
Manganese	mg/kg	5.94	4.09	15.30	21.38
Mercury	mg/kg	0.013	0.009	0.017	0.004
Methylmercury[a]	mg/kg	0.013	0.009	0.017	0.004
Molybdenum	mg/kg	0.03	0.02	0.04	0.04
Nickel	mg/kg	0.13	0.14	0.10	0.15
Phosphorus	mg/kg	5341	1513	3758	1019
Potassium	mg/kg	3795	203	3708	174

Analyte	Units	Bear River			
		BR01 (n=8)		BR08 (n=8)	
		Mean	SD	Mean	SD
Selenium[b]	mg/kg	1.37	0.39	0.96	0.20
Silver	mg/kg	0.005	0.00	0.02	0.02
Sodium	mg/kg	853	82	836	43
Strontium	mg/kg	7.36	2.87	4.30	1.86
Thallium	mg/kg	0.015	0.007	0.030	0.011
Tin	mg/kg	0.01	0.00	0.01	0.00
Titanium	mg/kg	1.30	1.16	3.62	5.35
Uranium	mg/kg	0.002	0.002	0.009	0.013
Vanadium	mg/kg	0.20	0.22	0.49	0.85
Zinc	mg/kg	33.1	7.5	32.9	8.7

Notes:
All units are mg/kg wet weight unless otherwise specified
SD=Standard deviation, sample size (n) = 8, * Reference sites
Health Canada mercury guidelines range from 0.2-0.5 for subsistence consumers (Health and Welfare Canada 1979) and maximum allowable level for sale (Canadian Food Inspection Agency 2011), respectively
Canadian Council of Ministers of the Environment tissue residue guideline (CCME 2000) to protect piscivorous wildlife from methylmercury toxicity is 0.033 mg/L.
British Columbia Ministry of Environment aquatic life (whole-body) selenium guideline (BC MOE 2014) for the protection of freshwater aquatic life is 4.0 mg/kg dry weight.
British Columbia Ministry of Environment human consumption selenium screening values for low (0.03 kg/day), medium (0.11 kg/day), and high (0.22 kg/day) fish intake (BC MOE 2014)
[a]Methylmercury is estimated based on 100% of total mercury (Bloom 1992)
[d]Selenium is reported in mg/kg dry weight

18.4.4.2.5 Fish Diet

Bitter Creek

Analysis of fish stomach contents (*i.e.* diet) of Dolly Varden in 1993-1994 found that benthic invertebrates from the order Diptera (flies) formed approximately 50% of stomach contents of sampled fish. This order of invertebrates is generally least sensitive to disturbance, and the readily available prey in the benthos.

18.4.4.2.6 Species at Risk

While there are no fish species in the Project area that have formal designation in the *Species At Risk Act*, Bear River Eulachon are Blue-Listed in the province of BC and are designated as having "Special Concern" by the COSEWIC. No invertebrate species at risk are known to be present in the Project area.

18.5 Potential Effects

18.5.1 Methods

Activities associated with the Project have the potential to cause adverse effects to Fish and Fish Habitat in the downstream fish-bearing reaches of Bitter Creek and Bear River. Effects were assessed in relation to planned discharges, runoff, atmospheric deposition, and instream works for all mine components using project interaction matrices (Section 18.5.2). Once links between mine components and project interactions were identified, key potential effects were discussed in terms of potential pathways of effects to Fish and Fish Habitat (Section 18.5.3).

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

18.5.2 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 Fish and Fish Habitat VCs. Evaluation of the interaction matrix led to identification of potential effects (Table 18.5-1).

Table 18.5-1: Potential Project Interactions, Fish and Fish Habitat

Project Component/Activity	Dolly Varden	Bull Trout	Eulachon	Salmonid Species	Fish Habitat	Potential Effect / Pathway of Interaction with Fish and Fish Habitat
Construction Phase						
Workforce (including employment of staff and contractors)	X	X				Potential increased fishing pressure due to increased access and increased presence in the Bitter Creek valley.
Construct Access Road and Haul Road from Hwy 37A to the Upper Portal	X	X	X	X	X	Changes in water and sediment chemistry from erosion, sedimentation and dust deposition; direct mortality from mine footprint and associated infrastructure; habitat loss from mine footprint development and associated infrastructure; habitat loss from changes to streamflow and channel morphology; direct mortality from increased fishing pressure.
Install powerline from substation tie-in to the Lower Portal laydown area	X	X			X	Changes to surface water quality as a result of erosion and sedimentation, dust deposition.
Discharge of water from underground workings at the Mine Site	X	X	X	X	X	Changes to surface water quality as a result of mine water discharge; habitat loss from changes in streamflow.
Water withdrawal for the purposes of dust suppression and construction use (primarily contact water management ponds; secondarily Bitter Creek, Goldslide Creek, and Otter Creek) and to meet freshwater needs (Otter Creek, Goldslide Creek)	X	X			X	Habitat loss from changes to streamflow.
Clear and prepare the TMF basin and Process Plant site pad	X	X			X	Direct mortality and habitat loss due to mine footprint development and associated infrastructure; changes to water and sediment chemistry from 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)	X	X			X	Changes in water and sediment chemistry from erosion, sedimentation and dust deposition.

Project Component/Activity	Dolly Varden	Bull Trout	Eulachon	Salmonid Species	Fish Habitat	Potential Effect / Pathway of Interaction with Fish and Fish Habitat
Establish water management facilities including diversion ditches for the TMF and Process Plant	X	X			X	Changes in water and sediment chemistry from erosion, sedimentation and dust deposition.
Construct the TMF	X	X			X	Changes in water and sediment chemistry from erosion, sedimentation and dust deposition.
Construct the Process Plant and Run of Mine Stockpile location	X	X			X	Changes in water and sediment chemistry from erosion, sedimentation and dust deposition.
Construct water treatment facilities and test facilities at Bromley Humps	X	X			X	Changes in water and sediment chemistry from erosion, sedimentation and dust deposition.
Construct Bromley Humps ancillary buildings and facilities	X	X			X	Changes in water and sediment chemistry from erosion, sedimentation and dust deposition.
Commence milling to ramp up to full production	X	X			X	Changes in water and sediment chemistry from erosion, sedimentation and dust deposition.
Operation Phase						
Workforce (including employment of staff and contractors)	X	X				Potential increased fishing pressure due to increased access and increased presence in the Bitter Creek valley.
Use Access Road for personnel transport, haulage, and delivery of goods	X	X	X	X	X	Changes in surface water and sediment chemistry from erosion, sedimentation and dust deposition.
Maintain Access Road and Haul Road, including grading and plowing as necessary	X	X	X	X	X	Changes in surface water and sediment chemistry from erosion, sedimentation and dust deposition.
Maintain powerline right-of-way from substation tie-in to portal entrance, including brushing activities as necessary	X	X			X	Changes in surface water and sediment chemistry from erosion, sedimentation and dust deposition.
Discharge of water from underground facilities	X	X	X	X	X	Changes in surface water and sediment chemistry from mine discharge; habitat loss from changes to streamflow.
Extract ore from the underground load-haul-dump and transport to Bromley Humps to Run of Mine Stockpile (ore transport and storage)	X	X			X	Changes in surface water and sediment chemistry from erosion, sedimentation and dust deposition.

Project Component/Activity	Dolly Varden	Bull Trout	Eulachon	Salmonid Species	Fish Habitat	Potential Effect / Pathway of Interaction with Fish and Fish Habitat
Freshwater for the Process Plant will be obtained through water withdrawal from Bitter Creek	X	X			X	Habitat loss from changes to streamflow.
Treat and discharge, as necessary, excess water from the TMF	X	X	X	X	X	Changes in hydrology, and water and sediment chemistry from TMF discharges.
Progressively reclaim disturbed areas no longer required for the Project	X	X			X	Changes in surface water and sediment chemistry from erosion and sedimentation.
Closure and Reclamation Phase						
Workforce (including employment of staff and contractors)	X	X				Potential increased fishing pressure due to increased access and increased presence in the Bitter Creek valley.
Use and maintain Access Road for personnel transport, haulage, and removal of decommissioned components until road is decommissioned and reclaimed.	X	X	X	X	X	Changes in surface water and sediment chemistry from erosion, sedimentation and dust deposition.
Decommission underground infrastructure	X	X			X	Changes in surface water and sediment chemistry from erosion, sedimentation and dust deposition.
Flood underground	X	X	X	X	X	Changes in hydrology, and water and sediment chemistry from mine discharges.
Decommission and reclaim Lower Portal Area and Powerline	X	X			X	Changes in surface water and sediment chemistry from erosion, sedimentation and dust deposition.
Decommission and reclaim Haul Road	X	X			X	Changes in surface water and sediment chemistry from erosion, sedimentation and dust deposition.
Decommission and reclaim all remaining mine infrastructure (Mine Site and Bromley Humps, except TMF) in accordance with Closure Plan	X	X			X	Changes in surface water and sediment chemistry from erosion, sedimentation and dust deposition
Construct the closure spillway	X	X			X	Changes in surface water and sediment chemistry from erosion, sedimentation and dust deposition
Treat and discharge water from the TMF	X	X	X	X	X	Changes to surface water quality as a result of discharge, erosion and sedimentation, and dust deposition

Project Component/Activity	Dolly Varden	Bull Trout	Eulachon	Salmonid Species	Fish Habitat	Potential Effect / Pathway of Interaction with Fish and Fish Habitat
Conduct maintenance of mine drainage, seepage, and discharge	X	X	X	X	X	Changes in hydrology, and water and sediment chemistry from discharges
Remove discharge water line and water treatment plant	X	X			X	Changes in surface water and sediment chemistry (due to filling of the TMF and discharge via the closure spillway)
Decommission and reclaim Access Road	X	X	X	X	X	Changes in surface water and sediment chemistry from erosion, sedimentation and dust deposition
Post-Closure Phase						
Flood underground	X	X	X	X	X	Changes to surface water quality as a result of ML/ARD and groundwater interaction

*The potential interactions identified between the Project components / activities and two Fish VCs (Salmonid Species and Eulachon) only relate to the Access Road (construction, use, maintenance, decommissioning) and to discharges from the Mine Site and TMF.

