15 Fish and Aquatic Habitat

15.1 Fish and Aquatic Habitat Setting

15.1.1 Overview

Elevations in the KSM Project (the Project) range from under 240 m at the confluence of Sulphurets Creek with the Unuk River, to over 2,300 m at the peak of the Unuk Finger, 8 km away. Proximity to the coast, high elevation, and substantial glacier coverage produce relatively high precipitation and runoff from watersheds in the KSM Project. Proximity to the Pacific Ocean and mountainous topography result in complex interactions between incoming weather systems and local topography that produce a high degree of spatial variability in snowfall and precipitation. The presence of large glacierized areas also affects snowmelt rates and produces high runoff volumes during summer months. The higher elevation, upper watershed of Sulphurets Creek, including Mitchell Creek, McTagg Creek, and Ted Morris Creek are substantially glaciated, while the lower elevation watersheds have almost no glaciers (e.g., Teigen Creek). Annual low flows occur during the winter when most available water is stored in the snowpack. Maximum monthly runoff occurs during June in the Teigen and Treaty catchments, and during August in the Unuk and Sulphurets catchments. Therefore, freshet runoff occurs earlier in the low elevation, non-glacierized catchments compared to the majority of the high elevation and glacierized catchments.

The baseline fish and aquatic habitat study area (i.e., the baseline study area) encompasses two major watersheds that include the Unuk and Bell-Irving rivers (Figure 15.1-1). The baseline study area is based upon the locations of the Project infrastructure within those watersheds. The north and west areas of the Project are situated within the Unuk River watershed, which crosses into Alaska and discharges into Burroughs Bay and eventually the Pacific Ocean. The eastern area of the Project is situated within the Bell-Irving River watershed, which discharges into the Nass River. The Bowser River is part of the Bell-Irving watershed.

A number of sub-watersheds are included within the baseline study area (Figure 15.1-2). There are eight assessed sub-watersheds within the Unuk River watershed, in addition to the main stem of the Unuk River. There are eight assessed sub-watersheds within the Bell-Irving River watershed, in addition to the main stem of the Bell-Irving River. There is one assessed sub-watershed within the Bowser River watershed (Scott Creek), in addition to the main stem of the Bowser River. The baseline study area sub-watersheds and their locations relative to Project infrastructure are summarized in Table 15.1-1.

Dolly Varden was the only species present in North Treaty and South Teigen creeks within the proposed Tailing Management Facility (TMF). Dolly Varden, bull trout, mountain whitefish, and rainbow trout were present in South Teigen Creek downstream of a 2.5-m-high falls and outside of the TMF. Dolly Varden dominated the species composition (95%) downstream of the falls in the lower reach of South Teigen Creek. No salmon species were observed in South Teigen, North Treaty, or Tumbling creeks, based upon electrofishing sampling effort (conducted in 2008, 2009, 2010, and 2011), ground-truthed spawning surveys for salmon species (conducted in 2009 and 2010), and habitat assessments (conducted in 2008, 2009, and 2010).

There is a 200-m-long cascade in Sulphurets Creek, approximately 500 m upstream of the confluence with the Unuk River. Dolly Varden were present in Sulphurets Creek below the cascade, but no fish species were present above the cascade.

In 2008, Sulphurets Creek and its tributaries (McTagg, Mitchell, and Ted Morris creeks) were sampled. No fish were caught above the cascade despite 6,698 seconds (s) of electrofishing effort. A total of nine sites were sampled in August 2008. Sulphurets Lake was sampled in September and no fish were caught despite a total of 118 hours (h) of gillnetting and 297 h of minnow trapping effort.

In 2009, a total of 3,046 s of electrofishing effort was exerted above the cascade at three sites in Sulphurets and Mitchell creeks. Sampling occurred in August and September 2009 and no fish were caught (Appendix 15-C). Sulphurets Lake was sampled in July, and no fish were caught after a total of 45 h of gillnetting and 235 h of minnow trapping effort.

In 2012, a total of 913 h of minnow trapping effort was exerted above the cascade at 40 sites in Sulphurets and Mitchell creeks. Sampling occurred in November 2012 and no fish were caught (Rescan 2012; Appendix 15-S). Therefore, all stream reaches above the Sulphurets Creek cascade were classified as non-fish-bearing.

Small numbers of Dolly Varden were present in Sulphurets Creek downstream of the cascade. The catch per unit effort (CPUE) of Dolly Varden in this area was orders of magnitude lower (0.01 fish/100 s of electrofishing effort) than that in the Unuk River (2.06 fish/100 s) and the South Unuk River (2.09 fish/100 s). No salmon species were present within Sulphurets Creek based upon electrofishing sampling effort in 2008 and 2009, ground-truthed and aerial spawning surveys for salmon species in August and October 2009 and 2010, and habitat assessments conducted in 2008 and 2009.

Sediments in the area downstream of the Mine Site (Mitchell Creek and Sulphurets Creek) were of poor quality. These sediments were often inhospitable with low nutrient availability (total organic carbon, nitrogen, and phosphorus), relatively coarse sediment structure that would limit the range of available habitat for benthic invertebrates, and metal concentrations that were frequently higher than sediment quality guidelines. Surveys of primary producer (periphyton) and benthic invertebrates in the creeks downstream of the Mine Site in 2008 and 2009 revealed low standing stocks (biomass and density) and low diversities (richness and Simpson's diversity) of the aquatic communities consistent with both poor water quality (Chapter 14) and sediment quality (this chapter).

Sediment quality in the Processing and Tailing Management Area (PTMA) was generally better than downstream of the Mine Site, but metal concentrations were often elevated above sediment quality guidelines. Some areas, particularly those downstream of the wetlands (e.g., South Teigen Creek), had relatively high organic carbon content and favourable particle size distributions that would provide a better range of suitable habitat to support more diverse benthic populations. There were some areas that supported more abundant and diverse aquatic communities (e.g., Teigen Creek), while other areas had periphyton and benthic invertebrate communities that were less abundant and diverse (e.g., Treaty Creek).

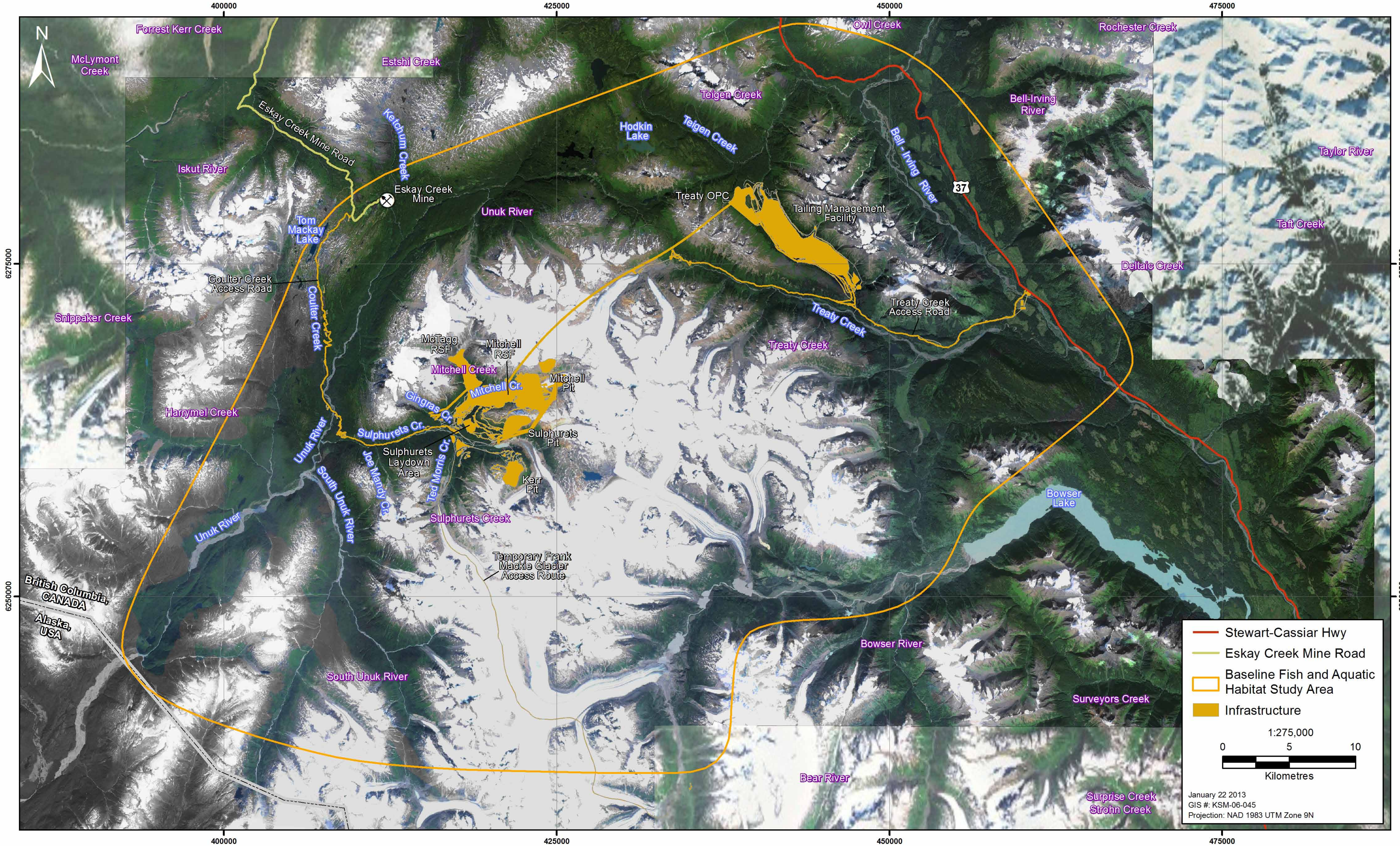

Figure 15.1-1

Rescan Engineers & Scientists

KSM Fish and Aquatic Habitat Baseline Study Area (2008 to 2012)

SEABRIDGE GOLD
KSM PROJECT

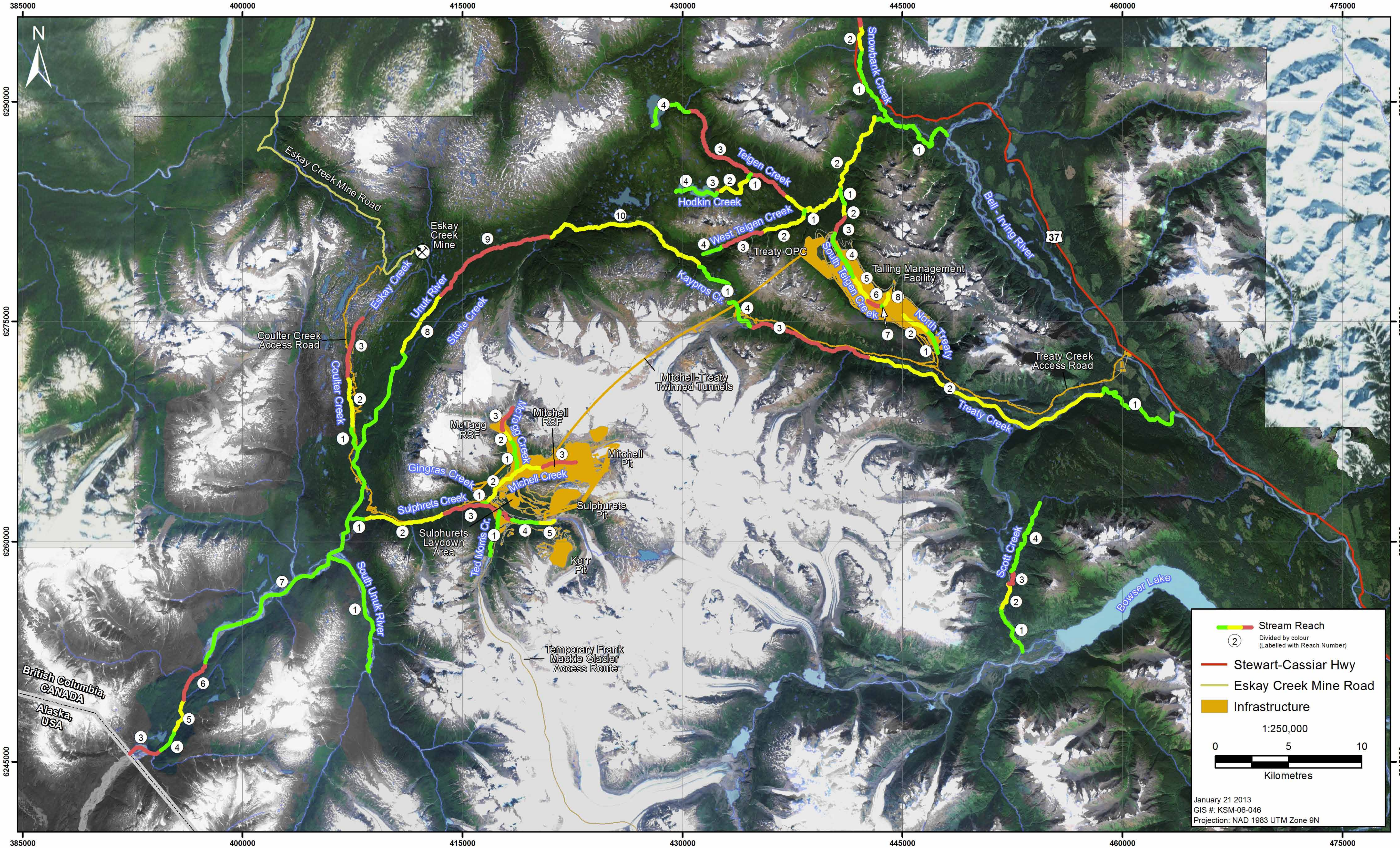

Figure 15.1-2

Rescan Engineers & Scientists

Stream Reaches within the Baseline Fish and Aquatic Habitat Study Area

SEABRIDGE GOLD
KSM PROJECT

Table 15.1-1. Watersheds within the Baseline Fish and Aquatic Habitat Study Area

Watershed	Watershed Description	Location Relative to Project Infrastructure	No. Reaches	Total Stream Length (km)
Unuk River Watershed				
Coulter Creek	Tributary of Unuk River	Coulter Creek access road (CCAR) within watershed	3	9.9
Gingras Creek	Tributary of Sulphurets Creek	Within location of McTagg penstock tunnel and power plant	1	4.0
Kaypros Creek	Headwater tributary of Unuk River	-	1	2.8
McTagg Creek	Tributary of Unuk River that discharges into Mitchell Creek	Within waste rock storage	3	5.2
Mitchell Creek	Tributary of Unuk River that discharges into Sulphurets Creek	Within and downstream of Mitchell Pit, waste rock storage and Water Storage Facility	3	8.1
South Unuk River	Tributary of Unuk River	-	1	9.5
Sulphurets Creek	Tributary of Unuk River	Within and downstream of Kerr-Sulphurets-Mitchell pits, waste rock storage, and Water Storage Facility; CCAR within watershed	5	14.3
Ted Morris Creek	Tributary of Unuk River that discharges into Sulphurets Creek	Location of explosives plant and magazines	1	9.5
Unuk River	-	Downstream of Kerr-Sulphurets-Mitchell pits, waste rock storage, and Water Storage Facility; crossed by CCAR	10[a]	66.2[b]
Bell-Irving River Watershed				
Bell-Irving River	Tributary of the Nass River	Downstream of PTMA	-	-
Hodkin Creek	Tributary of Bell-Irving River that discharges into Teigen Creek	-	4	3.9
North Treaty Creek	Tributary that discharges into Tumbling Creek	Within and downstream of TMF	2	2.8
Snowbank Creek	Tributary of Bell-Irving River that discharges into Teigen Creek	-	3	9.7
South Teigen Creek	Tributary of Teigen Creek	Within and downstream of PTMA	8	7.6
Teigen Creek	6^{th} order tributary of Bell-Irving River	Downstream of PTMA	4	30.3
Treaty Creek	4th order tributary of Bell-Irving River	Downstream of TMF; within Teigen Creek access road	4	38.3

(continued)

Table 15.1-1. Watersheds within the Baseline Fish and Aquatic Habitat Study Area (completed)

Watershed	Watershed Description	Location Relative to Project Infrastructure	No. Reaches	Total Stream Length (km)
Bell-Irving River Watershed (cont'd)				
Tumbling Creek	Tributary of Treaty Creek	Downstream of TMF	1	4.5
West Teigen Creek	Tributary of Bell-Irving River that discharges into Teigen Creek	-	4	6.8
Bowser River Watershed				
Bowser River	Tributary of the Bell-Irving River	Temporary Frank Mackie Glacier access route within watershed	-	-
Scott Creek	4th order tributary of Bowser River	-	4	13.7

Notes:
Dashes indicates not applicable.
[a] The first three reaches are located in the United States section of the Unuk River and are excluded from total stream length.
[b] Total stream length is for the Unuk River within Canada.

15.1.2 Legislation and Regulation

15.1.2.1 *Fisheries Act*

Many fish species serve an important role in the ecological, economic, and cultural aspects of British Columbia (BC). In particular, salmonid species (e.g., Pacific salmon, bull trout, rainbow trout/steelhead) support local economies and cultures, and are captured in recreational fisheries, while other species act as indicators of aquatic environmental health (e.g., sculpin species). Fish and aquatic habitat are protected under several forms of federal and provincial legislation, including the federal *Fisheries Act* (1985). Under the *Fisheries Act*, the term "fish" includes:

- parts of fish;
- shellfish, crustaceans, marine animals, and any parts of shellfish, crustaceans, or marine animals; and
- the eggs, sperm, larvae, spat, and juvenile stages of fish, shellfish, crustaceans, and marine animals.

Section 35(1) of the *Fisheries Act* (1985) defines fish habitat as "spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly to carry out their life processes." The *Fisheries Act* also prevents the "harmful alteration, disruption, or destruction" of fish habitat through physical, chemical, or biological means. The Policy for the Management of Fish Habitat (DFO 1986) outlines the policy statement of Fisheries and Oceans Canada (DFO) as "no net loss of productive capacity" of fish habitat.

In June 2012, the federal government proposed amendments to the *Fisheries Act* (1985). The proposed changes would result in a shift for DFO from a focus on managing impacts to all fish habitat to managing threats to fisheries. These amendments would support the long-term productivity and sustainability of Canada's commercial, recreational, and Aboriginal fisheries. The current *Fisheries Act* (1985) provisions used for the review of Project effects are indiscriminate and require consideration of all projects, on all waters, regardless of the importance of fish species present or their contribution to fisheries.

Currently, DFO is in a transition phase with respect to implementing *Fisheries Act* (1985) legislative changes. During the transition phase, the existing provision of the *Fisheries Act* will continue to apply. The transition phase is expected to last until January 2013, at which time the legislative changes are expected to come into force. Following the legislative changes, DFO's Policy for Management of Fish Habitat (1986) and guiding principle of "No Net Loss" will be changed. However, the details on the timing of policy changes are unknown at the time.

15.1.2.2 Metal Mining Effluent Regulations

In 1996, Environment Canada undertook an assessment of the aquatic effects of mining in Canada, which provided recommendations regarding the review and amendments of the Metal Mining Liquid Effluent Regulations, currently titled the Metal Mining Effluent Regulations (MMER; SOR/2002-222), and the design of a national Environmental Effects Monitoring (EEM) program for metal mining. The MMER, under the *Fisheries Act* (1985), direct metal mines to conduct EEM as a condition governing the authority to deposit effluent (MMER, Part 2, section 7).

The MMER (SOR/2002-222) permit the deposit of mine effluent if the effluent pH is within a defined range, if the concentrations of the MMER deleterious substances in the effluent do not exceed authorized limits, and if the effluent is demonstrated to be non-acutely lethal to rainbow trout. These discharge limits were established to be minimum national standards based on best available technology economically achievable at the time that the MMER were promulgated. To assess the adequacy of the effluent regulations for protecting the aquatic environment, the MMER include EEM requirements to evaluate the potential effects of effluent on fish, fish habitat, and the use of fisheries resources.

Regulations Amending the MMER were published in the Canada Gazette, Part II, in October 2006 (Canada Gazette 2006). The purpose of these amendments was to clarify the regulatory requirements by addressing matters related to the interpretation and clarity of the regulatory text that had emerged from the implementation of the Regulations.

Additional amendments to the MMER (SOR/2002-222) were published in the Canada Gazette, Part II, in March 2012 (Canada Gazette 2012). The following changes were made to improve the EEM provisions of the MMER:

- modifications to the definition of an "effect on fish tissue" in order to be consistent with the Health Canada fish consumption guidelines (2007) and to clarify that the concentration of total mercury in tissue of fish from the exposure area must be statistically different from and higher than its concentration in fish tissue from the reference area;

- addition of selenium and electrical conductivity to the list of parameters required for effluent characterization and water quality monitoring;
- exemption for mines, other than uranium mines, from monitoring radium 226 as part of the water quality monitoring, if 10 consecutive test results showed that radium 226 levels are less than 10% of the authorized monthly mean concentration (subsection 13(2) of the Regulations);
- change to the time frame for the submission of interpretative reports for mines with effects on the fish population, fish tissue, and benthic invertebrate community from 24 to 36 months;
- change to the time frame for the submission of interpretative reports for magnitude and geographic extent of effects and for investigation of cause of effects from 24 to 36 months; and
- minor changes to the wording for consistency within Schedule 5.

15.1.2.3 *Environmental Management Act*

The *Environmental Management Act* (EMA; 2003) was brought into force on July 8, 2004. The EMA replaces the old *Waste Management Act* (1996c) and the *Environment Management Act* (1996a) and brings provisions from both of those acts into one statute.

The EMA provides flexible authorization framework, increases enforcement options, and uses modern environmental management tools to protect human health and the quality of water, land, and air in BC.

Under section 6(2) and 6(3) of the EMA, only introductions of waste from “prescribed” industries, trades, businesses, operations, and activities require authorization. Industries, trades, businesses, operations, and activities are “prescribed” in the Waste Discharge Regulation (BC Reg. 320/2004). If an industry, trade, business, activity, or operation is not “prescribed” by the regulation, it does not require an authorization to introduce waste into the environment; however, the discharge must not cause pollution (Section 6[4]; 2003).

The Waste Discharge Regulation (BC Reg. 320/2004), which was brought into force on July 8, 2004, “prescribes” industries, trades, businesses, activities, and operations for the purposes of the EMA, sections 6(2) and 6(3). These industries, trades, businesses, activities, and operations are listed in Schedule 1 and 2 of the Regulation. Industries, trades, businesses, activities, and operations listed on Schedule 1 require an authorization, which could be in the form of a permit, an approval, a regulation, an operational certificate, an order, or a waste management plan to introduce waste into the environment. Introductions of waste into the environment from industries, trades, businesses, activities, and operations listed on Schedule 2 are eligible to be authorized by a minister’s code of practice.

15.1.2.4 *Water Act*

In BC, the ownership of water is vested in the Crown, as stated in the *Water Act* (1996d), the primary provincial statute regulating water resources. Under the *Water Act* (1996d), a "stream" is defined as: "includes a natural watercourse or source of water supply, whether usually containing water or not, and a lake, river, creek, spring, ravine, swamp and gulch."

Section 9 of the *Water Act* (1996d) requires that a person may only make "changes in and about a stream" under an Approval, in accordance with Part 7 of the Water Regulation (BC Reg. 204/88), including Notification where required, or under a Water Licence or Order.

Under the *Water Act* (1996d), "changes in and about a stream" means;

- any modification to the nature of the stream including the land, vegetation, natural environment or flow of water within the stream; or
- any activity or construction within the stream channel that has or may have an impact on a stream.

Approvals are the responsibility of the Resource Stewardship Division of the BC Ministry of Forests, Lands and Natural Resource Operations.

In order to minimize potential impacts that instream work may have on aquatic species and habitats, work should be undertaken during periods of reduced risk to the aquatic resource (Work Windows). Because BC has such a rich diversity of species and habitats, windows vary between and within regions.

15.1.2.5 Municipal Wastewater Regulation and Sewerage Systems Regulation

Treatment of sewage and disposal of the effluent is regulated in BC by the Municipal Wastewater Regulation (BC Reg. 87/2012; made under the *Environmental Management Act* [2003] and administered by the BC Ministry of Environment [BC MOE]) for larger systems, and by the Sewerage System Regulation (BC Reg. 326/2004; made under the *Health Act* (1996b) and administered by local health authorities) for smaller systems. A small system is considered to be a sewerage system that generates less than 22,700 L of effluent per day (approximately 22.7 m^3/day or 6,000 gallons/day); anything greater than this would be regulated under the Municipal Wastewater Regulation (BC Reg. 87/2012). Based on this definition, the wastewater treatment and disposal systems at the largest temporary construction and operating camps will be regulated by the Municipal Wastewater Regulation, including at Camp 4: Mitchell North Camp, Camp 9: Mitchell Initial Camp, Camp 10: Mitchell Secondary Camp, Camp 5: Treaty Plant Camp, Camp 6: Treaty Saddle Camp, Treaty operating camp, and Mitchell operating camp. Wastewater treatment at the remaining temporary construction camps will be regulated under the Sewerage System Regulation. The intent of these regulations is to ensure that environmental impacts of sewage treatment and disposal are minimized and that human health is protected.

For smaller systems, Section 2.1 of the Sewerage System Regulation (BC Reg. 326/2004) indicates that the discharge of domestic sewage or effluent to surface water is prohibited, since they constitute a health hazard; only disposal to ground or holding tank can be considered.

For larger systems, three types of effluent disposal are allowed: disposal to ground, disposal to surface water, or reclaimed water uses. The Municipal Wastewater Regulation (BC Reg. 87/2012) requires that, for each proposed new system, an Environmental Impact Study (EIS) must be completed that assesses the potential for effects to both the environment and to human health. The EIS must also detail a monitoring plan that will be used to ensure that no alteration to the receiving environment occurs as a result of effluent discharge. Both of these regulations serve to protect aquatic habitat and its resident species by either prohibiting or regulating discharge of sewage treatment plant (STP) effluent to surface waters.

15.1.3 Baseline Study Area Program

Fish and aquatic habitat baseline studies were undertaken in 2008, 2009, 2010, 2011 (fish only), and 2012 (fish only) to collect comprehensive data on fish communities and aquatic habitat specific to the proposed Project. Baseline reports are presented in Appendices 15-A to 15-I.

The information sources for the Application for an Environmental Assessment Certificate / Environmental Impact Statement (Application/EIS) were fish and aquatic habitat baseline studies completed in 2008, 2009, 2010, 2011, and 2012. Relevant fish and fish habitat information for the baseline study area was obtained from a variety of sources (Table 15.1-2). This information was reviewed prior to initiating fieldwork to assist in determining fish presence/absence, distribution, and fish habitat quality. Table 15.1-2 provides a list of information sources reviewed as well as data sources. The information sources were also used to support field observations with evidence from the published literature.

Table 15.1-2. Information Sources for the Fish and Aquatic Habitat Baseline Studies

Information Reviewed	Data Source
Stream names, BC watershed groups, and codes	• Fisheries Information Summary System (FISS) • BC Watershed Atlas
Sediment quality	• Environment Canada report[a]
Fish distribution, abundance, and aquatic habitat attribute data	• Nisga'a and First Nation reports[a] • DFO, Alaska Department of Fish and Game (ADFG), and BC Ministry of Environment (BC MOE) reports[a] • Consultant reports[a] • Online provincial and federal databases (i.e., FISS, Habitat Wizard, WAVES, Ecocat)
Fish species at risk and species of special concern	• Committee of the Status of Endangered Wildlife in Canada (COSEWIC) • BC Conservation Data Centre (BC CDC)
Fish species life histories	• McPhail 2007, Scott and Crossman 1973, Quinn 2005, Groot and Margolis 1991, Roberge et al. 2002

[a] Reports:
ADFG (1996, 1997, 2001, 2002, 2003a, 2003b, 2004, 2006, 2008, 2009); BC MOE (n.d., 1982a, 1982b, 1988, 1997, 2000); Bocking and Peacock (2004); Bocking, Parken, and Atagi (2005); DFO (1987); Environment Canada (1990); Knight Piesold and Homestake Canada (1993); Koski, Link, and English (1996a); Koski, Alexander, and English (1996b); LGL (1995, 1999); Mecum and Kissner (1989); NLG (2007); SKR (1998); Tripp (1987,1988, 1995).

A summary of baseline fisheries and aquatic habitat studies conducted is provided in Table 15.1-3, by watershed and year. The objectives of the fish and aquatic habitat baseline studies varied depending upon the study year and Project component; therefore similar studies were not completed for each watershed or year. Listed below is a summary of study objectives.

Table 15.1-3. Summary of Fish and Aquatic Habitat Studies for the KSM Project

		Fish Community				Fish Habitat				Aquatic Habitat					
Watershed	Study Year	Population Sampling	Population Density Assessment	Spawning Survey	Fish Tissue Sampling	Habitat Assessment	Habitat Mapping	Instream Flow Assessment	Water Temperature Monitoring	Sediment	Periphyton	Benthic Invertebrates	Limnology	Phytoplankton	Zooplankton
Unuk River Watershed															
Unuk River	2008	P	-	-	-	P	-	-	-	P	P	P	-	-	-
	2009	P	-	-	-	P	-	-	-	P	P	P	-	-	-
	2010	P	-	-	-	P	-	-	-	-	-	-	-	-	-
	2012		-	-	-	-	-	-	-	P	-	-	-	-	-
Coulter Creek	2008	P	-	-	-	P	-	-	-	P	P	P	-	-	-
	2009	P	-	-	-	P	-	-	-	P	P	P	-	-	-
	2012	-	-	-	-	-	-	-	-	P	-	-	-	-	-
Gingras Creek	2010	-	-	-	-	-	-	-	-	P	P	P	-	-	-
	2012	-	-	-	-	-	-	-	-	P	-	-	-	-	-
Mitchell Creek	2008	P	-	-	-	P	-	-	-	P	P	P	-	-	-
	2009	P	-	-	-	P	-	-	-	P	P	P	-	-	-
	2012	P	-	-	-	-	-	-	-	P	-	-	-	-	-
McTagg Creek	2008	P	-	-	-	P	-	-	-	-	-	-	-	-	-
	2009	-	-	-	-	-	-	-	-	-	-	-	-	-	-
South Unuk River	2008	P	-	-	-	P	-	-	-	P	P	P	-	-	-
	2009	P	-	-	-	P	-	-	-	P	P	P	-	-	-
	2012	-	-	-	-	-	-	-	-	P	-	-	-	-	-
Sulphurets Creek	2008	P	-	-	P	P	-	-	-	P	P	P	-	-	-
	2009	P	-	-	P	P	-	-	-	P	P	P	-	-	-
	2010	-	-	P	-	-	-	P	-	-	-	-	-	-	-
	2012	P	-	-	-	-	-	-	-	P	-	-	-	-	-
Ted Morris Creek	2008	P	-	-	-	P	-	-	-	P	P	P	-	-	-
	2009	-	-	-	-	-	-	-	-	P	P	P	-	-	-
	2012	P	-	-	-	-	-	-	-	P	-	-	-	-	-
Kaypros Creek	2008	P	-	-	-	P	-	-	-	-	-	-	-	-	-
	2009	P	-	-	-	P	-	-	-	-	-	-	-	-	-
Sulphurets Lake	2008	P	-	-	-	P	P	-	-	P	-	P	P	P	P
	2009	P	-	-	-	-	-	-	-	P	-	P	P	P	P
Unuk Lake	2010	P	-	-	-	P	-	-	-	-	-	-	-	-	-
Bell-Irving River Watershed															
Bell-Irving River	2009	P	-	-	-	P	-	-	-	-	-	-	-	-	-
	2010	P	-	P	-	P	P	-	-	-	-	-	-	-	-
Snowbank Creek	2008	P	-	-	-	P	-	-	-	P	P	P	-	-	-
	2009	P	-	-	-	P	-	-	-	P	P	P	-	-	-
	2010	P	-	P	-	P	-	-	-	-	-	-	-	-	-
	2011	P	P	-	-	P	-	-	-	-	-	-	-	-	-
	2012	-	-	-	-	-	-	-	-	P	-	-	-	-	-
Teigen Creek	2008	P	-	-	-	P	-	-	-	P	P	P	-	-	-
	2009	P	-	P	-	P	-	-	-	P	P	P	-	-	-
	2010	P	-	P	P	P	P	-	-	-	-	-	-	-	-
	2011	P	P	P	-	P	-	-	-	-	-	-	-	-	-
	2012	-	-	-	-	-	-	-	-	P	-	-	-	-	-
South Teigen Creek	2008	P	-	-	P	P	-	-	-	P	P	P	-	-	-
	2009	P	P	P	P	P	P	P	P	P	P	P	-	-	-
	2010	P	P	P	-	P	-	P	P	-	-	-	-	-	-
	2011	P	P	P	-	P	-	-	-	-	-	-	-	-	-
	2012	-	-	-	-	-	-	-	-	P	-	-	-	-	-
Treaty Creek	2008	P	-	-	-	P	-	-	-	P	P	P	-	-	-
	2009	P	-	P	-	P	-	-	-	P	P	P	-	-	-
	2010	P	-	P	-	P	P	-	-	-	-	-	-	-	-
	2011	P	-	P	-	P	-	-	-	-	-	-	-	-	-
	2012	P	P	-	-	P	-	-	-	P	-	-	-	-	-

Note:

Study years represent Rescan baseline studies

P indicates study conducted

(continued)

Table 15.1-3. Summary of Fish and Aquatic Habitat Studies for the KSM Project (completed)

		Fish Community				Fish Habitat				Aquatic Habitat					
Watershed	Study Year	Population Sampling	Population Density Assessment	Spawning Survey	Fish Tissue Sampling	Habitat Assessment	Habitat Mapping	Instream Flow Assessment	Water Temperature Monitoring	Sediment	Periphyton	Benthic Invertebrates	Limnology	Phytoplankton	Zooplankton
West Teigen Creek	2008	P	-	-	-	P	-	-	-	P	P	P	-	-	-
	2009	P	P	-	-	P	-	-	-	P	P	P	-	-	-
	2012	-	-	-	-	-	-	-	-	P			-	-	-
North Treaty Creek	2008	P	-	-	-	P	-	-	-	P	P	P	-	-	-
	2009	P	P	P	-	P	P	P	P	P	P	P	-	-	-
	2010			P	-	-	-	P	P	-	-	-	-	-	-
	2011	P	P	P	-	P	-	-	-	-	-	-	-	-	-
	2012		-	-	-	-	-	-	-	P	-	-	-	-	-
Tumbling Creek	2008	P	-	-	P	P	-	-	-	P	P	P	-	-	-
	2009	P	P	P	P	P	-	-	-	P	P	P	-	-	-
	2010	-	-	P	-	-	-	-	-	-	-	-	-	-	-
	2011	-	-	P	-	-	-	-	-	-	-	-	-	-	-
Hodkin Creek	2008	P	-	-	-	P	-	-	-	-	-	-	-	-	-
	2009	P	-	-	-	P	-	-	-	-	-	-	-	-	-
	2010	P	-	-	-	P	P	-	-	-	-	-	-	-	-
Todedada Creek	2010	P	-	P	-	P	P	-	-	-	-	-	-	-	-
	2011	P	P	P	-	P	-	-	-	-	-	-	-	-	-
Gilbert Creek	2010	P	-	P	-	P	P	-	-	-	-	-	-	-	-
	2011	P	P	P	-	P	-	-	-	-	-	-	-	-	-
Mere Creek	2010	P	-	P	-	P	P	-	-	-	-	-	-	-	-
Taft Creek	2010	P	-	P	-	P	-	-	-	-	-	-	-	-	-
	2011	P	-	-	-	P	-	-	-	-	-	-	-	-	-
Glacier Creek	2010	P	-	-	-	P	-	-	-	-	-	-	-	-	-
	2011	P	-	-	-	P	-	-	-	-	-	-	-	-	-
Oweegee Creek	2009	P	-	P	-	P	-	-	-	-	-	-	-	-	-
	2010	P	-	P	-	P	P	-	-	-	-	-	-	-	-
	2011	P	P	P	-	P	-	-	-	-	-	-	-	-	-
West Teigen Lake	2008	P	-	-	-	P	P	-	-	P	-	P	P	P	P
	2009	P	-	-	-	-	-	-	-	P	-	P	P	P	P
	2010	-	-	-	-	P	-	-	-	-	-	-	-	-	-
Teigen Lake	2008	P	-	-	-	P	P	-	-	-	-	-	-	-	-
	2009	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hodkin Lake	2008	P	-	-	-	P	P	-	-	-	-	-	-	-	-
	2009	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2010	P	-	-	-	-	-	-	-	-	-	-	-	-	-
Todedada Lake	2008	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2009	P	-	-	-	P	P	-	-	P	-	P	P	P	P
Gilbert Lake	2010	P	-	-	-	P	-	-	-	-	-	-	-	-	-
Bowser River Watershed															
Bowser River	2008	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2009	P	-	-	-	P	-	-	-	-	-	-	-	-	-
	2010	P	-	-	-	P	-	-	-	-	-	-	-	-	-
Scott Creek	2008	P	-	-	P	P	-	-	-	P	P	P	-	-	-
	2009	P	-	-	P	P	-	-	-	P	P	P	-	-	-
Knipple Glacier Lake	2008	P	-	-	-	P	P	-	-	P	-	P	P	P	P
	2009	-	-	-	-	-	-	-	-	P	-	P	P	P	P

Note:

Study years represent Rescan baseline studies

P indicates study conducted; dash no study conducted

15.1.3.1.1 2008 Fish and Fish Habitat Study

- determine the location and type of watercourses (e.g., stream, lake, or wetland) crossed by the access roads and within Project infrastructure;
- determine fish presence, barriers to fish movement, fish distribution, and the provincial classification of watercourses within the baseline study area;
- assess fish habitat and community of watercourses within the baseline study area;
- determine fish community composition and fish habitat quality of lakes and wetlands within the baseline study area; and
- assess fish tissue metals concentrations, fish diet, fish health, fish energy, and reproductive investment at sites downstream of the Project infrastructure.

15.1.3.1.2 2008 Aquatic Habitat Study

- obtain baseline information of sediment quality (physical, organics, metals, nutrients, and polycyclic aromatic hydrocarbons) in rivers and streams within the baseline study area in terms of spatial variation among sites;
- obtain baseline information regarding the diversity and distribution of algal and benthic invertebrate communities in stream and river habitat within the baseline study area; and
- obtain baseline information on sediment, physical limnology, phytoplankton, zooplankton, and benthic invertebrate communities in key lakes in the baseline study area.

15.1.3.1.3 2009 Fish and Fish Habitat Study

- determine fish presence, community, distribution, and barriers to fish movement for watercourses within the baseline study area, with an emphasis on non-fish-bearing stream reaches identified in 2008;
- assess the fish habitat of watercourses within the baseline study area, with a detailed emphasis on streams within the proposed TMF;
- assess the fish population density and structure of watercourses for South Teigen and North Treaty Creek watersheds within and downstream of the proposed TMF;
- assess the instream flow and fish habitat relationships for South Teigen and North Treaty creeks downstream of the TMF, and for Sulphurets Creek downstream of the Mine Site;
- determine if genetic differences exist between and within Dolly Varden (*Salvelinus malma*) populations of Treaty and Teigen watersheds and if significant genetic differences exist among the South Teigen Creek Dolly Varden population, above the falls barrier, and Dolly Varden populations throughout the province;
- determine fish community composition and fish habitat quality of lakes and wetlands within the baseline study area; and
- assess whole body fish tissue quality (e.g., metal concentrations), fish diet, fish health, fish energy, and reproductive investment at sites downstream of the Project infrastructure.

15.1.3.1.4 2009 Aquatic Habitat Study

- obtain a second year of baseline data on sediment quality (physical, organics, metals, and nutrients) in rivers and streams within the proposed baseline study area to assess inter-annual variability;
- obtain further baseline information regarding the density, diversity, and distribution of algal and benthic invertebrate communities in stream and river habitat within the baseline study area to assess inter-annual variability; and
- obtain baseline information on sediment, physical limnology, phytoplankton, zooplankton, and benthic invertebrate communities in key lakes in the baseline study areas to assess inter-annual variability.

15.1.3.1.5 2010 Fish and Fish Habitat Study

- assess the fish and fish habitat of watercourses within the baseline study area, with a detailed emphasis on sites for fish habitat compensation project development;
- assess the quality of fish habitat in watercourses along proposed access roads;
- assess the instream flow and fish habitat relationships for South Teigen and North Treaty creeks downstream of the TMF, and for Sulphurets Creek downstream of the Mine Site;
- assess Dolly Varden abundance in South Teigen Creek downstream of the TMF; and
- assess the abundance, timing, and distribution of spawning habitat for chinook, coho and sockeye salmon, steelhead, and bull trout in Teigen, South Teigen, Treaty, North Treaty, and Sulphurets creeks.

15.1.3.1.6 2010 Aquatic Habitat Study

- obtain baseline information of sediment quality (physical, organics, metals, and nutrients) in Gingras Creek; and
- obtain baseline information regarding the diversity and distribution of algal and benthic invertebrate communities in Gingras Creek.

15.1.3.1.7 2011 Fish and Fish Habitat Study

- determine fish presence, community composition, spatial distribution and barriers to fish movement for watercourses along the proposed access roads and transmission line;
- assess the quality of fish habitat in watercourses along the proposed access roads and transmission line;
- assess Dolly Varden abundance in South Teigen Creek and North Treaty Creek downstream of the TMF; and
- determine steelhead spawning habitat distribution and escapement/redd abundance in watercourses downstream of the TMF.

15.1.3.1.8 2011 Fish and Fish Habitat Compensation Study

- determine fish presence, community composition, habitat quality, and spatial distribution of overwintering fish habitat within identified fish habitat compensation sites;
- determine steelhead spawning habitat distribution and redd abundance in Oweegee Creek, Gilbert Creek, and East Todedada Creek fish habitat compensation sites;
- assess the relative abundance, growth, and condition of stream-rearing salmonids within instream fish habitat compensation sites; and
- assess the relative abundance, growth, and condition of wetland-rearing Dolly Varden and coho salmon within wetland fish habitat compensation sites.

15.1.3.1.9 2012 Fish and Fish Habitat Study

- determine fish presence, community composition, spatial distribution, and barriers to fish movement for watercourses along the proposed access roads and transmission line;
- assess the quality of fish habitat in watercourses along the proposed access roads and transmission line; and
- confirm non-fish-bearing status of the Sulphurets Creek watershed upstream of the cascade.

The following sections describe fish, fish habitat, and aquatic resources for the baseline fish and aquatic habitat study area.

15.1.4 Fish and Fish Habitat

15.1.4.1 Baseline Study Methods

Fish and fish habitat baseline studies were completed following provincial and federal approved assessment standards (Appendices 15-A to 15-I and 15-S). Provincial Resource Inventory Committee (RIC) standards for fish and aquatic habitat assessment were adopted for baseline studies. The following RIC and other standards were followed for baseline studies: RIC Fish Collection Methods and Standards (RISC 1997); Reconnaissance (1:20,000) fish and fish habitat inventory: Lake Survey Form Field Guide (RISC 1999a); Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Site Card Field Guide (RISC 1999b); Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Fish Collection Field Guide (RISC 1999c); Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures (RISC 2001a); Standards for Fish and Fish Habitat Maps (RISC 2001b); Forest Practices Code of British Columbia *Fish-Stream Identification Guidebook* (BC MOF 1998); Sensitive Habitat Inventory Mapping (SHIM) Protocol (Mason and Knight 2001); BC Watershed Restoration Fish Habitat Assessment Procedures (Johnston and Slaney 1996); Redd Enumeration Field Guide (RISC 2003); British Columbia Instream Flow Methodology (Lewis et al. 2004); and *Salmonid Field Protocols Handbook: Techniques for Assessing Status and Trends in Salmon and Trout Populations* (Johnson et al. 2007).

Fish and aquatic habitat assessments were conducted in numerous watersheds within the baseline study area (Table 15.1-3). Figures 15.1-3a through 15.1-3j show the location of fish and fish habitat assessment sites. Sites were categorized as fish community and habitat, tissue metals, or instream flow habitat assessments.

The following sections provide a summary of fish and fish habitat within the baseline study area and relative to important Project components. Overall fish community, distribution, and relative abundance are described for watersheds. Assessment methods, locations, fish habitat, and community are described related to the Project components. The Project components are access roads, and the PTMA and Mine Site.

15.1.4.2 Baseline Study Area Fish Community

15.1.4.2.1 Overview

The Unuk and Bell-Irving rivers are large river systems with diverse fish communities and cultural values. They provide spawning routes for Pacific salmon (*Oncorhynchus* spp.), anadromous steelhead (*O. mykiss*), and cutthroat trout (*O. clarkii clarkii*), and serve as habitat for resident rainbow and cutthroat trout, Dolly Varden (*Salvelinus malma*), bull trout (*S. confluentus*), and mountain whitefish (*Prosopium williamsoni*). A total of 10 fish species were present within the baseline study area (Table 15.1-4). These species were identified from Project-specific sampling data and existing historical data (Appendix 15-T). Two blue-listed species (bull trout and coastal cutthroat trout) were present in the baseline study area. One yellow-listed species (Dolly Varden) was present in the baseline study area. No Committee on the Status of Endangered Wildlife in Canada (COSEWIC)-listed species were present in the baseline study area. Nine species were present in the Bell-Irving watershed and seven species were present in the Unuk watershed (Canadian waters). Eight species were present in the Bowser watershed, three species were present in Scott Creek, and only Dolly Varden were present in the headwaters of Bowser River.

Dolly Varden were the most widely distributed species within all watershed reaches in the baseline study area. This is a reflection of the species' ability to tolerate cold, turbid glacial water conditions (McPhail 2007), which is generally a limiting factor for other fish species. They are also able to reside in steep gradient streams (less than 30%) and sustain populations above physical barriers such as waterfalls (Ihlenfeldt 2005; McPhail 2007). Dolly Varden and bull trout coexist in Teigen, Treaty, Snowbank, and Scott watersheds. Hybrids of the two species were identified in Teigen, South Teigen (below the falls), and Scott creeks through genetic analysis (Appendix 15-C).

Existing Conservation Units (CUs) under the DFO *Wild Salmon Policy* were identified within the baseline fish and aquatic habitat study area. There were two coho salmon CUs (of 43) present: UNUK (Unuk River Watershed – Canadian Waters) and UNASS (Upper Nass). The Unuk River coho salmon CU is differentiated by ecotype and the UNASS CU is differentiated by ecotype and genetics (they are more closely related to the Skeena coho than the other Nass coho).

There were two chinook salmon CUs (of 63) present within the baseline fish and aquatic habitat study area. The chinook salmon CUs were:

- UNR (Upper Nass) - there are inconclusive genetic indicators and so are primarily differentiated from the Lower Nass stocks by spawning timing; and
- UNUK (Unuk) - chinook salmon are different from all other CUs based on ecotype and general ecology (late spawning timing and rearing habits).

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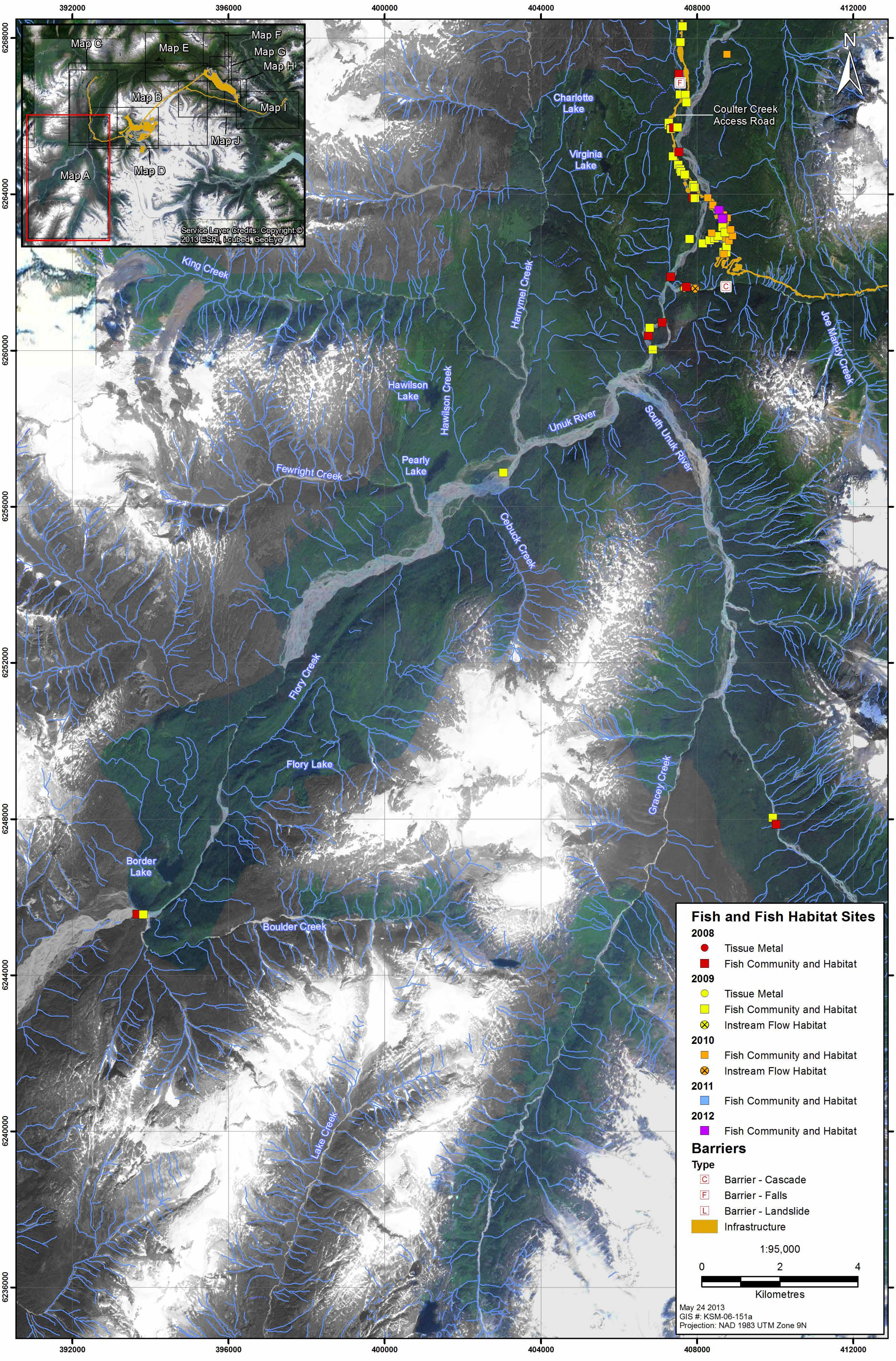

Figure 15.1-3a

SEABRIDGE GOLD
KSM PROJECT

Baseline Fish and Fish Habitat Sampling Sites, 2008 to 2012

Figure 15.1-3a

Rescan
Engineers & Scientists

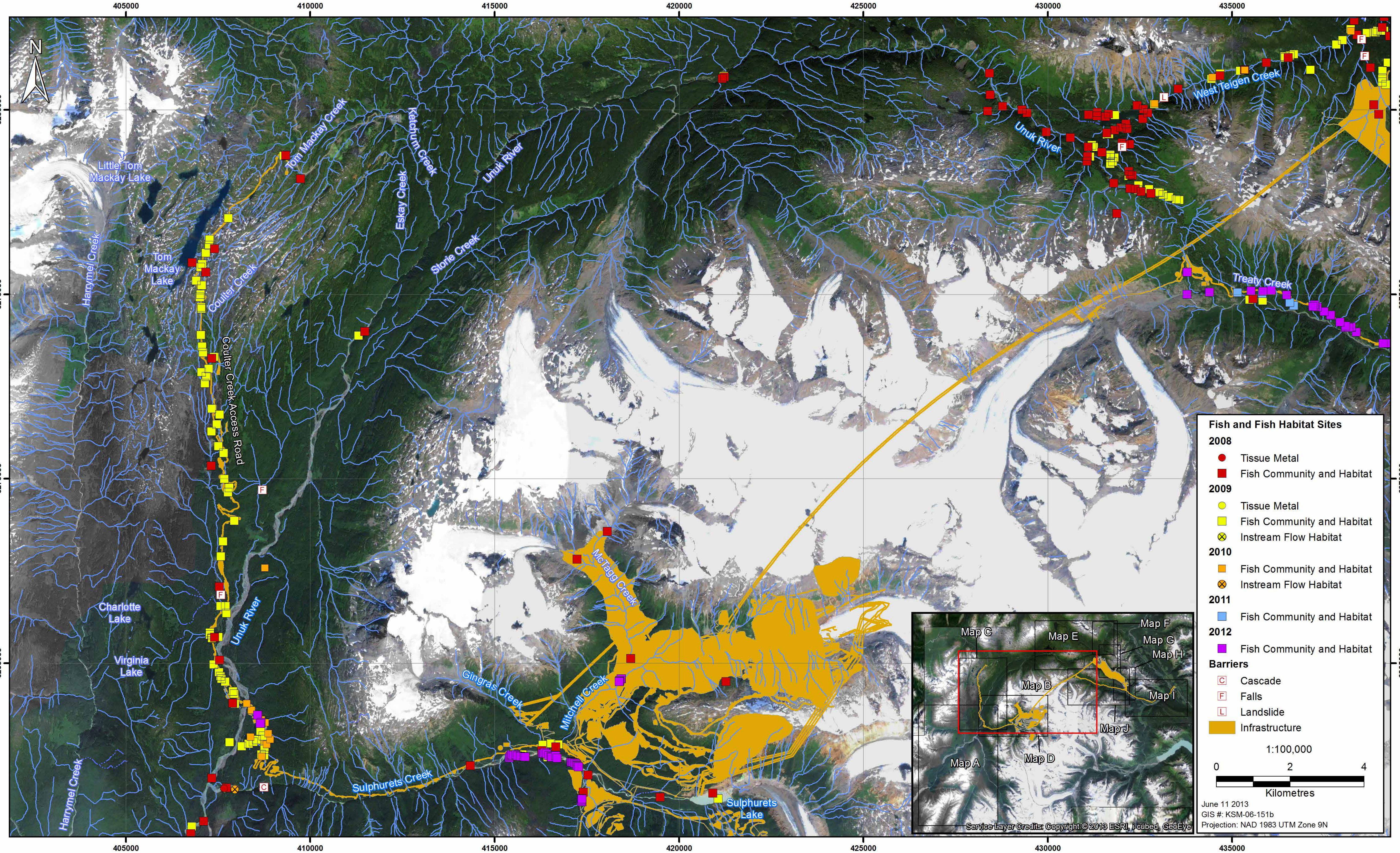

Figure 15.1-3b

Baseline Fish and Fish Habitat Sampling Sites, 2008 to 2012

Rescan Engineers & Scientists

SEABRIDGE GOLD
KSM PROJECT

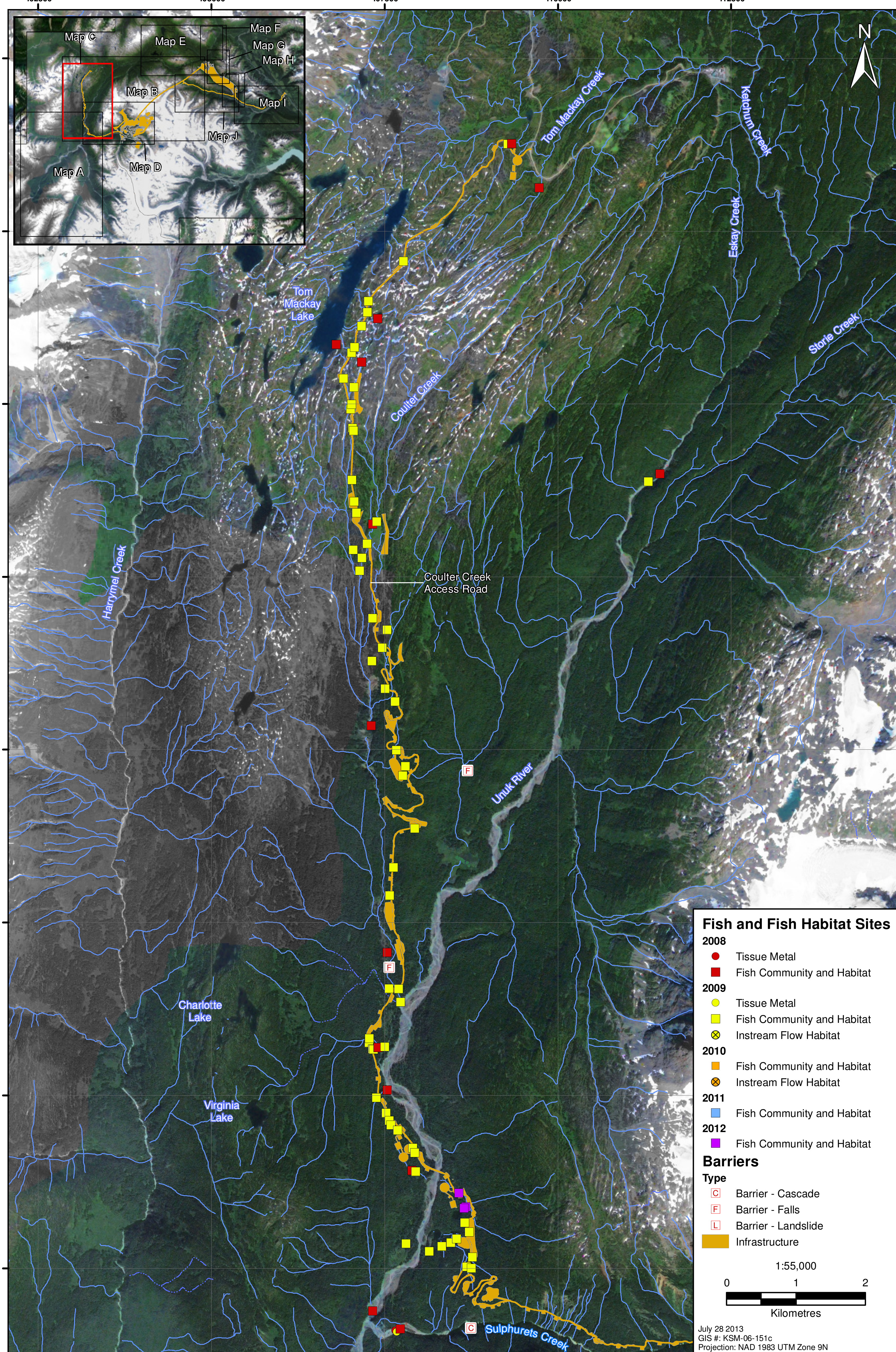

Figure 15.1-3c

SEABRIDGE GOLD KSM PROJECT

Baseline Fish and Fish Habitat Sampling Sites, 2008 to 2012

Rescan Engineers & Scientists

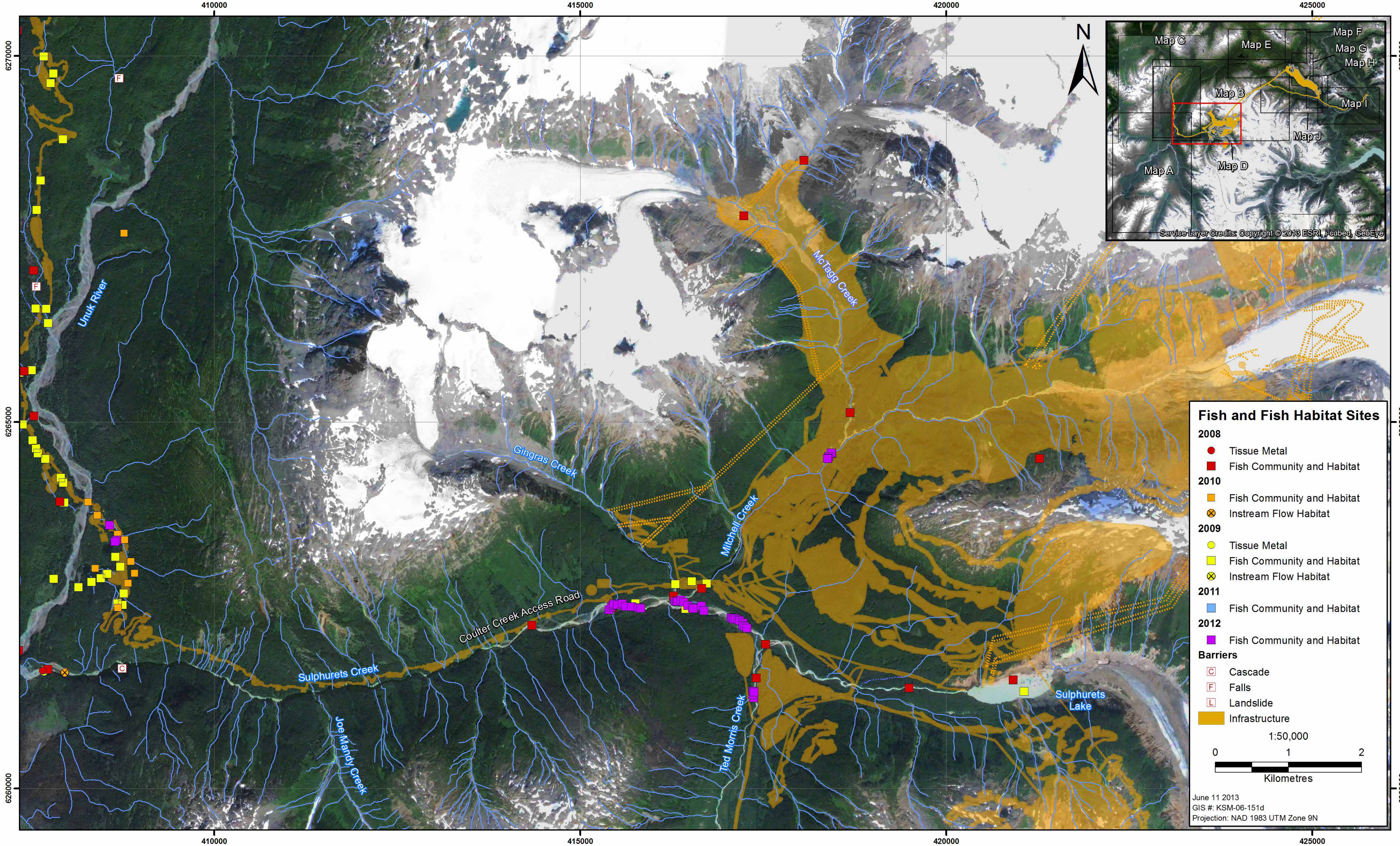

Figure 15.1-3d

Rescan Engineers & Scientists

Baseline Fish and Fish Habitat Sampling Sites, 2008 to 2012

SEABRIDGE GOLD
KSM PROJECT

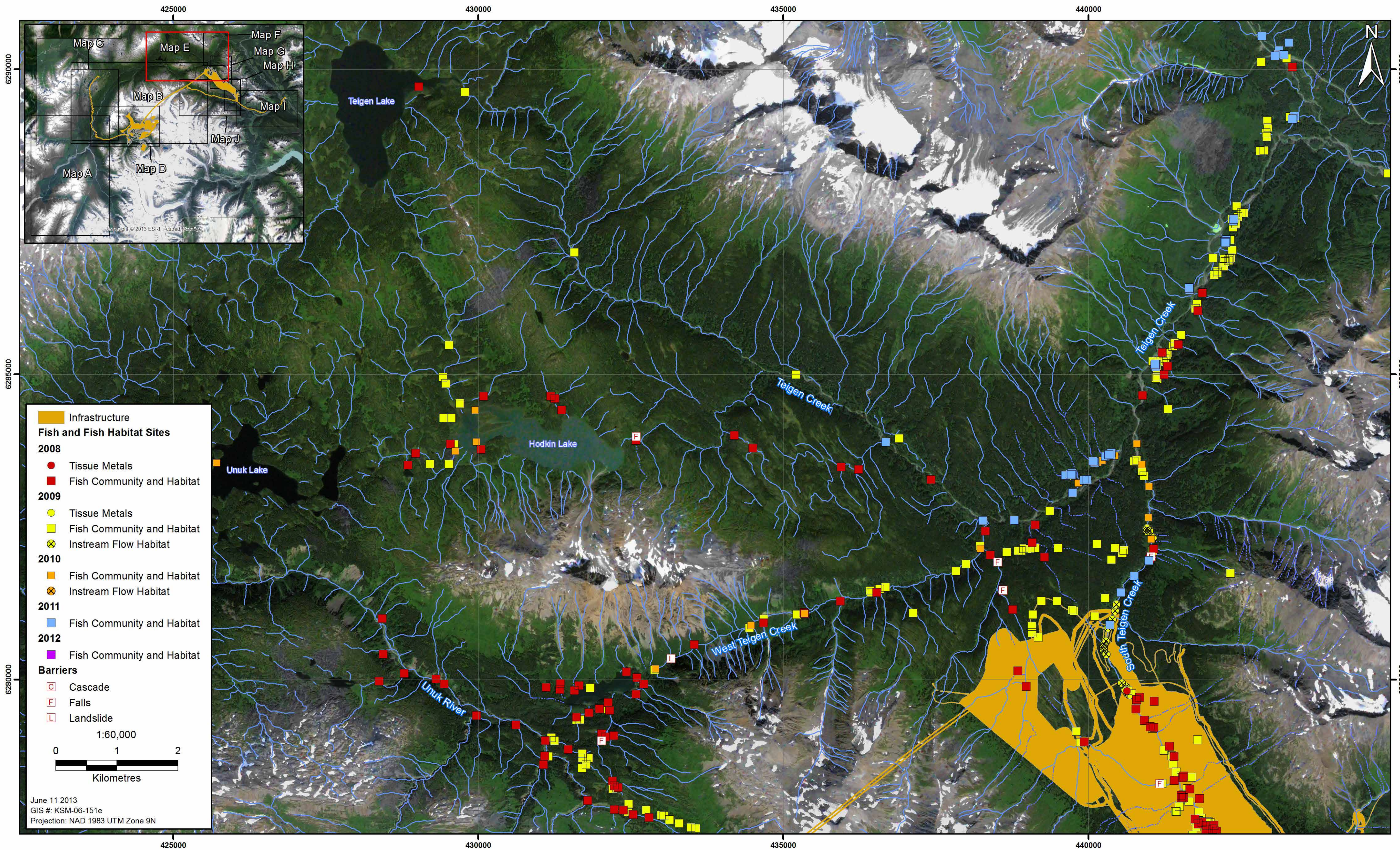

Figure 15.1-3e

Rescan Engineers & Scientists

Baseline Fish and Fish Habitat Sampling Sites, 2008 to 2012

SEABRIDGE GOLD
KSM PROJECT

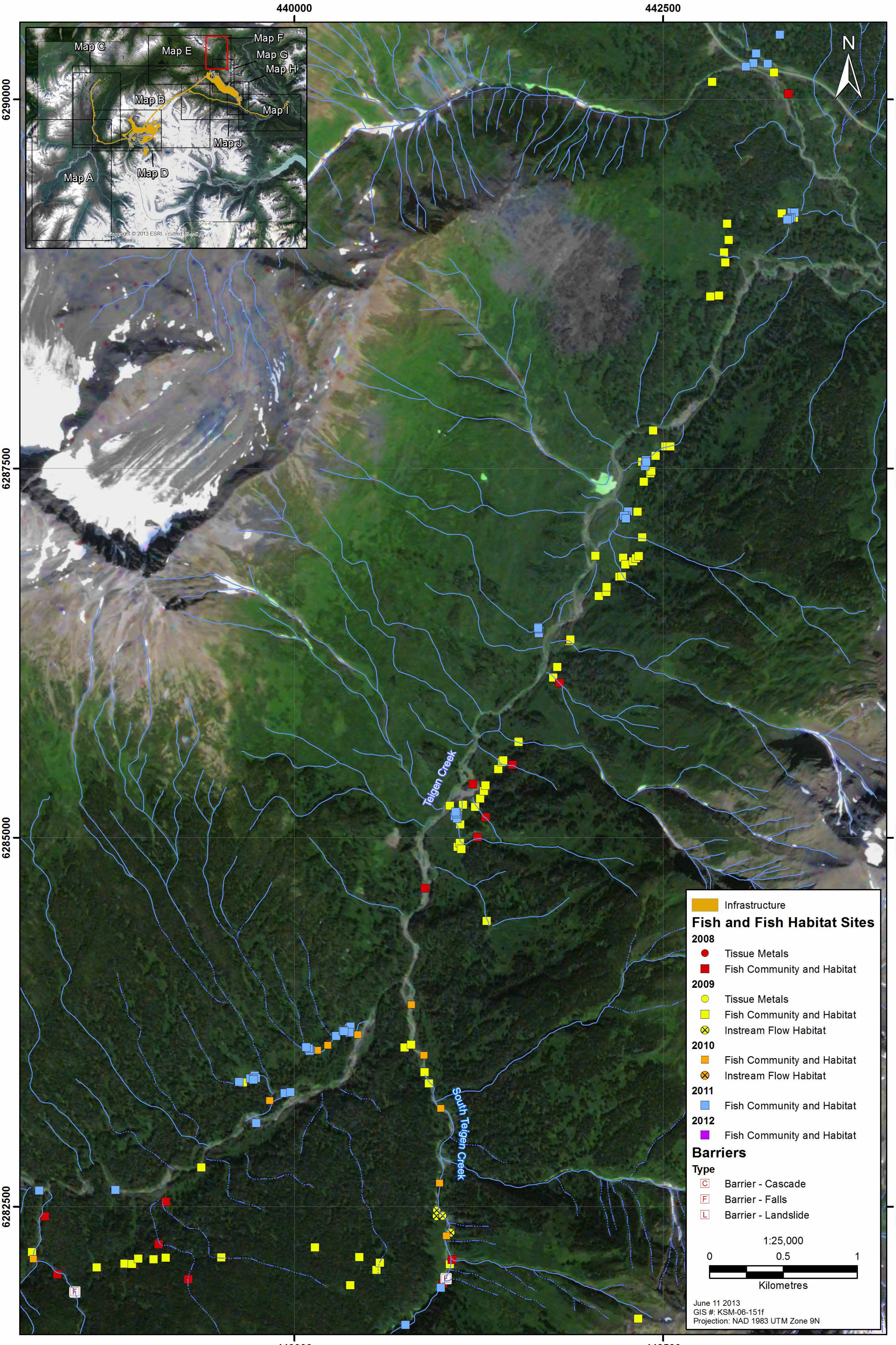

Figure 15.1-3f

SEABRIDGE GOLD
KSM PROJECT

Baseline Fish and Fish Habitat Sampling Sites, 2008 to 2012

Rescan
Engineers & Scientists

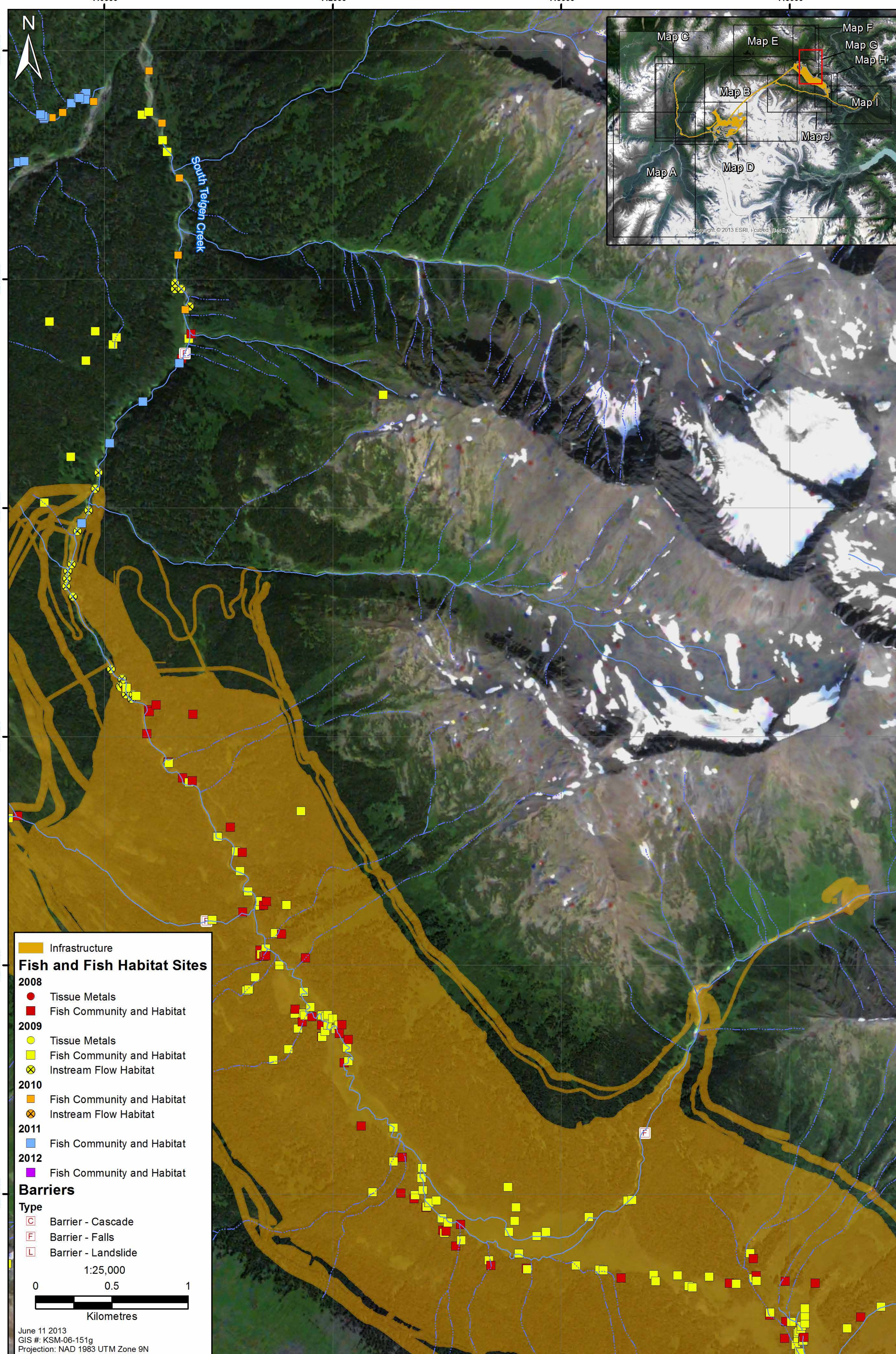

Figure 15.1-3g

SEABRIDGE GOLD
KSM PROJECT

Baseline Fish and Fish Habitat Sampling Sites, 2008 to 2012

Rescan
Engineers & Scientists

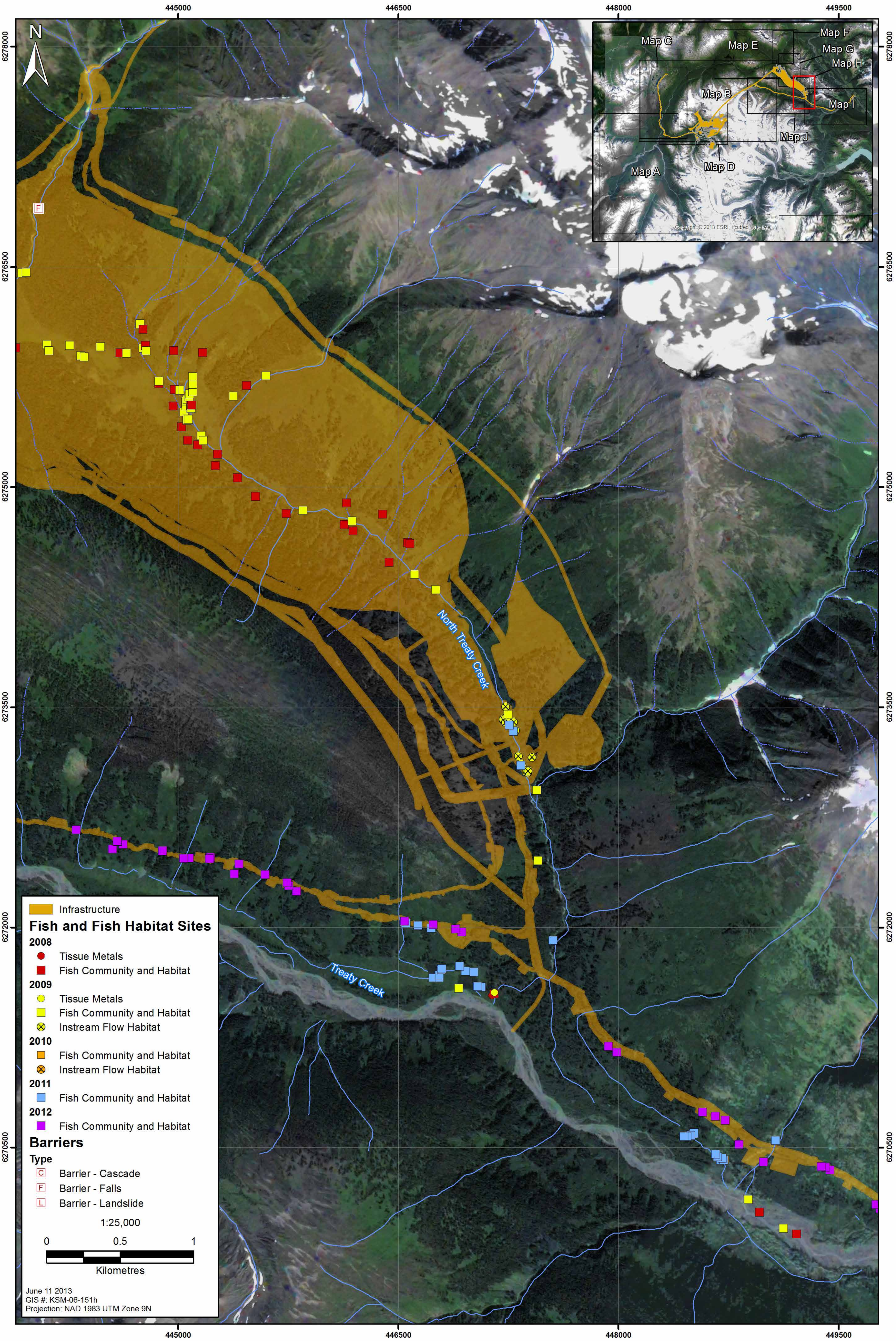

Figure 15.1-3h

SEABRIDGE GOLD
KSM PROJECT

Baseline Fish and Fish Habitat Sampling Sites, 2008 to 2012

Rescan
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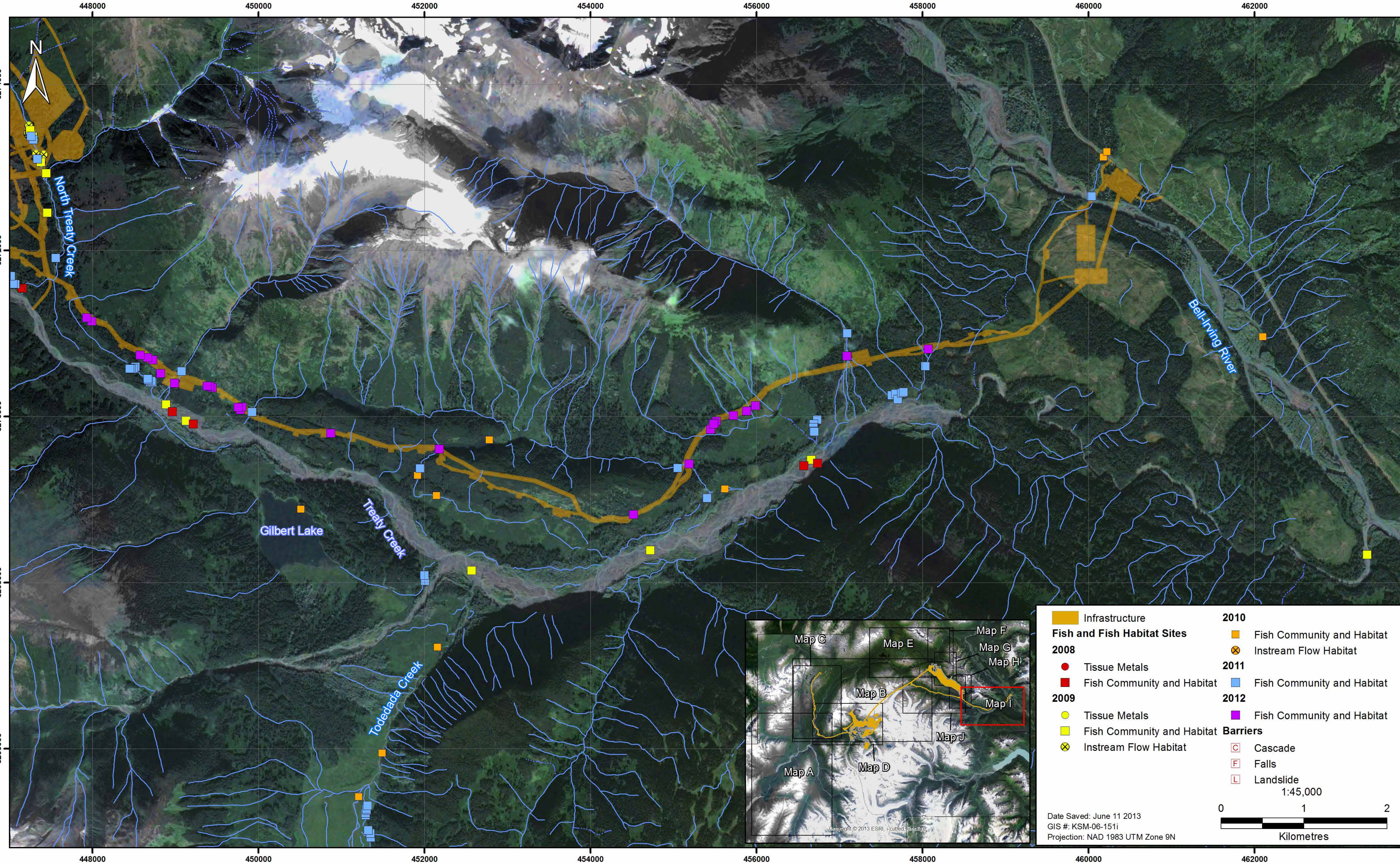