18.5.3 Discussion of Potential Effects

Potential effects to Fish and Fish Habitat may occur through various pathways during the life of the Project. These pathways, if unmitigated, can lead to adverse effects on Fish and Fish Habitat. The effects through these pathways would vary in terms of severity, with some effects causing direct mortality of fish, while others cause sub-lethal effects that lead to a reduction in the health of the fish. For the purposes of the Fish and Fish Habitat assessment, the potential effects were classified under the following categories, which represent all of the possible pathways that could lead to a reduction in the quality and quantity of Fish and Fish Habitat. Furthermore, these categories draw on predictive analyses conducted for other VCs, such as Surface Water Quality, to provide predictions of potential effects on Fish and Fish Habitat. There were no interactions that were excluded from assessment of potential effects.

The categories are:

- Habitat loss;
- Increased Fishing Pressure;
- Change in Aquatic Resources;
- Change in Surface Water Quality;
- Change in Sediment Quality;
- Changes in Streamflows; and
- Blasting.

18.5.3.1 Habitat Loss

There will be no Fish Habitat loss under the mine infrastructure in Bromley Humps or the Mine Site because there are no fish bearing watercourses within these areas. Loss of non-fish bearing aquatic habitat is described in the effect assessment for Aquatic Resources (Volume 3, Chapter 17).

There will be no instream loss of Fish Habitat at watercourse crossings along the road, because only two crossings, Roosevelt Creek and Hartley Gulch, are fish bearing and these will be facility via clearspan bridges. No fish habitat loss is associated with clearspan bridges, as there is no instream infrastructure required for this type of crossing.

There is potential for Fish Habitat loss where infilling for the Access Road is required within the Bitter Creek channel. The proposed road alignment along the North/North East bank of Bitter Creek follows an abandoned existing road at the toe of steep hillside on the North side of Bitter Creek. To avoid destabilizing sensitive slopes and putting road users and workers in an unsafe position, portions of the road will encroach on the Bitter Creek channel.

Sections of the existing road were washed away during a flood event in 2011, and therefore upgrading of the road along its original alignment requires construction within the channel formed during the 2011 flood. However, the 2011 flood was a 1-in-25 to 1-in-100 year event, and therefore some of the areas where the road construction is proposed are very rarely wetted and well above the annual high water level.

One 150 m section of the Access Road requires realignment of Bitter Creek at the toe of a weak fractured bedrock face. The works involve realignment of the Bitter Creek channel towards the South/South East bank, and construction of a road prism along North/North East bank, with bank armouring. Approximately 1.14 ha of habitat will be altered, however no net loss of habitat is expected, because the existing channel can accommodate the annual range of flows, and realignment of the creek will not reduce average channel width.

Loss of riparian habitat is also anticipated along the Access Road. Potential effects from riparian habitat loss include a slightly lowered capacity for stream temperature regulation, reduced quantities of instream cover, and lowered nutrient and food inputs into the stream.

18.5.3.2 Increased Fish Pressure

Project personnel or their families, including contractors and sub-contractors, living in Stewart may choose to engage in recreational fishing, which might result in increased pressure on CRA Fisheries resources. Increased fishing pressure could also arise due to greater accessibility provided by the restored Access Road, although use of this industrial road will be tightly controlled for safety reasons. Unauthorized use will not be permitted. Currently, recreational fishing in the Bear River and its tributaries is not permitted. No adverse effect is expected on recreational fisheries due to increased fishing pressure.

While Aboriginal fisheries are not known to take place currently on the Bear River or Bitter Creek, Nisga'a citizens and other Aboriginal people could potentially exercise their Treaty or Aboriginal right to fish, particularly for Eulachon on the lower reaches of the Bear River, in the future. The Eulachon fishery is a culturally and historically significant fishery for many west coast Aboriginal societies. Eulachon are not widely sought after by non-Aboriginal fishers and, while the number of Aboriginal people who might choose to move to Stewart because of business and employment opportunities is not known, it is not expected to be large. Subsequently, there is no evidence to suggest that there will be additional pressure on the Eulachon fishery due to a population increase in Stewart.

Further details on fishing pressure are found in Volume 3, Chapter 19 (Economic Effects Assessment).

18.5.3.3 Change in Aquatic Resources

Potential effects to Aquatic Resources (benthic invertebrates and periphyton) may occur through various pathways during the life of the Project, including habitat loss, changes in water and sediment quality, and changes in streamflow. The mechanisms through which these pathways lead to changes in Aquatic Resources are addressed in Chapter 17. This section discusses the next effect along the pathway, which is on Fish and Fish Habitat *i.e.* the indirect effects of aquatic habitat loss, changes in water and sediment quality, and streamflow, on Fish and Fish Habitat, because they occur via Aquatic Resources.

As periphyton and benthic invertebrates are primary and secondary producers respectively, they form the basis of the aquatic food web, and changes to these organisms can cause cascading trophic effects in the aquatic ecosystem that supports fish. Benthivorous fish success is coupled with benthic invertebrate abundance, and benthic invertebrate success is often based on an abundant and diverse periphyton community.

Reduction in periphyton or benthic invertebrate abundance reduces the available food for fish, which can cause a reduction in fish populations (productivity), and/or a shift in fish size distribution (for example, smaller maximum size of fish). Changes in benthic invertebrate community composition or diversity can also affect fish, even if the overall abundance of benthic invertebrate remains stable. Fish may have a preference for specific invertebrate prey, but if this prey species becomes less abundant and is out-competed by a benthic invertebrate species that is more suited to the altered conditions, fish may have to adapt their feeding habits in response. Another potential change to Aquatic Resources is increased in metal concentrations in benthic tissue, which, when fed on by fish, causes increased bioaccumulation in the food chain.

The effects assessment for Aquatic Resources (Volume 3, Chapter 17), determined that effects to Aquatic Resources are limited primarily to Goldslide Creek, from changes in water quality, sediment quality, and streamflows. Goldslide Creek is non-fish bearing, and flows to the Bromley Glacier, approximately 5 km from the upstream limit of fish distribution in Bitter Creek. Benthic drift from Goldslide Creek past the Bromley Glacier and downstream into Bitter Creek fish bearing reaches is unlikely to occur, and if it did occur, it would not constitute a significant proportion of the food and nutrient inputs, because Goldslide Creek only contributes about 1-2% of the total flow in Bitter Creek (at BC06) in any given month.

Effects to Aquatic Resources in Bitter Creek within fish bearing reaches arise from relatively small changes in water quality, sediment quality and streamflow and were assessed as low magnitude. Changes in benthic invertebrate abundance in Bitter Creek are not expected to affect food availability for fish because changes will be minor. Analysis of fish stomach contents (*i.e.* diet) of Dolly Varden in 1993 to 1994 found that benthic invertebrates from the order Diptera (flies) formed approximately 50% of stomach contents of sampled fish. This order of invertebrates is generally least sensitive to disturbance. The more recent baseline studies (2014 to 2016) found that Bitter Creek has low benthic invertebrate abundance (typically less than a hundred individuals per sample), and the benthic samples were dominated by benthic invertebrates from the order Plecoptera, which is sensitive to disturbance.

The effects assessment for Aquatic Resources (Chapter 17), indicates that there are no residual effects on Aquatic Resources in Bear River. Accordingly, there no potential effects on fish populations of the Bear River from changes in Aquatic Resources.

18.5.3.4 Change in Surface Water Quality

Potential effects to Fish from changes in Surface Water Quality arise if fish are exposed to water borne contaminants. Potential effects to Fish Habitat due to Changes in Surface Water Quality arise through changes in Sediment Quality and in Aquatic Resources, which, along with water, are key components of Fish Habitat. Changes to Sediment Quality and

Aquatic Resources are discussed as separate categories of potential effects in Sections 18.5.3.3 and 18.5.3.5, respectively. These components of Fish Habitat are also assessed as separate VCs in Chapters 14 (Sediment Quality) and (Aquatic Resources).

The following pathways to physical and chemical changes to water quality are described in Volume 3, Chapter 13, and are discussed here in the context of potential effects on the Fish and Fish Habitat VCs (Table 18.5-2):

- 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), Total Suspended Solids (TSS), and water hardness. Each of these components of water quality, and the interaction with Fish and Fish Habitat, is summarized in Table 18.5-2.

Table 18.5-2: Water Quality Components and Interactions with Fish and Fish Habitat

Water Quality Component	Description	Project Activity/Pathway	Potential Effect on Fish and Fish Habitat from Change in Water Quality Component
pH	Acid-base balance of water 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	Acidification of surface waters can shift the pH outside the tolerance range of aquatic species. Sudden shifts in pH associated with runoff events can cause direct mortality in aquatic organisms. Acidification of receiving waters can also increase metal mobility and bioavailability in the aquatic environment.
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	Increased dissolved metals can cause toxic responses in aquatic organisms. In general, acids and metals introduction into aquatic environments can result in decreased growth and diversities of primary producer and secondary communities, which may affect food availability to fish; as well as direct toxicity.

Water Quality Component	Description	Project Activity/Pathway	Potential Effect on Fish and Fish Habitat from Change in Water Quality Component
TSS	Quantity of suspended material in the water column.	Works in or near water, discharge, runoff (*e.g.*, from ford crossings), aerial deposition	Reduction in water clarity and increased suspended particle loads alters light penetration and intensity thereby effecting rates of primary productivity of benthic aquatic organisms, which may affect food availability for fish; Increased suspended sediments can cause direct mortality through clogging of gills and smothering of eggs and early life stages.
Nutrients	Chemical compounds that are taken up by periphyton for growth. The primary bioavailable nutrients in surface water are soluble forms of nitrogen and phosphorus, as well as ammonia. 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 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 to effects on fish.
Hydrocarbons	Polycyclic aromatic hydrocarbons (PAHs) are formed during combustion processes, sources include vehicular exhaust, crude oil, and petroleum.	Discharge, runoff, aerial deposition	Several PAHs have been identified as carcinogens or mutagens and can be acutely or chronically toxic to aquatic organisms.

18.5.3.4.1 Mine Discharge

Water from the underground mine will be 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 Fish and Fish Habitat from discharge to the

Cambria Icefield during construction are not expected, and this interaction is not carried forward in the assessment.

During operations, 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.

Water will meet MMER requirements prior to discharge to Goldslide Creek, which is non-fish bearing, therefore no effects to Fish and Fish Habitat are anticipated within Goldslide Creek.

However, changes in water quality within fish bearing reaches of Bitter Creek are anticipated that are partially attributable to mine discharge as the mine discharge travel downstream, and compounded by inputs of TMF discharge at Bitter Creek.

18.5.3.4.2 TMF Discharge

During the Operation Phase, process water, runoff from the Process Plant area, and water used in the 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.

Excess TMF supernatant water will be treated to meet MMER requirements prior to discharge to Bitter Creek. Potential effects on Fish and Fish Habitat will be greatest in the dilution zone (estimated 100 m long), where the discharge is not yet fully mixed.

Changes in Surface Water Quality within fish bearing reaches of Bitter Creek that are downstream of the Project are anticipated. These changes arise of the TMF discharge input, combined with upstream inputs of mine discharge. The magnitude of changes in Surface Water Quality will decrease with distance downstream, from natural dilution, however the potential for effects on Fish and Fish Habitat remains. Effects on Fish may be lethal, or sub-lethal, depending on the nature of contaminants (e.g. metals, nutrients, TSS), predicted concentrations, timing of discharge releases, the resilience of fish exposed to those contaminants.

18.5.3.4.3 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 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 each portal entrance and access tunnel, construction of the TMF and road construction, will require some degree of 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. The loading of nitrogen into the freshwater environment can increase primary production, cause the accumulation of primary producer biomass, alter the composition of primary producer and secondary producer communities, and cause cascading trophic effects in the food web. Furthermore, some nitrogen compounds (nitrate, nitrite, and ammonia) can have sublethal and lethal effects on aquatic organisms.

During road construction, blasting residues have the potential to leach from excavated rock to access road watersheds. Runoff from blasting areas adjacent to the road, and aerial deposition, also form a potential pathway for blasting residues to enter watercourses 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 and blasting residues along the roads will be negligible.

18.5.3.4.4 Runoff

At the Mine Site and Bromley Humps, surface water runoff to watercourses will be non-contact water, as contact water will be intercepted, and directed to the TMF (Bromley Humps), or to Portal Collection Pond (Mine Site), prior to discharge to the receiving environment. Non-contact water runoff in these areas will be directed away from developed areas by means of natural or man-made diversion channels and routed to receiving environment watercourses. Changes to the existing drainage patterns will be minimized, however the altered runoff routes may increase erosion potential as well as sediment loading. Increased TSS, and turbidity reduces light penetration in the water column, which in turn reduces primary (photosynthesis) and secondary production, and can also affect visibility for Fish.

The highest potential for increased erosion and sedimentation will be during periods of disturbance of natural surface cover and vegetation, such as during construction and reclamation. During closure, drainage patterns will be returned to pre-Project conditions to the maximum extent possible.

Surface water runoff from the road will be a mix of contact and non-contact water. Road runoff has the potential to occur during construction and subsequent use. This will increase erosion and sedimentation potential, particularly where the road is near a watercourse, or where the road fords a watercourse. Road runoff can also contribute metals and other contaminants (blasting residues, PAHs, road salts from de-icing) to the receiving aquatic environment. This source of potential contamination is not captured as contact water (which is treated and discharged).

18.5.3.4.5 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 on the

Access and Haul roads. Dustfall on watercourses, at high enough rates, can increase TSS. This can lead to effects on Fish and Fish Habitat from changes in physical habitat such as homogenization of stream bed features and reduced pool depths. Indirect effects on Fish may occur through Aquatic Resources (periphyton and benthic invertebrates), which are also susceptible to changes in physical habitat and increased TSS.

Using an air dispersion model, CALPUFF, annual maximum dustfall rates (milligrams per square decimeter per day; mg/dm2/day) from Project sources, at Aquatic Resources 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.

Acid Deposition

Acid deposition forms when nitrogen oxides (NOx) and sulphur dioxides (SOx) are emitted from burning fossil fuels. Baseline studies indicated that 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.

CALPUFF modelling indicates that the annual maximum concentrations of SOx, NOx (micrograms per cubic meter of air; $\mu g/m^3$), at the aquatic sampling site locations will remain well below the ambient air quality objectives. Based on this, acid deposition is considered negligible.

18.5.3.5 Change in Sediment Quality

Potential effects to Fish and Fish Habitat from changes in Sediment Quality may occur through the chemical and physical alteration of the sediment which forms a part of their habitat.

Pathways to changes to the VC, Sediment Quality, are described in Sediment Quality (Volume 3, Chapter 14), and are discussed here in the context of potential effects on Fish and Fish Habitat.

Chemical changes to Sediment Quality may occur within fish bearing reaches of Bitter Creek, from changes in Surface Water Quality. Accordingly, potential effects to Fish and Fish Habitat from chemical changes in Sediment Quality occur through the same pathways as changes to Surface Water Quality, namely discharge, which are discussed above in Section 18.5.3.2 and in Volume 3, Chapter 14.

Other pathways to changes in Sediment Quality are runoff (non-contact water), aerial deposition, and blasting vibration and shockwaves. Physical alteration of sediment through these pathways includes changes in particle size distribution, and increased sedimentation. These are discussed Volume 3, Chapter 14.

Sediment runoff from the Mine Site will be limited primarily to the Construction Phase. 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 receiving environment watercourses. Changes to the existing drainage patterns will be minimized, however the altered runoff routes may increase erosion potential and sediment loading.

Road runoff will occur during road construction and subsequent use. This will increase erosion and sedimentation potential, particularly where the road is near a watercourse, or where the road fords a watercourse.

Increased sedimentation can cause direct mortality of Fish through smothering. Rates of adsorption of metals into sediment are also linked to particle sizes, and consequently a change in particle size distribution can increase exposure of benthic organisms to metals contamination, which may be transferred through the food web to Fish.

18.5.3.6 Changes in Streamflow

Potential activities that are likely to influence surface water flows include the dewatering of the underground mine, construction of surface water management facilities, and the use of water for mine-related activities such as dust suppression and providing freshwater for the Process Plant. Flow changes during construction will be negligible. During post-closure flow changes will not exceed 10%, which is within the natural range of flows and therefore considered to have a low probability of impact. The maximum flow reduction in all watercourses throughout mine life is 2.7%, which occurs in Goldslide Creek in December and February; therefore effects from flow reduction are negligible.