Figure 15.1-3i

SEABRIDGE GOLD
KSM PROJECT

Rescan Engineers & Scientists

Baseline Fish and Fish Habitat Sampling Sites, 2008 to 2012

PROJECT # 0196301-0028-0002 GIS No. KSM-06-151j_T June 11, 2013

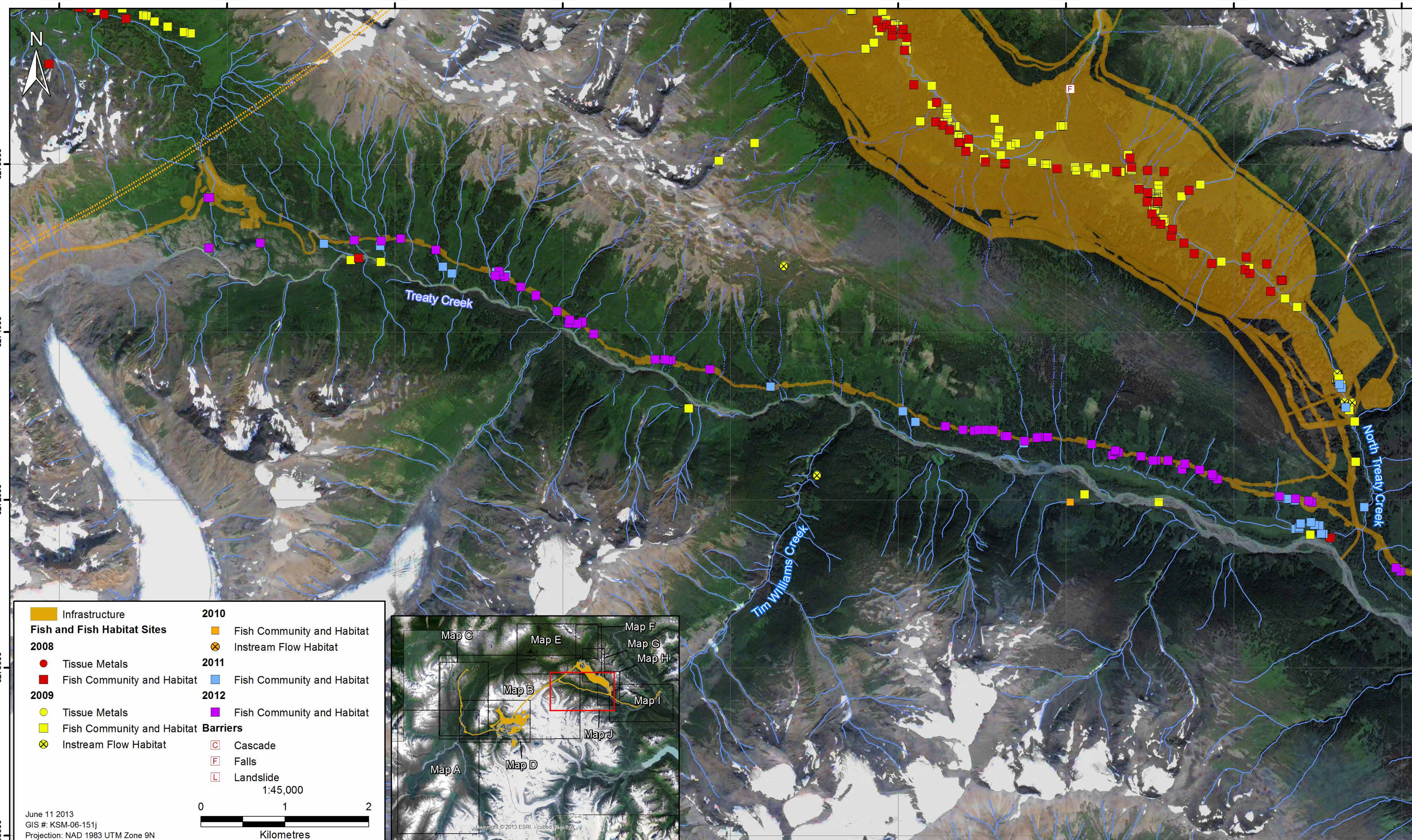

Figure 15.1-3j

SEABRIDGE GOLD
KSM PROJECT

Rescan Engineers & Scientists

Baseline Fish and Fish Habitat Sampling Sites, 2008 to 2012

Table 15.1-4. Summary of Known Fish Species by Watershed

Species	Bell-Irving Watershed															
	Bell-Irving River	Gilbert Creek	Hodkin Creek	North Treaty Creek	Snowbank Creek	South Teigen Creek	Teigen Creek	Todedada Creek	Treaty Creek	Tumbling Creek	West Teigen Creek	Gilbert Lake	Hodkin Lake	Teigen Lake	Todedada Lake	West Teigen Lake
Bull Trout*	X	-	X	-	X	X[a]	X	-	X	-	-	-	-	X	-	-
Chinook Salmon	X	X	-	-	X	-	X	X	X	-	-	-	-	O	-	-
Coastal Cutthroat Trout*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coho Salmon	X	X	-	-	X	-	X	X	X	-	-	-	-	-	-	-
Dolly Varden*	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X	X
Dolly Varden/Bull Trout*	O	-	-	-	-	X[a]	X	-	-	-	-	-	-	-	-	-
Longnose Sucker	-	-	-	-	-	-	-	-	-	-	-	-	O	O	-	-
Mountain Whitefish	X	X	-	X	X	X[a]	X	-	X	-	-	X	-	X	-	-
Sockeye Salmon	X	-	-	-	-	-	X	X	X	-	-	-	-	-	-	-
Rainbow Trout/Steelhead	X	X	X	-	X	X[a]	X	-	X	-	-	X	O	O	X	-

Species	Bowser Watershed		
	Bowser River	Scott Creek	Knipple Glacier Lake
Bull Trout*	O	X	-
Chinook Salmon	O	-	-
Coastal Cutthroat Trout*	-	-	-
Coho Salmon	X	-	-
Dolly Varden+	X	X	-
Dolly Varden/Bull Trout+	-	X	-
Mountain Whitefish	O	O	-
Sockeye Salmon	O	-	-
Rainbow Trout/Steelhead	O	-	-

Species	Unuk Watershed							
	Coulter Creek	Kaypros Creek	McTagg Creek	Mitchell Creek	South Unuk River	Sulphurets Creek	Unuk River	Sulphurets Lake
Chinook Salmon	-	-	-	-	-	-	X	-
Coastal Cutthroat Trout*	-	-	-	-	-	-	X	-
Coastrange Sculpin	-	-	-	-	-	-	X	-
Coho Salmon	X[a]	-	-	-	O	-	X	-
Dolly Varden+	X[a]	-	-	-	X	X[a]	X	-
Sockeye Salmon	O[a]	-	-	-	-	-	X	-
Rainbow Trout/Steelhead	-	-	-	-	-	-	X	-

*** Blue-listed species.**
+ Yellow-listed species.
Dolly Varden/Bull Trout indicates hybrid.
X = indicates that Project-specific sampling data was utilized to confirm fish species presence.
O = indicates that other sources of existing inventory data (e.g., historical literature) was used to confirm fish species presence.
Dashes indicate sampled and not present.
[a] Present below falls/cascade only.

Sockeye CUs are divided into stream-type and lake-type. For lake-type sockeye, each lake or lake complex is a separate CU, and the recognized CUs within or near the baseline fish and aquatic habitat study area are Oweegee Lake, Border Lake, and Bowser Lake. The river-type sockeye in the Bell-Irving River are all UNR (Upper Nass River) sockeye, differentiated by their late spawning times and ecotype. River-type sockeye were present in the Unuk River and are grouped into the TBFj (trans-boundary fjord) CU.

Since the DFO Wild Salmon Policy (WSP) was released in 2005 (DFO 2005), over 420 Conservation Units (CUs) for Pacific Salmon species have been mapped across the province of BC (DFO 2009). Primary objectives of the WSP are to maintain healthy and diverse salmon populations and their habitats, safeguard genetic diversity of wild salmon populations, and manage fisheries for sustainable benefits (DFO 2005). Under the WSP, wild salmon are conserved and managed by adopting a zoning approach based on species-specific "Conservation Units" (CUs). Using differences in geographic and genetic diversity, salmon using particular freshwater habitats are aggregated into CUs and management strategies are developed in alignment with a CUs biological status. Biological status is defined based on the abundance and distribution of spawners in the CU and grouped into three status zones: Green, Amber, and Red. As spawner abundance decreases, a CU moves towards the lower status zone, and the extent of management intervention for conservation purposes increases (DFO 2005). However, it is recognized that within a CU, variations in habitat type and quality are likely to result in differences in salmon productivity, meaning not all populations within a CU are likely to be maintained at equal levels of production or loss, all of the time. By ensuring networks of connected streams within CUs are maintained, localized, temporary losses of spawning groups pose little risk to the extirpation of the broader CU itself as neighboring demes or populations are unlikely to be genetically identical to those lost. Targets for each CU will be established to set the desired number of spawners that will ensure an adequate abundance and distribution of salmon throughout its geographic range. Decision-making will take into account various considerations including salmon habitat that is most productive, limiting, or at risk in a CU, in addition to its biological status (DFO 2005).

15.1.4.2.2 Bell-Irving Watershed

In the Bell-Irving watershed, Teigen and Treaty creeks support summer-run populations of steelhead (LGL 1995; Bocking, Parken, and Atagi 2005). The freshwater migration and spawning behaviour of summer-run steelhead was studied on the Nass River using radio telemetry techniques in 1992 and 1993 (LGL 1995). The radio tagging data indicated that 5% of the Nass River steelhead spawned within the Bell-Irving watershed (LGL 1995). One of the radio-tagged fish was relocated within Teigen Creek in August, September, and May.

Field observations of adult steelhead during bull trout snorkel surveys indicated that steelhead were present in Teigen Creek during mid-September (Appendix 15-E), which is in agreement with the radio tagging study. The majority of steelhead commence movement into Teigen Creek at 5°C during freshet from late May to early June (M. Beere, pers. comm.) when snorkeler detection and enumeration are not possible due to high discharge and poor water visibility (Appendix 15-G). The timing of steelhead snorkel surveys is difficult to determine annually (due to snowpack and melt) for effective enumeration of adults and redd and calculation of annual escapement (i.e., abundance of returning fish) in Teigen and Treaty creeks.

However, steelhead spawn in Teigen Creek because the distribution of steelhead fry provided an indication of spawning habitat distribution (M. Beere, pers. comm.). Steelhead fry were not caught in the main stem of Treaty Creek, but spawning steelhead were observed and fry were caught in Gilbert Creek (a tributary of Treaty Creek; Appendix 15-H).

The BC MOE has not conducted an estimation of stock abundance or total escapement for steelhead in the Bell-Irving River or specifically in the Teigen and Treaty creeks. Steelhead habitat capability models for smolt production and escapement goals were developed for these creeks (Bocking, Parken, and Atagi 2005). Maximum annual smolt production for Teigen and Treaty creeks was estimated at 9,924 and 6,948, respectively. Estimated escapement spawners to seed available habitat for Teigen and Treaty creeks were estimated at 808 and 515, respectively.

Pacific salmon species, such as coho (*Oncorhynchus kisutch*), sockeye (*Oncorhynchus nerka*), and chinook (*Oncorhynchus tshawytscha*) were present in Treaty and Teigen creeks.

Sockeye salmon spawned in Teigen Creek based upon baseline fieldwork conducted in 2008, 2009, and 2010. Sockeye salmon were observed spawning in Teigen Creek from the Hodkin Creek confluence (8.5 km downstream of Teigen Lake outlet) to the Snowbank Creek confluence. The sockeye salmon present in Teigen Creek were "stream type." Teigen Creek supported a low escapement of sockeye salmon based upon baseline spawning survey data (fewer than five individuals observed during spawning surveys). Sockeye salmon were not present in Teigen Lake based upon an extensive review of existing literature, provincial databases (FISS), and baseline fieldwork in 2008, 2009, and 2010. Sockeye salmon spawned in East Todedada Creek, a tributary of Treaty Creek. East Todedada Creek supported a low escapement of sockeye salmon based upon baseline spawning survey data (i.e., 15 individuals observed during spawning surveys).

Coho salmon spawned in side channels and wetland outlets along the Teigen Creek floodplain. During the 2010 peak spawning period, eight adults were observed in Teigen Creek side channels and wetland outlets. Based upon spawning survey baseline data, habitat data, observation, and professional expertise, Snowbank Creek (a tributary of Teigen Creek) had a higher productive capacity for coho salmon production relative to that of Teigen Creek. The most recent DFO mean annual escapement estimates were from 1980 to 1989. Mean annual coho salmon escapement for Snowbank and Teigen creeks were estimated at 245 and 17, respectively.

Coho salmon spawned in Todedada, East Todedada, and Gilbert creeks, which are tributaries of Treaty Creek. Based upon coho salmon spawning survey baseline data and habitat data, the primary coho salmon spawning tributary for the Treaty Creek watershed is East Todedada Creek where a maximum count of 42 coho was observed during coho salmon spawning surveys. There is no data from DFO on mean annual escapement estimates for Treaty Creek.

Coho salmon habitat capability models for smolt production and escapement goals were developed for Teigen and Treaty creeks (Bocking and Peacock 2004). Maximum annual smolt production for Teigen/Snowbank and Treaty creeks was estimated at 116,430 (upper limit) and 97,030 (upper limit), respectively. Estimated escapement spawners to seed available habitat for Teigen/Snowbank and Treaty creeks was estimated at 6,190 and 5,158, respectively.

Chinook salmon spawned in Teigen Creek upstream of the Snowbank Creek confluence. The freshwater migration and spawning behaviour of chinook salmon was studied on the Nass River using radio telemetry techniques in 1992 and 1993 (Koski et al. 1996a). Based upon the study results, the estimated escapement of chinook salmon for the Bell-Irving River was 4,831. Teigen Creek chinook salmon comprised approximately 42% of Bell-Irving River chinook salmon stocks, and approximately 8% of the total Nass River chinook salmon stocks (Koski et al. 1996a). During the peak spawning period in 2010, 285 adults were observed in Teigen Creek during spawning surveys (Figure 15.1-4). In the Treaty Creek watershed, chinook salmon spawned in Todedada and Gilbert creeks based upon the presence of rearing fry.

Chinook salmon fry were the most abundant species/life history stage in Teigen Creek, and rainbow trout/steelhead fry were the second most abundant (Appendices 15-A, 15-C, and 15-E). Rainbow trout/steelhead fry had a high abundance in the Upper Teigen Creek watershed, upstream of Hodkin Creek confluence. Rainbow trout/steelhead parr were distributed throughout the mainstem. Dolly Varden parr and adults were present throughout the mainstem, although their abundance was lower compared to Treaty Creek and the Unuk River. Bull trout parr and adults were more abundant in the Teigen Creek mainstem compared to Dolly Varden. Coho salmon fry and parr were the most abundant species/life history stage within side channels and off-channel wetlands of Teigen watershed. Dolly Varden fry, parr, and adults also occupied the side channels and off-channel wetlands.

Dolly Varden parr and adults were the most abundant species/life history stage throughout the Treaty Creek mainstem (Rescan 2008 and Appendices 15-A, 15-C, and 15-E). Rainbow trout/steelhead parr were the second most abundant species; however, their distribution was restricted to downstream of the Todedada Creek confluence. Mountain whitefish were present downstream of the Todedada Creek confluence. Dolly Varden fry, parr, and adults were the most abundant species within side channels and off-channel wetlands throughout the Treaty Creek watershed. Based upon previous fisheries assessments, coho salmon fry and parr occupied the side channels and off-channel wetlands downstream of the Todedada Creek confluence (Tripp 1987).

Dolly Varden were the only species present in North Treaty and South Teigen creeks within the proposed TMF. Dolly Varden, bull trout, mountain whitefish, and rainbow trout were present in South Teigen Creek downstream of a 2.5-m-high falls and outside of the TMF (Figure 15.1-3f). Dolly Varden dominated the species composition (95%) downstream of the falls in the lower reach of South Teigen Creek (Appendix 15-E). No salmon species were observed in South Teigen, North Treaty, or Tumbling creeks based upon electrofishing sampling effort (conducted in 2008, 2009, 2010, and 2011), ground-truthed spawning surveys for salmon species (conducted in 2009 and 2010), and habitat assessments (conducted in 2008, 2009, and 2010).

15.1.4.2.3 Unuk River Watershed

The Unuk River originates in a heavily glaciated area in BC and flows for 129 km to where it traverses Misty Fjords National Monument and discharges into Burroughs Bay, 85 km northeast of Ketchikan, Alaska. The drainage encompasses an area of approximately 3,885 km^2, with the lower 39 km flowing through Alaska.

Salmon species are present in the Unuk River, with the majority of the spawning and rearing occurring in the lower 39 km of the Alaska section (Mecum and Kissner 1989) and in Border Lake, approximately 2 km upstream of the BC-Alaska border. Border Lake discharges into the Unuk River. Border Lake is known to possess recruitment of chinook, sockeye, pink, coho, and chum salmon (Tripp 1987; DFO 1987). The canyons located upstream of Border Lake restrict the upstream migration of pink and chum salmon. However, spawning and rearing of sockeye, chinook, and coho salmon were known to extend as far upstream as Storie Creek, which is approximately 15 km upstream of the confluence of Sulphurets Creek and the Unuk River (Reach 7; Knight Piesold and Homestake 1993). Only Dolly Varden were captured in the Unuk River upstream of Storie Creek in this study and in others (Knight Piesold and Homestake 1993).

The Alaska Department of Fish and Game (ADFG) have monitored chinook salmon escapement since 1977 using helicopter and foot peak count surveys (ADFG 2004). The estimated 5-year mean (2004 to 2008) for chinook salmon escapement was estimated at 4,635 large-sized spawners (ADFG 2008). In most years, the Unuk River was the third or fourth largest producer of chinook salmon in southeastern Alaska (ADFG 2008). Unuk River chinook salmon are a spring run that produces yearling (age one) fish almost exclusively. The estimated mean (1982 to 1998) smolt abundance was estimated at 331,187 (ADFG 2008).

Coded wire tagging studies by the ADFG indicate that the majority of chinook salmon reared in the US portion of the river (ADFG 2004). Surveys and mark-recapture studies indicated that 83% of all chinook spawning occurred in six US tributaries. Indices of escapement were determined annually by summing the peak observer aerial and foot survey counts of large spawners seen in the following six tributaries: Cripple, Gene's Lake, Kerr, Clear, and Lake creeks, plus the Eulachon River (Figure 15.1-5). All of these watersheds are located in the US. Another tributary supporting a large chinook spawning population is Boundary (Border) Creek, which is located in Canadian waters downstream of Border Lake (ADFG 2009). Boundary Creek was excluded from the ADFG index because of difficulty in accessing the tributary; however, surveys were conducted sporadically since 1991.

The Unuk River is known to be a large producer of coho salmon stocks near Ketchikan, Alaska (ADFG 2006). Coho spawning occurs in small tributaries of the Unuk River in both Canadian and US waters based upon the species biology and professional expertise. The ADFG monitored coho salmon escapement from 1998 to 2004. During this period, the estimated mean escapement was 28,746 adult coho salmon. The estimated mean (1982 to 1998) smolt abundance was 713,713 (ADFG 2006).

Unuk River escapement size of sockeye, pink, and chum salmon is not monitored by the ADFG (ADFG 2004). However, the Unuk River canyons located upstream of Border Lake restrict the upstream migration of pink and chum salmon. Sockeye salmon are stream-type, which spawn and rear in fluvial environments.

Dolly Varden parr and adults were the most abundant species, and rear throughout the mainstem of the Unuk River (Rescan 2008; Appendices 15-A and 15-C). Coho fry were the second most abundant species present rearing in the mainstem, downstream of the Storie Creek confluence. Sockeye fry were present rearing in the mainstem downstream of the Harymel Creek confluence.

PROJECT # 868-022 GIS No. KSM-06-074_T January 31, 2013

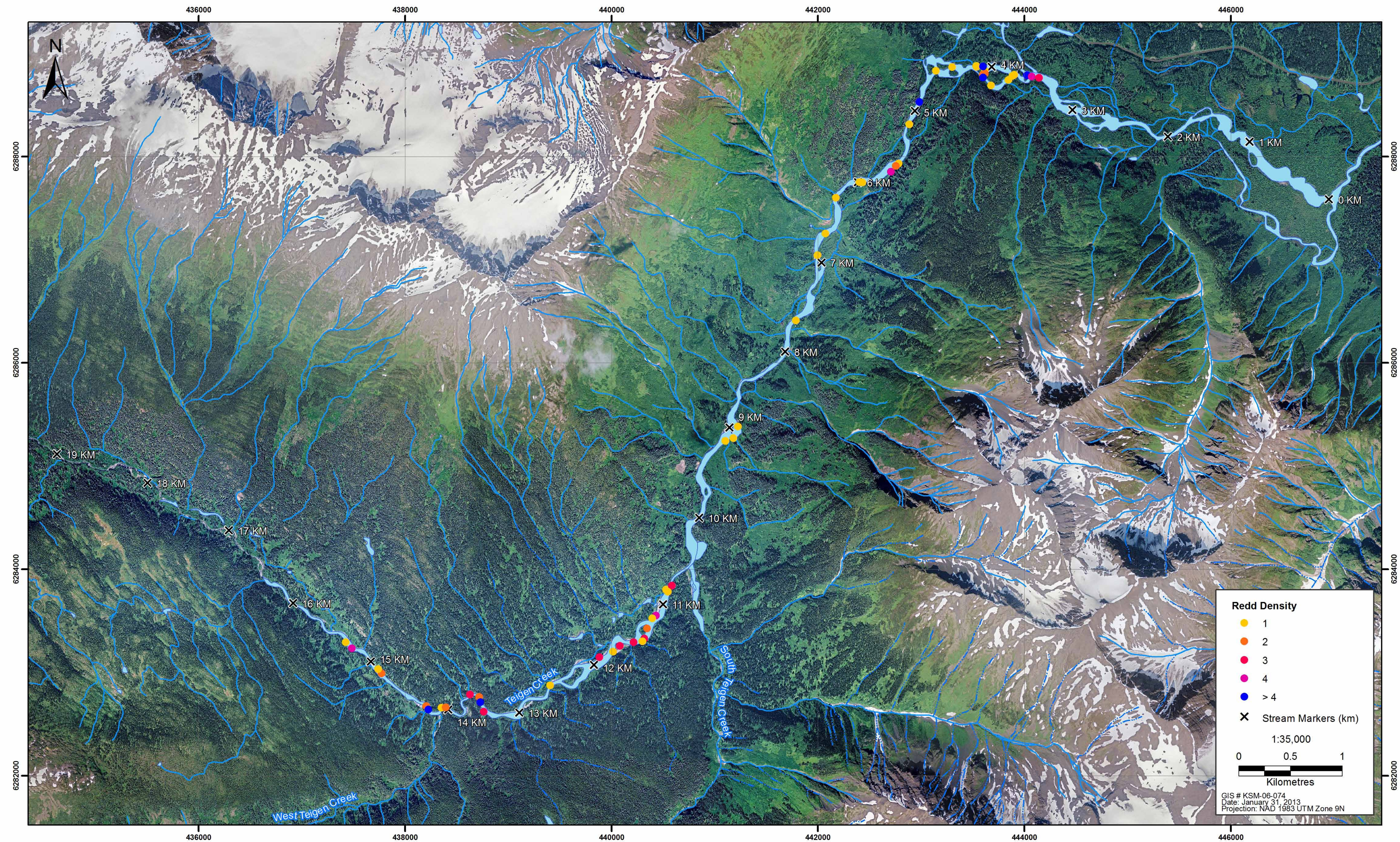

Figure 15.1-4

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Location of Chinook Salmon Redds within Teigen Creek, 2010

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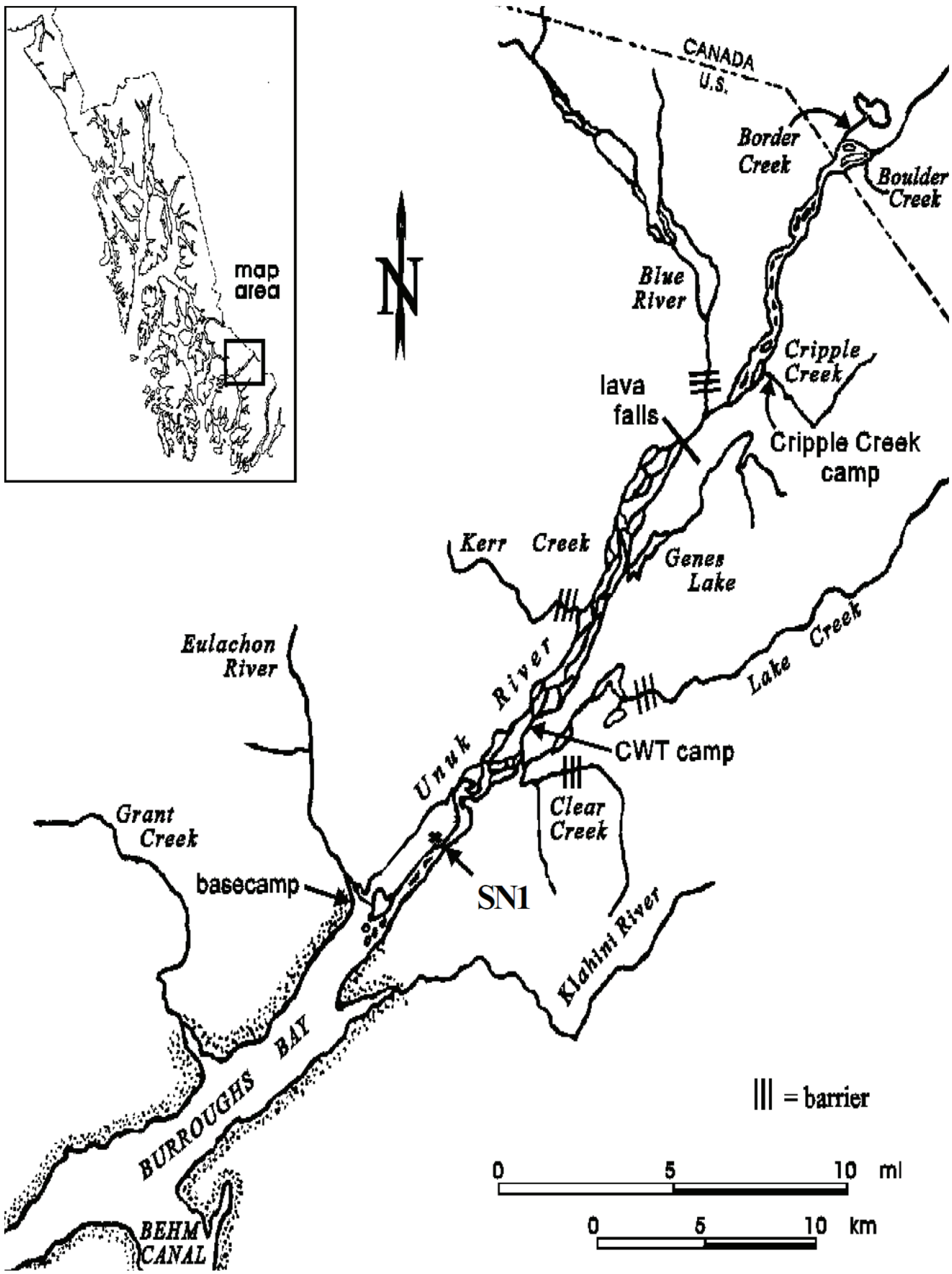

Source: Alaska Department of Fish and Game (2009).

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Figure 15.1-5

Location of Unuk River Chinook Salmon Spawning Tributaries

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15.1.4.3 Access Roads and Transmission Line

15.1.4.3.1 Location and Methods

There are two proposed access roads and one temporary glacier access route for the Project. The access roads will traverse a number of watersheds. They are as follows:

- Treaty Creek access road (TCAR) – Bell-Irving River, and Treaty and North Treaty creeks;
- Coulter Creek Access Road (CCAR) – Coulter, Tom MacKay, Sulphurets, and Mitchell creeks, and Unuk River; and
- Temporary Frank Mackie Glacier access route – Bowser River.

The TCAR has an associated parallel transmission line to the proposed process plant.

From 2008 to 2012, the location of the access roads was ground-truthed and flagged by surveyors prior to the start of the fisheries fieldwork. Field crews ground-truthed the access road alignments for locations of streams, fisheries sensitive zones, and non-classified drainages. At each stream crossing, fish habitat was assessed using methods based on RIC standards (RISC 1999b and 2001a). Streams were sampled using backpack electrofishers following RIC standards (RISC 1997, 1999c, 2001a). Barrier searches and assessments were conducted on streams downstream of the crossing. Streams were classified according to the Forest Practices Code of British Columbia's *Fish-Stream Identification Guidebook* (BC MOF 1998).

15.1.4.3.2 Fish Habitat

Stream classifications were determined using various habitat criteria including channel width, gradient, and fish presence. Of the sites classified as streams, the majority were considered non-fish-bearing due to habitat-limiting conditions such as high channel gradient (greater than 30%), natural barriers, and poor quality fish habitat.

The TCAR and transmission line will cross numerous ephemeral drainages that were not defined as streams. There will be 11 fish-bearing stream crossings along the TCAR (Figure 15.1-6; Table 15.1-5). There will be 11 fish-bearing stream crossings along the transmission line (Figure 15.1-6; Table 15.1-5). Generally, fish-bearing stream crossings along the TCAR and transmission line were small, high gradient channels subject to continuous disturbance (e.g., high bed load movement) with poor quality rearing habitat and poor to none spawning habitat. Channels had cascade-pool morphology and a sinuous pattern for all creeks. Channels were unconfined for the majority of streams.

The CCAR will traverse the Coulter Creek and Sulphurets Creek watersheds. Fish migration barriers were present in the lower reaches of Coulter and Sulphurets creeks; therefore, the stream crossings were classified as non-fish-bearing upstream of these fish migration barriers (Figure 15.1-3b). There will be seven fish-bearing stream crossings along the CCAR downstream of any physical barriers (Figure 15.1-7; Table 15.1-5). These fish-bearing stream crossings were low gradient channels with moderate to good rearing habitat and possessed spawning habitat for coho salmon and coastal cutthroat trout.

Table 15.1-5. Individual Fish-bearing Stream Crossings

Road	Waterbody Name	Habitat Type	Infrastructure Type	Stream Class	Location		Channel Measurements				Channel Characteristics		Habitat		Habitat Quality		
					Easting	Northing	Mean Channel Width (m)	Mean Gradient (%)	Mean Residual Pool Depth (m)	Mean Bankfull Depth (m)	Dominant Substrate	Morphology	Dominant Cover Type	Riparian Vegetation Type	Over-wintering	Rearing	Spawning
Coulter Creek Access Road	2060	Stream	Culvert	S3	407703	6266547	1.9	0.5	-	0.3	F	RP	OV	C	F	G	N
	Coulter Creek - 2061	Stream	Bridge	S2	407561	6266553	16.0	1.5	0.6	-	G	RP	LWD	C	G	G	G
	2063	Stream	Bridge	S2	407277	6265832	12.7	3.5	0.3	-	G	RP	LWD	C	P	F	N
	2064	Stream	Bridge	S4	407274	6265770	1.4	14.0	0.2	0.3	C	SP	OV	C	P	F	N
	Unuk River - 1025	Stream	Bridge	S1	408275	6263910	71.0	1.0	-	1.9	G	RP	LWD	C	G	G	P
	5008	Stream	Culvert	S4	408373	6263805	0.8	5.0	0.1	0.2	F	RP	U	C	P	G	F
	5007	Stream	Bridge	S2	408404	6263727	9.7	1.0	0.2	0.4	G	RP	LWD	C	G	G	G
Treaty Creek Access Road	100	Stream	Bridge, Transmission Line	S1	457091	6270729	63.3	19.0	-	3.0	C	RP	B	S	P	F	P
	108	Stream	Culvert, Transmission Line	S3	449782	6270082	2.0	24.0	0.2	0.4	C	CP	SWD	C	P	F	P
	114	Stream	Bridge, Transmission Line	S2	448987	6270402	15.5	20.0	-	0.6	B	CP	B	D, M	P	F	P
	204	Stream	Culvert, Transmission Line	S4	455882	6270066	0.3	18.0	0.4	0.1	C	CP	SWD,OV	S,C	P	P	P
	205	Stream	Culvert, Transmission Line	S4	455723	6270012	0.4	15.0	-	0.1	C	CP	OV	S,M	P	P	P
	209	Stream	Culvert, Transmission Line	S4	455448	6269847	0.9	9.0	-	8.7	C	CP	SWD,OV	M	P	F	P
	243	Stream	Bridge	S3	443508	6272703	2.1	18.0	0.1	0.5	C	CP	SWD	C	P	G	F
	244	Stream	Bridge, Transmission Line	S2	452180	6269610	5.5	18.0	-	1.2	C	CP	OV	C	P	F	P
	210	Stream	Bridge, Transmission Line	S3	455190	6269430	4.0	16.0	-	-	-	CP	OV	M	P	F	P
	North Treaty Creek - 4011	Stream	Bridge, Transmission Line	S2	447556	6271912	8.9	2.7	-	1.1	B	CP	B	D	G	F	P
	Bell Irving River - 4004	Stream	Bridge	S1	460039	6272653	70.0	0.5	-	-	G	RP	SWD	M	G	G	F
	Bell Irving River - 4005	Stream	Transmission Line	S1	460325	6272531	65.0	0.5	-	-	G	RP	SWD	M	G	G	F
	Glacier Creek - 4006	Stream	Transmission Line	S3	460192	6273853	3.0	14.0	0.2	0.6	C	CP	LWD	D	F	P	P

Dashes indicate not applicable or no data available.

Dominant Substrate:
F = fines
C = cobble
B = boulder
G = gravel

Morphology:
CP = cascade pool
RP = riffle pool
SP = step pool
LC = large channel

Riparian Vegetation Type:
D = deciduous
C = coniferous
S = shrubs
G = grass
M = mixed

Habitat:
G = good
P = poor
F = fair
N = none

PROJECT # 0868-016-26 GIS No. KSM-06-148 October 11, 2012

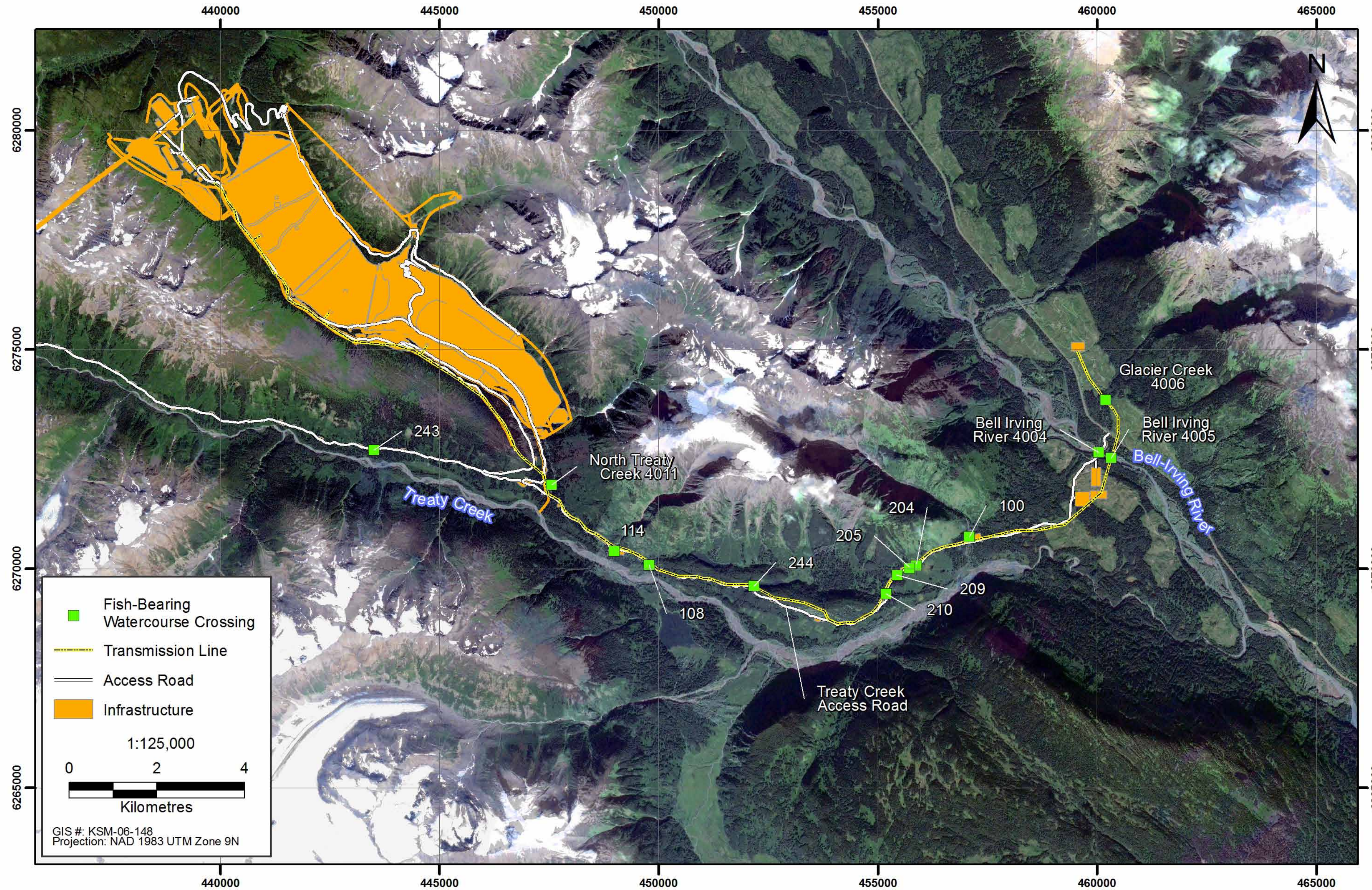

Figure 15.1-6

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Location of Treaty Access Road Fish-bearing Watercourse Crossings

Figure 15.1-6

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PROJECT # 0868-016-26 GIS No. KSM-06-147 January 22, 2013

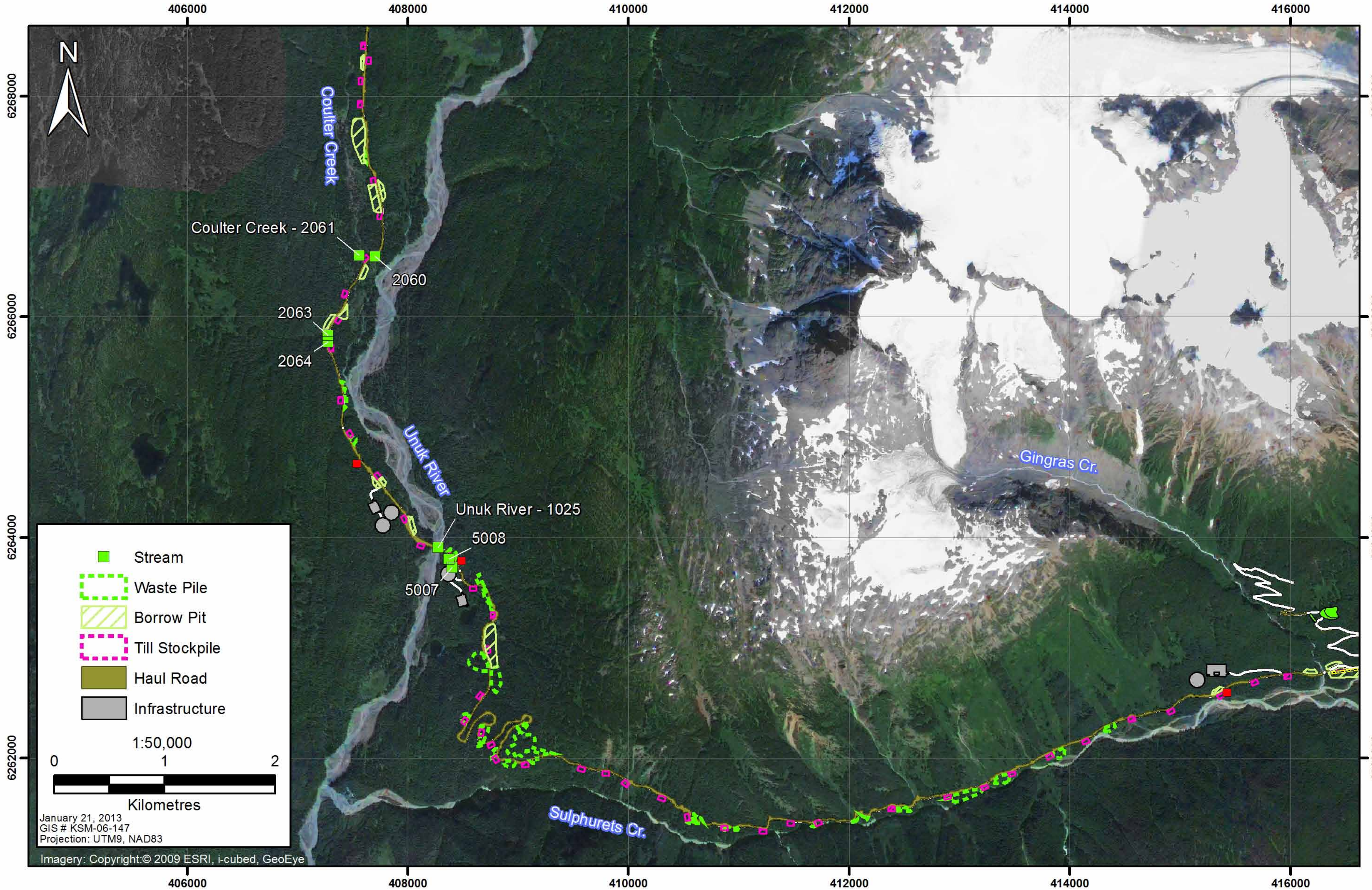

Figure 15.1-7

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Location of Coulter Creek Access Road Fish-bearing Watercourse Crossings

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Figure 15.1-7

The Temporary Frank Mackie Glacier access route will be in the Bowser River watershed. There will be no fish-bearing stream crossings along the temporary access route.

15.1.4.3.3 Fish Community

The fish-bearing status of streams along the proposed access roads were determined. To determine the fish-bearing status of a stream, fish species presence data was used from baseline studies in 2008, 2009, 2010, 2011, and 2012. If fish were observed or caught in the stream, the stream was classified as confirmed fish-bearing. Streams were classified as default fish-bearing when fish were not observed or caught at a site, fish presence was known downstream (from historical data), and no barriers to fish passage were present.

Table 15.1-6 summarizes fish species presence at individual stream sites. Dolly Varden were present along all access roads and were the dominant catch. Coho salmon were present along the CCAR, downstream of the falls. Rainbow trout were caught along the TCAR, while coastal cutthroat trout were caught along the CCAR (downstream of the falls). Larger stream sites (e.g., the Bell-Irving and Unuk rivers) have the most diverse fish communities.

Dolly Varden and coho salmon are present below a large falls (50 m) in Coulter Creek (Figure 15.1-3b). A total of 4,663 s of electrofishing effort was exerted above the falls at six sites over two years without the capture of a single fish (2008 and 2009). Therefore, all stream reaches above the falls were classified as non-fish-bearing.

15.1.4.4 Tailing Management Facility

15.1.4.4.1 Location and Methods

The TMF is situated within the South Teigen (61 km^2) and North Treaty (33 km^2) watersheds, and will encompass approximately 12.6% (7.7 km^2) and 14.5% (4.8 km^2) of each watershed. The proposed Treaty Process Plant is situated within the South Teigen Creek drainage.

South Teigen Creek originates from glaciers on the eastern hillslope and flows into a broad, flat valley surrounded by wetland fen habitat. The creek then increases in gradient flowing through a confined valley with a 2.5-m-high falls. Downstream of the falls, the creek flows through an unconfined valley and discharges into Teigen Creek. North Treaty Creek originates from the eastern hillslope and from wetland complexes. The eastern hillslope provides a significant water source during the freshet and early summer, after which the flow is reduced. The wetland complex provides continuous water throughout the duration of the year. Both water sources merge to form North Treaty Creek. The creek flows in a low gradient valley surrounded by shrub riparian habitat. The creek then increases in gradient flowing through a confined valley and discharges into Tumbling Creek. Tumbling Creek originates from the eastern hillslope and eventually discharges into Treaty Creek.

In 2008 and 2009, fish and fish habitat assessments were conducted within the South Teigen and North Treaty watersheds (Figures 15.1-3g and 15.1-3h). The following assessments were conducted within and downstream of the proposed TMF and Treaty Process Plant site:

- fish habitat quality assessment using methods based on RIC standards (Johnson and Slaney 1996; RISC 1997; RISC 1999c; RISC 1999b; RISC 2001a) and Sensitive Habitat Inventory Mapping (SHIM) standards (Mason and Knight 2001);
- identify and assess barriers to fish movement;
- confirm fish presence and fish distribution with a backpack electrofisher;
- validate rearing habitat quality ranks by electrofishing;
- Dolly Varden spawning surveys to confirm spawning locations and validate spawning habitat quality ranks in combination with presence/absence of fry and fish habitat quality;
- Dolly Varden population density assessments within the TMF, estimated by the three-pass multiple removal method;
- Dolly Varden relative abundance assessments downstream of the TMF, estimated by single-pass electrofishing;
- wetland habitat quality assessments and fish presence with minnow traps; and
- annual data logger water temperature assessment.

The British Columbia Instream Flow Methodology was conducted in North Treaty and South Teigen creeks downstream of the TMF in 2009 and 2010 (Lewis et al. 2004). Stratified-random transects were established based upon hydraulic habitat type (i.e., pool, riffle, glide, cascade) for fish habitat measurements with the objective of describing and quantifying habitat. Twenty-two instream flow habitat transects were established and assessed in South Teigen Creek downstream of the TMF (Figure 15.1-3g). Fifteen instream flow habitat transects were established and assessed in North Treaty Creek downstream of the TMF (Figure 15.1-3h).

In 2008 and 2009, Dolly Varden were collected from South Teigen Creek at site STE2 (downstream of the TMF northern dam) and from North Treaty Creek at site NTR2 (downstream of the TMF southern dam; Figures 15.1-3g and 15.1-3h). Eight whole-body fish samples (allocated by BC MOE fish collection permit) were selected from each of the sites for tissue metals, diet, and fecundity analyses.

A Dolly Varden genetic study was conducted within Teigen and Treaty watersheds in 2009. Adipose fin samples were taken from a subset of Dolly Varden captured from four areas, including upstream of South Teigen Creek falls, downstream of South Teigen Creek falls, North Treaty Creek within the proposed TMF, and Treaty Creek. Genetic analyses of fin tissue were performed by Dr. Eric Taylor at the University of British Columbia (Appendix 15-C).

Spawning surveys were completed downstream of the TMF in South Teigen, North Treaty, and Tumbling creeks. In 2009 and 2010, spawning surveys were conducted for steelhead, bull trout, chinook salmon, coho salmon, and sockeye salmon. Field crews used the methods and data cards from the Redd Enumeration Field Guide (RISC 2003), if redds were observed.

Table 15.1-6. Individual Fish-bearing Stream Crossing Details

					Year Sampled					Fish	
Road	Waterbody Name	Habitat Type	Infrastructure Type	Stream Class	2008	2009	2010	2011	2012	Fish-Bearing Status	Species Present
Coulter Creek Access Road	2060	Stream	Culvert	S3	X	X				Confirmed	CO, DV
	Coulter Creek - 2061	Stream	Bridge	S2	X	X				Confirmed	CO, DV
	2063	Stream	Bridge	S2	X	X				Confirmed	DV, CO, CCT
	2064	Stream	Bridge	S4	X	X				Default	DV*
	Unuk River - 1025	Stream	Bridge	S1	X	X				Confirmed	CO, CH, SK, DV, CCT
	5008	Stream	Culvert	S4		X				Default	DV*
	5007	Stream	Bridge	S2		X				Confirmed	DV, CO, CCT
Treaty Creek Access Road	100	Stream	Bridge, Transmission Line	S1					X	Default	DV*
	108	Stream	Culvert, Transmission Line	S3					X	Confirmed	RB, DV*
	114	Stream	Bridge, Transmission Line	S2			X	X		Confirmed	DV
	204	Stream	Culvert, Transmission Line	S4					X	Default	DV*
	205	Stream	Culvert, Transmission Line	S4					X	Default	DV*
	209	Stream	Culvert, Transmission Line	S4					X	Default	DV*
	243	Stream	Bridge	S3					X	Default	DV*
	244	Stream	Bridge, Transmission Line	S2			X			Confirmed	RB, DV
	210	Stream	Bridge, Transmission Line	S3					X	Confirmed	RB, DV
	North Treaty Creek - 4011	Stream	Bridge, Transmission Line	S2	X	X				Confirmed	DV, MWF
	Bell Irving River - 4004	Stream	Bridge	S1		X	X			Confirmed	BT, CH, CO, DV, MWF, SK, RB
	Bell Irving River - 4005	Stream	Transmission Line	S1		X	X			Confirmed	BT, CH, CO, DV, MWF, SK, RB
	Glacier Creek - 4006	Stream	Transmission Line	S2			X			Confirmed	DV

Species: BT = bull trout; CH = chinook salmon; CO = coho salmon; DV = Dolly Varden; MWF = mountain whitefish; SK = sockeye salmon; RB = rainbow trout/steelhead.
***Indicates species not confirmed but likely present based upon habitat characteristics.**
NA = not applicable.

15.1.4.4.2 Fish Habitat

Dolly Varden were the only species present in North Treaty and South Teigen creeks within the proposed TMF.

South Teigen Creek had a mean bankfull width of 6.4 m and depth of 0.7 m. Riffle and cascade habitat types were present in the creek. The habitat-weighted cover composition was dominated by overhanging vegetation and pool habitat. The majority of the creek had fair or better rearing habitat quality. Due to the high composition of glacial fine substrates and high flows during the spawning season, South Teigen Creek provided poor to non-existent spawning habitat for the Dolly Varden. All reaches provide good overwintering habitat for Dolly Varden. This assessment was based upon the presence, frequency, and distribution of pools, adequate residual pool depths, instream cover, and maintenance of base flows throughout the winter months. All reaches of South Teigen Creek provide important fish habitat for Dolly Varden.

South Teigen tributaries had a mean bankfull width of 1.9 m and a depth of 0.3 m. South Teigen tributaries had a high proportion of cascades (50.2%). There was a high proportion of residual pools in South Teigen. Suitable spawning habitat was present and fish were observed spawning in the lower discharge South Teigen tributaries. The majority of tributaries had few deep pools and deeper runs of less than 20 cm residual depth. The channels were mostly cobble riffles and runs, which provide little overwintering habitat. Important habitat quality (as per DFO definition) was observed in 68% of South Teigen tributaries.

North Treaty Creek had a mean bankfull width of 5.8 m and depth of 0.5 m. The habitat unit ratio was evenly distributed between three habitat types: riffles, pools, and cascades. The habitat-weighted cover composition was dominated by overhanging vegetation and pool habitat. North Treaty Creek possessed higher quality rearing habitat because of greater habitat diversity and fish habitat cover compared to South Teigen Creek. The creek provided good and abundant Dolly Varden spawning habitat due to suitable substrate and habitat characteristics, suitable flow, and good water quality. All reaches provided good overwintering habitat for Dolly Varden. This assessment was based upon the presence, frequency and distribution of pools, adequate residual pool depths, instream cover, and maintenance of base flows throughout the winter months.

North Treaty tributaries had a mean bankfull width of 1.2 m and depth of 0.3 m. A high proportion of riffles (79%) were present in tributaries. Dolly Varden were observed spawning in tributaries. The majority of tributaries had few deep pools and deeper runs of less than 20 cm residual depth. The channels were mostly cobble riffles and runs, which were anticipated to provide little overwintering habitat.

15.1.4.4.3 Fish Community

A 2.5-m-high falls on South Teigen Creek prevents upstream fish movement (Figure 15.1-3a). Dolly Varden were present above and below the falls. Dolly Varden were the only species present in North Treaty and South Teigen creeks within the proposed TMF. Dolly Varden, bull trout, mountain whitefish, and rainbow trout were present in South Teigen Creek downstream of a 2.5-m-high falls and outside of the TMF (Table 15.1-4). CPUE was higher for Dolly Varden compared to the other fish species within South Teigen Creek (Appendix 15-C).

Mean Dolly Varden population densities were higher in North Treaty tributaries compared to South Teigen tributaries. This is due to the presence of higher quality rearing habitat for juveniles in North Treaty tributaries. South Teigen tributaries provided the majority of fry- and parr-rearing habitat within the South Teigen watershed. Mean Dolly Varden population densities were higher in North Treaty Creek compared to South Teigen Creek.

North Treaty Creek provided suitable rearing habitat for Dolly Varden fry, parr, and adults. The overall rearing habitat for juveniles was of higher quality in North Treaty Creek compared to South Teigen Creek based upon electrofishing sampling data.

The results of the Dolly Varden genetic study indicated that there were genetic differences between the Treaty and Teigen creek populations. There was a clear distinction within the Teigen Creek watershed between samples collected from the lower watershed (below the falls) and those from the upper watershed (above the falls). Such within-stream variation above and below migration barriers is a common phenomenon in fluvial-dwelling salmonid populations, including char. The presence of within-stream variation in Treaty and Teigen creeks is not a unique situation and not significant on a species-specific level (Appendix 15-C).

No salmon species were present within South Teigen, North Treaty, and Tumbling creeks based upon electrofishing sampling data (2008 to 2011), spawning surveys (2009 and 2010), and habitat assessments (2008 to 2011). Salmon have not been observed or sampled in the lower reach of South Teigen Creek, below the falls, despite considerable electrofishing effort in 2008 (635 s), 2009 (1,194 s), and 2010 (10,198 s). Steelhead did not use South Teigen¸ North Treaty, or Tumbling creeks for spawning based upon sampling data, spawning surveys (2010 and 2011), and habitat assessments. Bull trout used South Teigen Creek (below the falls) for spawning in highly localized sites (two locations) based upon snorkel spawning assessments.

Stream 1010 is above a series of cascades in the South Teigen watershed and is located near the proposed Process Plant site (Figure 15.1-3g). A total of 2,947 s electrofishing effort was exerted in Stream 1010 on three separate sampling events over two years. No fish were caught during these surveys; therefore, all streams above the cascades and in the location on the plant site were classified as non-fish-bearing.

15.1.4.5 Mine Site

15.1.4.5.1 Location and Methods

The Mine Site is situated within Sulphurets and Mitchell watersheds (Figure 15.1-3d).

In 2008, 2009, and 2012, fish and fish habitat assessments were conducted within Sulphurets, Mitchell, McTagg, and Ted Morris creeks as well as in Sulphurets Lake (Figure 15.1-3d). Assessments were conducted within and downstream of the proposed Mine Site to determine fish habitat quality, barriers to fish movement, fish presence, and fish distribution.

In 2008 and 2009, Dolly Varden were collected from Sulphurets Creek at site SC3 (downstream of the proposed Mine Site and cascade; Figure 15.1-3d).

The British Columbia Instream Flow Methodology was conducted in Sulphurets Creek downstream of the cascade in 2009 and 2010. One transect was established in Sulphurets Creek downstream of the cascade (Figure 15.1-3d) because of the homogenous channel and shortness of the creek section (approximately 500 m).

15.1.4.5.2 Fish Habitat

All watersheds at the proposed Mine Site originate from glaciers, which produce turbid water flowing at high velocities. Dominant bank and bed substrates are cobble substrates for all creeks. Channels possess cascade-pool morphology and a sinuous pattern for all creeks. Channels are unconfined for the majority of creeks.

Sulphurets Lake is located in the Sulphurets watershed at an elevation of 580 masl. It is a small (16.9 ha surface area), turbid, glacial headwater lake with steep talus slopes along the northern shoreline. The maximum depth is 15 m. Except near the outlet, shoreline vegetation is absent within the glacially carved lake valley.

15.1.4.5.3 Fish Community

There is a 200-m-long cascade in Sulphurets Creek, approximately 500 m upstream of the confluence with the Unuk River (Figure 15.1-3b). Dolly Varden were present in Sulphurets Creek below the cascade, but no fish species were present above the cascade.

In 2008, Sulphurets Creek and its tributaries (McTagg, Mitchell, and Ted Morris creeks) were sampled. No fish were caught above the cascade despite 6,698 s of electrofishing effort. A total of nine sites were sampled in August 2008 (Rescan 2009). Sulphurets Lake was sampled in September and no fish were caught despite a total of 118 h of gillnetting and 297 h of minnow trapping effort.

In 2009, a total of 3,046 s of electrofishing effort was exerted above the cascade at three sites in Sulphurets and Mitchell creeks. Sampling occurred in August and September 2009 and no fish were caught (Appendix 15-C). Sulphurets Lake was sampled in July, and no fish were caught after a total of 45 h of gillnetting and 235 h of minnow trapping effort.

In 2012, a total of 913 h of minnow trapping effort was exerted above the cascade at 40 sites in Sulphurets and Mitchell creeks. Sampling occurred in November 2012, and no fish were caught (Rescan 2012; Appendix 15-S). Therefore, all stream reaches above the Sulphurets Creek cascade were classified as non-fish-bearing.

Small numbers of Dolly Varden were present in Sulphurets Creek downstream of the cascade. The CPUE of Dolly Varden in this area was orders of magnitude lower (0.01 fish/100 s of electrofishing effort) than that in the Unuk River (2.06 fish/100 s) and the South Unuk River (2.09 fish/100 s). No salmon species were present within Sulphurets Creek based upon electrofishing sampling effort in 2008 and 2009, ground-truthed and aerial spawning surveys for salmon species in August and October 2009 and 2010, and habitat assessments conducted in 2008 and 2009.

15.1.5 Aquatic Resources

15.1.5.1 Overview

Aquatic resources include both sediment quality and aquatic biological communities residing within that habitat. These communities include primary producers (organisms that photosynthesize to produce their own energy and provide the basis of the food web) and secondary producers (organisms that feed on primary producers and on each other). Primary producers include periphyton in streams (algae attached to substrates and along bottoms), macrophytes, and phytoplankton (free-floating algae found in lakes). Secondary producers include benthic invertebrates (dwelling in and on sediment of streams and lakes) and zooplankton (invertebrates that live in the open waters of lakes).

Sediment quality includes the physical and chemical properties of sediment in streams and lakes sampled in the baseline study area. Sediment quality is an indicator of long-term patterns in water quality because sediment particles adsorb water constituents. Fluxes of these constituents are always moving between the water and sediment depending on the environmental conditions. Aquatic organisms living on or within sediment (e.g., periphytic algae, macrophytes, benthos, benthivorous, and bottom-dwelling fish) can be adversely affected by poor sediment quality. Sediment quality can influence contaminant transfer through bioaccumulation by benthic organisms and can affect upper trophic level structure and function in aquatic ecosystems. Sediment quality monitoring is used to support aquatic monitoring programs to assess potential effects from development. Sediment concentrations at reference sites and from baseline, pre-development periods are compared to exposure sites through the life of the Project to assess chemical changes that may be caused by mine activities and that can be linked to biological effects.

Sediment quality and aquatic biological communities in streams, rivers, and lakes of the baseline study area were monitored in 2008, 2009, and 2010 (Appendices 15-B, 15-D, and 15-F). Some historical sediment quality data was available from previous studies (Environment Canada 1990 in Appendix 15-J).

A total of 29 stream/river sites and 4 lakes in 8 sub-watersheds were surveyed for aquatic biology and sediment quality in one or both years during the 2008 and 2009 baseline studies; only Gingras Creek was surveyed in 2010 (Figure 15.1-8; Tables 15.1-3 and 15.1-7; Appendices 15-B, 15-D, and 15-F). The aquatic resources program was adapted to the monitoring needs of the Project as the design changed over time and incorporated data gaps and information requests from regulators and Aboriginal groups. The detailed baseline dataset characterizes pre-development conditions. Federal and provincial sediment quality guidelines for the protection of aquatic life were used to assess sediment quality in the baseline study area (CCME 1999; BC MOE 2006a).

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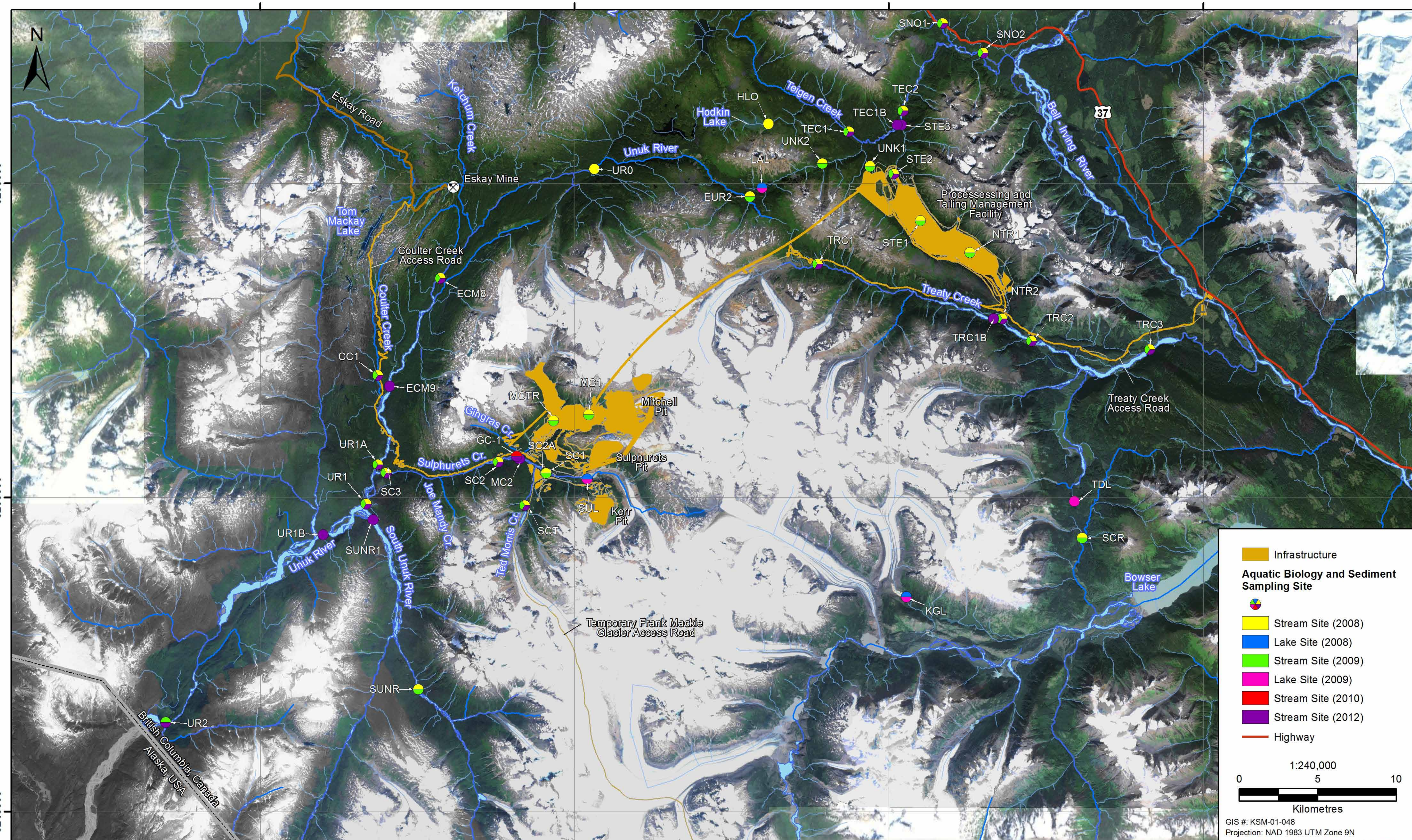


Figure 15.1-8

SEABRIDGE GOLD
KSM PROJECT

Rescan Engineers & Scientists

Aquatic Biology and Sediment Sampling Sites, 2008 to 2012, KSM Project

Table 15.1-7. Summary of Aquatic Biology and Sediment Quality Data for Streams of the KSM Project, 2008 to 2012

Component	Watershed Mitchell Creek (3 sites)	Sulphurets Creek (5 sites)	Unuk River (9 sites)	Teigen Creek (11 sites)	Treaty Creek (6 sites)	Reference Sites (3 sites)
	MC1, MC2, MCTR	SC1, SC2, SC3, SCT, GC1	EUR2, ECM8, ECM9 CC1, UR0, UR1A, UR1, UR1B, UR2	SNO1, SNO2, STE1, STE2, STE3, UNK1, UNK2, HLO, TEC1, TEC1B TEC2	TRC1, TRC1B, TRC2, TRC3, NTR1, NTR2	SUNR and SUNR1 (South Unuk River), SCR (Scott Creek)
Sediment Quality						
Substrates Present	Mainly sand, some silt and gravel	Mainly sand, some gravel and silt	Mainly sand, some silt, except UR1A with high % silt with sand. Coulter Creek with sand and gravel (2008) or silt (2009)	Mainly sand, some silt; some sites in upper Teigen Creek had high silt content.	Mainly sand, some silt, except Upper North Treaty Creek had high silt, gravel and sand.	Mainly sand, some silt and gravel
Nutrients and Organics	Low nutrients and organics	Low nutrients and organics	Low nutrients and organics	Low nutrients and organics, except Upper South Teigen Creek with elevated organic carbon and phosphates and slightly acidic pH.	Low nutrients and organics, except Upper North Treaty Creek with elevated organic carbon, nitrogen and phosphate, and slightly acidic pH.	Low nutrients and organics
Metals Exceeding Sediment Quality Guidelines [1]	Arsenic, cadmium, copper, iron, lead, manganese, mercury, nickel, selenium, zinc	Aresenic, cadmium, copper, iron, manganese, mercury, nickel, selenium, zinc	Arsenic, cadmium, chromium, copper, iron, manganese, mercury, nickel, selenium, zinc	Arsenic, chromium, cooper, iron, manganese, nickel	Arsenic, cadmium, chromium, copper, iron, manganese, mercury, nickel, zinc	Arsenic, cadmium, copper, iron, manganese, nickel
Periphyton						
Biomass	Low	Low (except at GC1)	Low	High	Low in Treaty Creek, high in North Treaty Creek.	Intermediate
Density	Low	Low (except at GC1)	Low	Very high in TEC2 and UNK2 in 2008	Low both years in Treaty Creek, but intermediate in North Treaty Creek.	Intermediate in 2008, low in 2009
Dominance, Richness and Diversity	Almost entirely diatoms. Low richness and diversity.	Almost entirely diatoms (cyanophytes at GC1). Low richness and diversity.	Almost entirely diatoms. Low richness and diversity in lower Unuk, higher values for Upper Unuk River	Almost entirely diatoms, except UNK2 with chlorophytes and diatoms. High richness and diversity	Almost entirely diatoms. Low richness and diversity for Teigen Creek, but high values for North Treaty Creek.	Almost entirely diatoms, except SCR with chlorophytes and diatoms
Benthic Invertebrates						
Density	Very Low	Very Low	Low	Variable (Low to high)	High in North Treaty Creek, very low in Treaty Creek	Low
Dominance, Richness and Diversity	Mainly chironomids. Low overall richness and EPT richness. Moderate diversity except at MC1 where it was low.	Mainly chironomids. Low overall richness and EPT richness. Moderate or high diversity except at SCT where it was low.	Variable over time; mix of chironomids, mayflies or stoneflies. High overall richness in Upper Unuk R., moderate overall richness in Lower Unuk River	Variable, mix of chironomids, mayflies and stoneflies. High overall richness and EPT richness. High diversity except at UNK2.	Variable, mix of chironomids and mayflies. High overall richness and EPT richness in N Treaty Creek, Low overall richness and EPT richness in Treaty Creek. High diversity except at TRC1.	Mixture of mayflies, stoneflies and chironomids. Moderate overall richness, higher EPT richness

Stream sites are grouped by watershed

[1] **Guidelines are BC MOE and CCME sediment quality guidelines and metals were listed if the mean concentration in sediment samples collected between 2009-2012 for the watershed exceeded guideline limits**

The sediment and aquatic biology sites represent all areas potentially affected by the Project, including the three proposed receiving environments: 1) Sulphurets Creek/Unuk River (downstream of the Mine Site); 2) South Teigen Creek/Teigen Creek/Bell-Irving River (downstream of the PTMA); and 3) North Treaty Creek/Treaty Creek/Bell-Irving River (downstream of the PTMA). They also include proposed mine infrastructure such as open pits, ore and rock storage facilities (RSFs), the TMF, transmission lines, pipelines, and reference sites. Many of these sites overlap locations where baseline studies of other disciplines were conducted, including surface water quality (Chapter 14) and fish and fish habitat.

15.1.5.2 Streams

15.1.5.2.1 Sediment Quality

In 2008 and 2009, 29 stream sites were surveyed for sediment quality, using methods consistent with the *British Columbia Field Sampling Manual* (BC MWLAP 2003). In 2008, whole (total) sediment samples were analyzed for metal content. In 2009, the 63 µm fraction was analyzed for metal content, consistent with the Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators (BC MOE 2012). For the purposes of summarizing and compiling baseline sediment quality data, emphasis will be placed on the 2009 samples and data to best represent baseline sediment chemistry. Summarized results are presented by watershed group in Tables 15.1-7 and 15.1-8, while the complete baseline studies are provided in Appendices 15-B (2008), 15-D (2009), and 15-F (2010).

It was noted that detection limits for some metals were close to or greater than guideline limits in 2008 to 2009, so additional sampling at 27 sites was completed in 2012. Ideally, detection limits should be lower than guideline concentrations by one order of magnitude, but at minimum should be at least five times lower (BC MOE 2012). When the measured concentration and detection limits are too close together, accuracy and precision of the data is decreased which can affect the confidence in the comparison between guideline concentrations and measured concentrations. Since the detection limits were substantially improved for the 2012 sediment samples (63 µm fraction), these data are summarized separately in Table 15.1-9, and raw data are compiled in Appendix 15-J.

Sediment data were compared to either Canadian Council of Ministers of the Environment (CCME) or BC sediment quality guidelines (BC MOE 2006a; CCME 1999). For most metals, BC guidelines are based on those from CCME and are called interim sediment quality (ISQ) guidelines or probable effect level (PEL) guidelines. The exceptions to this are iron, nickel, and silver in the BC guidelines, which do not have CCME equivalents, and are based on screening level concentrations that provide a lowest effect level (LEL) and severe effect level (SEL). The selenium guideline in BC is an ISQ, but does not have a CCME equivalent. Metal concentrations in the sediment that are greater than the PEL or SEL are likely to have deleterious effects on aquatic life, such as benthic invertebrates that reside in close proximity to the sediment. Concentrations in excess of the ISQ or LEL may also have a negative impact on aquatic life, particularly for sensitive species within the aquatic community.

Table 15.1-8. Summary of Stream Sediment Quality for the KSM Project, 2009 and 2010

Watershed	Mitchell (n = 6)				Sulphurets (n = 15)				Unuk River (n = 18)				Teigen (n = 24)				Treaty (n = 16)				Reference Sites (n = 6)				CCME or BC Guideline	
	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	ISQG or LEL	PEL or SEL
Particle Size																										
% Gravel (>2 mm)	<1	6.00	2.50	2.72	<1	42.00	12.24	14.50	<1	54.00	15.86	18.14	<1	55.00	17.88	17.65	<1	58.00	12.84	18.22	<1	11.00	4.92	4.52		
% Sand (2.0mm - 0.063 mm)	78.00	93.50	84.75	6.87	39.00	96.00	75.59	16.67	44.00	94.00	77.11	15.76	39.00	95.00	73.69	15.75	32.00	94.00	75.16	20.11	57.00	87.00	75.67	11.41		
% Silt (0.063mm - 4 μm)	6.00	18.00	11.33	4.46	3.00	23.00	10.11	7.31	1.00	12.00	6.06	3.24	2.00	22.00	6.75	4.95	3.00	36.00	10.03	8.68	5.00	39.00	17.83	12.78		
% Clay (<4 μm)	1.00	3.00	1.50	0.84	<1	7.00	1.99	1.94	<1	3.00	1.17	0.66	1.00	10.00	1.83	1.86	<1	12.00	2.06	2.87	<1	4.00	1.92	1.36		
General Parameters																										
Moisture (%)	14.50	18.60	16.87	1.65	1.96	25.20	12.74	6.87	8.69	28.60	17.42	4.00	8.41	51.30	18.30	9.26	8.57	74.00	21.15	16.95	10.10	19.35	14.54	3.30		
Total Organic Carbon (%)	1.71	6.74	3.99	2.40	1.76	5.59	3.19	1.06	<0.7	10.20	5.03	3.59	<0.7	1.45	<0.7	0.35	<0.7	3.51	1.80	1.12	1.31	5.77	3.48	2.21		
pH	7.95	8.34	8.14	0.17	8.07	8.65	8.28	0.17	7.10	8.52	7.92	0.46	6.74	7.93	7.38	0.41	6.06	8.40	7.71	0.77	8.21	8.49	8.36	0.10		
Total Nitrogen (%)	<0.02	0.06	0.03	0.02	<0.02	0.06	0.03	0.02	0.05	0.17	0.09	0.04	0.08	0.23	0.10	0.03	0.05	0.45	0.11	0.10	<0.02	0.05	0.03	0.02		
Cyanide, Total	<3	<3	<3	0	<3	<3	<3	0	<3	<3	<3	0	<3	<3	<3	0	<3	<3	<3	0	<3	<3	<3	0		
Available Phosphate-P					<2	<2	<2	0	<2	2.50	<2	0.55	2.90	4.80	3.66	0.57	<2	<2	<2	0						
Metals																										
Aluminum (Al)	9,915	17,400	14,386	3,040	11,400	22,600	16,479	4,060	12,600	19,100	15,611	1,634	11,000	25,600	20,317	3,307	12,100	22,700	17,063	3,889	9,810	14,600	12,918	1,952		
Antimony (Sb)	<10	26.00	11.67	8.48	<10	18.00	<10	4.98	<10	<10	<10	0	<10	<10	<10	0	<10	<10	<10	0	<10	<10	<10	0		
Arsenic (As)	**23.3**	**173.0**	**69.8**	59.3	**17.4**	**237.0**	**107.1**	71.0	**21.5**	**117.0**	**61.4**	24.6	6.1	**17.4**	11.8	2.5	6.7	**96.0**	**45.3**	29.4	9.4	**41.4**	**26.2**	14.8	5.9	**17.0**
Barium (Ba)	67.4	151.0	114.5	31.6	53.0	473.0	254.7	148.4	121.0	589.0	226.5	122.5	117.0	443.0	195.5	88.2	89.2	288.0	169.4	71.9	148.0	220.0	186.6	33.1		
Beryllium (Be)	<0.5	<0.5	<0.5	0	<0.5	0.520	<0.5	0.070	<0.5	1.200	0.551	0.316	<0.5	0.850	<0.5	0.192	<0.5	0.650	<0.5	0.176	<0.5	<0.5	<0.5	0		
Bismuth (Bi)	<20	<20	<20	0	<20	<20	<20	0	<20	<20	<20	0	<20	<20	<20	0	<20	<20	<20	0	<20	<20	<20	0		
Cadmium (Cd)	1.10	3.20	2.01	0.82	0.25	**3.73**	1.83	0.96	0.50	**25.40**	**4.45**	8.37	<0.5	2.09	<0.5	0.47	0.25	2.03	1.38	0.62	0.66	1.00	0.81	0.12	0.6	**3.5**
Calcium (Ca)	11,700	40,200	26,117	13,547	11,200	23,000	17,950	4,115	4,060	40,000	20,662	13,399	1,680	8,110	5,011	1,877	2,950	18,500	11,159	6,114	13,600	37,200	25,100	11,677		
Chromium (Cr)	3.0	20.3	11.8	9.2	15.4	53.9	25.1	11.2	23.5	75.7	41.7	13.3	46.6	**117.0**	87.2	15.3	19.5	**91.7**	46.7	27.6	13.8	53.7	31.2	18.9	37.3	**90**
Cobalt (Co)	14.9	36.3	21.0	7.7	16.0	44.0	25.6	7.8	16.9	32.0	22.9	4.4	11.4	65.3	24.7	11.1	14.5	21.9	18.2	2.1	14.2	22.0	16.9	3.2		
Copper (Cu)	122.0	**463.0**	**256.3**	147.4	86.6	**428.0**	**220.9**	102.8	62.4	**214.0**	118.7	46.0	28.6	79.9	51.2	12.0	38.9	92.3	65.3	14.3	30.0	91.6	53.9	26.7	35.7	**197**
Iron (Fe)	**43,500**	**118,500**	**61,183**	29,131	**47,900**	**106,000**	**62,092**	15,713	40,700	**78,100**	**53,894**	12,100	18,200	**60,200**	37,133	8,629	31,000	**72,000**	**45,778**	9,066	38,400	**70,900**	**50,042**	15,535	21,200	**43,766**
Lead (Pb)	<30	**93.0**	39.7	31.5	<30	**100.0**	32.3	26.6	<30	36.0	<30	9.0	<30	<30	<30	0	<30	43.0	<30	9.7	<30	45.0	<30	14.6	35	**91**
Lithium (Li)	12.8	17.7	14.4	2.0	5.8	22.2	12.9	6.0	9.5	37.6	18.7	9.0	17.6	36.4	31.3	4.1	17.4	38.7	27.8	7.3	5.2	17.5	11.6	6.1		
Magnesium (Mg)	5,010	14,400	9,848	4,413	7,350	15,800	11,069	2,780	7,120	14,300	11,296	2,363	7,580	18,100	14,045	2,135	8,600	15,300	11,546	2,241	7,070	9,240	8,723	834		
Manganese (Mn)	588	890	781	112	577	**4,860**	**1,407**	1,273	629	**1,520**	949	267	569	**19,600**	**1,866**	3,804	257	925	791	155	369	**1,430**	871	490	460	**1,100**
Mercury (Hg)	0.094	**0.676**	0.282	0.224	0.050	0.461	0.184	0.137	0.113	**0.496**	0.249	0.095	0.060	0.179	0.120	0.033	0.100	0.367	0.218	0.094	<0.005	0.095	0.047	0.046	0.170	**0.486**
Molybdenum (Mo)	<4	36.45	19.09	16.49	<4	17.00	6.68	5.59	<4	20.30	6.37	5.55	<4	5.30	<4	0.84	<4	4.10	<4	0.52	<4	5.30	<4	1.73		
Nickel (Ni)	<5	42.9	19.3	17.2	17.2	59.2	26.3	10.7	28.0	**157.0**	67.3	46.0	59.6	**205.0**	**116.9**	26.8	38.3	**114.0**	67.3	29.2	16.0	28.0	21.1	5.4	16	**75**
Phosphorus (P)	2,170	2,470	2,307	123	1,850	2,480	2,110	199	1,110	2,320	1,818	458	521	1,700	1,095	235	951	2,390	1,320	389	1,810	2,100	1,927	132		
Potassium (K)	815	1,340	1,129	197	1,760	3,880	2,606	675	1,040	1,780	1,384	244	1,080	2,370	1,636	327	700	2,870	1,514	820	990	1,570	1,352	221		
Selenium (Se)	<6	23.25	7.91	7.73	<0.5	19.10	4.30	4.55	<2	19.10	5.64	5.71	<2	2.53	<2	0.35	<2	9.87	2.11	2.28	<2	<2	<2	0	2	
Silver (Ag)	<2	3.40	<2	0.98	<2	3.50	<2	0.74	<2	2.30	<2	0.31	<2	<2	<2	0	<2	<2	<2	0	<2	<2	<2	0	0.5	
Sodium (Na)	<200	300	<200	85	240	620	344	111	<200	500	271	136	<200	330	<200	85	<200	220	<200	51	<200	370	223	137		
Strontium (Sr)	40.2	162.0	101.1	58.7	62.7	117.0	86.7	16.5	48.9	152.0	93.9	36.9	18.1	93.1	41.4	19.1	34.1	89.1	62.1	18.1	65.2	149.0	106.3	41.3		
Thallium (Tl)	<1	<1	<1	0	<1	<1	<1	0	<1	<1	<1	0	<1	<1	<1	0	<1	<1	<1	0	<1	<1	<1	0		
Tin (Sn)	<5	<5	<5	0	<5	46.50	5.43	11.36	<5	<5	<5	0	<5	<5	<5	0	<5	<5	<5	0	<5	<5	<5	0		
Titanium (Ti)	1200	1610	1370	165	789	1700	1200	316	22	1620	788	564	45	3220	636	764	54	1012	570	414	256	1510	878	659		
Vanadium (V)	47.9	133.0	87.2	42.3	82.7	125.0	95.1	13.6	48.1	157.0	89.7	34.0	32.2	71.1	54.0	8.7	44.6	64.8	53.5	6.2	38.9	172.0	95.8	64.6		
Zinc (Zn)	95.9	224.5	160.6	53.6	60.9	**334.0**	169.4	71.8	111.0	**1460**	**344.8**	464.9	60.3	185.0	117.3	24.2	103.0	205.0	159.3	37.3	43.3	99.2	71.9	24.9	123	**315**

SD = standard deviation of the mean, ISQ = interim sediment quality, LEL = lowest effect level, PEL = probable effects level, SEL = severe effects level

All units in μg/g dry weight unless otherwise noted, and metal concentrations were measured on the 63 μm fraction

Data are grouped by watershed with n showing the number of sediment samples

Samples where the concentration was below the detection limit were replaced with values of half the detection limit for calculation purposes

< indicates the value or mean was below the method detection limit for that parameter