During operations, flow in Goldslide Creek is predicted to greatly increase from baseline conditions (up to 400%) due to the direct discharge from the Portal Collection Pond. Since Goldslide Creek flows into Bromley Glacier, the increased flow in Goldslide Creek would add volume, to a much lesser extent, to Bitter Creek.

Potential effects to Fish and Fish Habitat from changes in flow include alterations to their physical habitat. Changes in stream velocities, water depth, and substrate can cause deviations that result in a deterioration of habitat conditions. For example, fish require areas of flow refuge, including side channels for spawning and rearing habitat. The quantity of this habitat type could be reduced with increased flow levels and replaced with deeper run habitat. In winter, increases in flow can increase the amount of open water habitat that remains available for fish.

Changes in streamflow can also affect Fish directly as sudden increases in flow can flush eggs or fry downstream or cause fish to avoid certain areas that they would otherwise use for refuge or foraging.

18.5.3.7 Blasting

The potential effects on Fish and Fish Habitat from blasting occur through blasting residues, as well as vibration and shockwaves from detonation of explosives. By-products from the detonation of explosives may include ammonia or similar compounds and may be toxic to aquatic organisms. The potential for increased nitrogen loading to streams from the use of nitrogen-containing explosives is discussed in Section 18.5.3.3 (Changes to Surface Water Quality).

Blasting vibration and shockwaves have the potential to impact fish through physical effects on their tissues and organs. In addition, there is also potential for increased sedimentation which can smother fish eggs.

The detonation of explosives can impact nearby watercourses when ground vibrations propagate into the watercourse causing water overpressures and particle motions at the water substrate interface (Kolden and Aimone-Martin 2013). Water overpressure is the sudden change in water pressure from ambient pressure, and is measured in Pascals (Pa). Ground vibration measurements are typically reported as Peak Particle Velocity (PPV) in millimetres per second (mm/s). Methods for calculating setback distances, based on the total net explosive weight of the blasting charge and delay, have been established for fish (Wright and Hopky 1998). The setback distances specify the distance from the explosive source at which overpressure and particle velocity levels would fall below thresholds for detrimental impacts on free swimming fishes or fish eggs.

The effects of blasting on Fish and Fish Habitat are outlined in Guidelines for the Use of Explosives In or Near Canadian Waters (Wright and Hopky 1998) and include:

- Damage to the fish swimbladder, and potential rupture and hemorrhage of the kidney, liver, spleen, and sinus venosus when overpressure is in excess of 100 kPa;
- Damage to incubating eggs from mechanical shock and from sedimentation covering spawning areas;
- Changes in fish behavior;
- Sedimentation resulting from the use of explosives may reduce or eliminate bottom-dwelling life forms that fish use for food (e.g., benthic macroinvertebrates); and
- Ammonia or other by-products from the detonation of explosives may be toxic to fish and other aquatic biota.

18.6 Mitigation Measures

18.6.1 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. The need for any proposed compensation or offset is identified where required, along with the management plan where the scope of such compensation or offset is described.

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

Specific mitigation measures were identified and compiled for each category of potential effect on Fish and Fish Habitat 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 Fish and Fish Habitat. Key approaches include:

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

One key approach that will be applicable to all potential effects on Fish and Fish Habitat is the implementation of an Aquatic Effects Management and Response Plan (Volume 5, Chapter 29). This plan outlines the aquatic effects management and response to be carried out during all phases of the Project. The Aquatic Effects Management and Response Plan (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 discharged to the environment, then additional sampling for MMER requirements may be conducted (effluent characterization; acute toxicity testing; site characterization studies (including surface hydrology); sublethal toxicity testing).

18.6.1.1 Mitigation Measures for Habitat Loss

All the major mine components are contained within non-fish bearing areas of one watershed, and overlap with Fish Habitat is limited to the Access Road only. The Access Road will follow the existing alignment, and crosses two fish bearing tributaries, where clearspan bridges will be installed. Although the road is designed to minimize impacts to fish habitat, habitat loss cannot be avoided or fully mitigated, and is therefore carried forward in this assessment as a residual effect.

18.6.1.2 Mitigation Measures for Increased Fishing Pressure

The potential for increased fishing pressure brought on by improved accessibility and/or increased population in Stewart related to the Project's workforce, contractors, and sub-contractors, was assessed as a very low level effect that requires minimal direct management or mitigation measures. The Project will have a no fishing policy in place during construction. During operations, new residents to Stewart associated with the Project will be bound by existing DFO regulations, which include a ban on recreational fishing in the Bear River and Bitter Creek. Furthermore, access along the Bitter Creek Access Road will be tightly monitored and controlled, including a gate at the entrance. IDM will work closely with NLG to monitor any effects to Aboriginal fisheries, especially with respect to Eulachon in the Bear River. Increased fishing pressure is not carried forward as a residual effect.

18.6.1.3 Mitigation Measures for Change to Aquatic Resources

Potential changes to Aquatic Resources arise from habitat loss, changes in Surface Water Quality, changes in Sediment Quality, changes in streamflow, and blasting. Accordingly, the mitigation measures for potential effects to Fish and Fish Habitat from changes to Aquatic Resources are covered in the effects assessment for the Aquatic Resources VC (Volume 3, Chapter 17).

No residual effects from changes in Aquatic Resources are predicted on Fish and Fish Habitat with the employment of these mitigation measures, including monitoring and adaptive management.

18.6.1.4 Mitigation Measures for Change in Surface Water Quality

The primary mitigation measure for potential changes to Fish and Fish Habitat from changes in Surface Water Quality will be to sequester all mine and site contact water prior to entering the aquatic environment. Mine Site discharge and contact water will be directed to a collection pond 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 and Recycle Ponds and pumped back to the TMF. Project activities related to fuels, oils and other hydrocarbons will employ Best Management Practices for machinery operation, maintenance, refueling, and secondary containment systems.

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

A complete list of mitigation measures to avoid and mitigate effects to Fish and Fish Habitat from changes in Surface Water Quality can be found in the effects assessment for Surface Water Quality (Volume 3, Chapter 13).

Even with the application of the mitigation measures described above, exceedances of guidelines are predicted in the fish-bearing section of Bitter Creek. The effects on Fish and Fish Habitat from changes in Surface Water Quality are therefore carried forward as a residual effect.

18.6.1.5 Mitigation Measures for Change in Sediment Quality

The mitigation measures for potential effects to Fish and Fish Habitat from chemical changes in sediment quality are the same as those discussed for water quality. Effects on Fish and Fish Habitat associated with sedimentation and erosion will be minimized through adherence to Best Management Practices as outlined in management plans in Volume 5, Chapter 29, including the Site Water Management Plan and Erosion and Sediment Control Plan.

A complete list of mitigation measures to avoid and mitigate effects to Fish and Fish Habitat from changes in Sediment Quality can be found in the effects assessment for Sediment Quality (Volume 3, Chapter 14). No residual effects from changes in Sediment Quality are predicted on Fish and Fish Habitat with the employment of these mitigation measures, including monitoring and adaptive management.

The Reduced Risk Work Window for instream works (i.e. timing window) for Dolly Varden in Bitter Creek is from June 1 to August 31 (BC MOE, 2004). The only works in or near fish-bearing waters are associated with road construction. This includes bank protections works (rip rap), where the river will flow along rock works. Realignment of the creek is also proposed at one location to facilitate construction of a road prism. Installation of clear span bridges where the road crosses Roosevelt Creek, Cambria Creek, and Hartley Gulch will also be required. These works are scheduled to take place within the timing window.

18.6.1.6 Mitigation Measures for Changes in Streamflow

The primary mitigation measures for changes in streamflow are discussed in the Hydrology Effects Assessment (Volume 3, Chapter 12) and include the construction of site water management infrastructure, limiting withdrawal to no more than 10% of stream flows, and matching the discharge from the TMF to the hydrograph. Monitoring of stream flow during operations will determine whether additional measures are needed as mining continues. A complete list of mitigation measures to avoid and mitigate effects to Fish and Fish Habitat from changes in stream flows can be found in Volume 3, Chapter 12.

However, with these mitigation measures in place, there will still be potential for residual effects on Fish and Fish Habitat.

18.6.1.7 Mitigation Measures for Blasting

The primary mitigation measure for potential effects to Fish and Fish Habitat from blasting will be to prevent or avoid the destruction of fish, or any potentially harmful effects to fish habitat, when using explosives in or around water frequented by fish. In addition, blasting shall be conducted by taking into consideration Fisheries and Oceans Canada's Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters (Wright and Hopky 1998).

Primarily, there will be no use of ammonium nitrate-fuel oil mixtures occurring in or near water due to the production of toxic by-products (ammonia).

The use of explosives and subsequent deposition of blasting residues on surfaces, with subsequent possibility of transport to nearby watercourses will be primarily mitigated by capturing runoff and diverting it to settling ponds in the Mine Site or to the TMF for treatment prior to discharge. In addition to the mitigation measures outlined in the Surface Water Quality Chapter (Volume 3, Chapter 13), specific mitigation measures related to Fish and Fish Habitat listed in Table 18.6.1.

No residual effects from blasting are predicted on Fish and Fish Habitat with the employment of these mitigation measures, including monitoring and adaptive management.

18.6.2 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;
- Explosives Management Plan;
- Fuel Management Plan;
- Mine Closure and Reclamation Plan;
- Material Handling & ML/ARD Management Plan;
- Spill Contingency Plan;
- Tailings Management Plan;
- Terrain and Soil Management Plan;
- Vegetation and Ecosystems Management Plan; and
- Site Water Management Plan;

18.6.3 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 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 uncertainty associated with their use is primarily low. Any further uncertainty associated with the effectiveness of the proposed mitigation tends will be addressed through the AEMRP. If monitoring indicates that effectiveness of mitigation measures is lower than predicted, further mitigation may be required as per adaptive management strategies outlined in the AEMRP.

The key measures proposed for mitigating potential effects on the Aquatic Resources VC, along with mitigation effectiveness and uncertainty are outlined in Table 18.6-1. This table also identifies the residual effects that will be carried forward for residual effects characterization and significance determination.

Table 18.6-1: Proposed Mitigation Measures and Their Effectiveness

VC/IC	Potential Effects	Mitigation Measures	Rationale	Applicable Phase(s)	Effectiveness[1]	Uncertainty[2]	Residual Effect
Fish (as represented by dolly vardon, bull trout, eulachon and Oncorynchus salmonids)	Increased fishing pressure	No fishing policy for Project employees and guests	Staff training and awareness plus monitoring and enforcement of company policies are key components of many of IDM's management plans.	Construction, Operation, Closure and Reclamation	High	Low	No
		Existing DFO regulations will be followed.	IDM is committed to lawful operation of the Project.				
		All Project roads will be closed to the public, including private vehicles (snowmobile, all-terrain vehicles, etc.) and all foot traffic, with the possible exception of individuals with existing rights to access the Bitter Creek valley. Project road use will be restricted only to Persons required for Project construction, operation, and maintenance.	Public awareness is a key component of IDM's management plans.		Moderate (Providing round-the-clock monitoring of activity on the roads is not feasible)	Moderate (Difficult to predict how many individuals will ignore signage and rules)	
	Changes in aquatic resources	All implemented mitigation measures for Aquatic Resources will serve as mitigation for Fish and Fish Habitat relative to this effect (Chapter 17, Section 17.6).					No
	Changes in surface water quality	All implemented mitigation measures for Surface Water Quality will serve as mitigation for Fish and Fish Habitat relative to this effect (Chapter 13, Section 13.6).					Yes
	Changes in sediment quality	All implemented mitigation measures for Sediment Quality will serve as mitigation for Fish and Fish Habitat relative to this effect (Chapter 14, Section 14.6).					No
	Changes in stream flow	All implemented mitigation measures for Hydrology will serve as mitigation for Fish and Fish Habitat relative to this effect (Chapter 12, Section 12.6.3).					Yes
		Water withdrawal will follow provincial regulatory requirements and standard best practices to avoid adverse impacts to streamflows, fish and fish habitat.	IDM is committed to lawful operation of the Project.	Operation, Closure and Reclamation	High	Low	
	Effects of blasting	All implemented mitigation measures for Surface Water Quality will serve as mitigation for Fish and Fish Habitat relative to this effect (Chapter 13, Section 13.6).					No
		Blasting activities will be limited to the Mine Site during operations; there is no potential for effects on fish from explosive shockwaves as the blasting zone will not be near any fish-bearing watercourses.	Avoidance of blasting activities within fish-bearing watercourses.	Construction, Operation, Closure and Reclamation	High	Low	
		Capture surface runoff and diverting it to the Portal Collection Pond in the Mine Site or the TMF in Bromley Humps for treatment prior to discharge.	Minimizes the potential for increased nitrogen loading to streams		High		
Fish Habitat	Habitat loss	Infrastructure (including the Access Road) shall be designed in a manner that minimizes or avoids habitat loss to Fish and Fish Habitat, including minimize the number of stream crossings.	Directly avoids and minimizes the amount of habitat loss to fish and fish habitat	Construction	Moderate (Some habitat loss will occur)	Low	Yes
		Road crossings have been designed to avoid unnecessary impact on fish-bearing streams.					

[1]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

[2]Uncertainty: Low = proposed measure has been successfully applied in similar situations; Moderate = proposed measure has been successfully implemented, but perhaps not in a directly comparable situation; High = proposed measure is experimental, or has not been applied in similar circumstances

18.7 Residual Effects Characterization

18.7.1 Summary of Residual Effects

The residual effects after application of mitigation measures are:

- Effects on Fish Habitat from Habitat Loss;
- Effects on Fish from Change in Surface Water Quality; and
- Effects on Fish and Fish Habitat from Changes in Streamflow.

Some residual effects on the Fish and Fish Habitat VCs will result from loss of habitat due to the construction of the Access Road, a predicted increase in selenium in Bitter Creek, as well as predicted streamflow changes in Bitter Creek in winter. Specifically, residual effects are possible on the Fish Habitat and Dolly Varden VCs. There are no residual effects on other VCs as habitat loss, changes in water quality, or changes in streamflow, are not predicted outside of the LSA; therefore, there are no pathways of effects to Salmon species or Eulachon.

This section provides an assessment and characterization of these predicted residual effects in order to determine the likelihood and significance of the effects, and ultimately the confidence relating to the residual effects conclusions.

18.7.2 Methods

Significance of residual effects was evaluated based on several criteria including: magnitude, duration, frequency, reversibility, context, and probability of occurrence, as defined for Fish and Fish Habitat (Table 18.7-1).

18.7.2.1 Residual Effects Criteria

Table 18.7-1: Characterization of Residual Effect on Fish and Fish Habitat

Criteria	Characterization for Fish and Fish Habitat
Magnitude	• **Low (L):** The magnitude of effect is within the range of natural variation and is unlikely to affect the existing productive capacity of fish habitat. • **Moderate (M):** The magnitude of the effect is at the limits of natural variation or habitat changes affect up to 10% of the available habitat in a watercourse, such that the productive capacity of the habitat may be reduced and affect fish populations in the entire watercourse; and/or the value of the measurement indicator is up to 30% greater than guideline or threshold value for the protection of aquatic life. • **High (H):** The magnitude of effects exceeds natural variation, or habitat changes affect more than 10% of the available habitat in a watercourse, such that the productive capacity of the habitat may be reduced and affect an entire fish population, or more than one fish population; and/or the value of a measurement indicator is more than 30% greater than guideline or threshold value for the protection of aquatic life.

Criteria	Characterization for Fish and Fish Habitat
Geographical Extent	• **Discrete (D):** Effect is limited to the immediate receiving environment in Goldslide Creek watershed (mine area) or the immediate freshwater environment in Bitter Creek (TMF area, Access Road) • **Local (L):** Effect is limited to the immediate receiving environment in Goldslide Creek watershed (Mine Site) or the immediate freshwater environment in Otter Creek (Bromley Humps) or the immediate receiving environment in Bitter Creek (Access Road). • **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, Reclamation and Closure, and Post-Closure Phases) • **Permanent (P):** Effect lasts more than 22 years
Frequency	• **One time (O)**: Effect is confined to one discrete event (month). • **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.
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.

18.7.2.2 Analytical Assessment Techniques for Fish and Fish Habitat

Habitat loss along Bitter Creek was based on the approximate areal extent of aquatic habitat below the annual high water mark that will be infilled as part of road construction.

Riparian habitat loss from the Access Road was estimated based on a 15 m riparian buffer along fish-bearing watercourses, and a road right of way of 25 m.

For other effects, predictions from Appendix 14-C informed the Aquatic Resources residual effects assessment.

18.7.2.3 Assessment of Likelihood

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

18.7.2.4 Significance Determination

Definitions of significant and not significance based on residual effects criteria were as follows.

- Not significant: Residual effects have low or moderate magnitude; discrete to local 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. The effects on Fish and Fish Habitat are either indistinguishable from background conditions (*i.e.,* occur within the range of natural variation as influenced by physical, chemical, and biological processes), or distinguishable at the individual level.

- Significant: Residual effects have high magnitude; regional or beyond regional geographic extent; duration is permanent; and can occur at all frequencies. Residual effects on Fish and Fish Habitat are consequential (*i.e.*, structural and functional changes in populations, communities, and ecosystems are predicted) and are irreversible.

18.7.2.5 Confidence and Risk

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

18.7.3 Potential Residual Effects Assessment

18.7.3.1 Fish Habitat Loss

There will be no fish habitat loss under the mine infrastructure in Bromley Humps or the Mine Site because there are no fish bearing watercourses within these areas. Loss of non-fish bearing aquatic habitat is described in the assessment for Aquatic Resources (Volume 3, Chapter 17).