Shaded cells indicate values exceed CCME (1999) or BC MOE (2006a) interim sediment quality guidelines, bold numbers exceed the PEL

Table 15.1-9. Summary of Stream Sediment Quality for the KSM Project, 2012

Watershed	Mitchell (n = 3)				Sulphurets (n = 21)				Unuk River (n= 25)				Teigen (n = 23)				Treaty (n=15)				Reference Sites (n = 3)				CCME or BC Guideline	
	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	ISQG or LEL	PEL or SEL
Particle Size																										
% Gravel (>2 mm)	10.40	42.00	24.23	16.16	<0.1	49.90	17.73	14.13	<0.1	53.80	29.10	18.64	1.17	78.90	26.86	19.82	0.33	66.00	22.33	19.28	1.95	20.20	8.46	10.18		
% Sand (2.0mm - 0.063 mm)	45.60	88.20	67.97	21.38	48.40	90.70	67.60	13.33	45.00	98.00	67.34	16.35	20.80	93.50	69.61	18.58	33.60	94.90	73.93	17.82	78.70	97.00	90.63	10.34		
% Silt (0.063 mm - 4 μm)	1.11	11.70	7.28	5.51	0.93	47.80	13.72	16.96	0.58	20.00	3.30	4.45	0.24	7.74	2.95	2.01	0.26	6.60	2.86	2.09	0.54	1.06	0.85	0.27		
% Clay (<4 μm)	0.27	0.74	0.53	0.24	0.10	3.07	0.96	0.94	0.05	0.85	0.27	0.17	<0.1	2.00	0.58	0.56	<0.1	2.07	0.89	0.53	<0.1	0.12	<0.1	0.04		
General Parameters																										
Moisture (%)	12.30	20.20	16.40	3.96	12.40	36.30	22.02	5.62	11.20	32.80	20.85	6.30	13.10	31.60	19.86	4.89	14.70	26.90	18.34	3.41	17.40	21.20	18.90	2.02		
Total Organic Carbon (%)	0.17	0.20	0.18	0.02	0.13	1.05	0.27	0.20	<0.1	1.62	0.48	0.41	0.32	0.79	0.52	0.11	0.37	0.68	0.49	0.09	0.10	0.11	0.11	0.01		
pH	8.53	8.65	8.57	0.07	7.67	8.47	8.06	0.22	7.29	8.54	8.19	0.38	7.07	8.05	7.44	0.27	7.51	8.28	7.93	0.24	7.94	8.16	8.08	0.12		
Total Nitrogen (%)	0.03	0.04	0.03	0.00	0.02	0.09	0.03	0.01	0.03	0.16	0.06	0.04	0.06	0.10	0.07	0.01	0.04	0.10	0.06	0.02	<0.02	0.03	0.02	0.01		
Total Cyanide	<0.06	<0.06	<0.06	-	<0.06	0.03	-	0.00	<0.06	<0.06	<0.06	-	<0.06	<0.06	<0.06	-	<0.06	0.09	<0.06	0.02	<0.06	<0.06	<0.06	-		
Available Phosphate-P	<2	<2	<2	-	<2	3.30	<2	0.90	<2	4.30	2.09	1.26	1.00	5.60	3.24	1.13	<2	3.00	<2	0.71	<2	<2	<2	-		
Metals																										
Aluminum (Al)	12,900	20,600	15,467	4,446	10,300	19,500	14,438	2,684	8,830	29,700	16,297	3,327	16,500	22,600	19,404	1,597	11,900	22,800	15,973	3,123	13,100	13,500	13,367	231		
Antimony (Sb)	1.75	5.94	3.18	2.39	1.12	32.80	6.97	7.93	1.11	14.50	6.18	3.98	0.60	1.94	0.89	0.33	0.66	7.62	4.52	2.12	0.47	0.52	0.49	0.03		
Arsenic (As)	**29.40**	**73.90**	**46.23**	24.1	15.40	**665.00**	**100.36**	144.70	13.10	**107.00**	**55.85**	26.14	9.00	16.40	11.44	2.05	11.50	**107.00**	**56.05**	27.28	7.37	8.14	7.66	0.42	5.9	**17.0**
Barium (Ba)	177	228	202	25.5	65	362	189	83	106	485	222	81	110	210	160	32	89	267	154	60	143	155	150	6		
Beryllium (Be)	0.230	0.290	0.253	0.032	0.180	0.630	0.396	0.135	0.240	1.130	0.652	0.238	0.440	0.720	0.524	0.062	0.380	0.610	0.440	0.061	0.210	0.230	0.217	0.012		
Bismuth (Bi)	0.500	0.790	0.600	0.165	<1	1.070	0.463	0.253	<1	0.720	0.248	0.165	<1	0.160	0.118	0.025	0.140	0.680	0.381	0.147	0.200	0.320	0.257	0.060		
Cadmium (Cd)	1.05	2.67	1.60	0.93	0.54	**4.86**	2.22	1.48	0.70	**32.20**	**5.26**	9.77	0.31	0.54	0.40	0.08	0.31	**3.66**	2.30	1.08	0.27	0.34	0.31	0.04	0.6	**3.5**
Calcium (Ca)	19,200	23,600	20,867	2,386	10,500	29,100	19,348	3,899	6,040	32,500	16,762	7,569	3,080	6,670	4,891	1,022	2,670	15,400	10,785	3,943	10,700	11,800	11,333	569		
Chromium (Cr)	18.7	36.3	24.9	9.9	13.9	49.0	25.2	10.6	23.1	**248.0**	62.6	47.4	85.1	**148.0**	**104.1**	18.5	25.4	**345.0**	67.2	82.0	36.6	45.4	42.0	4.8	37.3	**90**
Cobalt (Co)	17.5	30.5	22.1	7.3	14.8	56.0	24.1	9.5	9.5	43.3	22.9	6.3	17.5	28.9	21.2	3.1	18.1	24.3	21.3	1.8	13.5	17.9	15.9	2.2		
Copper (Cu)	113	**205**	147	50.2	83.6	**584**	**238**	134	75.6	**512**	167	117	36.3	59.2	46.4	5.9	50.8	93.7	70.1	11.9	63.1	70.3	67.3	3.8	35.7	**197**
Iron (Fe)	33,600	**61,700**	43,567	15,730	29,700	**105,000**	**50,005**	16,872	21,600	**91,800**	**52,504**	15,352	32,000	39,900	35,870	2,301	36,300	**59,700**	**50,160**	6,799	32,800	**52,200**	42,700	9,706	21,200	**43,766**
Lead (Pb)	13.1	26.8	18.3	7.4	10.0	**149.0**	32.6	33.6	7.4	50.2	25.4	11.0	7.1	10.2	8.0	0.9	8.0	38.1	24.0	9.4	16.4	27.4	20.1	6.4	35	**91**
Lithium (Li)	5.40	9.20	6.70	2.17	<5	20.10	10.33	5.58	5.80	25.50	16.22	4.84	22.50	32.90	26.53	2.71	13.80	35.90	23.29	5.80	7.20	7.90	7.67	0.40		
Magnesium (Mg)	8,920	16,200	11,363	4,189	6,830	14,300	10,243	2,289	5,870	21,400	11,804	3,243	11,100	14,700	12,961	793	8,080	14,600	10,760	2,035	8,890	9,230	9,053	170		
Manganese (Mn)	794	**1,290**	965	281	612	**5,030**	**1,330**	1,095	400	**2,140**	1,002	355	608	**1,590**	1,008	275	809	**1,330**	1,055	126	420	446	437	15	460	**1,100**
Mercury (Hg)	0.038	0.143	0.073	0.061	0.013	**0.523**	0.157	0.146	0.074	**1.430**	0.374	0.313	0.078	0.124	0.098	0.013	0.089	0.420	0.263	0.097	0.009	0.014	0.011	0.002	0.170	**0.486**
Molybdenum (Mo)	2.29	4.26	3.01	1.08	1.67	10.80	5.32	3.22	1.78	20.40	5.46	5.67	1.07	4.80	2.19	1.11	1.62	26.60	5.44	5.92	1.37	2.43	1.82	0.55		
Nickel (Ni)	18.8	42.3	27.1	13.2	15.1	53.2	26.0	9.1	18.6	**205**	72.8	44.5	**94.1**	**148**	**117**	13.2	51.5	**245**	**82.5**	50.6	22.8	29.9	26.4	3.6	16	**75**
Phosphorus (P)	1,790	1,960	1,887	87	1,730	2,830	2,057	314	834	3,680	1,863	455	891	1,080	976	58	939	2,000	1,264	236	1,230	1,690	1,477	232		
Potassium (K)	2,370	3,560	2,777	679	910	2,760	1,796	414	700	2,570	1,298	374	820	2,210	1,210	361	670	2,810	1,150	649	1,720	1,810	1,777	49		
Selenium (Se)	1.98	5.77	3.34	2.11	1.62	7.53	3.81	2.08	0.89	33.10	6.38	8.94	0.65	1.36	0.94	0.20	0.97	6.11	3.59	1.50	0.52	0.74	0.65	0.12	2	
Silver (Ag)	0.562	1.160	0.767	0.340	0.332	5.57	1.15	1.13	0.222	4.28	1.49	1.13	0.205	0.358	0.256	0.039	0.279	1.07	0.650	0.238	0.251	0.287	0.265	0.020	0.5	
Sodium (Na)	310	400	350	46	<100	300	206	75	<100	670	376	165	110	180	144	20	110	240	147	31	410	460	440	26		
Strontium (Sr)	80.1	100	86.8	11.4	71.0	145	92.7	20.1	35.3	161	94.3	30.5	30.9	50.3	40.3	6.6	32.9	82.3	63.3	12.9	55.0	59.1	56.6	2.2		
Thallium (Tl)	0.154	0.248	0.189	0.051	0.104	0.456	0.174	0.076	0.058	1.050	0.284	0.277	0.081	0.149	0.104	0.015	0.094	0.429	0.290	0.105	0.089	0.101	0.094	0.006		
Tin (Sn)	0.230	2.10	1.17	1.152	<0.2	0.760	0.277	0.157	0.220	2.01	0.552	0.402	0.250	1.07	0.454	0.183	0.310	1.40	0.439	0.278	0.320	0.610	0.510	0.165		
Titanium (Ti)	919	1,610	1,180	375	465	1,680	1,044	342	13	1,700	913	404	73	1,090	464	266	27	974	593	271	1,250	1,550	1,433	161		
Uranium (U)	0.537	0.698	0.595	0.089	0.306	1.14	0.716	0.237	0.353	4.48	1.15	1.183	0.173	0.368	0.247	0.047	0.197	0.546	0.392	0.092	1.450	3.35	2.27	0.978		
Vanadium (V)	67.3	116.0	84.2	27.6	53.4	138.0	83.6	24.8	47.1	159.0	92.4	22.8	47.7	62.1	53.4	3.5	46.7	76.1	54.3	7.1	85.7	137.0	111.6	25.7		
Zinc (Zn)	120	234	160	64	91.4	**522**	216	119	88.7	**1,540**	**362**	430	93.3	138	114	13	119	283	219	50	55.6	60.5	58.7	2.7	123	**315**

SD = standard deviation of the mean, ISQ = interim sediment quality, LEL = lowest effect level, PEL = probable effects level, SEL = severe effects level

All units in μg/g dry weight unless otherwise noted, and metal concentrations were measured on the 63 μm fraction

Data are grouped by watershed with n showing the number of sediment samples

Samples where the concentration was below the detection limit were replaced with values of half the detection limit for calculation purposes

< indicates the value or mean was below the method detection limit for that parameter

Shaded cells indicate values exceed CCME (1999) or BC MOE (2006a) ISQ guidelines or LEL guidelines, bold numbers exceed the PELguidelines

The substrate at most sites was composed mainly of sand, with lesser proportions of silt, gravel, and clay varying from site to site (Tables 15.1-8 and 15.1-9). Sites NTR1 and NTR2 on North Treaty Creek were the exception, as there was more silt followed by gravel and sand in 2008 and 2009. This was likely due to its location downstream of a wetland system, which may have acted as a source of the fines and reduced the water flow causing the coarser material to settle upstream.

Sediment pH was slightly alkaline in most streams, with the mean pH ranging from 7.26 to 8.57 (Tables 15.1-8 and 15.1-9). Sites in the South Teigen and North Treaty creeks that were situated downstream of wetland habitat (NTR1, STE1) had slightly acidic pH (minimum pH ranging from 6.0 to 6.4), which would likely be related to natural microbial processes. During the summer months (2008/09 sampling), these sites, particularly NTR1 in North Treaty Creek, had elevated levels of nutrients and organic carbon as their maximum total available phosphate (24 mg P/kg), nitrogen (1%), and organic carbon (16.8%) concentrations were an order of magnitude higher than other streams. No cyanides were detected in any stream sediment, except at NTR1. This was likely related to the upstream wetlands, as these habitats are known to produce cyanide naturally during nutrient and organic cycling processes (Appendices 15-B, 15-D, and 15-F).

Due to the presence of the Mitchell deposit within the watershed, Mitchell Creek had high natural concentrations of mercury, selenium, and zinc that were greater than the CCME (1999) and BC MOE (2006a) ISQ guideline levels. The sediment in Sulphurets Creek and Unuk River also showed elevated levels of these parameters, indicative of downstream transport of these metals from the Mitchell basin.

Selenium is an element of interest due to its potential to bioaccumulate in the aquatic food web (Chapman et al. 2009). All sediment samples collected in 2009 from Mitchell Creek (MC1) and Coulter Creek (CC1, in both 2009 and 2012) had selenium concentrations greater than the BC ISQ guideline. Most other watersheds in both 2009 and 2012 had localized areas where mean selenium sediment concentrations were greater than the BC ISQ guideline (Tables 15.1-8 and 15.1-9). The exception to this is the Teigen Creek watershed, where only one sample (collected at UNK1 in 2009) had a measured concentration of selenium greater than 2 µg/g dry weight (dw), but mean concentrations were all below guideline limits (Appendix 15-D).

Mean concentrations of arsenic, copper, iron, manganese, and nickel in all of the watersheds, including the reference sites, were naturally above CCME and BC ISQ Guidelines (Tables 15.1-8 and 15.1-9). The maximum arsenic concentrations in sediment were greater than the PEL in all watersheds, and mean arsenic was greater than the PEL in all watersheds except Teigen. In more localized areas, iron was greater than the PEL in one or more sampling years in the Unuk (CC1, UR1, UR2), Mitchell (MCTR, MC1), and Sulphurets (SC1, SC2, SC3, SCT) watersheds, while manganese and copper concentrations were greater than the PEL at some sites in Mitchell (MC1), Sulphurets (SC1, SC2, SC3), and Teigen (SNO1, UNK1, UNK2) watersheds. Chromium was elevated above ISQ guideline limits at most sites in the Teigen Creek, Treaty Creek, and Unuk River watersheds, and was near or above the PEL at some sites in the Teigen Creek watershed (UNK1, UNK2, STE2, TEC1, TEC2). Nickel was greater than the SEL at all sites in Teigen Creek.

Mean cadmium concentrations were above ISQ guidelines in all watersheds, except Teigen (and the reference site in 2012). Specifically, cadmium was above guidelines at several sites in the Treaty (TRC1B, TRC1, TRC2), Unuk (UR1), Mitchell (MCTR, MC1, MC2), and Sulphurets (SC1, SC2, SC3) watersheds as well as at the reference sites, but was an order of magnitude higher at Coulter Creek (CC1) in the Unuk River watershed. Zinc showed a similar pattern to cadmium indicating that Coulter Creek possesses geology rich in cadmium and zinc minerals. Archaeologists employed by Seabridge Gold Inc. observed red bluffs present in Upper Coulter Creek indicating exposed mineralized rock (S. McKnight, pers. comm.). Coulter Creek was also the receiving environment for discharges from the now-closed Eskay Creek Mine, and the elevated metal concentrations observed in this creek may also be due to historical inputs from this site.

Additionally, in 2008, sediments from two sites (TEC2 and SC2) were analyzed for polycyclic aromatic hydrocarbons (PAHs). Concentrations of PAHs in the sediments were below detection limits for all compounds measured (Appendix 15-B).

Overall, the sediments located in areas downstream of the future Mine Site (Mitchell and Sulphurets creeks, and the Lower Unuk River) are of poor quality, with low nutrient availability. Metal concentrations were greater than most of the sediment quality guidelines and in some instances were higher than the PEL concentrations. Sediment quality data under baseline conditions (i.e., naturally occurring environment) suggest that these areas are unlikely to support large or healthy populations of aquatic life, particularly for organisms such as benthic invertebrates that would live in close contact with the sediments. While sediment quality in areas downstream of the TMF (South Teigen, Teigen, North Treaty, and Treaty creeks) is of somewhat better quality and contain slightly higher organic carbon content, there are still a number of metals that occur at concentrations greater than sediment quality guidelines that could affect the health of aquatic life. The ability of the sediments downstream of the TMF to support healthy and robust communities of periphyton and benthic invertebrates is better than downstream of the Mine Site, but may be limited and patchy.

Comparison to Historical Sediment Data

Baseline sediment data for the Brucejack Creek Mine, also called the Sulphurets Project, was collected in 1988 (Environment Canada 1990; Appendix 15-J). This baseline report provides historic sediment quality data at three sites in the current baseline study area. These sites included:

- Lower Sulphurets Creek (SC3);
- Unuk River just above Sulphurets Creek (UR1A); and
- Unuk River just below Sulphurets Creek (UR1).

Four replicate samples were collected at each of these sites on August 8, 1988. Metals analyses were conducted on sieved (150 µm) fractions only. Arsenic, cadmium, chromium, copper, iron, manganese, and mercury, which were elevated above guidelines at these sites in 2008 to 2009, and were analyzed both in 1988 and in 2008 to 2009, were compared between periods. The historic results match closely the current Project baseline data for most metals.

However, sediment mercury concentrations have increased in recent years compared to 1988 at all three sites (range: 30 to 56%), while sediment cadmium concentrations have decreased (15 to 59%). These differences could be attributed to sampler variation, differences in laboratory precision and accuracy, or actual changes in metal concentrations. The depth of sampling could have affected the concentrations if higher concentrations were found in shallower depths and if 1988 samples were collected to include deeper sediment than those of 2008 and 2009. Cobalt and silver were not detected in any samples in 1988. In recent years, analytic improvements have resulted in lower detection limits for cobalt in sediments. Silver was not detected in recent samples at these sites, in agreement with 1988 data. Due to advances in technology, the more recent data is viewed as more reliable than the data collected 24 years ago, and will be used as baseline in the effects assessment.

15.1.5.2.2 Periphyton

Triplicate composite periphyton samples were collected from 28 stream sites in 2008, 27 sites in 2009, and 1 site (GC1) in 2010 using sampling methods and data analysis consistent with the *British Columbia Field Sampling Manual*, and the *Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring* (BC MWLAP 2003; Environment Canada 2012).

Periphyton biomass was typically low in the baseline study area (Table 15.1-7), with a mean biomass of 0.38 µg chl *a*/cm^2 in 2008, 0.61 µg chl *a*/cm^2 in 2009, and 0.13 µg chl *a*/cm^2 in Gingras Creek in 2010. Biomass was variable among sites and did not show a consistent pattern between 2008 and 2009, except for a few sites with very low biomass in Mitchell Creek (MCTR, MC1), Lower Sulphurets Creek (SC2, SC3, SCT), and lower reaches of the Unuk River (UR1, UR2; Appendices 15-B, 15-D, and 15-F).

Overall, mean periphyton density was spatially and temporally variable. Density was higher in 2008 at most sites (ranged from 1,037 to greater than 5×10^7 cells/cm^2) than in 2009 (ranged from 6.4 to greater than 1×10^6 cells/cm^2) and was quite high at the only site sampled in 2010 (GC1, mean of 6.6×10^6 cells/cm^2). Density was consistently lowest in the Unuk River (UR1 UR1A, UR2); Coulter (CC1), Sulphurets (SC1, SC2, SC3), Mitchell (MC1), Snowbank (SNO1), and Treaty (TRC1, TRC3) creeks; and higher at sites in Teigen Creek (TEC2 and UNK2). Periphyton density was dependent on the dominant taxa present at the various sites.

A total of 73 periphyton species were identified in 2009, the majority of which were diatoms (68 species). Other identified groups included chlorophytes (two species), cyanophytes (two species), and chrysophytes (one species). The communities were composed almost entirely of diatoms (96 to 100%) in both 2008 and 2009, except at sites UNK2 (Teigen Creek watershed) and SCR (Scott Creek reference site) that had large numbers of chlorophytes present in one of the two years, and GC1 in 2010 (Gingras Creek, Suphurets Creek watershed) where the community consisted predominantly of cyanophytes.

Mean periphyton species richness (the number of species present) ranged from 1 to 22 species per site in 2008, with a similar range (1 to 20 species per site) in 2009. While there was inter-annual variation in richness, there was a trend of higher richness in the Teigen Creek watershed (all sites), sites in the Upper Unuk River watershed (EUR2 and CC1), and in North

Treaty Creek (NTR1, NTR2), and there was lower richness in Treaty Creek (TRC1, TRC2, TRC3), Mitchell Creek (MC1, MCTR), Sulphurets Creek (SC2, SC3, SCT), and the Lower Unuk River (UR1, UR2) sites.

Species diversity (as measured by Simpson's diversity indices) was also variable between years. In 2008, the diversity was very low at a few sites in different watersheds (UNK2, TRC1, UR1); and intermediate in many sites, including those of South Teigen Creek (STE2), most of the Unuk River (EUR2, UR1A) and Mitchell Creek (MC1), and some sites along Sulphurets Creek (SC2, SC3). Periphyton diversity was highest in North Treaty Creek (NTR1) and Teigen Creek (TEC2). In 2009, diversity was relatively low at sites in Treaty (TRC1, TRC2, TRC3), Sulphurets (SC2, SC3, SCT), and Mitchell (MC1) creeks, with the highest diversity at sites in Teigen Creek (TEC1, TEC2), North Treaty Creek (NTR1, NTR2), and Upper Unuk River (EUR2).

The results indicate some general trends of lower periphyton community richness and diversity within the Mine Site watersheds and better aquatic community quality in the TMF watersheds. This is consistent with lower quality aquatic habitat downstream of the Mine Site due to elevated concentrations of metals in the sediments (see Section 15.1.5.2.1) and water (Chapter 14).

15.1.5.2.3 Benthic Invertebrates

Communities of benthic invertebrates were compared among streams using density, richness, diversity, evenness (how well distributed the community is), and community composition metrics. This was done using sampling methods and data analysis consistent with the *British Columbia Field Sampling Manual*; the *Canadian Aquatic Biomonitoring Network Laboratory Methods: Processing, Taxonomy, and Quality Control of Benthic Macroinvertebrate Samples*; the *Canadian Aquatic Biomonitoring Network (CABIN): Wadeable streams Field Manual*; and the *2012 Metal Mining Environmental Effects Monitoring Technical Guidance* (BC MWLAP 2003; Environment Canada 2010a, 2010b, and 2012).

Overall, the mean density of benthic invertebrates was spatially and temporally variable, with generally higher densities in 2009 compared to 2008. This may be attributed to higher ambient temperatures in 2009, or due to increased runoff in 2008 and a delay in peak flows in 2008 (occurred in August for most sites) compared to 2009 when peak flows occurred in July for most sites (Appendix 7-B and 13-A). Density was higher at some sites in the North Treaty Creek (NTR1) and Teigen Creek (TEC2) watersheds, and was lowest in the Unuk River (ECM8, CC1, UR1, UR1A), Mitchell Creek (MC1), and Sulphurets Creek (SC1, SC2, SC3, SCR) watersheds, and in Treaty Creek (TRC1, TRC2, TRC3) sites, following a similar pattern as periphyton density and biomass (Table 15.1-7).

Mean genus richness ranged from 1 to 27 genera/site in 2008, with a similar range of 2 to 25 genera/site in 2009, and 19 genera/site at GC1 in 2010 (Appendices 15-B, 15-D, and 15-F). Richness was highest at sites in North Treaty Creek (NTR1, NTR2), Upper Unuk River (EUR2, CC1), Teigen (UNK1, TEC2) and Snowbank (SNO1) creeks, and lowest in Treaty Creek (TRC1) and Mitchell (MC1) and Sulphurets (SC2, SC3, SCT) creeks watersheds. The reference sites showed intermediate richness.

Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly; EPT) are important benthic taxonomic groups and are indicative of good water quality. EPT richness showed a similar pattern to overall benthic invertebrate richness, with low richness in Treaty Creek (TRC1, TRC2, TRC3) and Mitchell (MC1) and Sulphurets (SC2, SC3, SCT) watersheds, and high EPT richness in some sites within the Teigen (UNK1, TEC2, HLO), North Treaty (NTR2), and Unuk (EUR2, UR0) systems. EPT richness ranged from zero to 15 EPT genera/site in 2008 and one to 12 EPT genera/site in 2009. Treaty Creek (TRC3 in particular) and Coulter Creek (CC1) had highly variable EPT richness between years.

Diversity and evenness indices are useful indicators of community health. The mean Simpson's diversity index ranged from 0.09 to 0.92 in 2008, but most sites were between 0.6 and 0.9. The lower diversities (less than 0.4) in 2008 were observed at single sites in four different watersheds: MC1 (Mitchell), SCT (Sulphurets), TRC1 (Treaty), and UNK2 (Teigen), all of which are smaller stream sites. In 2009 the Simpson's diversity index ranged from 0.58 to 0.91, which was similar to the range for most of the sites in 2008, and was 0.61 in 2010.

Mean evenness ranged from 0.31 to 1.0 in 2008, and 0.50 to 0.99 in 2009. Evenness generally ranged from 0.60 to 0.85 at most sites, and showed a similar pattern to Simpson's diversity index among sites. Evenness can be biased in cases where richness is extremely low (at MC1, richness was 1 taxa only), resulting in an artificially high evenness value.

In 2008, chironomids (non-biting midges) dominated the stream benthos community at 19 of the Project sites, while mayflies were dominant at 4 sites. In 2009, chironomids were dominant at eight sites, stoneflies were dominant at seven sites, and mayflies were dominant at six sites. In 2010 at GC1, stoneflies were dominant (64%) with chironomids making up about 33% of the benthos density. This benthic community structure is typical of coldwater streams of northwest BC. Notably, Oligochaeta (a class of segmented worms) dominated the benthic community in Coulter Creek (CC1; in 2008) and in Lower Treaty Creek (TRC3; in 2009). These segmented worms are considered tolerant of environmental stress and their dominance is indicative of soft mud bottoms and/or impacted systems. In general, the benthic communities within Mitchell, Sulphurets, and Upper Treaty creeks indicate lower habitat quality than at other sites, based on the metrics assessed.

Diptera (true flies, primarily chironomids at sites), stoneflies, and mayflies were the dominant taxonomic groups present in the streams and rivers of the baseline study area. There was considerable variation within sites of the same watershed and between years at the same sites. In the case of Coulter Creek, a change in the site location moving it upstream 800 m in 2009, may have contributed to the variation. Also, water levels were much higher in Snowbank Creek in 2009 compared to 2008. Thus, stoneflies and mayflies could have been transported downstream to the main channel from smaller tributaries in the heavy flows of 2009.

The results indicate some general trends of lower benthic community density, richness, and diversity within the Mine Site watersheds and better aquatic community quality in the TMF watersheds. In general, these attributes of the benthic community tend to improve with distance downstream of the Mine Site through Mitchell Creek to Sulphurets Creek and the Unuk River, although benthic communities are still relatively small. This is consistent with lower quality aquatic habitat downstream of the Mine Site due to elevated concentrations of metals in the sediments (see Section 15.1.5.2.1) and water (Chapter 14).

15.1.5.3 Lakes

15.1.5.3.1 Sampling Sites

Three lakes were surveyed for sediment quality and aquatic biology in 2008: West Teigen Lake (LAL, referred to as Teigen Lake in the baseline studies), Sulphurets Lake (SUL), and Knipple Glacier Lake (KGL; reference lake). At the time of sampling in 2008, West Teigen Lake was considered to be a lake that might be affected by Project development. Note that since the 2008 and 2009 sampling events, the Project has been realigned, and West Teigen Lake is no longer at risk of alteration due to Project activities, although the previously prepared baseline studies (Appendices 15-B and 15-D) refer to it as a potentially impacted lake site. The reference lake, Todedada Lake (TDL), was added to the sampling program in 2009.

Sampling was conducted in August each year to characterize the baseline water quality and aquatic habitat at each site. SUL and KGL are both glacier-fed lakes at higher elevations, while TDL and LAL are stream-fed lakes in valley basins. SUL is located near the proposed open pits. All lakes were spatially separated into three zones: shallow (0 to 3 m), mid-depth (approximately one-half total depth), and deep (1 m less than maximum depth) to fully characterize the lake habitat when sampling. All data are presented in the 2008 and 2009 baseline reports (Appendices 15-B and 15-D), and are summarized in Tables 15.1-10 and 15.1-11.

15.1.5.3.2 Limnology

Bathymetric measurements, Secchi depths (related to water clarity), and profiles of dissolved oxygen and temperature were collected from each lake in August (Table 15.1-10). All four lakes had similar maximum depths between 13 and 19 m. SUL was well-mixed, had the coldest temperatures (near freezing) and most oxygenated waters (14 mg/L), and had small sections of glacier ice floating on its surface during sampling. KGL was stratified (thermocline at 2 m), slightly warmer (4 to 12°C), and had an oxycline at approximately 6 m in depth. The lower elevation lakes, LAL and TDL, were the warmest, with surface temperatures near 15 to 16°C. LAL was weakly stratified (at 8 to 10 m), while TDL had a strong thermocline at 5 m. Both of these lakes were well-oxygenated in the epilimnion, but in LAL, dissolved oxygen levels dropped to near anoxic conditions near the sediment bed in the deeper parts of the lake. An oxycline was most apparent in TDL at depths of approximately 7 m. Being glacier-fed, both KGL and SUL were highly turbid with poor clarity (Secchi depth of 0.1 to 0.2 m), likely caused by glacial clays clouding the lake waters. TDL and LAL each had greater water clarity with Secchi depths of 4.0 to 5.3 m.

Table 15.1-10. Summary of Aquatic Biology and Sediment Quality Data for Lakes of the KSM Project, 2008 to 2009

Lake **Component**	**Sulphurets Lake** **SUL**	**Knipple Glacier Lake** **KGL**	**West Teigen Lake** **LAL**	**Todedaga Lake** **TDL**
Limnology				
Maximum depth	15 m*	16 m*	13 m*	19 m*
Stratification (thermocline)	Well-mixed, no thermocline	Thermocline present (at 2 m)	Weak stratification (at 8 to 10 m)	Strong thermocline present (at 5 m)
Temperature	Near 2°C temperature throughout	4 to 12°C	4 to 15°C	0 to 16°C
Dissolved Oxygen	Highly saturated; DO ~14 mg/L	Low DO in hypolimnion, saturated in epilimnion; DO 1 to 10 mg/L	Low DO in hypolimnion, saturated in epilimnion; DO 1 to 10 mg/L	Low DO in hypolimnion, saturated in epilimnion; DO 0 to 10 mg/L
Water Clarity	Poor (Secchi depth 0.1 to 0.2 m)	Poor (Secchi depth 0.1 to 0.2 m)	Moderate (Secchi depth 4.0 to 4.6 m)	Moderate (Secchi depth 4.7 to 5.3 m)
Sediment Quality				
Particle Composition	Clays and silt, some sand in shallows	Mainly clays, some silt, small amounts of sand or gravel in shallows	Clays and silt, some sand and/or gravel in shallows	Clay, silt and sand, with some gravel in shallows
Nutrients and Organics	Highest metal concentrations in general, low nutrients and organics, alkaline pH	Low nutrients and organics, alkaline pH	Highest nutrients and organics, slightly acidic pH	High nutrients and organics, slightly acidic pH
Metals Exceeding Guidelines[1]	Arsenic, cadmium, copper, iron, lead, manganese, mercury, nickel, selenium, zinc	Arsenic, iron, manganese, mercury, zinc	Arsenic, chromium, copper, iron manganese, mercury, nickel, selenium, zinc	Arsenic, cadmium, chromium, copper, iron, manganese, nickel, zinc
Aquatic Life				
Phytoplankton	Very low biomass, species richness and diversity	Low (2008) to moderate (2009) biomass, low species richness and diversity	Moderate biomass, high species richness and diversity	High biomass and species richness, moderate diversity
Zooplankton	Low density and richness	Low density and richness	High density and richness	High density and richness
Benthic Invertebrates	Very low density and richness	Low density and richness	Highest density, high richness, diverse community	High density, highest richness, diverse community

DO = Dissolved Oxygen (mg/L).
*** denotes 2009 value.**
[1] Guidelines are BC MOE (2006a) and CCME (1999) sediment quality guidelines, and metals were listed if the mean concentration in sediment samples collected between 2008 and 2009 for the lake was greater than the guideline limits.

Table 15.1-11. Summary of Sediment Quality in Lakes of the KSM Project, 2008 to 2009

	Knipple Glacier Lake (KGL; n = 6)				West Teigen Lake (LAL; n = 6)				Sulphurets Lake (SUL; n = 6)				Todedada Lake (TDL; n = 3*)				CCME or BC Guideline	
Lake	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	ISQG or LEL	PEL or SEL
Particle Size																		
% Gravel (>2mm)	0.5	2.5	0.8	0.8	0.5	38.0	12.8	18.8	0.5	37.0	6.7	14.8	0.5	14.5	5.4	7.9		
% Sand (2.0mm - 0.063mm)	0.5	10.0	2.1	3.9	2.0	23.0	11.0	9.6	0.5	58.0	18.8	24.9	1.5	46.0	26.7	22.8		
% Silt (0.063mm - 4um)	13.0	37.0	27.2	8.2	30.0	54.0	44.1	10.7	5.0	64.0	40.3	20.0	35.5	44.5	38.7	5.1		
% Clay (<4um)	63.0	75.0	70.6	4.6	12.0	49.0	32.8	15.2	1.0	59.3	34.8	20.3	17.0	53.5	29.3	20.9		
General Parameters																		
% Moisture	36.6	56.2	48.4	6.5	50.4	78.8	62.7	11.0	12.0	58.1	37.9	15.1	76.2	89.1	82.1	6.5		
Total Organic Carbon (%)	<0.1	2.7	1.3	1.3	1.5	5.8	4.2	1.8	0.1	5.0	1.8	2.2	0.4	2.3	1.0	1.2		
pH	7.91	8.48	8.20	0.25	6.11	7.05	6.59	0.33	7.11	8.14	7.68	0.38	6.45	6.66	6.54	0.10		
Total Nitrogen (%)	<0.02	0.07	0.05	0.03	0.13	0.61	0.35	0.16	0.04	0.09	0.06	0.02	0.50	1.33	0.79	0.47		
Available Phosphate-P	<1	<1	<1	-	<1	7.5	4.0	2.7	<1	<1	<1	-	9.6	38.3	19.4	16.4		
Cyanide, Total	<3	<3	<3	-	<3	<3	<3	-	<3	<3	<3	-	<3	<3	<3	-		
Metals																		
Aluminum (Al)	20,300	29,350	25,533	3,306	17,300	35,200	28,808	6,500	13,000	26,150	20,358	4,491	13,400	16,250	14,500	1,532		
Antimony (Sb)	<10	<10	<10	-	<10	<10	<10	-	<10	29.00	14.96	7.80	<10	<10	<10	-		
Arsenic (As)	**31.3**	**63.0**	**40.2**	12.8	9.1	**33.4**	**21.5**	8.2	**69.2**	**151.0**	**108.0**	26.2	9.1	15.1	11.2	3.3	5.9	**17.0**
Barium (Ba)	639	681	666	16	132	222	180	29	85	520	376	152	164	229	204	35		
Beryllium (Be)	0.500	0.730	0.663	0.091	0.250	0.870	0.732	0.238	0.250	0.633	0.457	0.165	0.250	0.395	0.342	0.080		
Bismuth (Bi)	<20	<20	<20	-	<20	<20	<20	-	<20	<20	<20	-	<20	<20	<20	-		
Cadmium (Cd)	<0.5	0.64	0.48	0.18	0.25	0.50	0.32	0.11	0.25	1.50	0.99	0.45	0.88	1.40	1.06	0.30	0.6	**3.5**
Calcium (Ca)	11,600	21,500	15,388	3,425	3,820	5,955	4,837	761	6,505	28,500	19,488	8,373	8,595	10,130	9,417	773		
Chromium (Cr)	5.8	9.0	8.0	1.2	58.5	**137.0**	**106.4**	29.5	15.0	22.7	18.8	3.0	32.8	44.6	40.1	6.4	37.3	**90**
Cobalt (Co)	16.7	20.0	18.7	1.1	13.5	54.7	39.1	15.0	11.5	20.7	17.8	4.0	12.4	17.0	14.7	2.3		
Copper (Cu)	27.7	34.6	30.9	2.3	37.2	116.0	89.0	27.6	118.0	**657.0**	**348.3**	187.2	23.9	49.3	33.4	13.8	35.7	**197**
Iron (Fe)	43,050	**49,300**	**45,625**	2,340	28,200	**65,150**	**55,242**	14,051	35,200	**62,250**	**49,529**	8,601	35,300	**60,700**	**45,950**	13,187	21,200	**43,766**
Lead (Pb)	<30	33.5	23.6	9.5	15.0	15.0	15.0	-	15.0	70.0	48.4	18.1	15.0	15.0	15.0	-	35	**91**
Lithium (Li)	20.1	25.1	23.2	1.8	32.5	57.1	50.5	9.2	17.0	26.0	22.0	3.9	17.4	39.6	27.5	11.2		
Magnesium (Mg)	10,600	12,900	11,596	829	9,540	23,200	17,648	5,041	10,090	15,150	13,173	2,363	3,810	6,005	5,263	1,259		
Manganese (Mn)	**1,675**	**2,200**	**1,876**	190	374	**1,255**	830	357	848	**1,870**	**1,470**	459	650	**3,335**	**1,629**	1,483	460	**1,100**
Mercury (Hg)	0.152	0.272	0.193	0.045	0.108	0.254	0.212	0.052	0.124	**1.680**	**0.554**	0.562	0.138	0.195	0.161	0.030	0.170	**0.486**
Molybdenum (Mo)	<4	<4	<4	-	<4	3.550	2.258	0.633	<4	12.450	4.383	4.070	<4	3.000	2.333	0.577		
Nickel (Ni)	7.3	13.2	10.5	2.1	**88.9**	**230.0**	**179.1**	52.4	9.7	20.4	16.6	4.0	**79.9**	**83.5**	**81.2**	2.0	16	**75**
Phosphorus (P)	1,130	1,275	1,209	60	683	1,810	1,302	393	1,070	2,125	1,541	374	950	982	964	17		
Potassium (K)	3,260	6,245	4,967	1,281	1,570	2,050	1,733	170	820	3,625	2,439	922	1,070	1,420	1,223	179		
Selenium (Se)	<2	<2	<2	-	0.38	6.30	2.99	2.18	<2	10.75	2.71	3.94	0.25	4.06	1.65	2.10	2	
Silver (Ag)	<2	<2	<2	-	<2	<2	<2	-	<2	<2	<2	-	<2	<2	<2	-	0.5	
Sodium (Na)	<200	530	280	204	<200	270	128	69	<200	278	149	78	<200	285	210	97		
Strontium (Sr)	44.0	56.6	49.4	4.1	49.4	76.0	64.4	8.9	47.2	122.0	96.6	25.9	134.5	140.5	137.0	3.1		
Thallium (Tl)	<1	<1	<1	-	<1	<1	<1	-	<1	<1	<1	-	<1	<1	<1	-		
Tin (Sn)	<5	<5	<5	-	<5	<5	<5	-	<5	<5	<5	-	<5	<5	<5	-		
Titanium (Ti)	246	568	425	111	55	188	115	44	405	730	548	123	62	203	130	71		
Vanadium (V)	54.5	67.4	60.9	5.4	44.6	74.4	64.2	10.4	58.5	90.6	77.2	11.8	24.9	31.4	28.7	3.4		
Zinc (Zn)	114	141	132	10	110	227	189	42	106	227	188	44	133	188	165	29	123	**315**

*** Todedaga Lake only sampled in 2009**

[1] The detection limit for selenium varied between samples and ranged from 1 to 10 mg/kg

SD = standard deviation of the mean, ISQ = interim sediment quality, LEL = lowest effect level, PEL = probable effects level, SEL = severe effects level

All units in µg/g dry weight unless otherwise noted

< indicates the value was below the method detection limit for the parameter

Shaded cells indicate values exceed CCME or BC MOE ISQ guidelines or LEL guideline, bolded numbers exceed PEL or SEL guidelines

15.1.5.3.3 Sediment Quality

Sediment samples were collected from shallow, mid-depth, and deep zones in each lake. Lake bottom substrates in SUL, TDL, and LAL were predominantly silt with clay, but had higher proportions of sand and small amounts of gravel (LAL and TDL only) in shallower depths (Table 15.1-10). KGL contained mainly clay with lesser amounts of silt at all depths, with some sand or gravel in shallow areas. The mean pH of SUL and KGL (7.7 and 8.2, respectively) was alkaline compared to LAL and TDL (mean pH of 6.6 at both lakes), which was slightly acidic (Table 15.1-10 and 15.1-11). This was likely due to increased microbial degradation of organic matter in LAL and TDL, since these sites had higher levels of organic carbon, total nitrogen, and total available phosphate compared to the two glacier lakes that had almost no sedimentary organic matter. The lower DO concentrations noted previously for LAL and TDL are also indicative of microbial respiration. These results point toward LAL and TDL being more biologically active than SUL and KGL.