No residual effects are anticipated on Bull trout, Eulachon or Salmonid Species as they do not occur in the LSA or mainstem of Bitter Creek where road access is proposed.

There will be no instream fish habitat loss at watercourse crossings along the Access Road, because only two crossings, Roosevelt Creek and Hartley Gulch, are fish bearing and these will be facilitated using clearspan bridges. No instream fish habitat loss is associated with clearspan bridges, as there is no instream infrastructure required for this type of crossing. Riparian habitat loss at clear span bridges is expected where the road right of way intersects with the riparian buffer zone.

There is potential for fish habitat loss where infilling for the Access Road is required within the Bitter Creek channel. The proposed road alignment along the North/North East bank of Bitter Creek follows an abandoned existing road at the toe of steep hillside on the North side of Bitter Creek. To avoid destabilizing sensitive slopes and putting road users and workers in an unsafe position, portions of the access road will encroach on the Bitter Creek channel.

Sections of the existing road were washed away during a flood event in 2011, and therefore upgrading of the road along its original alignment requires construction within the channel formed during the 2011 flood. However, the 2011 flood was 1-in-25 to 1-in-100 year event, and therefore some of the areas where the road construction is proposed are very rarely wetted and well above the annual high water.

One 150 m section of the access road requires re-alignment of Bitter Creek at the toe of a weak fractured bedrock face. The works involve realignment of the Bitter Creek channel towards the South/South East bank, construction of a road prism along North/North East bank, with bank armouring. Approximately 1.14 ha of habitat will be altered, however no net loss of habitat is expected, because the existing channel can accommodate the annual range of flows, and realignment of the creek will not reduce average channel width.

Approximately 2.7 ha of riparian habitat will be disturbed adjacent to fish bearing streams (e.g. earthworks, armouring, slope cut and fill, roadway surface, crossings), the majority of this occurs where the road right of way intersects with the Bitter Creek riparian buffer zone. Some of the disturbed riparian area will be re-vegetated post construction, although maintenance of a maximum canopy height will be necessary to maintain slight lines along the road. The road will be deactivated prior to the end of the Closure and Reclamation Phase, using forestry practices, and therefore riparian vegetation will revert to near baseline conditions.

18.7.3.1.1 Residual Effect Analysis

Instream habitat loss is anticipated in Bitter Creek where a section of the Access Road will be placed within the annual high water mark. Riparian habitat loss will also be incurred where the access road overlaps with the Bitter Creek riparian zone, and there is a small amount of riparian habitat loss at fish-bearing crossings on Roosevelt Creek and Hartley Gulch (clearspan bridges).

18.7.3.1.2 Characterization of Residual Effect

The residual effect to Fish Habitat is the loss of habitat through infilling for road construction, and riparian habitat loss, potentially leading to a reduction in fish population for Dolly Varden.

These effects are characterized as follows:

- Magnitude is Low; the area of habitat loss is limited to the LSA and to less than 150 m stretch along the Access Road/Bitter Creek.
- Geographical extent is Discrete; the areas of total habitat loss are limited to a short section of Bitter Creek from the road.
- Duration is Short-term; habitat loss occurs once during the Construction Phase; Fish populations will recover once conditions return to their pre-disturbance state.
- Frequency is One time; habitat loss and will be limited to a discrete occurrence during the construction of the Access Road.

- Reversibility is Partial; replacement habitat will become available when the channel is realigned, although it may not be the same quality or type of habitat. Riparian areas will be replanted where possible, and reclaimed in closure.

- Context is High; Fish populations have high resilience to a relatively small and temporary decrease in available habitat.

18.7.3.1.3 Likelihood

The likelihood rating for this residual effect on Fish Habitat is Moderate; although some fish habitat will be infilled, no net loss of habitat is anticipated because the channel will be realigned.

18.7.3.1.4 Significance

Residual effects are limited to the LSA (150 m stretch of the mainstem of Bitter Creek), and existing habitat does not provide critical function that could not be provided elsewhere in the LSA. Overall, ecological conditions that support Fish Habitat relative to existing baseline will be maintained. Therefore, the residual effect is considered not significant.

18.7.3.1.5 Confidence and Risk

The level of confidence associated with the predicted residual effect on Fish Habitat from habitat loss is High. There is sufficient baseline data to understand the form and function of existing Fish Habitat in the LSA. The proposed mitigation measures are commonly applied best management practices with a high degree of effectiveness. This leads to high confidence in the conclusions of the assessment.

There is little uncertainty associated with the residual effect analysis. Some uncertainty arises because fish utilization of the affected areas, and the resulting importance of these areas in terms of contribution to overall productivity is not fully quantified. However, risk of affecting ecological conditions that support populations relative to existing baseline is low to negligible because the areas lost represent a very small proportion of the available habitat. As such, additional risk analysis is not required.

18.7.3.2 Changes in Surface Water Quality – Potential Residual Effects to Dolly Varden Reproduction.

Residual effects on Fish 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, occur 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). Contaminants of potential concern (COPCs) for Fish were identified as those parameters predicted to exceed water quality guidelines (CCME or BC MOE), in the expected case (P50), at model assessment nodes located in the fish-bearing areas (BC06 and BC02). The following COPCs were identified in Bitter Creek, which are discussed below in relation to residual effects on Dolly Varden:

- Operations: selenium; and
- Post Closure: cadmium, selenium, silver, and zinc.

There are no potential contaminants of concern for Fish in Bear River.

Cadmium

There are cadmium exceedances during operations in Bitter Creek. During post-closure, cadmium marginally exceeds the BC WQG (1.1 times and 1.2 times higher) at BC06 and BC02, respectively, and exceeds the CCME WQG (1.6 times and 1.7 times higher) at BC06 and BC02, respectively.

Toxicity of cadmium (Cd) is highly variable among taxonomic groups and life-stages, and is also highly dependent on length of exposure. Excess cadmium interferes with the uptake of calcium by fish, which can result in cellular damage, decreases in metabolic activity, increased mortality, decreased growth, and decreased reproductive capacity and success (BC MOE, 2015). The BC WQG is the more relevant guideline for Bitter Creek, whereas the CCME guidelines are more stringent as they apply to all Canadian waters. Cadmium has been found to be toxic to salmonid species, however tolerance is highly dependent on species and life-stage. Rainbow Trout are particularly sensitive to high cadmium concentrations, whereas Bull Trout have been found to be more tolerant (Hansen *et al.,* 2002).

The exceedances of the BC WQG are marginal, and therefore adverse effects on Dolly Varden from water borne exposure to this contaminant is expected to be low. Furthermore, exceedances are seasonal (spring / summer), thereby limiting the potential for chronic effects on Dolly Varden.

Selenium

Selenium exceeds the BC WQG and CCME WQG during both operations and post-closure at both BC06 and BC02. During operations, BC WQGs are exceeded by 1.2 times and 2.1 times and CCME WQGs are exceeded by 2.7 times and 4.1 times at BC06 and BC02, respectively. During post-closure, BC WQGS are exceeded by 2.2 times and 3.8 times at BC06 and BC02, respectively. These exceedances are largely due to background concentrations, which exceeded guidelines in both the water and sediment.

CCME and BC water quality guidelines for selenium are based on a lowest observed effect level (LOEL) of 0.01 mg/L introduced by the International Joint Commission (IJC) to protect species in the Great Lakes (IJC 1981). For the CCME guideline, a safety factor of 10 was applied to the LOEL to end up with the guidance of 0.001 mg/L. The BC WQG of 0.002 mg/L incorporates a safety factor of 5 to recognize that selenium is an essential trace element for animal nutrition and that it is the bioaccumulation of selenium through the food chain (chronic effects) that is the major source, not through the water column.

Selenium has the potential to induce both reproductive and non-reproductive effects in fish. Reproductive impacts originate from the maternal transfer of selenium, whereas non-reproductive effects are related to direct effects on individuals, and both primarily result from dietary uptake (Lemly, 2008; DeForest and Adams, 2011). Chronic effects of selenium toxicity include lack of fertilization, hatchability and higher mortalities of eggs as well as increased cataracts, pathological alterations in liver, kidneys, heart and ovaries and skeletal deformities (Lemly 2002, 1997). The likelihood of adverse effects to fish in Bitter Creek is low, as selenium exceeds BC WQG during the winter months (September to March/April). Additionally, a difference in selenium toxicity and bioaccumulation has been noted between lentic and lotic systems. In a review compiled by Adams *et al.* (2000), a clear distinction was demonstrated between fast and slow moving water systems, with selenium bioaccumulation generally ten times greater in lentic environments in comparison to lotic environments. Bitter Creek is a fast moving, lotic systems, therefore bioaccumulation and associated dietary uptake by fish are expected to be low.

Silver

There are silver exceedances during operations in Bitter Creek. During post-closure, silver is below BC WQG at both BC06, and marginally exceeds the CCME WQG (1.6 times and 1.2 times higher) at BC06 and BC02, respectively.