Metal concentrations were often highest at SUL due to its proximity to the mineral deposits and glacial influences (i.e., increased suspended material; Table 15.1-11). Mean concentrations of numerous metals were naturally greater than BC or CCME guidelines in all lakes including arsenic, iron, manganese, and zinc. Mean sediment concentrations of arsenic were greater than the PEL guidelines at all lakes, except TDL. Mercury in the sediment was present at levels above the ISQ guideline at all lakes, except TDL, and was above the PEL in sediments of SUL. Concentrations of cadmium, chromium, and copper were above sediment guidelines at two or more lake sites.

Mean concentrations of selenium in sediments collected from SUL and LAL in 2009 were greater than the BC MOE (2006a) guideline limit of 2 µg/g dw. Selenium was detected in one of the three sediment samples from TDL in 2009 at a concentration (4.1 µg/g) that was greater than the guideline. All sediment samples from KGL had selenium concentrations below the method detection limit. Samples were also spatially variable within a lake; selenium was found only in the sediments of the deep sampling sites at LAL and TDL, while it was found only in the shallow sediment sample from SUL.

15.1.5.3.4 Phytoplankton

Phytoplankton were sampled in the shallow, mid-depth, and deep lake zones in 2008 and 2009 (Appendices 15-B and 15-D). Samples were collected from SUL, KGL, and LAL in 2008 and 2009, while TDL was added in 2009 as a reference lake. SUL contained little phytoplankton in both years, with the lowest biomass (0.02 to 1.08 µg chlorophyll *a*/L), density (0 to less than 10 cells/mL), and richness (only 0 to 3 diatom taxa) of all lakes. KGL had low biomass in 2008 but moderate biomass in 2009, with moderate density and lower richness compared to TDL and LAL. The phytoplankton community in KGL consisted of entirely diatoms in 2008, and of predominantly cryptophytes with some diatoms in 2009. Phytoplankton density and diversity were lower in SUL and KGL, owing to their higher elevation (shorter growing season and lower temperatures) and low nutrient and organic concentrations, leading to lower standing stocks (Table 15.1-10).

In both years, LAL had the highest densities, richness, and diversity, followed by TDL in 2009. These two lakes are at lower elevations and had water quality more favourable for phytoplankton growth (i.e., higher nutrients and increased light penetration), relative to the two glacial-fed lakes. As seen at KGL, LAL phytoplankton density was twice as high in 2009 compared to 2008, though richness and diversity were similar between the years. This may be associated with the generally higher ambient temperatures and earlier freshet in 2009 compared to 2008. Diatoms dominated the community in LAL for both years. Cyanophytes, diatoms, cryptomonads, and chlorophytes dominated the community in TDL.

15.1.5.3.5 Zooplankton

Zooplankton were sampled in each zone of SUL, KGL, and LAL in 2008, and were resampled in 2009, including TDL (Appendices 15-B and 15-D). Phytoplankton is the main food source for zooplankton and therefore their biomass reflects the primary producer biomass found within these lakes. In both 2008 and 2009, zooplankton density was close to zero in glacial lakes KGL and SUL, indicating naturally low productivity in these lakes (Table 15.1-10). LAL and TDL had higher densities, genus richness, and diversities than the glacial lakes, particularly in the deeper zones. In LAL, zooplankton densities increased from approximately 600 to 1,400 organisms/m^3 in 2008, to 50,000 to 160,000 organisms/m^3 in 2009, though richness and diversity remained relatively the same between the two years. Genus richness of zooplankton was higher in TDL (up to 10 genera), intermediate in LAL (7 to 9), followed by KGL and SUL (both 4 to 6). SUL and KGL communities were dominated by the cyclopoid copepod *Diacyclops* in 2008, shifting to rotifers and various copepod nauplii in 2009. LAL and TDL had more diverse communities and were dominated by rotifers, calanoid and cyclopoid copepods (including nauplii), and smaller proportions of other groups.

15.1.5.3.6 Benthic Invertebrates

Benthic invertebrate communities were sampled in 2008 at SUL and KGL in the mid-depth and deep zones, and at LAL in all three zones (Appendices 15-B, 15-D, and 15-F). The hard-packed sediments in the shallow zones of SUL and KGL made it unfeasible to collect benthic invertebrate samples in 2008. These three lakes, in addition to TDL, were re-sampled in 2009, with all zones sampled except SUL medium depth (5 to 10 m).

The benthic invertebrate community in the Project lakes followed a similar trend as that observed for phytoplankton and zooplankton (Table 15.1-10). Benthic invertebrate density was greater, and the community composition was richer and more diverse in LAL and TDL (density up to approximately 22,000 organisms/m^3, approximately 11 genera/sample) than observed in the glacial lakes, SUL and KGL (density less than 1,000 organisms/m^3, 0 to 1 genera/sample). There were greater densities of benthos in SUL, KGL, and LAL in 2009 compared to 2008, though richness and diversity was relatively stable. Variability in the benthos densities in LAL's three zones was observed between the years; in 2008, benthos densities increased with depth, but in 2009 they decreased with depth.

The benthic community in SUL and KGL was composed entirely of Diptera, while a diverse community of Diptera, Pelecypoda (bivalves), Oligochaeta, Nematoda, Ostracoda (seed shrimp), and smaller proportions of other groups, was present in LAL and TDL.

15.2 Historical Activities

There have been various projects and human activities in the baseline study area surrounding the proposed KSM Project. These activities have included mineral exploration, forest harvesting, development and use of roads, recreation and tourism, and hunting and gathering. All projects and activities have potential effects on fish and aquatic habitat.

Potential effects on aquatic resources can include the release of foreign substances into the environment altering water quality, changes to water quantity, changes in acid rock drainage (ARD), changes in allochtonous and autochtonous primary production, changes in temperature, and encounters with humans. There can also be physical changes to the structure of the aquatic habitat. However, identifiable traces of past impacts within the watersheds that make up the baseline study area are not present. Fish populations, aquatic habitats, and biology suggest influences are strongly associated with natural influences rather than anthropogenic influences.

The potential for historical cumulative effects on the setting are considered in detail in Section 15.6, Identification of Potential Effects.

15.3 Land Use Planning Objectives

The KSM Project: Non-traditional Land Use Baseline Report (Appendix 23-A) identified land management plans that guide activities, existing land uses and tenures near the Project, and overlapping and adjacent protected areas. Details of these can be found in the baseline study reports (Appendix 23-A). This section summarizes the goals of the land use management plan and strategies as they relate to the effects of mining on fish and aquatic habitat.

Land and resource management plans that encompass parts of the Project's land use local study area (LSA) include the Cassiar Iskut-Stikine Land and Resource Management Plan (LRMP; BC ILMB 2000) and the Nass South Sustainable Resource Management Plan (SRMP; BC MFLNRO 2012).

15.3.1 Cassiar Iskut-Stikine Land and Resource Management Plan

The CIS LRMP defines specific land and resource management objectives that are designed to balance environmental, economic, and social objectives of the local area, region, and province while creating greater economic certainty for local economic development and maintaining lifestyle opportunities. Its principal goals and objectives as they relate to fish and aquatic habitat include the maintenance of a healthy environment and sustainable ecosystems with abundant fish and wildlife, while also creating sustainable development and effective planning and management of natural resources with a minimal environmental footprint (BC ILMB 2000).

The LRMP has area-specific resource management zones (RMZs), with additional objectives and strategies. A segment of the Unuk River RMZ overlaps the proposed mine access route. Management objectives for the RMZ are to maintain high-value grizzly bear habitat and visual quality from the Unuk River, while allowing for adjacent logging and mineral development. The Unuk River Management Strategy for aquatic ecosystems and riparian habitat is to manage all activities along the Unuk River and its tributaries to provide no net loss of fish habitat. It also strives to apply best management practices (BMPs) to wetlands, floodplains, and riparian habitat (BC ILMB 2000).

There are parks and protected areas defined in the LRMP that have water resources of high ecological and cultural value. In these areas, resource conservation is emphasized and activities such as mining, logging, and hydro dams are precluded. There are two provincial parks near the baseline study area: Ningunsaw Provincial Park and Ningunsaw River Ecological Reserve. These are located approximately 15 km northwest of the proposed TMF and are in watersheds outside of the baseline study area. Thus, they will not be affected by the Project. Border Lake Provincial Park is located approximately 25 km southwest of the ore deposits, along the Unuk River. Mitigation measures will include treating all mine contact water prior to its release, thus it will not be affected by the Project.

15.3.2 Nass South Sustainable Resource Management Plan

The purpose of the Nass South SRMP is to provide long-term sustainability of jobs, communities, and natural resources in the southern portion of the Nass Timber Supply Area (BC MFLNRO 2012). The SRMP was developed in partnership with Nisga'a Nation, the Gitanyow First Nation, stakeholders, and government agencies (BC MFLNRO 2012). It provides guidance on permitted land-use activity in the area, and its northern finger intersects a portion of the baseline study area (Appendix 23-A).

The Nass South SRMP provides management direction in seven areas: water, biodiversity, botanical forest products, wildlife, fisheries, cultural heritage resources, and timber (BC MFLNRO 2012). Management directions for water resources include the following:

- limit potential for surface soil erosion;
- manage human activities to maintain the hydrological stability of watersheds;
- maintain the ecological functioning of streams, rivers, wetland complexes, and lakes, including those that do not have fish populations;
- maintain functional integrity of floodplains and alluvial fans; and
- restore the water quality and hydrological integrity of damaged watersheds.

Management directions for fisheries include the maintenance of habitat for indigenous fish populations and the restoration of habitat for indigenous fish populations (BC MFLNRO 2012).

Proposed mitigation measures for Project effects on fish and aquatic habitat will meet the goals and objectives of the CIS LRMP and the Nass South SRMP. Details of potential Project-related effects, their significance on fish and aquatic habitat, and mitigation measures are discussed in the following sections.

15.4 Spatial and Temporal Boundaries

15.4.1 Spatial Boundaries

The spatial boundaries for the fish and aquatic habitat effects assessment for the Project consist of an LSA and a regional study area (RSA). The LSA encompass watersheds in the immediate area of the Project with a potential for direct effects (Figure 15.4-1). The LSA includes streams that are located within and downstream of the proposed open pits, RSFs, PTMA, as well as ancillary components such as buildings, roads, tunnels, power generation facilities, and transmission line routes, which include existing and proposed access roads. The sub-watersheds with a potential for direct effects include those identified in Table 15.1-1, except Scott Creek, South Unuk River, Hodkin Creek, West Teigen Creek, and Bowser River.

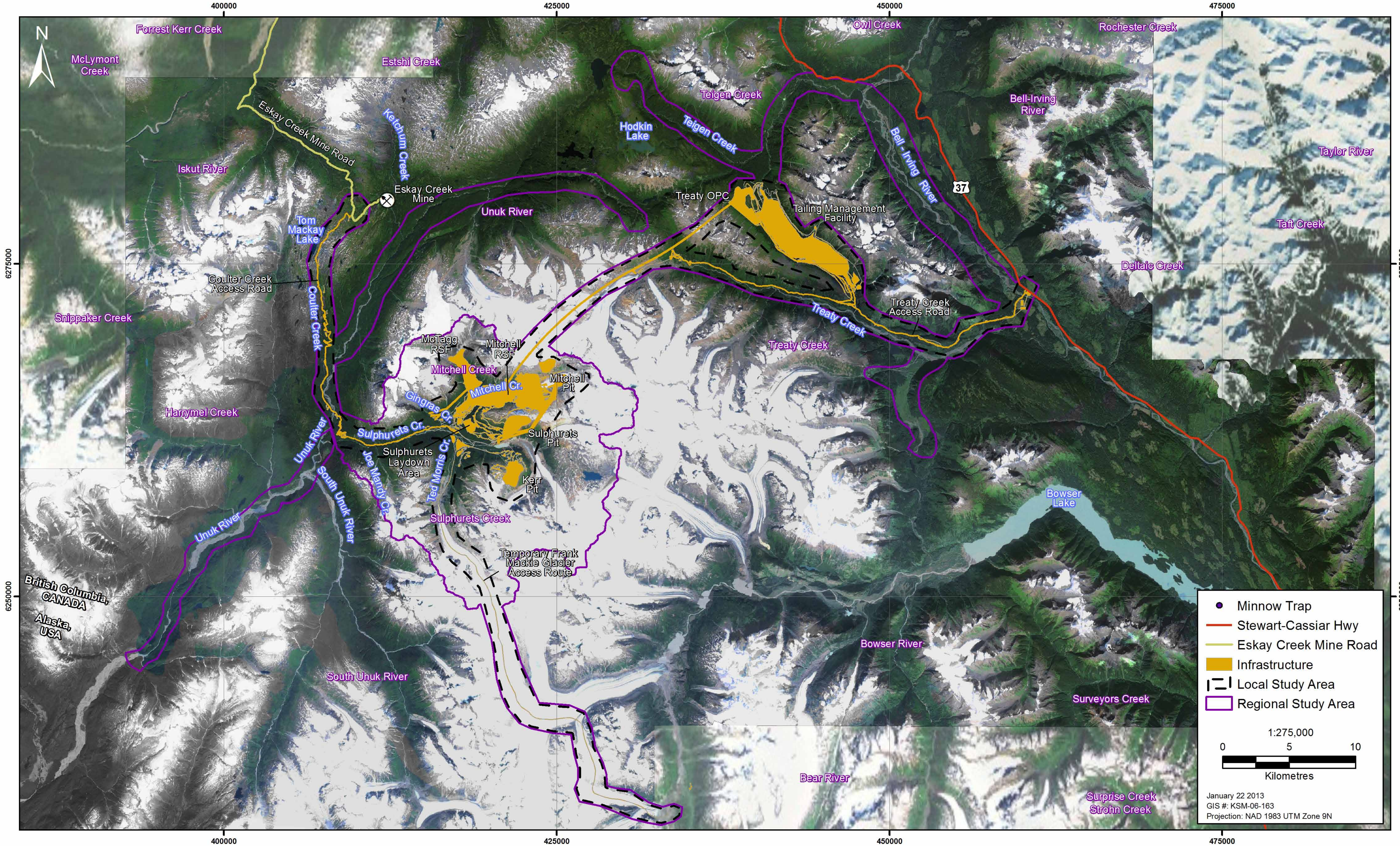


Figure 15.4-1

Rescan Engineers & Scientists

KSM Fish and Aquatic Habitat Local and Regional Study Areas

SEABRIDGE GOLD
KSM PROJECT

The RSA includes the portion of the watersheds downstream of the Project with a potential for direct effects, as well as watersheds upstream of those with a potential for direct effects (Figure 15.4-1). The primary factor that determined the placement of the RSA boundary was the potential extent of water quality degradation due to the KSM Project. Specific downstream extents of the RSA for the Project are anticipated to be immediately downstream of the Treaty Creek confluence with the Bell-Irving River, and the Unuk River at the Canada/United States Border.

Potential effects and habitat losses are considered with respect to fish and aquatic habitat existing in the LSA and RSA. Potential effects are assessed at the scale of the entire length of a stream, or an entire lake, as appropriate for that local biological community, and to the extent that these potential effects could affect an entire community rather than individuals. Applicable potential effects on a sub-local scale are noted and considered in this assessment and in the cumulative environmental effects assessment.

15.4.2 Temporal Boundaries

For the purposes of the effects assessment, the temporal boundaries include the following four phases:

- construction phase: 5 years;
- operation phase: 51.5 year life of the Project;
- closure phase: Project decommissioning and reclamation (3 years); and
- post-closure phase: post-closure monitoring (250 years).

15.5 Valued Components

Valued components (VCs) are used to focus the Application/EIS on the issues of highest concern. To be considered a VC for assessment purposes, a component must meet the following criteria:

- it must be known to occur in, or be applicable to, the baseline study area;
- it must be of recognized importance to society, the local community, or the environmental system; and
- there must be a perceived likelihood that the VC will be affected by the Project.

The Project has the potential to directly and indirectly affect fish and aquatic habitat. Fish and aquatic habitat embrace a number of VCs. As a result, individual fish species and groups of fish species were isolated for further study as VCs because of their conservation status, commercial value, cultural importance, and ecological significance.

Before selecting the VCs, two procedures were performed. First, baseline information was acquired by sampling fish and aquatic habitat from watercourses within the baseline study area, including background literature review. Then, issue scoping was undertaken through consultation. This process considered input from the Aboriginal groups, local interest groups, regional and local government agencies, technical expertise, and/or the general public. Groups expressed concerns of potential water quality degradation downstream of the TMF in salmon-bearing watercourses and salmon habitat loss downstream of the TMF in Teigen Creek.

Fish and aquatic habitat VCs were selected based on the information gathered from the baseline studies, conservation status, and feedback. Together, this approach reflects a balanced and informative synthesis of a wide range of information. Conservation status was determined by consulting the following sources to identify species at risk and those of conservation concern:

- Canada's *Species at Risk Act* (2002);
- COSEWIC;
- DFO;
- BC MOE;
- British Columbia Conservation Data Centre; and
- British Columbia Blue List and Red List.

15.5.1 Valued Components Included in Assessment

All proposed fish and aquatic habitat VCs identified in the Application Information Requirements (AIR) were included in the Application/EIS process. Certain VCs were grouped together because of similar species habitat requirements and distribution within the LSA and RSA. Fish and aquatic habitat VCs in the LSA and RSA and their rationale for inclusion in the Application/EIS process are identified in Table 15.5-1 and below:

Table 15.5-1. Identification and Rationale for Fish and Aquatic Habitat Valued Component Selection

	Identified by*					
	AG	G	P/S	O	Source[1]	Rationale for Inclusion
Dolly Varden	✓	✓			BC MOE, CDC, Aboriginal groups	Yellow-listed fish species. Indicator stream ecosystem species. Potential loss of habitat.
Bull Trout	✓	✓			BC MOE, CDC, Aboriginal groups	Blue-listed fish species. Indicator stream ecosystem species. Potential loss of habitat.
Rainbow Trout/ Steelhead	✓	✓	✓		BC MOE, Aboriginal groups	Indicator stream ecosystem species. Economically important to sport fishing industry. Potential loss of habitat.
Pacific Salmon	✓	✓	✓		DFO, Aboriginal groups	Culturally/commercially valuable species. Indicator species, important for sport fishing. Potential loss of habitat.
Aquatic Habitat	✓	✓	✓		BC MOE, DFO, Aboriginal groups	Potential degradation or loss of habitat.

[1] **Where the importance of the VC was identified.**
BC MOE = British Columbia Ministry of Environment; DFO = Fisheries and Oceans Canada; CDC = British Columbia Conservation Data Centre.
*** AG = Aboriginal Group; G = Government; P/S = Public/Stakeholder; O = other.**

- Dolly Varden (*Salvelinus malma*): Dolly Varden is a yellow-listed species (species of concern) in BC. Dolly Varden has the widest distribution compared to all other species within the baseline study area, based on baseline and historical data, but are not present in the Mine Site. Stream and lake-resident life history forms are present within the baseline study area. Dolly Varden is the only species present within the proposed TMF. They are also the most abundant species present in most baseline study area watersheds, based upon baseline CPUE data. This fish species has been selected as a VC because they are an important part of stream ecosystems, particularly higher gradient streams. This species responds to changes in the aquatic environment with respect to their ecological and physiological requirements for long-term sustainability. Dolly Varden was selected as the keystone species for monitoring fish and aquatic environment health for numerous ecological reasons. Dolly Varden is a resident fish species with limited movement and dispersal (Bryant and Lukey 2004; Ihlenfeldt 2005). The species possesses short- to medium-term longevity (8 to 9 years), prey preference is benthic invertebrates, age and length to maturation is short (3 to 5 years; 130 to 162 mm), and spawning is site-specific (Environment Canada 2002; Ihlenfeldt 2005; McPhail 2007).
- Bull trout (*Salvelinus confluentus*): Bull trout is a blue-listed species (species of concern) in BC. Bull trout distribution is less widespread within the baseline study area than is Dolly Varden distribution, based on baseline and historical data. Stream-resident, fluvial, and adfluvial life history forms are present within the baseline study area. Bull trout are more abundant in Teigen Creek than are Dolly Varden, based upon baseline CPUE data, but are not present in the Mine Site or TMF footprint. Bull trout are known to hybridize with Dolly Varden where these species occur in sympatry, as in the Bell-Irving and Bowser watersheds within the baseline study area. Ecological and niche selection are important to maintain bull trout populations that coexist with Dolly Varden. These fish are sought and consumed by sport anglers. They have been identified as culturally significant for Nisga'a Nation. The Tahltan Nation has also identified bull trout and their habitat as culturally significant (THREAT 2009).
- Rainbow trout/steelhead (*Oncorhynchus mykiss*): Rainbow trout are present within baseline study area watersheds based upon baseline and historical data. These fish species have been selected as a VC because they are an important part of stream ecosystems, particularly lower gradient streams. Summer-run steelhead are present in Teigen and Treaty creeks, but not in the TMF footprint or Mine Site. Steelhead are valuable for recreational fisheries and are sought and consumed by sport anglers. Steelhead are culturally and economically important to Nisga'a Nation. Through the Nisga'a Final Agreement (NLG, Government of Canada, Province of British Columbia 1999), Nisga'a Nation has the right to harvest an allocation of steelhead. Steelhead are culturally and economically significant to Gitxsan Nation, the Gitanyow First Nation, the Tahltan Nation, and wilp Skii km Lax Ha.
- Anadromous (migratory) Pacific salmon, including coho (*O. kisutch*), chinook (*O. tshawytscha*), and sockeye (*O. nerka*): These species use certain watersheds within the baseline study area as spawning, rearing, and overwintering habitat. Chinook salmon spawn in the Teigen Creek mainstem, but not in the TMF footprint or Mine Site. Past studies have shown that the Teigen Creek chinook salmon make up less than 8% of Nass River chinook salmon stocks, based upon estimated escapement data (Koski,

Alexander, and English 1996b). Pacific salmon are culturally and economically important to Nisga'a Nation. Through the Nisga'a Final Agreement (NLG, Government of Canada, Province of British Columbia 1999), Nisga'a Nation has the right to harvest an allocation of salmon. Pacific salmon are also central to the culture and economies of the Skii km Lax Ha, the Tahltan Nation, Gitxsan Nation, and Gitanyow First Nation. These species are also valuable for both commercial and recreational fisheries.

- Aquatic habitat: Aquatic habitat is defined as those parts of the environment on which fish depend, directly or indirectly, to carry out their life processes (DFO 1986). Thus, aquatic habitat is also important to the future economic, social, and cultural well-being of Nisga'a Nation and Nisga'a citizens. Nisga'a Lisims Government has indicated that salmon returning to the Bell-Irving tributaries are important to Nisga'a Nation. Salmon habitat in Teigen and Treaty creeks is also important to Nisga'a Nation, since Nisga'a harvest salmon in the lower reaches of the Nass River, and some of these salmon spawn in Teigen or Treaty creeks (comments from Nisga'a Nation on 2008 Environmental Workplan). Due to the cultural and economic importance of fish, fish and aquatic habitat is also important to the Tahltan Nation, the Gitanyow First Nation, the Gitxsan Nation, and the Skii km Lax Ha. As identified by the Skii km Lax Ha, the Tahltan Nation, and the Gitanyow First Nation, the Treaty and Teigen watersheds are culturally and ecologically important for subsistence fishing. Fish and aquatic habitat includes riparian habitat and physical instream features (e.g., large woody debris [LWD], boulders, and pools) that support spawning, rearing, overwintering, and migration life history stages. Aquatic habitat also includes water quality, sediment quality, primary producers, and secondary producers, which perform a critical function in the transfer of energy from primary producers to higher trophic levels (e.g., fish, birds, and humans). Potential effects to instream habitat, riparian habitat, water and sediment quality, and primary and secondary producers are addressed through this VC.

15.5.2 Fish Species Life History Types and Habitat Preferences

Table 15.5-2 lists the fish and aquatic habitat VCs and summarizes their life history and habitat requirements. Tables 15.5-3 and 15.5-4 describe spawning, fry, and parr habitat and distribution data for the selected VC fish species within Teigen and Treaty watersheds. Information presented in these tables and below is summarized from Rescan (Appendices 15-A, 15-C, and 15-E), Scott and Crossman (1973), Groot and Margolis (1991), Roberge et al. (2002), Quinn (2005), McPhail (2007), and from specific references cited in the tables. A similar table was not presented for the Unuk River because there are no fish in the Mine Site and because of the large distance from the Mine Site to the Unuk River.

15.5.3 Valued Components Excluded from Assessment

Eulachon (also spelled oolichan; *Thaleichthys pacificus*) was suggested as a VC by Nisga'a Nation and the ADFG. The eulachon is a provincially blue-listed, anadromous fish that spawns within the Skeena and Nass Rivers within the North Coast LRMP area. Mature eulachon migrate up rivers during mid-March to mid-May to spawn. Adults lay their eggs in freshwater in coarse sand or gravel. Eggs hatch in two to three weeks' time. The current carries the small larvae to the sea where they rear in estuaries (Stoffels 2001).

Table 15.5-2. Summary of Life History and Habitat Requirements of Selected Valued Component Fish Species of the KSM Project

Requirements	Bull Trout	Dolly Varden	Rainbow Trout/Steelhead	Pacific Salmon		
				Coho	Sockeye	Chinook
Life History						
Life-History Strategy	R, F, AD	R	A, R	A	A	A
Age at Maturity (years)	5 to 6	3 to 5	1 to 6	2 to 3	4 to 6	2 to 5 years
Spawning Dates	Sept to Oct	Sept. to Oct	May to June	Oct to Nov	August	August
Egg Incubation	4 to 5 months	4 to 5 months	28 to 40 days	228 days	282 days	316 days
Hatching Dates	March to Apr	March to Apr	June to July	late spring	late spring	early spring
Emergence Dates	Apr to May	Apr to May	June to July	May to July	May to July	May to July
Freshwater Residence (years)	N/A	N/A	≤4	2	1 to 2	1 to 2
Migration Timing (if anadromous forms present)						
Age at First Migration	N/A	N/A	3	2	1 to 2	1 to 2
Downstream Migration	N/A	N/A	spring	May to June	May to June	May to June
Spawning Migration	N/A	N/A	summer	Sept to Oct	July to August	July to August
Time Spent at Sea	N/A	N/A	≤4 years	~2 years	~2 to 3 years	~2 to 3 years
Habitat						
Spawning						
Habitat	S	S	S*, R	R, S*	R,S	R, S
Substrate Preference	G	G	G	G	G	G
Depth	≥0.2 m	≥0.2 m	0.1 to 0.3 m	shallow	-	deep
Current velocity	moderate	moderate	0.30 to 0.90 m/s	fast	-	~0.5 m/s
Temperature	~6 to 7°C	~6 to 7°C	7 to 13°C	-	~5°C	-
Rearing						
Habitat	S*, R	S*, R, L	R, S, L	S, R	R, S, L	R, S
Substrate Preference	C	G	C, B	G	G	G
Temperature	4 to 18°C	4 to 18°C	≤20°C	12 to 14°C	12 to 14°C	3 to 15°C

(continued)

Table 15.5-2. Summary of Life History and Habitat Requirements of Selected Valued Component Fish Species of the KSM Project (completed)

Requirements	Bull Trout	Dolly Varden	Rainbow Trout/Steelhead	Pacific Salmon		
				Coho	Sockeye	Chinook
Other						
Freshwater Feeding	FI, TI, F, M, A, Bi	FI, TI, F, M, A	FI, TI, F	FI, TI, F	FI	FI, TI
Predators	M, W, O, Bi	M, W, O, Bi	F, M, Bi	F, Bi, M	-	F, Bi
Conservation Status						
Provincial (BC)	Blue-listed	Yellow-listed	N/A	N/A	N/A	N/A
Federal (Canada)	Globally Rare	N/A	N/A	N/A	N/A	N/A

Note:
Dashes indicate no available information.
N/A = not applicable.
Life History Strategy: A = anadromous, R = resident (freshwater), F = fluvial, AD = adfluvial.
Freshwater Residence: pertains only to anadromous populations.
Habitat: R = river, S = stream (includes small tributaries), L = lake; * indicates preferred habitat type.
Substrate Preference: S = sand, G = gravel, C = cobble, B = boulder.
Diet: FI = freshwater invertebrates, TI = terrestrial invertebrates, F = fish and fish eggs, M =small mammals, A = amphibians including frogs, Bi = birds.
Predators: F = fish, M = mammals including bears, W = wolves, O = otters, Bi = birds.

Table 15.5-3. VC Fish Species Life History Periodicity and Distribution for Teigen Watershed

	Specific Life History							
	Spawning			Fry Emergence	Fry Rearing (0+)		Parr Rearing (1+)	Smoltification
Species	Timing	Habitat	Distribution	Timing	Habitat	Distribution	Habitat and Distribution	Timing
Chinook (Stream Type)	Arrival in late-July, start of spawning in early-August, peak spawning in mid-August and die-off in late-August (Rescan 2009, 2010, 2011; Koski *et al.* 1996).	Only mainstream spawning has been observed in Teigen Creek (Rescan 2009, 2010, 2011; Koski et al. 1996). No spawning habitat or observed spawning within South Teigen Creek. Spawning observed in pool tailouts, depth (cm) and velocity (m/s) of pool tailouts vary. Spawning substrates consist of large gravels.	Spawning observed from the Snowbank Creek confluence, upstream to the outlet of Teigen Lake (Rescan 2009, 2010, 2011; Koski et al. 1996). Majority of suitable spawning habitat between Snowbank Creek confluence and Hodkin Creek confluence. Prime spawning habitat near West Teigen Creek confluence and upstream of Snowbank Creek confluence.	Fry emergence is approx. late spring. Fry emergence date is dependent upon water temperature and is 316 days from egg deposition (Quinn 2005). Mean fry length at emergence is 31-35 mm (McPhail 2007).	Fry rear amoung boulder/cobble and pool habitats in Teigen Creek (Rescan 2009 and 2010). Fry migrate downstream upon emergence and take up residency in Teigen Creek and Bell-Irving River.	Field data demonstrates that an abundance of fry (0+) rear throughout Teigen Creek from the Bell-Irving River confluence to Teigen Lake outlet (Rescan 2009 and 2010). Mean fry length in August and September is 57 mm. No rearing habitat or observed spawning within South Teigen Creek.	Parr (1+) have not been captured in Teigen Creek during the 2 field sampling seasons (Rescan 2009 and 2010). Field data and life history suggests that majority parr (1+) migrate downstream out of Teigen Creek into the Bell-Irving River to commence ocean migration. Limited parr likely overwinter in Teigen Creek.No rearing habitat or observed spawning within South Teigen Creek.	Ocean migration takes place at 1+ age or older (Quinn 2005).
Sockeye (Stream Type)	Sockeye have been observed spawning in mid to late August (Rescan 2009, 2010, 2011).	Only mainstream spawning has been observed in Teigen Creek (Rescan 2009, 2010, 2011). No spawning habitat or observed spawning within South Teigen Creek. Spawning observed in pool tailouts, depth (cm) and velocity (m/s) of pool tailouts vary. Spawning substrates consist of large gravels.	Low escapement of adult sockeye in Teigen Creek (Rescan 2010 and 2011). The distribution of spawning throughout Teigen Creek has a scattered distribution, although suitable habitat exists from Snowbank Creek confluence and Hodkin Creek confluence. Shore spawning in Teigen Lake and its inlet tributaries unconfirmed (MOE 1982b; FDIS; Rescan 2011).	Fry emergence is approx. late spring. Fry emergence date is dependent upon water temperature and is 282 days from egg deposition (Quinn 2005). Mean fry length at emergence is 26-29 mm (Quinn 2005).	Lake-type fry migrate downstream to rear in a lake environment for 1-2 years (Quinn 2005; McPhail 2007). However, upstream migration of 'stream type' fry is not likely given the large distance (8.5 km) from known spawning locations to Teigen Lake. Therefore, only stream-type sockeye are assumed to be present.	Sockeye fry have not been captured in Teigen Creek (Rescan 2009 and 2010) given the low escapement and immediate downstream movement upon emergence (McPhail 2007).No rearing habitat or observed spawning within South Teigen Creek.	Sockeye parr have not been sampled in Teigen Creek (Rescan 2009 and 2010). Stream-type sockeye parr are known to commence migration after 1 year (McPhail 2007). No rearing habitat or observed spawning within South Teigen Creek.	Ocean migration takes place at 1+ age or older (Quinn 2005).
Coho (Stream Type)	Arrival in late-September and peak spawning in mid-October ((Rescan 2009, 2010, and 2011; Tripp 1987).	Spawning has not been observed in Teigen Creek mainstem (Rescan 2009, 2010, 2011), rather spawning takes place in side channels/wetland outlets of Teigen Creek floodplain. Snowbank Creek is the primary Coho producing creek (Bocking and Peacock 2004; Rescan 2010 and 2011). Spawning occurs in small tribuaries and side channel habitat (McPhail 2007). No spawning habitat or observed spawning within South Teigen Creek.	Majority of coho spawning habitat occurs in Snowbank Creek. Limited coho spawning habitat is available upstream of Snowbank Creek confluence (Rescan 2010 and 2011).	Fry emergence is approx. late spring. Fry emergence date is dependent upon water temperature and is 228 days from egg deposition (Quinn 2005). Mean fry length at emergence is 25-28 mm (McPhail 2007).	Fry rear amoung low velocity side channels/ponds/wetlands in Teigen Creek with cobble, LWD and pool cover (Rescan 2009, 2010, and 2011).	Field data demonstrates that fry (0+) rear within Teigen Creek side channels/ponds/wetlands. Majority of rearing habitat is between Snowbank Creek confluence and the Bell-Irving River confluence. Fry rearing habitat is limited upstream of South Teigen Creek confleunce. Mean fry length is 51 mm (Rescan 2009, 2010, and 2011).No rearing habitat or observed spawning within South Teigen Creek.	Field data demonstrates that parr (1+) rear within Teigen Creek side channels/ponds/wetlands. Majority of rearing habitat is between Snowbank Creek confluence and the Bell-Irving River confluence. Parr rearing habitat is limited upstream of South Teigen Creek confluence (Rescan 2010 and 2011). Mean parr length is > 100 mm. Stream-type coho parr are known to commence migration after 1-2 years (McPhail 2007). No rearing habitat or observed spawning within South Teigen Creek.	Ocean migration takes place at 1+ age or older (Quinn 2005).
Rainbow Trout/Steelhead (Summer Run)	Arrival in mid-September. Spawning in mid-April to mid-May (LGL 1995). May 10, steelhead tag was retrieved from Teigen Creek (LGL 1995).	Spawning has not been observed in Teigen Creek (Rescan 2010, 2011, 2012a) during three years of spawning surveys. However, it is assumed that spawning occurs in the creek since steelhead overwinter in creek and a post-spawn kelt has been captured in the month of July. No spawning habitat or observed spawning in South Teigen Creek.	Abundance of fry in upper reaches of Teigen Creek (upstream of Hodkin Creek confleunce and Teigen Lake outlet) suggest suitable spawning in this area (Rescan 2010).	Fry emergence is approx. late June (Bocking et al. 2005). Fry emergence date is dependent upon water temperature and is 42 days from egg deposition (McPhail 2007). Mean fry length at emergence is 18-21 mm (McPhail 2007).	Fry rear in mainstem Teigen Creek, amoung stream margins within cobble unembeded substrate (Rescan 2009 and 2010; McPhail 2007).	Field data demonstrates that an abundance of fry (0+) rear in the upper reaches of mainstem Teigen Creek (upstream of Hodkin Creek confluence to Teigen Lake outlet (Rescan 2010). Fry also rear in Hodkin Creek. Mean fry length is 54 mm (Rescan 2009 and 2010).No rearing habitat or observed spawning within South Teigen Creek.	Field data demonstrates that parr (1+) rear in the lower reaches of mainstem Teigen Creek (downstream of Hodkin Creek confluence to Snowbank Creek confluence (Rescan 2009 and 2010). Parr also rear in Hodkin Creek and lower reach of South Teigen Creek. Parr are present in pool habitat, side channels and riffles with large substrates.	Smolt age is 4 years for Teigen Creek (Bocking et al. 2005).