Silver uptake in freshwater fish mainly occurs in cells related to nutrient uptake and ion regulation on the gills (CCME, 2015). The inhibition of sodium and chloride uptake channels on fish gills due to silver ions can negatively impact ion balances (CCME, 2015).

An effect on Dolly Varden from increased silver concentrations is considered highly unlikely as concentrations will not exceed the BC WQG and exceedances of the CCME guideline are small and occur in six months of the year only.

Zinc

There are zinc exceedances during operations in Bitter Creek. During post-closure zinc is predicted to be below the CCME WQG. Zinc will exceed the BC WQG (1.3 times higher) at BC06 but be essentially equal to or below the guideline at BC02.

Zinc is an important micronutrient and is therefore essential in the structure of numerous proteins (Hogstrand and Wood, 1996). Uptake of zinc primarily occurs on fish gills, and high concentrations of calcium in the water can reduce uptake (Bradley and Sprague, 1985). High concentrations of zinc can cause physical damage to the gills, which then induces hypoxia (Spry and Wood, 1984). Lower concentrations of zinc have been seen to impede calcium uptake, and cause hypocalcemia (Spry and Wood, 1985). Zinc exceedances at BC06 is predicted to occur during April to July when water hardness is lower. However, the overall potential for zinc toxicity to fish is expected to be low given the seasonal frequency and small magnitude of exceedance of the BC WQG..

18.7.3.2.1 Residual Effect Analysis

The effect of Changes in Surface Water Quality on Sediment Quality (Chapter 14) and Aquatic Resources (Chapter 17) was considered not significant. This means that there is no significant potential effect on fish (Dolly Varden), through food web effects. Changes in Surface Water Quality may affect Dolly Varden in Bitter Creek through water-borne exposure.

18.7.3.2.2 Characterization of Residual Effect

- Magnitude is Low; the effect on Dolly Varden is at the limits of natural variation, as only one parameter (selenium) is predicted to exceed the BC WQG for the protection of aquatic life by more than 30%.
- Geographical extent is Local; effect is limited to the immediate freshwater environment in Bitter Creek (TMF and Access Road).
- Duration is Permanent; changes to Surface Water Quality from TMF and Mine Site discharge are predicted to be beyond the Post-Closure Phase.
- Frequency is Sporadic; discharges, and predicted guideline exceedances occur on an intermittent basis, such that effects on Dolly Varden may not occur during periods where there are no discharges.
- Reversibility is Reversible; Complete reversibility of Surface Water Quality back to baseline conditions is unlikely or very far into the future. However, the magnitude of changes in Surface Water Quality in fish bearing receiving water bodies (i.e. lower Bitter Creek) is low and the frequency is sporadic. Therefore, it is expected that any potential effects to Dolly Varden would be reversible.
- Context is High; Generally, the highest quality spawning and rearing habitat (*i.e.* habitat that best matches known Dolly Varden habitat preferences), occurs within Bitter Creek side channels and at tributary inflows. This limits the exposure of eggs and early life stages to peak concentrations of COPCs, as water in the mainstem thalweg would be expected to have the highest concentrations. Under baseline conditions, Dolly Varden in Bitter Creek are exposed to elevated background metal concentrations, which points to high natural resilience of the population to stresses from changes in water quality. Dolly Varden can therefore adapt to changes in water quality because of their preferences for areas where streamflow is diluted by tributary inflows, as well as their natural resilience.

18.7.3.2.3 Likelihood

The likelihood of effects to Fish (Dolly Varden) from changes in Surface Water Quality is Low in Bitter Creek. Goldslide Creek is the immediate receiving environment and subject to the highest water quality parameter concentrations. Predicted increases in the contaminants of potential concern decrease with distance downstream in the Bitter Creek watershed. Fish bearing reaches of Bitter Creek will experience small changes in Surface Water Quality that are unlikely to result in effects.

18.7.3.2.4 Significance

Exceedances of water quality guidelines are predicted, but any effects on Fish (Dolly Varden), will be localized and have no far-reaching effects on regional productivity or diversity. Overall, ecological conditions that support Fish populations relative to existing baseline will be maintained. Therefore, the residual effect is considered not significant.

18.7.3.2.5 Confidence and Risk

The level of confidence associated with the predicted residual effect on Dolly Varden reproduction from Changes in Surface Water Quality is Moderate. The mechanism through which the predicted Changes to Surface Water Quality may impact Dolly Varden reproduction are reasonably well understood.

However, uncertainties are inherent in the water quality modelling, and model predictions are dependent on numerous input sources. This uncertainty may affect the likelihood or significance of the predicted residual effect on Dolly Varden reproduction, as concentrations may be higher than predicted. 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 Dolly Varden reproduction, the residual effect analysis considered factors such as the magnitude and timing of predicted water quality guideline exceedances relative to the life cycle of Dolly Varden (e.g. spawning).

To reduce uncertainty and maintain the ecological conditions that support populations relative to existing baseline, monitoring and adaptive management strategies will be implemented, as described in the AEMRP (Volume 5, Chapter 29.5) and the Adaptive Management Plan (Volume 5, Chapter 29.2). These management plans have been designed to mitigate the risk related to a residual effect on Aquatic Resources. 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, operations, reclamation and closure, 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 Aquatic Resources.

IDM has also committed to conducting a Screening Level Ecological Risk Assessment (SLERA), which focuses on ecological receptors, including fish, for baseline conditions and for construction and operation. The SLERA will allow for an estimate of the incremental risk/hazard related to the Project.

18.7.3.3 Changes in Streamflows

18.7.3.3.1 Residual Effect Analysis

A residual effect to Fish and Fish Habitat from changes in streamflow in Bitter Creek is anticipated based on the water quantity predictions in Appendix 14-C.

During operations, increases in flow will occur in Bitter Creek as result of mine discharge into Goldslide Creek.

- The maximum predicted increase in flow in January and December is 5% and 4% of baseline conditions at BC06 and BC02 respectively. During freshet and summer (May to September) the change in flow is negligible in Bitter Creek.

- The increased flow during operations for the winter is much less than the peak flows during the summer in Bitter Creek, so the increase in flow during the winter is not expected to have any effect on the geomorphology of the stream channel.

Under natural conditions, winter is a low flow period. Dolly Varden egg incubation occurs over the winter period, and increases in flow could therefore effect incubating eggs and fry emergence timing. Increased winter flows are also expected to improve the availability of overwintering habitat (deeper areas that do not freeze to bottom) for juveniles.

18.7.3.3.2 Characterization of Residual Effect

The residual effect from changes in streamflow is characterized as follows:

- Magnitude is Low for Bitter Creek; based on the predictions for increases in flow;

- Geographical extent is Local; the effect is limited to the immediate receiving environment in Bitter Creek (TMF and Access Roads);

- Duration is Short-term; changes to streamflows from discharge inputs is limited to the Operations Phase;

- Frequency is Regular; flow increases will occur seasonally, during the winter months;

- Reversibility is Reversible; after operations, the flow regime will return to within baseline levels and therefore Fish and Fish Habitat will recover as well; and

- Context is High; Fish and Fish Habitat can recover once flows revert to baseline levels.

18.7.3.3.3 Likelihood

The likelihood of effects to Fish from changes in streamflows in Bitter Creek is High.

18.7.3.3.4 Significance

Although effects on Dolly Varden life stages may occur as a result of winter flow increases in Bitter Creek, the effect will be localized and have no far-reaching effects on regional productivity or diversity. The effect is also seasonal (winter only), short-term (operations), and reversible. Overall, ecological conditions that support Fish populations relative to existing baseline will be maintained. Therefore, the residual effect is considered not significant.

18.7.3.3.5 Confidence and Risk

The level of confidence associated with the predicted residual effect on Fish and Fish Habitat from Changes in Streamflows is Moderate. The magnitude of the effect can be indirectly quantified (magnitude of flow changes), and the mechanism through which changes in streamflow impact Fish and Fish Habitat is reasonably well understood. However, uncertainties are inherent in the water quantity (flow) modelling, and model predictions are dependent on numerous input sources. Further uncertainty arises from qualitatively predicting how changes in stream flow lead to an ultimate effect on Fish and Fish Habitat. Where there were uncertainties in the model input assumptions for flow predictions, reasonably conservative assumptions were made to address those uncertainties and thereby reduce risk. Further details on the assumptions, uncertainty, and conservatism in the model are provided in Appendix 14-C.

To address uncertainty in predicting how the changes in streamflow would affect Fish and Fish Habitat, the residual effect analysis considered the magnitude of the flow changes (relative to baseline), and any predicted increases above mean peak flow. Understanding of how these changes in flow would affect fish life stages (e.g. by flushing eggs or fry downstream), and fish habitat (e.g. by altering sedimentation and erosion patterns, or increasing stream velocities) during the mine life was crucial for increasing the level of confidence in predicting the residual effect. Based on the confidence in the water quantity (streamflow) predictions, and the baseline fisheries data, it was determined that additional risk analysis was not required for the residual effect.

To reduce uncertainty and maintain the ecological conditions that support populations relative to existing baseline, monitoring and adaptive management strategies will be implemented, as described in the AEMRP (Volume 5, Chapter 29.5) and the Adaptive Management Plan (Volume 5, Chapter 29.2). These management plans have been designed to mitigate the risk related to a residual effect on Fish and Fish Habitat. 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, operations, reclamation and closure, 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 Fish and Fish Habitat.

18.7.4 Summary of Residual Effects Assessment

Residual effects and the selected mitigation measures, characterization criteria, likelihood, significance determination, and confidence evaluations are summarized for the two residual effects to Fish and Fish Habitat (Table 18.7-2).

Although the identified residual effects may result in localized effects on Fish Habitat, as well as individual level effects on Fish, overall, changes to the Dolly Varden population composition and characteristics (distribution, densities) in Bitter Creek, are not anticipated. As none of the residual effects extend to the Bear River, effects on fish populations in this system are also not anticipated.

Table 18.7-2: Summary of the Residual Effects Assessment for Fish and Fish Habitat

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)*
Loss of Fish Habitat	C	Mitigation by Project Design, including minimizing infrastructure footprint disturbance and road crossings	Magnitude: Low Geographic extent: Discrete Duration: Short-term Frequency: One time Reversibility: Partial Context: High	Moderate	Not Significant	High
Reduced Reproduction of Dolly Varden from Changes in Surface Water Quality	C,O,D	Surface Water Quality mitigation measures, Project design mitigations (including water treatment, seepage collection and pump back, geomembrane cover), BMPs, Management Plans.	Magnitude: Low Geographic extent: Local Duration: Permanent Frequency: Sporadic Reversibility: Reversible Context: High	Low	Not Significant	Moderate
Effects on Dolly Varden from Changes in Streamflow	O	Hydrology mitigation measures, Project design mitigations, BMPs, Management Plans, regulatory requirements.	Magnitude: Low Geographic extent: Local Duration: Short-term Frequency: Regular Reversibility: Reversible Context: High	High	Not Significant	Moderate

18.8 Cumulative Effects

Cumulative effects are the result of Project residual effects on Fish and Fish Habitat 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. (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).

18.8.1 Review Residual Effects

The residual effects after application of mitigation measures are:

- Effects on Fish Habitat from Habitat Loss;
- Effects on Fish from Changes in Surface Water Quality; and
- Effects on Fish from Changes in Streamflows.

18.8.2 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 Fish and Fish Habitat to interact with the residual effects of other past, present, and future projects and activities.

18.8.2.1 Spatial Boundaries

The spatial boundaries for the cumulative effects assessment on Fish and Fish Habitat are restricted to areas that are hydrologically linked to the residual effects of the Project. Given that the residual effects to Fish and Fish Habitat 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.

18.8.2.2 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.

18.8.3 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 Fish and Fish Habitat. Projects and activities with potential to interact with Fish and Fish Habitat residual effects are in Table 18.8-1.

Table 18.8-1: List of Projects and Activities with potential to interact within the Fish and Fish Habitat 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

18.8.4 Potential Cumulative Effects and Mitigation Measures

18.8.4.1 Habitat Loss

Direct habitat loss under the footprint could occur from the Bitter Creek Hydroelectric Project. The proposed Bitter Creek Hydroelectric Project includes the following site components:

- An intake and diversion structure on upper Bitter Creek, located close to the Rio Blanco confluence with Bitter Creek;
- Approximately 2 km of penstock through which water will diverted from Bitter Creek; and
- A powerhouse located on the north east side of Bitter Creek, on the opposite side to the Red Mountain TMF.

Loss of habitat from the Bitter Creek Hydroelectric Project would be in addition to the habitat loss associated with the Access Road for the Red Mountain Underground Gold Project.

18.8.4.2 Changes in Water Quality

The land use activities outlined in 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 Fish and Fish Habitat. Projects and activities with potential to interact with Fish and Fish Habitat residual effects are in Table 18.8-1.

Table 18.8-1 have the potential to interact with residual effects on Fish and Fish Habitat 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 into Bitter Creek.

Mineral exploration could also result in reduced water quality and disturbances to the aquatic habitat from drilling and trail clearing.

The Hydroelectric project could reduce flows and therefore dilution capacity in Bitter Creek.

18.8.4.3 Changes in Stream Flows

Operation of the Bitter Creek Hydroelectric Project can lead to reduced flow in the diversion reach, between the point of diversion (intake) and the point of return (tailrace).

18.8.4.4 Additional Mitigation Measures

Proposed Mitigation Measures for the Project are outlined in Section 18.6.

Additional mitigation measures for cumulative effects may involve taking further action, where possible, to avoid or minimize cumulative effects on the Fish and Fish Habitat VCs.

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 Red Mountain Underground Gold Project, areas of spatial and temporal overlap between projects will be monitored and mitigated, where necessary. IDM and other project proponents, such as Bridge Power, will discuss the opportunity to 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. Instream flow requirements and ramping rates during operations are generally designed based on the fish bearing status of the stream. The Bitter Creek Hydroelectric Project is proposed within the non-fish bearing section of Bitter Creek. As such, instream flow and ramping requirements will be less stringent than for a fish bearing stream. However, given that fish are present downstream of the project, controls on the rate of flow change will still be required to protect fish below the Project. Applicable guidelines that cover protection of Fish and Fish Habitat include:

- Long term Aquatic Monitoring Protocols for New and Upgraded Hydroelectric Projects (DFO 2012; Lewis *et al.* 2011);
- Flow Ramping Guidelines for Hydroelectric Projects: Developing, Testing, and Compliance Monitoring (Lewis *et al.* 2013);
- Guidelines for the collection and analysis of fish and fish habitat data for the purpose of assessing impacts from small hydropower projects in British Columbia; and
- British Columbia Instream Flow Standards for Fish, Phase II: Development of instream flow thresholds as guidelines for reviewing proposed water uses.

18.8.5 Cumulative Effects Interaction Matrix

Potential cumulative effects on Fish and Fish Habitat are based on the potential for interaction between the on Fish and Fish Habitat residual effects with the projects and activities identified in Section 18.8.3. The interaction with effects of reasonably foreseeable future projects and activities are in Table 18.8-2.

Table 18.8-2: Interaction with Effects of Reasonably Foreseeable Future Projects and Activities

Residual Effects of this Project on Aquatic Resources	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
Habitat Loss	N	N	N	N	N	N	N	N	N
Changes in Surface Water Quality	N	N	N	N	N	N	N	N	N
Changes in Streamflows	N	N	N	N	N	N	N	N	N

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

All of the identified projects and activities were determined as not having an interaction due to the following reasons:

- The Bitter Creek Hydroelectric project is located in the non-fish bearing section of Bitter Creek, therefore:
  - There will no direct loss of Fish Habitat as result of the hydroelectric project. Furthermore, infrastructure below the high water mark is limited to the intake, and possibly the diversion structure.
  - Discharge will be fully mixed downstream of the tailrace (point of flow return) before reaching fish-bearing areas
  - Flow changes in the diversion reach of the hydroelectric project will not affect fish. 100% of the flow will be returned to Bitter Creek upstream of any fish bearing areas.
- The Stewart Bulk Terminal is located in the RSA, where no Fish and Fish Habitat 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 18.8-2 have the potential to interact with residual effects on Fish and Fish Habitat 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 license, 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; and
- 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, project roads will be decommissioned and reclaimed.

18.8.6 Cumulative Effects Characterization

There are no anticipated interactions between the Fish and Fish Habitat residual effects and the projects and activities listed in Table 18.8-1.

18.8.7 Summary of Cumulative Effects Assessment

The assessment of cumulative residual effects remains the same as the residual effects assessment for the Project alone as shown in Table 18.7-2.

18.9 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 Fish and Fish Habitat VCs. The strategy focuses on implementation of the AEMRP (Volume 5, Chapter 29.5). 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, Operations, 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 quality monitoring results will be compared with predictions of the Water Quality Model, and the post-project fish community will be assessed relative to the predicted effects on Fish and Fish Habitat.

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 Fish and Fish Habitat 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.

18.10 Conclusion

No significant change in Fish and Fish Habitat are predicted to occur at a regional scale due to the Project. Likewise, cumulative effects are not anticipated. All residual effects were considered non-significant due to the discrete or local geographical extent, and low to moderate magnitude of the anticipated effects. The assessment of significance is contingent on the complete implementation of mitigation measures. The maintenance of ecological conditions that support Fish may be altered in Bitter Creek, but not to the extent that productivity will be outside of the range of the existing baseline.

The results of the Fish and Fish Habitat Effects Assessment show that there will be no effects to Fish and Fish Habitat outside of Canada.

The results of this assessment have been carried forward to inform the effects assessment for Human Health (Volume 3, Chapter 22) and used in the development of the Screening Level Ecological Risk Assessment (Volume 8, Appendix 22-B).

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