NA = not applicable

(continued)

Table 15.5-3. VC Fish Species Life History Periodicity and Distribution for Teigen Watershed (completed)

Species	Specific Life History							
	Spawning			Fry Emergence	Fry Rearing (0+)		Parr Rearing (1+)	Smoltification
	Timing	Habitat	Distribution	Timing	Habitat	Distribution	Habitat and Distribution	Timing
Dolly Varden (stream resident)	Dolly Varden commence spawning by the last week in September in small tributaries. Spawning peak is early October (Rescan 2009 and 2010; Bustard 2006).	Spawning has not been observed in Teigen Creek main stem (Rescan 2010 and 2011). Spawning has been observed in small tributaries and seepages of Teigen Creek with small gravels.	High densities of Dolly Varden are not present in mainstem Teigen Creek, rather dominated by bull trout. Spawning habitat is restricted to small tributaries and seepages along Teigen Creek that provide suitable small gravels and winter baseflows. Only fish species in South Teigen Creek, upstream of falls.	Fry emergence is approx. April to early May (McPhail 2007). Eggs hatch is 3 months from egg deposition (McPhail 2007). Mean fry length at emergence is 20 mm (McPahil 2007).	Fry rear in small tributaries of Teigen Creek, in low gradient reaches with gravels and fines substrates, and woody debris cover (Rescan 2009 and 2010).	Field data demonstrates that fry (0+) don't rear in mainstem Teigen Creek rather in smaller tributaries, mainstem side channels and off-channel wetlands/ponds (Rescan 2009 and 2010). Mean fry length at end of first summer is 40 mm (Rescan 2010). Dolly Varden fry are distributed throughout Teigen Creek sidechannels, off-channel wetlands/ponds, and tributaries.	Field data demonstrates that parr (1+) don't generally rear in mainstem Teigen Creek; rather in smaller tributaries, mainstem side channels and off-channel wetlands/ponds (Rescan 2009 and 2010). Mean parr length at end of 2nd summer is 60 mm, 3rd summer is 80 mm (Rescan 2009 and 2010; McPhail 2007). Both sexes reach maturity by their fourth summer (>115 mm) (Rescan 2009 and 2010; McPhail 2007). Dolly Varden parr are distributed throughout Teigen Creek sidechannels, off-channel wetlands/ponds, and tributaries.	NA
Bull trout (stream resident/fluvial/ adfluvial)	Bull trout commence spawning in September in Teigen Creek and tributaries. Spawning peak is likely late September (Rescan 2011; McPhail and Baxter 1996; Bustard 2006).	Spawning has not been observed in Teigen Creek, however, direct snorkle surveys indicates strong evidence of spawning (Rescan 2011). Limited spawning (2 locations) occurs within South Teigen Creek, downstream of the falls (Rescan 2011).	Bull trout are present in Teigen Lake, mainstem Teigen Creek and lower reaches of South Teigen Creek. They spawn in mainstem Teigen Creek and limited locations (2) in South Teigen Creek (Rescan 2011; McPhail 2007).	Fry emergence is approx. April or early May (McPhail 2007). Emergence is 223 days from egg deposition (McPhail and Baxter 1996). Mean fry length at emergence is 25 mm (McPahil 2007).	Fry likely rear in small tributaries and side channels of Teigen Creek (McPhail 2007)	Fry (0+) don't rear in mainstem Teigen Creek (Rescan 2009 and 2010). Fry likely rear in small tributaries and migrate to larger streams to overwinter (McPhail 2007) Mean fry length at end of first summer is 30-50 mm (McPhail 2007).	Field data demonstrates that parr (1+) rear in mainstem Teigen Creek, South Teigen Creek (downstream of falls only), and likely Teigen Lake and larger tributaries (Rescan 2009 and 2010). Juvenile parr are known to rear in streams until their 3rd (2+) or 4th (3+) year (McPhail 2007). Parr are found in deep pool habitat and within boulders (Rescan 2009 and 2010). Bull trout parr were captured upstream of Snowbank Creek confluence and downstream of West Teigen Creek confluence.	NA

NA = not applicable

Table 15.5-4. VC Fish Species Life History Periodicity and Distribution for Treaty Watershed

	Specific Life History							
	Spawning			Fry Emergence	Fry Rearing (0+)		Parr Rearing (1+)	Smoltification
Species	**Timing**	**Habitat**	**Distribution**	**Timing**	**Habitat**	**Distribution**	**Habitat and Distribution**	**Timing**
Chinook (Stream Type)	Timing of Chinook in Treaty Creek is similar to that of Teigen Creek. Arrival in late-July, start of spawning in early-August, peak spawning in mid-August and die-off in late-August (Rescan 2009 and 2010; Koski *et al.* 1996).	Spawning occurs in tributaries of Treaty Creek.No spawning habitat or observed spawning within North Treaty Creek.	Chinook spawn in lower Todedada Creek and Gilbert Creek based upon fry presence and suitable habitat (Rescan 2011). Chinook do not spawn in North Treaty and Tumbling creeks because no fish were observed spawning and habitat is not suitable for Chinook spawning (Rescan 2010 and 2011).	Fry emergence is approx. late spring. Fry emergence date is dependent upon water temperature and is 316 days from egg deposition (Quinn 2005). Mean fry length at emergence is 31-35 mm (McPhail 2007).	Fry rear amoung boulder/cobble and pool habitats (Rescan 2009, 2010, and 2011). No rearing habitat or observed spawning within North Treaty Creek.	Chinnok fry (0+) have not been captured in Treaty Creek mainstem during the two field seasons. Field data suggests that Treaty Creek provides limited fry rearing habitat (Rescan 2009 and 2010). Fry have been captured in the lower reach of Todedada Creek and Gilbert Creek (Rescan 2011).	Parr (1+) have not been captured in Treaty Creek during the two field sampling seasons (Rescan 2009 and 2010). Field data suggests that parr (1+) migrate downstream out of Treaty Creek into the Bell-Irving River to commence ocean migration. Parr have been captured in the lower reach of Todedada Creek (Rescan 2011).No rearing habitat or observed spawning within North Treaty Creek.	Ocean migration takes place at 1+ age or older (Quinn 2005).
Coho (Stream Type)	Arrival in late-October, start of spawning in mid-October (Rescan 2011; Tripp 1987).	Spawning has been observed in Todedada Creek Watershed in clear headwater tributaries and Gilbert Creek (Rescan 2011; Tripp 1987). Spawning likely does not occur in mainstem Treaty Creek or in tributaries upstream of the Todedada Creek confluence due to the lack of fry captured in field assessments and lack of adequate spawning habitat.No spawning habitat or observed spawning within North Treaty Creek.	Majority of coho spawning habitat occurs in clear tributaries of Todedada Creek Watershed and Gilbert Creek (Rescan 2011; Tripp 1987). Coho spawning habitat does not appear to be available upstream of Todadada Creek confluence (Rescan 2010). Coho do not spawn in North Treaty and Tumbling creeks becuase no fish were observed and habitat is not suitable for Coho spawning (Rescan 2010 and 2011).	Fry emergence is approx. late spring. Fry emergence date is dependent upon water temperature and is 228 days from egg deposition (Quinn 2005). Mean fry length at emergence is 25-28 mm (McPahil 2007).	Fry rear amoung off-channel ponds/wetlands in Treaty Creek with cobble, LWD and pool cover (Rescan 2009 and 2010;Tripp 1987). Fry rear in Todedada Creek Watershed and Gilbert Creek (Rescan 2011; Tripp 1987).No rearing habitat or observed spawning within North Treaty Creek.No rearing habitat or observed spawning within North Treaty Creek.	Field data demonstrates that fry (0+) rear within Treaty Creek off-channel ponds/wetlands downstream of the Todedada Creek confluence (Rescan 2009, 2010, 2011), in Todedada Creek tributaries, and Gilbert Creek (Rescan 2011; Tripp 1987).	Field data demonstrates that parr (1+) rear within Treaty Creek off-channel ponds/wetlands downstream of the Todedada Creek confluence (Rescan 2009, 2010, 2011), Todedada Creek tributaries, and Gilbert Creek (Rescan 2011; Tripp 1987). Majority of parr habitat is in the Esat Todedada Creek wetlands (Rescan 2011). Mean parr length is > 100 mm. Stream-type coho parr are known to commence migration after 1-2 years (McPhail 2007).No rearing habitat or observed spawning within North Treaty Creek.	Ocean migration takes place at 1+ age or older (Quinn 2005).
Rainbow Trout/Steelhead (Summer Run)	Arrival in mid-September. Spawning in mid-May (LGL 1995).	Spawning has not been observed in Treaty Creek (Rescan 2010 and 2011). No spawning habitat or observed spawning within North Treaty Creek.	Steelhead/rainbow trout spawning habitat occurs in Gilbert Creek (Rescan 2011). Steelhead/rainbow trout spawning habitat does not appear to be available upstream of Todadada and Gilbert creek confluences based upon distribution of fry and parr sampled in Treaty Creek (Rescan 2010). Steelhead/rainbow trout do not spawn in North Treaty and Tumbling creeks because no fish were observed and habitat is not suitable for spawning (Rescan 2010 and 2011).	Fry emergence is approx. late June (Bocking et al. 2005). Fry emergence date is dependent upon water temperature and is 42 days from egg deposition (McPhail 2007). Mean fry length at emergence is 18-21 mm (McPahil 2007).	Majority of fry rearing habitat in Gilbert Creek (tributary of Treaty Creek) (Rescan 2011).No rearing habitat or observed spawning within North Treaty Creek.	Fry (0+) distribution in Treaty Creek is within Gilbert Creek and Treaty Creek (downstream of of Gilbert Creek confluence). Fry distribution does not extend upstream further then the Todedada and Gilbert creek confluences based upon the distribuion of fry sampled (Rescan 2009 and 2010).	Field data demonstrates that parr (1+) rear in the lower reaches of mainstem Treaty Creek (between Todedada Creek confluence and Bell-Iving River confluence) and Gilbert Creek (Rescan 2010 and 2011). Parr are present in pool habitat, side channels and riffles with large substrates.No rearing habitat or observed spawning within North Treaty Creek.	Smolt age of 4 years for Teigen Creek is likely similar to that of Treaty Creek (Bocking *et al.* 2005).

(continued)

Table 15.5-4. VC Fish Species Life History Periodicity and Distribution for Treaty Watershed (completed)

Species	Specific Life History							
	Spawning			Fry Emergence	Fry Rearing (0+)		Parr Rearing (1+)	Smoltification
	Timing	Habitat	Distribution	Timing	Habitat	Distribution	Habitat and Distribution	Timing
Dolly Varden (stream resident)	Dolly Varden commence spawning by the last week in September in small tributaries. Spawning peak is early October (Rescan 2009 and 2010; Bustard 2006).	Spawning has not been observed in Treaty Creek (Rescan 2010). Spawning has been observed in small tributaries and seepages of upper North Treaty Creek with small gravels (Rescan 2010).	Dolly Varden are present throughout mainstem Treaty Creek (glacial headwaters to confluence with the Bell-Irving River) and its tributaries. Spawning habitat is restricted to small tributaries and seepages along Treaty Creek that provide suitable small gravels and winter baseflows.	Fry emergence is approx. April or early May (McPhail 2007). Eggs hatch is 3 months from egg deposition (McPhail 2007). Mean fry length at emergence is 20 mm (McPahil 2007).	Fry rear in small tributaries of Treaty Creek, in low gradient reaches with gravels and fines substrates, and woody debris cover. Fry also rear in side channels of mainstem Treaty Creek (Rescan 2009 and 2010).	Field data demonstrates that fry (0+) rear in side channels of mainstem Treaty Creek and in small tributaries (Rescan 2008 and 2009). Mean fry length at end of first summer is 45 mm (McPhail 2007; Rescan 2009 and 2010). Dolly Varden fry are distributed throughout Treaty Creek sidechannels from the Bell-Irving River confluence to the glacial headwaters.	Field data demonstrates that parr (1+) rear in mainstem Treaty Creek, smaller tributaries, mainstem side channels and off-channel wetlands/ponds (Rescan 2009 and 2010). Mean parr length at end of 2nd summer is 60 mm, 3rd summer is 80 mm. Both sexes reach maturity by their fourth summer (>115 mm) (Rescan 2009 and 2010; McPhail 2007). Dolly Varden parr are distributed throughout Treaty Creek mainstem, sidechannels, off-channel wetlands/ponds from the Bell-Irving River confluence to the glacial headwaters.	NA
Bull trout (stream resident/fluvial)	Bull trout commence spawning by September in smaller tributaries of Treaty Creek and Todedada Creek tributaries. Spawning peak is late September (McPhail and Baxter 1996; Bustard 2006).	Spawning has not been observed in Treaty Creek or its tributaries (Rescan 2010). Mainstem Treaty Creek is not suitable for spawning.	Bull trout are only present in Treaty Creek mainstem, downstream of Todedada Creek confluence. Location of spawning is unknown; however they do not spawn in mainstem Treaty Creek and are known to prefer small streams with large gravels (McPhail and Baxter 1996). Bull trout do not spawn in North Treaty or Tumbling creeks based upon snorkle spawning surveys (Rescan 2011).	Fry emergence is approx. April or early May (McPhail 2007). Emergence is 223 days from egg deposition (McPhail and Baxter 1996). Mean fry length at emergence is 25 mm (McPhail 2007).	Fry rear in small tributaries and side channels of Treaty Creek (McPhail 2007)	Field data demonstrates that fry (0+) don't rear in mainstem Treaty Creek (Rescan 2009 and 2010). Fry likely rear in small tributaries and migrate to larger streams to overwinter (McPhail 2007) Mean fry length at end of first summer is 30-50 mm (McPhail 2007).	Field data demonstrates that parr (1+) rear in mainstem Treaty Creek, downstream of Todedada Creek confluence to the Bell-Irving River confleunce, and likely Todedada Creek (Rescan 2009 and 2010). Juvenile parr are knonw to rear in streams until their 3rd (2+) or 4th (3+) year (McPhail 2007). Parr are found in deep pool habitat and near boulders (Rescan 2010).	NA
Sockeye (Stream Type)	Sockeye have been observed spawning in mid to late September (Rescan 2011).	Spawning has been observed in East Todedada Creek (Rescan 2011). No spawning habitat or observed spawning within North Treaty or Tumbling creeks.	The distribution of spawning habitat is restricted to the lower reach of Esat Todedada Creek Rescan 2011).	Fry emergence is approx. late spring. Fry emergence date is dependent upon water temperature and is 282 days from egg deposition (Quinn 2005). Mean fry length at emergence is 26-29 mm (Quinn 2005).	Stream-type sockeye are assumed to be present because of the lack of lake rearing environment within the watershed (Rescan 2011).No rearing habitat or observed spawning within North Treaty Creek.	Sockeye fry have not been captured in Treaty or Todedada creeks (Rescan 2009, 2010, and 2011) given the low escapement and immediate downstream movement upon emergence (McPhail 2007).	Sockeye parr have not been sampled in Treaty Creek (Rescan 2009, 2010, and 2011). Stream-type sockeye parr are known to commence migration after 1 year (McPhail 2007). No rearing habitat or observed spawning within North Treaty Creek.	Ocean migration takes place at 1+ age or older (Quinn 2005).

Eulachon are very important to Nisga'a Nation and are a historic food staple of Nisga'a trade (Stoffels 2001). In comments provided on the draft AIR, Nisga'a Nation requested that eulachon be included as a VC. Eulachon are of high value and are traded to many Aboriginal groups, including the Tahltan Nation and Gitanyow First Nation.

Based upon a review of this eulachon biology, life history, and distribution with the Nass River and Unuk River watersheds, the proposed VC was excluded from the Application/EIS process (Table 15.5-5). The distribution of eulachon is within the lower reach of the Nass River and outside of the baseline fish and aquatic habitat study area. The lower reach is hundreds of kilometres downstream of the baseline study area boundary. Furthermore, numerous large watersheds discharge into the Nass River between the baseline study area boundary and lower Nass River reach. Some of these watersheds include Tseax, Kwinathl, Kiteen, Cranberry, Kinskutch, Meziadin, Bowser, and Bell-Irving rivers. Any potential effects related to the Project will be addressed within the LSA and RSA boundaries. If any changes to eulachon populations in the Lower Nass River occur, they cannot be reliably related to the Project hundreds of kilometres upstream. Similarly, the distribution of eulachon is within the lower reach of the Unuk River sloughs, the Hooligan River, and Klahini River (tributaries of the Unuk River), and are all outside of the baseline fish and aquatic habitat study area.

Table 15.5-5. Rationale for Fish and Aquatic Habitat Valued Components Considered and Excluded from Further Analysis

	Identified by*					
VC	AG	G	P/S	O	Source	Rationale for Exclusion
Eulachon	✓	✓			Stoffels 2001; NLG-GC-PBC 1999; Daly 2005; FDIS	Eulachon biology, life history and distribution with the Unuk and Nass River watersheds and the distance from the baseline study area
Lake Whitefish, Carp, River Lamprey, Smelt, Lake Trout, White Sturgeon	✓				Appendices 15-A, 15-C, and 15-E; FDIS	Species not present in the Unuk River, Bell-Irving River, or the baseline study area
Pink Salmon and Chum Salmon	✓				Appendices 15-A, 15-C, and 15-E; FDIS	Species not present in the Bell-Irving River watershed. Species present in the Unuk River but outside of the baseline study area
Coastal Cutthroat Trout and Mountain Whitefish	✓				Appendices 15-A, 15-C, and 15-E; Rescan 2009	Potential Project-related effects and mitigation measures covered by existing VCs

*** AG = Aboriginal Group; G = Government; P/S = Public/Stakeholder; O = other.**

The BC Environmental Assessment Office (BC EAO) determined that eulachon would not be included as a VC because eulachon are primarily restricted to the lower reaches of the Nass River, and the Project is a significant distance from the area. The BC EAO and DFO also determined that assessment of other VCs for aquatic species such as Dolly Varden, bull trout, rainbow trout/steelhead, and Pacific salmon will be sufficient to determine if there are any adverse effects on downstream eulachon populations.

Other fish species were suggested as VCs by Aboriginal groups. These species are not present in the Unuk or Bell-Irving watersheds; therefore, they were excluded from further assessment. These species and identified Aboriginal groups are:

- Gitanyow First Nation and wilp Wii'litsxw: lake whitefish, carp, river lamprey, and smelt;
- Gitxsan Nation: lake trout, white sturgeon, lake whitefish, carp, river lamprey, and smelt;
- Nisga'a Nation: Pacific herring; and
- wilp Skii km Lax Ha: Pacific herring.

Pink and chum salmon were suggested as VCs by Aboriginal groups (e.g., Gitanyow First Nation and wilp Wii'litsxw, Gitxsan Nation, Nisga'a Nation). These species are not present in the Bell-Irving River or in the baseline fish and aquatic habitat study area along the Unuk River.

Coastal cutthroat trout and mountain whitefish were suggested as VCs by Aboriginal groups (e.g., the Gitanyow First Nation and wilp Wii'litsxw, Gitxsan Nation, Tahltan Nation). Coastal cutthroat trout has a limited distribution within the baseline study area (Unuk River watershed), and mountain whitefish are located within Treaty, Teigen, and Bell-Irving watersheds. They were excluded as VCs because potential environmental effects and mitigation strategies for these species are the same as for the listed VC species.

15.6 Scoping of Potential Effects for Fish and Aquatic Habitat

15.6.1 Review of Application Information Requirements

The effects assessment explicitly addresses potential fish and aquatic habitat issues and concerns associated with construction, operation, closure, and post-closure of the Project. The assessment takes a VC approach, focusing on selected fish species, groups of fish species, and aquatic habitat. VCs include species that have conservation status, biological importance, or are regional species that have particular cultural, social, or economic significance to Aboriginal groups, the Province of British Columbia, or other Canadians.

Project fish and aquatic habitat issues identified in the AIR include:

- Potential effects such as predicted water and sediment chemistry changes on fish and aquatic habitat during all phases of the proposed Project with regard to:
  - footprint of development;
  - infrastructure development activities;
  - dewatering activities; and
  - flow changes from water management and diversions.
- Potential loss and/or alteration of fish habitat requiring identification of:
  - the locations and estimated areas of fish habitat potentially affected;
  - the types of fish habitats that will potentially be affected (e.g., wetlands, stream channels, and riparian habitat), as well as the use by fish (e.g., spawning/incubation,

rearing, food/nutrient, overwintering, and migration), including habitats that will potentially be affected by flow changes;
- the fish habitat types and areas of each type of habitat affected by the proposed Project; and
- the estimated population size or numbers of fish that use the habitat that could be affected by the proposed Project (particularly the TMF and the tributaries of Teigen and Treaty creeks that drain the TMF).

The analysis of potential effects will consider:

- creeks and rivers that may experience changes to fish resources, including, but not limited to, the Unuk River; Sulphurets, Mitchell, McTagg, Treaty, and Teigen creeks; and streams along access road routes;
- potential exposure (Sulphurets Lake) and reference lakes (Knipple Glacier and Todedada lakes);
- any rare and/or sensitive fish species and their habitat, as well as provincially and COSEWIC- or *Species at Risk Act* (2002)-listed species and their habitat;
- fish species of heritage or traditional importance to First Nations or Nisga'a Nation (e.g., salmon);
- mortality (including fishing);
- mitigation and/or habitat compensation requirements (based on the DFO's Policy for the Management of Fish Habitat and the related principle of no net loss of the productive capacity of fish habitat [1986]);
- aquatic organisms, including primary producers (algae) and secondary producers (zooplankton and benthic invertebrates), and their habitat (lakes, streams, and rivers);
- creeks, rivers, and lakes, and associated food webs and water use potential that may be affected by changes in water chemistry (suspended solids, nutrients, major ions, metals) due to runoff or discharges from the Project;
- potential physical and chemical changes to sediment quality, including total metals, anions, general physical parameters, total organic carbon, nutrients, and cyanide;
- potential acute and chronic toxic effects in the downstream receiving environment;
- the relationship and partitioning of trace elements between water and sediment media for key receiving environments; and
- an examination of these potential effects and their relationship to the surface water quality and quantity.

15.6.2 Overview of Effect Types

Many of the issues listed above overlap in terms of definition and scope. For the purposes of the fish and aquatic habitat section, they are grouped into five categories for scoping of effects:

- direct mortality;

- noise;
- erosion and sedimentation;
- water quality degradation (e.g., petroleum product spills, blasting residues, sewage effluent, metals, and other chemical toxicity); and
- habitat loss.

Habitat loss refers to the removal or physical alteration of the environment that is used either directly or indirectly by fish. Under the *Fisheries Act* (1985), the physical removal of fish-bearing habitat is considered a “harmful alteration, disruption or destruction” to fish habitat. Riparian vegetation is included as aquatic habitat because it provides numerous functions including shading, stabilizing stream banks and controlling erosion, contributing LWD and organic litter, and regulating the flux and composition of nutrients.

Adverse effects to water quality can reduce the health of fish populations and change the productivity of primary producers (phytoplankton and periphyton) or food sources (zooplankton and benthic invertebrates). Protecting this productive capacity of fish habitat, “the maximum natural capability of habitats to produce healthy fish, safe for human consumption, or to support or produce aquatic organisms upon which fish feed” is mandated by the DFO (1986). Water quality changes can result in sublethal effects. Sublethal effects are those that may affect the relative health or behaviour of individual fish within the LSA and RSA. Examples include: increased stress, decreased health or condition, and habitat avoidance. Sublethal effects do not result in direct or immediate mortality, but may ultimately decrease the fitness and fecundity of individual fish, and possibly translate to population level effects in the long-term.

Direct mortality of fish can occur due to fishing (increased access will increase fishing pressure), impact from construction machinery, dewatering during construction, salvage and relocation of fish to other waterbodies during TMF construction, and fish stranding during reductions in water quantity.

Noise and sedimentation can result in the immediate or near-immediate death of fish, such as blasting or smothering embryos by an erosion event.

All of the potential effects overlap in terms of their definition and scope. Each pathway describes one primary effect, but multiple effects may occur. Potential effects of the Project on fish and aquatic habitat were identified by reviewing the Project components and baseline data (Appendices 15-A to 15-J). If a Project component was considered not to have any potential for interaction (and thus no potential effect), no further consideration was given to the Project component in the assessment. To ensure all potential effects were identified, a matrix table was used to identify interactions between the identified effects and all aspects of the Project, as they pertain to the Project’s construction, operation, closure, and post-closure phases. A summary of the results is provided in Tables 15.6-1 to 15.6-5, each of which provides scoping conclusions for an individual VC for all Project phases, and the detailed results of the Project-environment interaction matrix are provided in Appendix 15-K.

Table 15.6-1. Potential Effects from the Project on Bull Trout

Project Area	Project Component	Direct Mortality	Noise	Erosion and Sedimentation	Water Quality Degradation
Processing and Tailing Management Area	Mitchell-Treaty Twinned Tunnels				X
	Construction Access Adit				
	Mitchell-Treaty Saddle Area				
	Camp 6: Treaty Saddle Camp				
	Camp 5: Treaty Plant Camp				
	Treaty Operating Camp				
	Treaty Ore Preparation Complex				
	Concentrate Storage and Loadout				X
	North Cell Tailing Management Facility			X	X
	East Catchment Diversion				X
	Centre Cell Tailing Management Facility				X
	South Cell Tailing Management Facility				X
	Treaty Creek Access Road	X	X	X	X
	Camp 11: Treaty Marshalling Yard Camp				X
	Camp 12: Highway 37 Construction Camp				X
Off-site Transportation	Highways 37 and 37A				X

X = interaction between component and effect.

Table 15.6-2. Potential Effects from the Project on Dolly Varden

Project Area	Project Component	Direct Mortality	Noise	Erosion and Sedimentation	Water Quality Degradation
Mine Site	Camp 3: Eskay Staging Camp				
	Camp 7: Unuk North Camp				
	Camp 8: Unuk South Camp				
	Coulter Creek Access Road	X	X	X	X
	Mitchell Operating Camp				
	McTagg Rock Storage Facility				
	McTagg Twinned Diversion Tunnels				
	McTagg Power Plant				
	Mitchell Rock Storage Facility				
	Camp 4: Mitchell North Camp (for MTT construction)				
	Mitchell Ore Preparation Complex				
	Mine Site Avalanche Control				
	Iron Cap Block Cave Mine				
	Mitchell Pit				

(continued)

Table 15.6-2. Potential Effects from the Project on Dolly Varden (completed)

Project Area	Project Component	Direct Mortality	Noise	Erosion and Sedimentation	Water Quality Degradation
Mine Site *(cont'd)*	Mitchell Block Cave Mine				
	Mitchell Diversion Tunnels				
	Upper Sulphurets Power Plant				
	Mitchell Truck Shop				
	Water Storage Facility				X
	Camp 9: Mitchell Initial Camp				
	Camp 10: Mitchell Secondary Camp				
	Water Treatment and Energy Recovery Area				X
	Sludge Management Facilities				
	Sulphurets Laydown Area				
	Sulphurets-Mitchell Conveyor Tunnel				
	Sulphurets Pit				
	Kerr Rope Conveyor				
	Kerr Pit				
	Camp 2: Ted Morris Camp				
	Explosives Manufacturing Facility				
	Temporary Frank Mackie Glacier Access Route				
	Camp 1: Granduc Staging Camp				
Processing and Tailing Management Area	Mitchell-Treaty Twinned Tunnels				X
	Construction Access Adit				
	Mitchell-Treaty Saddle Area				X
	Camp 6: Treaty Saddle Camp				X
	Camp 5: Treaty Plant Camp				
	Treaty Operating Camp				
	Treaty Ore Preparation Complex				
	Concentrate Storage and Loadout				X
	North Cell Tailing Management Facility	X	X	X	X
	East Catchment Diversion			X	X
	Centre Cell Tailing Management Facility	X	X	X	X
	South Cell Tailing Management Facility	X	X	X	X
	Treaty Creek Access Road	X	X	X	X
	Camp 11: Treaty Marshalling Yard Camp			X	X
	Camp 12: Highway 37 Construction Camp			X	X
Off-site Transportation	Highways 37 and 37A				X

X = interaction between component and effect.

Table 15.6-3. Potential Effects from the Project on Rainbow Trout/Steelhead

Project Area	Project Component	Direct Mortality	Noise	Water Quality Degradation
Mine Site	Camp 3: Eskay Staging Camp			
	Camp 7: Unuk North Camp			
	Camp 8: Unuk South Camp			
	Coulter Creek Access Road			X
	Mitchell Operating Camp			
	McTagg Rock Storage Facility			
	McTagg Twinned Diversion Tunnels			
	McTagg Power Plant			
	Mitchell Rock Storage Facility			
	Camp 4: Mitchell North Camp (for MTT construction)			
	Mitchell Ore Preparation Complex			
	Mine Site Avalanche Control			
	Iron Cap Block Cave Mine			
	Mitchell Pit			
	Mitchell Block Cave Mine			
	Mitchell Diversion Tunnels			
	Upper Sulphurets Power Plant			
	Mitchell Truck Shop			
	Water Storage Facility			X
	Camp 9: Mitchell Initial Camp			
	Camp 10: Mitchell Secondary Camp			
	Water Treatment and Energy Recovery Area			X
	Sludge Management Facilities			
	Sulphurets Laydown Area			
	Sulphurets-Mitchell Conveyor Tunnel			
	Sulphurets Pit			
	Kerr Rope Conveyor			
	Kerr Pit			
	Camp 2: Ted Morris Camp			
	Explosives Manufacturing Facility			
	Temporary Frank Mackie Glacier Access Route			
	Camp 1: Granduc Staging Camp			
Processing and Tailing Management Area	Mitchell-Treaty Twinned Tunnels			
	Construction Access Adit			
	Mitchell-Treaty Saddle Area			X
	Camp 6: Treaty Saddle Camp			
	Camp 5: Treaty Plant Camp			
	Treaty Operating Camp			

(continued)

Table 15.6-3. Potential Effects from the Project on Rainbow Trout/Steelhead (completed)

Project Area	Project Component	Direct Mortality	Noise	Water Quality Degradation
Processing and Tailing Management Area *(cont'd)*	Treaty Ore Preparation Complex			
	Concentrate Storage and Loadout			X
	North Cell Tailing Management Facility			X
	East Catchment Diversion			X
	Centre Cell Tailing Management Facility			X
	South Cell Tailing Management Facility			X
	Treaty Creek Access Road	X	X	X
	Camp 11: Treaty Marshalling Yard Camp			X
	Camp 12: Highway 37 Construction Camp			X
Off-site Transportation	Highways 37 and 37A			X

X = interaction between component and effect.

Table 15.6-4. Potential Effects from the Project on Pacific Salmon

Project Area	Project Component	Direct Mortality	Noise	Erosion and Sedimentation	Water Quality Degradation
Mine Site	Camp 3: Eskay Staging Camp				
	Camp 7: Unuk North Camp				
	Camp 8: Unuk South Camp				
	Coulter Creek Access Road	X	X	X	X
	Mitchell Operating Camp				
	McTagg Rock Storage Facility				
	McTagg Twinned Diversion Tunnels				
	McTagg Power Plant				
	Mitchell Rock Storage Facility				
	Camp 4: Mitchell North Camp (for MTT construction)				
	Mitchell Ore Preparation Complex				
	Mine Site Avalanche Control				
	Iron Cap Block Cave Mine				
	Mitchell Pit				
	Mitchell Block Cave Mine				
	Mitchell Diversion Tunnels				
	Upper Sulphurets Power Plant				
	Mitchell Truck Shop				

(continued)

Table 15.6-4. Potential Effects from the Project on Pacific Salmon (completed)

Project Area	Project Component	Direct Mortality	Noise	Erosion and Sedimentation	Water Quality Degradation
Mine Site *(cont'd)*	Water Storage Facility				X
	Camp 9: Mitchell Initial Camp				
	Camp 10: Mitchell Secondary Camp				
	Water Treatment and Energy Recovery Area				X
	Sludge Management Facilities				
	Sulphurets Laydown Area				
	Sulphurets-Mitchell Conveyor Tunnel				
	Sulphurets Pit				
	Kerr Rope Conveyor				
	Kerr Pit				
	Camp 2: Ted Morris Camp				
	Explosives Manufacturing Facility				
	Temporary Frank Mackie Glacier Access Route				
	Camp 1: Granduc Staging Camp				
Processing and Tailing Management Area	Mitchell-Treaty Twinned Tunnels				X
	Construction Access Adit				
	Mitchell-Treaty Saddle Area				
	Camp 6: Treaty Saddle Camp				
	Camp 5: Treaty Plant Camp				
	Treaty Operating Camp				
	Treaty Ore Preparation Complex				
	Concentrate Storage and Loadout				X
	North Cell Tailing Management Facility			X	X
	East Catchment Diversion				X
	Centre Cell Tailing Management Facility			X	X
	South Cell Tailing Management Facility			X	X
	Treaty Creek Access Road	X	X	X	X
	Camp 11: Treaty Marshalling Yard Camp			X	X
	Camp 12: Highway 37 Construction Camp			X	X
Off-site Transportation	Highways 37 and 37A				X

X = interaction between component and effect.

Table 15.6-5. Potential Effects from the Project on Aquatic Habitat

Project Area	Project Component	Erosion and Sedimentation	Water Quality Degradation	Habitat Loss
Mine Site	Camp 3: Eskay Staging Camp	X	X	
	Camp 7: Unuk North Camp	X	X	
	Camp 8: Unuk South Camp	X	X	
	Coulter Creek Access Road	X	X	X
	Mitchell Operating Camp	X	X	
	McTagg Rock Storage Facility	X	X	X
	McTagg Twinned Diversion Tunnels	X	X	X
	McTagg Power Plant	X	X	
	Mitchell Rock Storage Facility	X	X	X
	Camp 4: Mitchell North Camp (for MTT construction)	X	X	
	Mitchell Ore Preparation Complex	X	X	
	Mine Site Avalanche Control	X	X	
	Iron Cap Block Cave Mine		X	
	Mitchell Pit	X	X	X
	Mitchell Block Cave Mine	X	X	
	Mitchell Diversion Tunnels	X	X	X
	Upper Sulphurets Power Plant	X	X	
	Mitchell Truck Shop		X	
	Water Storage Facility	X	X	X
	Camp 9: Mitchell Initial Camp	X	X	
	Camp 10: Mitchell Secondary Camp	X	X	
	Water Treatment and Energy Recovery Area	X	X	
	Sludge Management Facilities	X	X	
	Sulphurets Laydown Area	X	X	X
	Sulphurets-Mitchell Conveyor Tunnel	X	X	
	Sulphurets Pit	X	X	X
	Kerr Rope Conveyor	X	X	
	Kerr Pit	X	X	X
	Camp 2: Ted Morris Camp	X	X	
	Explosives Manufacturing Facility		X	
	Temporary Frank Mackie Glacier Access Route	X	X	
	Camp 1: Granduc Staging Camp	X	X	

(continued)

Table 15.6-5. Potential Effects from the Project on Aquatic Habitat (completed)

Project Area	Project Component	Erosion and Sedimentation	Water Quality Degradation	Habitat Loss
Processing and Tailing Management Area	Mitchell-Treaty Twinned Tunnels	X	X	
	Construction Access Adit	X	X	
	Mitchell-Treaty Saddle Area	X	X	
	Camp 6: Treaty Saddle Camp	X	X	
	Camp 5: Treaty Plant Camp	X	X	
	Treaty Operating Camp	X	X	
	Treaty Ore Preparation Complex	X	X	
	Concentrate Storage and Loadout		X	
	North Cell Tailing Management Facility	X	X	X
	East Catchment Diversion	X	X	X
	Centre Cell Tailing Management Facility	X	X	X
	South Cell Tailing Management Facility	X	X	X
	Treaty Creek Access Road	X	X	X
	Camp 11: Treaty Marshalling Yard Camp	X	X	
	Camp 12: Highway 37 Construction Camp	X	X	
Off-site Transportation	Highways 37 and 37A		X	

X = interaction between component and effect.

15.6.3 Construction

Appendix 15-K provides the detailed scoping information for each VC during the construction phase, while Tables 15.6.-1 to 15.6-5 provide a summary of Project components that may cause effects to fish and aquatic habitat VCs. The scoping exercise identified potential effects caused by Project construction associated with direct mortality, noise, erosion and sedimentation, and water quality degradation (metals, process chemicals, petroleum products, and nutrients). The use of heavy equipment and explosives in and around water may result in direct mortality, noise, nutrient inputs, and toxic effects on fish and aquatic habitat during the construction phase. Erosion and sedimentation into streams and waterbodies may be caused by construction activities in and around water. The use of heavy equipment in and around water may result in petroleum product spills. Construction activities may expose acid-generating rock and result in metal leaching/acid rock drainage (ML/ARD) toxicity to waterbodies. During construction, the footprint of Project infrastructure may also result in the physical loss of aquatic habitat. Furthermore, there are no fish present at the Mine Site.

15.6.4 Operation

Appendix 15-K provides the detailed scoping information for each VC during the operation phase, while Tables 15.6.-1 to 15.6-5 provide a summary of Project components that may cause effects to fish and aquatic habitat VCs. Potential effects identified for the operation phase are similar to those anticipated to occur during construction. The main potential effects include erosion and sedimentation, water quality degradation (metals, process chemicals, petroleum products, and nutrients). Potential effects associated with erosion and sedimentation and petroleum product spills may result predominantly from maintenance activities such as road grading. Potential effects associated with blasting residues, sewage effluent, metals, and other chemicals may result from the operation of camps, the TMF, and the Water Treatment Plant/Water Storage Facility (WTP/WSF). Aquatic habitat may be affected through the potential release of deleterious substances from the TMF and the WTP. Aquatic habitat loss (e.g., fish habitat) may occur downstream of the TMF from the management of water diversions. Aquatic habitat loss may occur in the Mine Site due to infrastructure construction (WTP/WSF, RSFs, and diversion structures) and operation (staged discharges from the WSF). Furthermore, there are no fish present at the Mine Site.

15.6.5 Closure and Post-closure

Appendix 15-K provides the detailed scoping information for each VC during the closure and post-closure phases, while Tables 15.6-1 to 15.6-5 provide a summary of Project components that may affect fish and aquatic habitat VCs. Most activities during these phases involve decommissioning Project infrastructure and returning the site to baseline condition. These activities will involve the use of heavy equipment in or around water for the decommissioning of Project infrastructure (e.g., roads and bridges). As a result of working in and around water, erosion and sedimentation of waterbodies (e.g., sedimentation to streams from road decommissioning), and water quality degradation (e.g., petroleum product and metal toxicity effects) could occur when conducting closure activities. Toxicity due to ML/ARD could potentially occur due to the exposure of acid-generating rock when removing bridges and other infrastructure. Metal and process chemical toxicity could also occur through the continual operation and maintenance of the WTP/WSF. Aquatic habitat may be affected through the potential release of deleterious substances from the TMF and WSF.

15.7 Potential for Residual Effects for Fish and Aquatic Habitat

The LSA and RSA include numerous streams, rivers, lakes, and wetlands. A proportion of these watercourses provide fish and aquatic habitat to sustain fish populations upstream, within or downstream of the PTMA and Mine Site. Within these watersheds, productive fish and aquatic habitat exists and sustains diverse fish populations. Aquatic habitat includes physical limnology, sediment quality, benthic invertebrates, phytoplankton, and periphyton, as it relates to fish habitat. The fish and aquatic habitat effects assessment is detailed in the following sections.

The construction, operation, closure, and post-closure phase components vary depending upon the infrastructure. The areas were defined as Mine Site, PTMA, and off-site transportation. An extensive list of Project components, including activity description, is provided in Appendix 15-K. Some of these activities could potentially affect fish and aquatic habitat.

Potential effects of the Project on fish and aquatic habitat were identified in the scoping assessment (Appendix 15-K). Project-environment interaction matrix tables were then used for each VC to identify interactions between the identified effects and all aspects of the Project. The results of the Project-environment interaction matrix are provided in Tables 15.6-1 to 15.6-5, and more detailed matrices are provided as Appendix 15K.

From the scoping assessment, eight potential effects were identified. These included direct mortality, noise, erosion and sedimentation, petroleum product spills, blasting residues, sewage effluent, metals and other chemical toxicity, and habitat loss and alteration. Each of these potential effects, including mitigation and residual effects, will be discussed in detail in the following sections.

The fish and aquatic habitat effects assessment was prepared according to applicable scientifically defensible management guidelines. The assessment was based on currently available knowledge of species behaviour, presence, distribution, population biology, and ecology. Consideration was also given to linkages between predicted physical and biological changes resulting from the proposed development on both the individual and local population levels.

Given the hierarchical nature of biological systems, potential effects on fish and aquatic habitat are discussed with regard to changes at both the individual level (i.e., behaviour, physiological condition, and survival) and the population level (i.e., population size, distribution, mortality rate, and reproductive fitness). Effects at the population level are of greater concern than those at the individual level; thus, the assessment primarily focuses on the effects to local populations. However, population boundaries are not always distinct. A population is a group of organisms coexisting at the same time and place and capable of interbreeding, or is a group of non-specific organisms that occupy a loosely defined geographic region and exhibit reproductive continuity from generation to generation. Because the exact geographic boundaries for the local populations considered in this assessment are dynamic, the assessment is primarily qualitative.

The assessment was also informed by the fisheries objectives and management direction outlined in one strategic-level LRMP (the CIS LRMP), one SRMP (the Nass South SRMP), Nisga'a strategic-level plan, (the Nisga'a Land Use Plan), agreements (e.g., Nisga'a Final Agreement [NLG, Government of Canada, Province of British Columbia 1999]), watershed plans (e.g., Gitxsan Watershed Sustainability Plan), and policy documents (e.g., Gitxsan Policy). The CIS LRMP includes management objectives for fish and fish habitat.

15.7.1 Direct Mortality

15.7.1.1 Effect of Direct Mortality

Project-specific modes of potential direct mortality to fish in the LSA and RSA included Project access roads, the transmission line, and the TMF. Direct mortality can take place during all Project phases, but the construction phase has a higher likelihood of effect.

The geographic scope of direct mortality will be localized, but localized effects can result in far-reaching effects depending on the fish species affected, their life history characteristics, and abundance. Impact with construction machinery and increased fishing access can affect fish species by causing mortality to all fish life history stages.

Potential causes of direct mortality to fish in the LSA and RSA include construction equipment crossing streams for access road and transmission line right-of-way clearing if crossing structures are not used, dewatering activities for construction accidents during bridge and culvert construction, salvage and relocation of fish to other waterbodies during TMF construction, fish stranding during water quantity reductions, and associated rock blasting for roads close to watercourses. Effects from direct mortality are expected to be low.

Another form of direct mortality is increased angler pressure and harvesting of fish species from increased road access. Although all of the Project workers will not be anglers, some proportion of the workforce will be, and this influx of anglers has the potential to increase the fishing pressure on sport fish populations in lakes and rivers within the LSA and RSA.

15.7.1.2 Mitigation for Direct Mortality

Increased fishing access by the public within the LSA and RSA will be mitigated and controlled through the road construction and operation period. Limited sport fishing for trout, char (bull trout and Dolly Varden), and salmon already occurs within the LSA and RSA in the larger creeks, rivers, and lakes. This activity may decrease during the construction and operation of the access roads and associated access control points by limiting public access to these areas. The potential increase in fishing pressure and associated increase in fish harvesting due to the presence of the mine construction and operation workforces will be mitigated by the following features:

- gating the access roads to prohibit the entry by non-authorized vehicles;
- design of gates and security measures to control access and mobility of snow machines and all-terrain vehicles;
- at closure, all non-essential roads will be deactivated and traffic will be greatly reduced;
- implementing a company policy that prohibits employees and contractors from engaging in fishing while present at the Mine Site or while travelling to and from the mine on company business; and
- busing personnel from communities at the start and end of each shift during mine construction and operation.

As a result of these design features and mitigation measures, there will be no opportunities for employees or contractors to engage in fishing while on site during mine construction or operation.

To mitigate direct mortality effects within fish-bearing streams, construction activities will be done in accordance with the Land Development Guidelines for the Protection of Aquatic Habitat (DFO 1993), *Standards and Best Practices for Instream Works* (BC MWLAP 2004), and DFO's operational statements for temporary ford stream crossings (DFO 2010). Appropriate fisheries operating windows for fish-bearing streams will be adhered to where possible. Mitigation strategies include isolating Project work sites to prevent fish movement into the work site, salvaging/removing fish from the enclosed work site, and environmental monitoring. If fording is required, it will occur only if an existing crossing at another location is not available or practical to use. During TMF development, water flow will be reduced at a gradual rate as to not strand fish downstream. It is anticipated that there will be in-water work within fish-bearing streams associated with stream crossings and TMF dam construction within South Teigen and North Treaty creeks.

To minimize the effects of direct mortality, the Fish and Aquatic Habitat Protection and Mitigation Plan (Section 26.19.1) and the Fish Salvage Plan (Section 26.19.3) of the Environmental Management Plan will be adhered to during the Project component phases. To minimize the effects of direct mortality during road maintenance, an access road maintenance plan will be developed and adhered to. If BMPs and plans are implemented and followed, there is a low probability that a potential effect caused by direct mortality on the selected VCs may not be fully mitigated. This low probability that a potential effect could occur is due to the efficiency and size selectivity of sampling gear to remove fish from a work area.

The residual effects are discussed for each VC below.

15.7.1.3 Potential for Residual Effects

Table 15.7-1 presents potential residual effects on fish and aquatic habitat VCs due to direct mortality. Residual effects may potentially be caused from direct mortality resulting from Project components in all Project phases for bull trout, Dolly Varden, rainbow trout/steelhead, and Pacific salmon.

15.7.1.4 Bull Trout: Potential Residual Effects due to Direct Mortality

Bull trout may be affected by Project components along the TCAR and transmission line since the species is present in Teigen and Treaty creeks and the Bell-Irving River. Bull trout do not inhabit streams in remaining areas of the Project, and thus will not be affected by direct mortality in these Project sites.

The primary goal of direct mortality mitigation strategies is to prevent machinery from impacting fish. Fishing prohibition by Project-related staff will be effective, especially in those waterbodies where bull trout reside. Although these mitigation and best management strategies are effective in minimizing direct mortality, these strategies may not fully prevent all mortality. Thus, some residual effects due to machinery contact are expected to occur due to the construction, operation, and closure phases of these Project components.

15.7.1.5 Dolly Varden: Potential Residual Effects due to Direct Mortality

Dolly Varden may be affected by Project components in the PTMA (e.g., TCAR, transmission line, TMF) and CCAR. Dolly Varden is the only fish species that occurs in nearly all streams in the LSA and RSA, with the exception of streams within the Mine Site.

Direct mortality mitigation strategies and BMPs are the same as for bull trout, previously discussed.

Table 15.7-1. Potential Residual Effects on Fish and Aquatic Habitat Valued Components due to Direct Mortality

Valued Component	Timing Start	Project Area(s)	Component(s)	Description of Effect due to Component(s)	Type of Project Mitigation	Project Mitigation Description	Potential Residual Effect	Description of Residuals
Dolly Varden Rainbow trout Pacific salmon	Construction Closure	Mine Site	Coulter Creek Access Corridor	Impact with construction machinery and dewatering activities	Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize fish mortality with construction machinery; Adhere to DFO's operational statements; Adhere to appropriate construction operating window for instream work; Site isolation	Yes	Blunt tissue trauma causing mortality to early life history stages
Dolly Varden Rainbow trout Pacific salmon	Operation	Mine Site	Coulter Creek Access Corridor	Impact with construction machinery and dewatering activities	Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize fish mortality with construction machinery; Adhere to DFO's operational statements; Adhere to Fish and Aquatic Habitat Protection and Mitigation Plan	Yes	Blunt tissue trauma causing mortality to early life history stages
Dolly Varden Rainbow trout Pacific salmon	Operation	Mine Site	Coulter Creek Access Corridor	Increased fishing access	Access Control	Controlled access; Implement no fishing policy for employees	Yes	Blunt tissue trauma causing mortality to adult life stages
Bull trout Dolly Varden Rainbow trout Pacific salmon	Construction Closure	Processing and Tailing Management Area	Treaty Creek Access Road	Impact with construction machinery and dewatering activities	Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize fish mortality with construction machinery; Adhere to DFO's operational statements; Adhere to appropriate construction operating window for instream work; Site isolation	Yes	Blunt tissue trauma causing mortality to early life history stages
Bull trout Dolly Varden Rainbow trout Pacific salmon	Operation	Processing and Tailing Management Area	Treaty Creek Access Road	Impact with construction machinery and dewatering activities	Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize fish mortality with construction machinery; Adhere to DFO's operational statements; Adhere to Fish and Aquatic Habitat Protection and Mitigation Plan	Yes	Blunt tissue trauma causing mortality to early life history stages
Bull trout Dolly Varden Rainbow trout Pacific salmon	Operation	Processing and Tailing Management Area	Treaty Creek Access Road	Increased fishing access	Access Control	Controlled access; Implement no fishing policy for employees	Yes	Blunt tissue trauma causing mortality to adult life stages
Dolly Varden	Construction	Processing and Tailing Management Area	North Cell Tailing Management Facility	Impact with construction machinery within South Teigen Creek, dewatering activities, fish stranding due to flow reductions	Fish and Aquatic Habitat Protection and Mitigation Plan; Fish Salvage Plan	Use of best management practices to minimize fish mortality with construction machinery; Adhere to DFO's operational statements; Adhere to appropriate construction operating window for instream work; Site isolation	Yes	Blunt tissue trauma causing mortality to early life history stages
Dolly Varden	Construction	Processing and Tailing Management Area	South Cell Tailing Management Facility	Impact with construction machinery within North Treaty Creek, dewatering activities, fish stranding due to flow reductions	Fish and Aquatic Habitat Protection and Mitigation Plan; Fish Salvage Plan	Use of best management practices to minimize fish mortality with construction machinery; Adhere to DFO's operational statements; Adhere to appropriate construction operating window for instream work; Site isolation	Yes	Blunt tissue trauma causing mortality to early life history stages

(continued)

Table 15.7-1. Potential Residual Effects on Fish and Aquatic Habitat Valued Components due to Direct Mortality (completed)

Valued Component	Timing Start	Project Area(s)	Component(s)	Description of Effect due to Component(s)	Type of Project Mitigation	Project Mitigation Description	Potential Residual Effect	Description of Residuals
Dolly Varden	Construction	Processing and Tailing Management Area	Centre Cell Tailing Management Facility	Impact with construction machinery within South Teigen Creek, dewatering activities, fish stranding due to flow reductions	Fish and Aquatic Habitat Protection and Mitigation Plan; Fish Salvage Plan	Use of best management practices to minimize fish mortality with construction machinery; Adhere to DFO's operational statements; Adhere to appropriate construction operating window for instream work; Site isolation	Yes	Blunt tissue trauma causing mortality to early life history stages
Bull trout Dolly Varden Rainbow trout Pacific salmon	Construction Operation Closure	Processing and Tailing Management Area	Transmission Line	Impact with construction machinery	Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize fish mortality with construction machinery; Adhere to DFO's operational statements; Adhere to appropriate construction operating window for instream work; Site isolation	Yes	Blunt tissue trauma causing mortality to early life history stages

15.7.1.6 Rainbow Trout/Steelhead: Potential Residual Effects due to Direct Mortality

Rainbow trout/steelhead are present in Teigen and Treaty creeks and in the Unuk River. Rainbow trout/steelhead may be affected by Project components such as the TCAR, transmission line, and CCAR (north of Sulphurets Creek cascade).

Direct mortality mitigation strategies and BMPs are the same as for bull trout, previously discussed.

15.7.1.7 Pacific Salmon: Potential Residual Effects due to Direct Mortality

Pacific salmon are present in Teigen and Treaty creeks and in the Unuk River. Pacific salmon are not present in South Teigen or North Treaty creeks, nor in the Mine Site. Similar to rainbow trout/steelhead, Pacific salmon may be affected by Project components such as the TCAR, transmission line, and CCAR.

Direct mortality mitigation strategies and BMPs are the same as for bull trout, previously discussed.

15.7.2 Noise

15.7.2.1 Effect of Noise

Project-specific sources of noise include access roads and the TMF. Noise can take place during all Project phases, but the construction phase has a higher likelihood of effect with associated blasting activities and sustained construction. Blasting will occur during the operation phase; however, fish are not located near areas with continuous blasting (e.g., pits). The geographic scope of noise will be localized.

Sound waves created by blasting near watercourses can potentially cause physical damage to fish eggs, larvae, juveniles, and adults (Wright 1982; DFO 2004; Faulkner et al. 2006, 2008). The most common tissue damage occurs to the swim bladder of juveniles and adults, and to the embryo.

Noise pollution caused by construction machinery and blasting has been shown to affect fish behaviour. Behavioural changes can include an acute startle response, change in swimming patterns, change in vertical distribution and feeding, and interruption of spawning activities from noise caused by blasting (DFO 2004) or construction activities. When fish are startled by explosive blasts or construction activities, catecholamines are released that increase oxygen uptake and mobilize energy for swimming (Wendelaar Bonga 1997). A chronic stressor, such as noise exposure, can reduce growth and increase susceptibility to infection.

15.7.2.2 Mitigation for Noise

Blasting may be required for all access roads, and there will be sustained construction while building the TMF dams. The amount of blasting is anticipated to be minimal along the TCAR. Blasting will be required for the CCAR. The potential effect of blasting near fish-bearing streams along the access roads is anticipated to be low for the following reasons:

- lethal and sublethal effects of sound waves near water are localized (less than 10 m); and

- site blasting will be at least 10 m away from fish-bearing streams to avoid damage to possible spawning habitat and effects on fish behaviour. Blasts will also be kept below 100 kPa as recommended by Wright and Hopky (1998).

To mitigate potential noise effects within fish-bearing streams, construction activities will work in accordance with Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters (Wright and Hopky 1998), and the Fish and Aquatic Habitat Protection and Mitigation Plan (Section 26.9.1) of the Environmental Management Plan will be used and adhered to during the Project component phases.

If the above BMPs and plans are implemented and followed, there is a low probability of that potential effects caused by noise on the selected VCs may not be fully mitigated. These residual effects are discussed for each VC below.

15.7.2.3 Potential for Residual Effects

Table 15.7-2 presents potential residual effects on fish and aquatic habitat VCs due to noise. Residual effects may potentially be caused from noise resulting from Project components in all Project phases for bull trout, Dolly Varden, rainbow trout/steelhead, and Pacific salmon.

15.7.2.4 Bull Trout: Potential Residual Effects due to Noise

Bull trout may be affected by the TCAR and transmission line, since the species is present in Teigen and Treaty creeks and in the Bell-Irving River. Bull trout do not inhabit streams in remaining areas of the Project and thus will not be affected by noise in these Project sites.

Noise mitigation strategies and BMPs include isolating Project work sites, establishing setback distances, and environmental monitoring. Although these mitigation and best management strategies are effective in minimizing noise, these strategies may not fully prevent all noise effects. Thus, some residual effects due to blasting noise are expected to occur due to the construction phase in the PTMA.

15.7.2.5 Dolly Varden: Potential Residual Effects due to Noise

Dolly Varden may be affected by Project components in the PTMA (i.e., TCAR, transmission line, TMF) and CCAR. Dolly Varden is the only fish species that occurs in nearly all streams in the LSA and RSA, except upstream of the cascade in Sulphurets Creek.

Noise mitigation strategies and BMPs are the same as for bull trout, previously discussed.

15.7.2.6 Rainbow Trout/Steelhead: Potential Residual Effects due to Noise

Rainbow trout/steelhead are present in Teigen and Treaty creeks and in the Unuk River. Rainbow trout/steelhead may be affected by the TCAR and CCAR.

Noise mitigation strategies and BMPs are the same as for bull trout, previously discussed.

Table 15.7-2. Potential Residual Effects on Fish and Aquatic Habitat Valued Components due to Noise

Valued Component	Timing Start	Project Area(s)	Component(s)	Description of Effect due to Component(s)	Type of Project Mitigation	Project Mitigation Description	Potential Residual Effect	Description of Residuals
Dolly Varden Rainbow trout Pacific salmon	Construction Closure	Mine Site	Coulter Creek Access Corridor	Noise from blasting and construction activities	DFO Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters; Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize noise effects; Adhere to DFO's operational statements; Setback distances	Yes	Sub-lethal effects, decreased feeding efficiency and habitat avoidance
Dolly Varden	Construction	Processing and Tailing Management Area	North Cell Tailing Management Facility	Noise from construction activities near South Teigen and North Treaty Creeks	DFO Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters; Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize noise effects; Adhere to DFO's operational statements; Setback distances	Yes	Sub-lethal effects, decreased feeding efficiency and habitat avoidance
Dolly Varden	Construction	Processing and Tailing Management Area	South Cell Tailing Management Facility	Noise from construction activities near South Teigen and North Treaty Creeks	DFO Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters; Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize noise effects; Adhere to DFO's operational statements; Setback distances	Yes	Sub-lethal effects, decreased feeding efficiency and habitat avoidance
Dolly Varden	Construction	Processing and Tailing Management Area	Centre Cell Tailing Management Facility	Noise from construction activities near South Teigen and North Treaty Creeks	DFO Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters; Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize noise effects; Adhere to DFO's operational statements; Setback distances	Yes	Sub-lethal effects, decreased feeding efficiency and habitat avoidance
Bull trout Dolly Varden Rainbow trout Pacific salmon	Construction	Processing and Tailing Management Area	Treaty Creek Access Road	Noise from blasting and construction activities	DFO Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters; Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize noise effects; Adhere to DFO's operational statements; Setback distances	Yes	Sub-lethal effects, decreased feeding efficiency and habitat avoidance

15.7.2.7 Pacific Salmon: Potential Residual Effects due to Noise

Pacific salmon are present in Teigen and Treaty creeks and in the Unuk River. Pacific salmon may be affected by the TCAR and CCAR.

Noise mitigation strategies and BMPs are the same as for bull trout, previously discussed.

15.7.3 Erosion and Sedimentation

15.7.3.1 Effect of Erosion and Sedimentation

Potential Project-specific sources of erosion and sedimentation include all access roads, transmission line, TMF, tunnelling and portal development, development of RSFs and pits, construction of the Water Storage dam (WSD), camps, and diversion ditches. Sedimentation and erosion can take place during the construction, operation, and closure phases of a number of Project activities. These activities have the potential to cause temporary increases in turbidity in localized areas. Recovery from sedimentation will be more rapid in high-velocity streams relative to wetlands or lakes. Many streams and rivers in the LSA and RSA have naturally high sediment loads due to glacial origins, and thus will not be affected to the extent of clear, low-velocity streams.

The geographic scope of erosion and sedimentation can range from localized to far-reaching events, depending on the amount and type (e.g., particle size) of sediment that is introduced into the aquatic environment. Erosion and sedimentation can affect aquatic habitat in many ways, including the physical alterations to habitat in the form of increased turbidity. In turn, sedimentation can affect aquatic organisms by smothering primary and secondary producers at various life stages, reducing visibility, diminishing feeding efficiency, increasing exposure to elevated metal concentrations, and leading to habitat avoidance by aquatic organisms.

Smothering of fish life stages could potentially occur in the event of sediment releases. High precipitation in the summer, without the buffering effect of vegetation, could lead to increased sediment runoff into streams. Erosion events can be lethal to incubating fish eggs in streambeds and larvae present in the substrate because of fine sediment being deposited within the interstitial spaces of gravel (Platts and Megahan 1975; Lisle 1989). Sediment can block oxygen transport across the membrane to the growing embryo, creating hypoxic (low oxygen) or even anoxic (no oxygen) conditions (Turnpenny and Williams 1980; Ingendahl 2001). Also, larvae that have hatched can become buried under the sediment, which creates a physical barrier preventing them from emerging (Chapman 1988; Crisp 1996).

High levels of total suspended solids (TSS) can occur from erosion events during construction (e.g., materials accidently pushed into streams, loosening materials along stream banks) and runoff during spring freshet and summer rains. Other sources of TSS include particulates from construction equipment activity and blasting. High TSS levels can lead to behavioural changes in fish such as alterations in migration routes and spawning behaviour (Cordone and Kelley 1961).

TSS produced by erosion and the particulates within can cause minor physical damages, such as gill damage, leading to decreased fitness because of reduced ability to feed, spawn, and avoid predators. Increased respiratory and osmoregulatory stress can occur as a result of abrasion to the gill filaments and matting action reducing the surface area (Cordone and Kelley 1961; Newcombe and MacDonald 1991; Sutherland and Meyer 2007). Moderate gill damage to small riverine fish has been shown to occur at suspended sediment levels greater than 100 mg/L, with severe damage at 500 mg/L (Sutherland and Meyer 2007). Eye damage also is possible, but sediment loads would have to be very high in fast-moving water because the continuous secretion of mucus washes away most sediment particles and protects the eyes.

Incidental erosional and sedimentation events may occur within or near streams during the construction phase because of equipment activities and precipitation runoff. These events can temporarily cause elevated TSS as well as siltation of the substrate. The resulting decrease in water clarity and enhanced particle loads could reduce primary production by decreasing photosynthesis and through scouring of the substrates they adhere to. Sediments may accumulate in some streams that are shallow with low discharge rates. Silt deposited from erosion and erosion events can affect invertebrate production as gravel interstices are filled by silt, and algae are buried or abraded (Beschta et al. 1995). In these instances, invertebrate assemblages are typically made up of a few tolerant, colonizing species (Newbold, Erman, and Roby 1980; Murphy, Hawkins, and Anderson 1981; Hawkins, Murphy, and Anderson 1982; Laniberti et al. 1991). This loss of substrate complexity, including LWD, tends to decrease the diversity of aquatic invertebrates.

Fish habitat may also be affected by catastrophic slope failures, debris torrents, and avalanches associated with access roads and their stream crossings. Road building has been associated with increased rates of slope failure and large-scale erosion, particularly in steep, coastal watersheds (Furniss et al. 1991). Debris torrents in streams can affect fish and productivity in streams for hundreds of years by scouring channels to bedrock, depositing fine sediment over downstream habitat, and blocking access to upstream habitat.

15.7.3.2 Mitigation for Erosion and Sedimentation

To minimize the effects on aquatic life and their habitats, several mitigation measures relating to erosion and sedimentation will be required. Mitigation strategies will be tailored to address Project-specific issues associated with erosion and sedimentation. Mitigation objectives outlined in accordance with DFO Land Development Guidelines for the Protection of Aquatic Habitat (DFO 1993), *Standards and Best Practices for Instream Works* (BC MWLAP 2004), *Fish-Stream Crossing Guidebook* (BC MOF 2002), and Pacific Region Operational Statements (DFO 2010) all provide guidelines for the mitigation of erosion and sedimentation effects on the aquatic environment.

Erosion and sedimentation will be mitigated in the LSA and RSA through the implementation of BMPs, particularly during the construction and operation stages. BMPs relating to erosion and sedimentation are described in detail under the Erosion Control Plan for the Project (Section 26.13.2) and within the Fish and Aquatic Habitat Effects Protection and Mitigation Plan (Section 26.18.1). The Erosion Control Plan will provide performance-based environmental specifications for preventing and controlling the release of sediments during the construction, operation, and closure phases to minimize adverse effects to downstream water quality.

These measures will be monitored and modified, as necessary, to ensure compliance with regulatory requirements and BMPs. When in-water work occurs, an Environmental Monitor will be on site monitoring water quality. Construction will occur during appropriate fisheries operating windows for fish-bearing streams. In-water works outside of fisheries operating windows will only be conducted under permit.

To minimize the effects of erosion and sedimentation during access road maintenance, an access road maintenance plan will be developed and adhered to during the Project operation and closure phases. To minimize the effects of sedimentation during transmission line construction and maintenance, initial site-specific riparian management prescriptions and riparian vegetation maintenance plan/prescriptions will be developed and adhered to.

Specific BMPs relating to the mitigation and/or minimizing of effects caused by erosion and sedimentation to the aquatic environment include environmental monitoring, repair of areas that are potential sediment sources, adhering to appropriate construction operating windows for instream work, and sediment control measures (e.g., silt fences surrounding waterbodies).

If the above BMPs are implemented and followed, potential effects caused by sedimentation on the selected VCs may not be fully mitigated. Potential effects associated with sedimentation that surpass mitigation strategies are expected to have a residual negative effect. These residual effects are discussed for each VC below.

15.7.3.3 Potential for Residual Effects

Table 15.7-3 presents potential residual effects on fish and aquatic habitat VCs due to erosion and sedimentation. Residual effects may be caused from erosion and sedimentation resulting from Project components in the construction and operation phases for bull trout. Residual effects may be caused from erosion and sedimentation resulting from Project components in the construction, operation, and closure phases for Dolly Varden, rainbow trout/steelhead, Pacific salmon, and aquatic habitat.

15.7.3.4 Bull Trout: Potential Residual Effects due to Erosion and Sedimentation

Bull trout may be affected by the TCAR and transmission line, since the species is present in Teigen and Treaty creeks, and the Bell-Irving River. Bull trout do not inhabit streams in remaining areas of the Project and thus will not be affected by erosion and sedimentation in these Project sites. Bull trout will only be affected by the TMF if there is a catastrophic dam rupture. The distance from the TMF to the lower reach of South Teigen Creek and Treaty Creek is approximately 3 km and 2.2 km, respectively. Bull trout spawn and rear in Teigen Creek, and the distance from the TMF to Teigen Creek is approximately 5 km. Bull trout spawn (two localized sites) and rear in the lower reach of South Teigen Creek.

Table 15.7-3. Potential Residual Effects on Fish and Aquatic Habitat Valued Components due to Erosion and Sedimentation

Valued Component	Timing Start	Project Area(s)	Component(s)	Description of Effect due to Component(s)	Type of Project Mitigation	Project Mitigation Description	Potential Residual Effect	Description of Residuals
Dolly Varden Rainbow trout Pacific salmon Aquatic Habitat	Construction Closure	Mine Site	Coulter Creek Access Corridor	Entry of sediment to water bodies during instream construction and bridge/culvert removal	Erosion and Sediment Management Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize sediment entry to water bodies; Adhere to DFO's operational statements; Adhere to appropriate construction operating window for instream work and the Sediment and Erosion Control Plan; Site isolation; Water quality maintenance	Yes	Smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity
Dolly Varden Rainbow trout Pacific salmon Aquatic Habitat	Operation	Mine Site	Coulter Creek Access Corridor	Entry of sediment to water bodies from road runoff during operation and maintenance	Erosion and Sediment Management Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize sediment entry to water bodies; Adhere to Fish and Aquatic Habitat Protection and Mitigation Plan	Yes	Smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity
Aquatic Habitat	Construction Operation Closure	Mine Site	All Components except: Iron Cap Block Cave Mine; Truck Shop; Explosives Manufacturing Facility	Entry of sediment to water bodies from runoff	Erosion and Sediment Management Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize sediment entry to water bodies; Adhere to DFO's operational statements; Adhere to Sediment and Erosion Control Plan; Water quality maintenance	Yes	Smothering of aquatic invertebrates, loss of productive habitat capacity
Bull Trout Dolly Varden Rainbow trout Pacific salmon Aquatic Habitat	Construction Operation	Processing and Tailing Management Area	Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction	Entry of sediment to water bodies from camp runoff	Erosion and Sediment Management Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize sediment entry to water bodies; Adhere to DFO's operational statements; Adhere to Sediment and Erosion Control Plan; Water quality maintenance	Yes	Smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity
Dolly Varden Aquatic Habitat	Construction Operation Closure	Processing and Tailing Management Area	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility	Entry of sediment to South Teigen and North Treaty Creeks during instream construction	Erosion and Sediment Management Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize sediment entry to water bodies; Adhere to DFO's operational statements; Adhere to appropriate construction operating window for instream work and the Sediment and Erosion Control Plan; Site isolation; Water quality maintenance	Yes	Smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity

(continued)

Table 15.7-3. Potential Residual Effects on Fish and Aquatic Habitat Valued Components due to Erosion and Sedimentation (completed)

Valued Component	Timing Start	Project Area(s)	Component(s)	Description of Effect due to Component(s)	Type of Project Mitigation	Project Mitigation Description	Potential Residual Effect	Description of Residuals
Bull trout Dolly Varden Rainbow trout Pacific salmon Aquatic Habitat	Construction	Processing and Tailing Management Area	Treaty Creek Access Road	Entry of sediment to water bodies during instream construction; Entry of sediment to water bodies during removal of riparian vegetation	Erosion and Sediment Management Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize sediment entry to water bodies; Adhere to DFO's operational statements; Adhere to appropriate construction operating window for instream work and the Sediment and Erosion Control Plan; Site isolation; Water quality maintenance	Yes	Smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity
Bull trout Dolly Varden Rainbow trout Pacific salmon Aquatic Habitat	Operation Closure	Processing and Tailing Management Area	Treaty Creek Access Road	Entry of sediment to water bodies from road runoff during operation and maintenance; Entry of sediment to water bodies from riparian vegetation maintenance	Erosion and Sediment Management Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize sediment entry to water bodies; Adhere to Fish and Aquatic Habitat Protection and Mitigation Plan	Yes	Smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity
Aquatic habitat	Construction Operation Closure	Processing and Tailing Management Area	All Components	Entry of sediment to water bodies and decreasing the productivity of aquatic habitat	Erosion and Sediment Management Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize sediment entry to water bodies; Adhere to the Sediment and Erosion Control Plan; Site isolation; Water quality maintenance	Yes	Smothering of aquatic invertebrates, loss of productive habitat capacity

The primary goal of sediment mitigation strategies is to prevent sediment from entering all waterbodies, especially those waterbodies where bull trout reside. Sediment mitigation strategies and BMPs will include the use of geotextile cloth surrounding sediment entry sites near waterbodies, isolating Project work sites, and environmental monitoring. Although these mitigation and best management strategies are effective in minimizing sediment entry to fish-bearing waterbodies, these strategies may not fully prevent all sediment entry. Thus, some residual effects due to erosion and sedimentation are expected to occur due to the construction and operation of these Project components.

15.7.3.5 Dolly Varden: Potential Residual Effects due to Erosion and Sedimentation

Dolly Varden may be affected by Project components in the PTMA of the Project. Dolly Varden is the only fish species that occurs in nearly all streams in the LSA and RSA, except upstream of the cascade in Sulphurets Creek.

Dolly Varden inhabiting streams in LSA and RSA may be affected by erosion and sedimentation during the construction and operation of access roads, transmission line, camps, and the TMF.

Erosion and sedimentation mitigation strategies and BMPs are the same as for bull trout, previously discussed.

15.7.3.6 Rainbow Trout/Steelhead: Potential Residual Effects due to Erosion and Sedimentation

Rainbow trout/steelhead are present in Teigen and Treaty creeks and in the Unuk River. Rainbow trout/steelhead may be affected by Project components related to the construction and maintenance of the TCAR, transmission line, and CCAR. Rainbow trout/steelhead will only be affected by the TMF if there is a catastrophic dam rupture because of the large distance from the TMF to Teigen Creek. Steelhead rear in Treaty Creek (downstream of Todedada Creek confluence), and the distance to the TMF is 8.1 km. Steelhead spawn and rear in Teigen Creek, and the distance from the TMF to Teigen Creek is 5 km.

Erosion and sedimentation mitigation strategies and BMPs are the same as for bull trout, previously discussed.

15.7.3.7 Pacific Salmon: Potential Residual Effects due to Erosion and Sedimentation

Residual effects may be caused from erosion and sedimentation resulting from Project components in the construction, operation, and closure phases. Pacific salmon are present in Teigen and Treaty creeks and in the Unuk River. Pacific salmon are not present in South Teigen or North Treaty creeks, or in the Mine Site. Similar to steelhead and/or rainbow trout, Pacific salmon may be affected by Project components such as the TCAR, transmission line, and the CCAR (Unuk River and northwards). Pacific salmon will only be affected by the TMF if there is a catastrophic dam rupture because of the large distance from the TMF to Teigen Creek. The distance from the TMF to Teigen Creek and Treaty Creek (downstream of Todedada Creek confluence) is 5 km and 8.1 km, respectively.

Erosion and sedimentation mitigation strategies and BMPs are the same as for bull trout, previously discussed.

15.7.3.8 Aquatic Habitat: Potential Residual Effects due to Erosion and Sedimentation

Residual effects may be caused by erosion and sedimentation resulting from Project components in the construction, operation, and closure phases. Aquatic habitats may be affected by Project components in the PTMA and Mine Site. The majority of Project components can affect their respective aquatic habitats.

Aquatic habitats in the LSA and RSA may be affected by components such as the construction and operation of access roads, tunnels, RSFs and pits, the TMF, diversions, and the Water Treatment Plant (WTP).

The primary goal of the sediment mitigation strategies is to prevent sediment from entering all waterbodies. Sediment mitigation strategies and BMPs are detailed in the Erosion Control Plan (Section 26.13.2) and in the Fish and Aquatic Habitat Effects Protection and Mitigation Plan (Section 26.18.1). They include, and are not limited to, using buffers or leave strips, using geotextile cloth surrounding sediment entry sites near waterbodies, isolating Project work sites, retaining vegetation and re-vegetating exposed riparian habitat, and environmental monitoring.

Although these mitigation and best management strategies are effective in minimizing sediment entry to aquatic habitats, these strategies may not fully prevent all sediment entry. Thus, some residual effects due to erosion and sedimentation are expected to occur during the construction and operation phases of the Project components in all of the LSA and RSA.

15.7.4 Water Quality Degradation

15.7.4.1 Effects of Water Quality Degradation

The health of fish, other aquatic life, and sediment quality are all intimately linked to the quality of the water in the aquatic environment. Chemical contaminants may enter the aquatic environment from a number of sources as a result of Project activities in all phases and may pose a risk to fish and aquatic resources (fish habitat, aquatic life, and sediment).

A number of different chemical classes may be used or naturally present within the LSA or RSA. Examples of types of chemicals that could be introduced into the aquatic environment as a result of Project activities include metals, process chemicals (e.g., chemicals used in water treatment or ore processing), petroleum products, and nitrogen and phosphorus associated with blasting residues or sewage disposal. Each of these classes of chemicals will be discussed, including potential sources and general potential impacts on fish and aquatic resources.

The potential effects considered in this section relate only to the Project activities that may occur under normal operating conditions. Effects related to substantial spills or unusual events (e.g. accidents, infrastructure failure) are addressed in Chapter 35, Environmental Effects of Accidents and Malfunctions.

The potential for changes in sediment quality was assessed quantitatively using sediment quality modelling based on TSS loading and consideration of sediment-water partitioning coefficients (K_d) and is summarized in Section 15.7.4.3.1. Detailed results are provided in Appendix 15-L. Identification of metals that may be of concern to aquatic life that were associated with discharges from the TMF (PTMA) or WTP was determined quantitatively in Chapter 14 (Appendix 14-H) based on water quality predictions during various phases of the Project. The potential impacts of Project activities on aquatic life related to the introduction of nitrogen and phosphorus were assessed quantitatively using a comparison of loading during baseline and predicted loading during Project operation associated with discharge from the TMF and the Mine Site WTP and is summarized in Section 15.7.4.3.4, with more detailed calculations available in Appendix 15-M. The potential effects of the remaining classes of chemicals were assessed in a more qualitative manner.

15.7.4.1.1 Metals

Metals occur naturally in the water (Section 14.1) and sediments (Tables 15.1-7 and 15.1-10) of the LSA and RSA due to the presence of mineral-rich deposits, sometimes at concentrations above federal and/or provincial guideline limits.

The generation of ML/ARD can affect the aquatic environment through the alteration of pH due to the introduction of acid. Acidification can also increase the proportion of metals present in the dissolved phase, which are more bioavailable, since metals are often more soluble at lower pH. This can lead to increased exposure to metals and risk of toxicity in fish and other aquatic organisms. The potential for fish or aquatic habitat exposure to acidic water or metals could occur during all phases of the Project (construction, operation, closure, and post-closure). Sources of metals due to Project activities may include diffuse sources (e.g., ML/ARD associated with road or other infrastructure construction) or point sources (e.g., discharges from the TMF or WTP). Potential sources of ML/ARD include any locations where potentially acid generating (PAG) rock may be exposed, such as access roads, mine pits, or other mine infrastructure.

The results of the Access Roads Metal Leaching and Acid Rock Drainage Potential Assessment identify the sections of the access roads that may be PAG (Appendix 10-B). For the CCAR, 3% of the access road was classified as high PAG, and 29% was possible PAG. For the TCAR, a few 200-m segments of the access road (reported as less than 1%) was classified as high PAG, and 23% was possible PAG.

Exposure of fish in the aquatic environment to extremes in pH or metals can lead to both lethal and sublethal effects. At high enough concentrations, metals can cause mortality in exposed organisms. At lower concentrations, sublethal effects may occur and although these effects do not cause immediate mortality, they can affect population dynamics or stability in the long term. The interaction of acidic water with metals can change metal speciation and increase the mobility and bioavailability of metals in the aquatic environment, thereby altering the toxicological implications of exposure. Low pH, such as what naturally occurs in the Upper Mitchell Creek area near the Mitchell deposit, can mobilize surface-bound metals, leading to increased potential for toxic effects on aquatic life. The toxicology of mixtures of metals and other chemicals in the aquatic environment is poorly understood, although it is known that antagonistic, additive, synergistic, or potentiating effects are possible outcomes.

ML/ARD has been shown to cause lethality at high concentrations and various other toxic effects at lower concentrations, which are largely attributed to the metal content. High, acutely lethal concentrations of metals or changes in pH are not expected to occur in the LSA and RSA (Appendix 10-B, Access Roads ML/ARD Potential Assessment; Appendix 14-H, Water Quality Model Results), except in the event of a large chemical spill. Spills and other accidents are addressed elsewhere (e.g., Spill Prevention and Emergency Response Plan; Appendix 22-C, *Highways 37 and 37A Traffic Effects Assessment*); thus, acutely lethal effects are not considered likely to occur as a result of normal Project activities, and are not considered further.

Fish are sensitive to changes in environmental pH. Exposure to acidic aquatic environments can lead to sublethal effects such as alteration in blood acid-base regulation and disruption of ionoregulation (Wood 1992). In chronic exposures, contact with low pH can lead to decreased growth and development, impaired swimming ability, increased stress and impaired smoltification in fish (Wood 1989; Kennedy and Picard 2012).

Sublethal toxicity of metals in fish can manifest as effects on various physiological functions, and can be different for each metal. Toxicity occurs because of metal interaction with the external surfaces of the organism or metal uptake through water or diet, and can result in osmoregulatory impairment, immunotoxicity, neurotoxicity, endocrine disruption, embryotoxicity, or behavioural changes (Evans 1987; Baatrup 1991; Kime 1998; Hansen et al. 1999; Sanchez-Dardon et al. 1999; Todd et al. 2006; Chapman et al. 2009). Exposure to metals can also cause a generalized stress response in fish that can lead to similar effects including immunosuppression, osmoregulatory imbalance, and decreased growth because of higher metabolic demands (Todd et al. 2006). The stress response is caused by metal accumulation or damage at the gill, or metal uptake and pH surges that in turn stimulate increased gas exchange (Wood 1992). Olfactory toxicity in fish has also been associated with exposure to low pH, metals, and various other contaminants (Tierney et al. 2010). Some metals, such as copper, can interact with sensory nerves located in the olfactory rosettes causing avoidance responses or impairment of the ability to "smell," which can alter normal olfactory-mediated behaviours (Tierney et al. 2010).

Exposure of fish to metals in their aquatic habitat can lead to accumulation of those contaminants in fish tissue. As part of baseline studies, Dolly Varden were collected at the following five sites for whole body tissue metal analysis: Sulphurets Creek (SC3, 4 fish, 2008/09), Unuk River (UR1, 5 fish, 2011), North Treaty Creek (NTR2, 13 fish, 2008/09), South Teigen Creek (STE2, 16 fish, 2008/2009), and Scott Creek (SCR, reference site, 14 fish, 2008/2009). The location of the sample sites are shown in Figure 15.1-8, and results of these analyses are provided in Table 15.7-4. The results indicate that fish in the PTMA and downstream of the Mine Site had naturally high tissue metal residues for certain metals. Concentrations of selenium in Dolly Varden tissue collected during baseline studies were above the BC MOE tissue residue guideline of 1 µg/g wet weight (ww; equivalent to approximately 4 µg/g dw; Nagpal 2001, BC MOE 2006b) in fish sampled from Sulphurets, North Treaty, and South Teigen creeks, as well as at the Scott Creek reference site (Table 15.7-4). Selenium has been associated with reproductive and developmental toxicity, particularly in egg-laying vertebrates (Chapman et al. 2009). It is currently unknown whether fish are experiencing sublethal toxic effects since the effects thresholds for fish vary between species; however, evidence suggests that Dolly Varden may be less sensitive to selenium toxicity than other fish species (McDonald et al. 2010).

Table 15.7-4. Tissue Metal Concentrations in Dolly Varden in the Baseline Study Area, 2008 to 2011

Parameters	Sulphurets Creek (n = 4)			Unuk River (n = 5)			North Treaty Creek (n = 13)			South Teigen Creek (n = 16)			Scott Creek (Reference Site, n = 14)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Physical Tests															
Moisture (%)	73.9	76.7	74.9	73.9	77.6	76.3	71.2	80.3	74.5	74.2	83.6	76.8	73.4	82.0	76.4
Total Metals															
Aluminum	53.2	204.0	132.8	79.1	379.3	195.7	15.44	388.68	145.50	<30	1,980.0	199.1	76.4	585.0	255.9
Antimony	<0.05	0.056	<0.05	<0.05	0.050	<0.05	<0.05	<0.05	<0.05	<0.2	<0.2	<0.2	<0.05	0.083	<0.05
Arsenic	0.38	0.66	0.51	0.32	1.10	0.66	<0.1	0.39	0.18	0.08	0.73	0.17	0.15	1.34	0.48
Barium	5.52	6.33	6.04	1.73	8.66	4.13	1.72	8.38	4.47	1.52	28.10	5.03	4.08	10.79	7.70
Beryllium	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Bismuth	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Cadmium	0.548	0.806	0.700	0.025	0.065	0.040	0.07	0.48	0.17	<0.1	0.242	0.123	0.119	1.090	0.427
Calcium	17,132	22,976	19,841	566	1,004	797	8,600	22,000	14,483	13,000	29,378	20,057	16,031	44,700	22,436
Chromium	0.620	3.710	1.462	0.205	<0.5	0.491	0.57	4.02	1.59	0.879	8.300	2.462	0.445	1.410	0.840
Cobalt	0.480	0.736	0.625	0.206	0.425	0.305	0.18	1.00	0.45	0.530	2.320	1.150	0.294	1.021	0.551
Copper	10.0	24.3	16.5	1.9	8.9	3.8	2.15	4.35	3.15	2.5	6.0	3.9	2.4	3.8	2.9
Iron	142	324	232	na	na	na	53.53	390.15	167.22	49	1,660	226	147	818	356
Lead	0.083	0.180	0.144	<0.1	0.245	0.134	<0.1	0.12	<0.1	0.089	<0.4	<0.4	<0.1	0.397	0.140
Lithium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.38	<0.5	<0.5	<2	<2	<2	0.450	<0.5	<0.5
Magnesium	1,195	1,300	1,245	1,285	1,478	1,347	1,010	1,570	1,285	1,100	2,720	1,460	1,140	1,800	1,429
Manganese	10.52	13.95	12.54	3.42	12.84	7.21	4.08	15.76	8.92	5.34	29.40	13.62	10.27	39.92	20.20
Mercury	0.056	0.094	0.070	0.057	0.147	0.102	0.020	0.159	0.046	0.048	0.781	0.122	0.021	0.048	0.031
Molybdenum	0.063	0.632	0.216	<0.05	0.069	<0.05	0.019	0.12	0.07	0.054	0.750	0.149	<0.05	0.109	0.066
Nickel	<0.50	1.69	0.57	<0.50	0.54	<0.50	<0.5	2.10	0.75	<0.4	5.90	1.35	<0.5	0.81	<0.5
Phosphorus	16,667	20,600	18,634	na	na	na	12,900	22,600	16,822	15,400	30,711	20,823	15,153	31,000	20,893
Potassium	12,337	13,915	13,172	na	na	na	10,196	16,000	13,197	12,500	21,333	14,923	11,600	15,591	13,700
Selenium	4.29	4.60	4.47	2.94	3.90	3.34	3.90	10.10	5.70	5.70	9.60	6.66	2.52	5.97	3.97
Sodium	2,837	3,270	3,061	na	na	na	2,430	3,900	3,224	2,830	5,556	4,000	2,576	4,070	3,252
Strontium	21.5	27.9	24.7	0.8	2.3	1.5	10.80	34.90	25.05	19.8	44.9	31.8	19.3	59.0	31.8
Thallium	0.052	0.077	0.068	0.022	0.065	0.048	<0.03	0.06	<0.03	<0.10	<0.10	<0.10	<0.03	0.097	0.067
Tin	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.2	<0.2	<0.2	<1	<1	<1	<0.2	0.241	<0.2
Titanium	4.29	7.98	6.55	na	na	na	0.25	2.88	1.20	0.25	7.99	1.71	0.25	8.60	3.85
Uranium	<0.01	0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.04	<0.04	<0.04	<0.001	0.0149	0.0064
Vanadium	0.198	0.770	0.531	0.482	2.069	1.044	<0.5	1.40	<0.5	<0.5	7.300	1.069	<0.5	1.322	0.625
Zinc	120	153	133	28	40	32	71.85	155.29	105.35	97	223	137	75	135	110

na = not analysed

Concentrations are expressed in µg/g dry weight, unless otherwise noted

Shaded concentrations exceed tissue residue guidelines for methylmercury (0.132 µg/g dry weight, 0.033 µg/g wet weight; to protect consumers of aquatic life) or selenium (4 µg/g dry weight, 1 µg/g wet weight; to protect aquatic life). Note that guidelines are based on wet weight concentrations, which have been converted to dry weight assuming 75% moisture content in fish tissue.

Mercury can also bioaccumulate through the food chain and pose a risk to higher trophic level organisms. Elevated tissue mercury concentrations in fish have been associated with sublethal effects such as decreased growth, developmental and reproduction abnormalities, and neurological and behavioural effects (Kidd and Batchelar 2012). Concentrations of mercury in some of the analyzed fish from the Unuk River, North Treaty Creek, and South Teigen Creek were greater than tissue residue guidelines (shown as maximum concentrations in Table 15.7-4), which are intended to be protective of consumers of fish such as wildlife or humans. The CCME and BC tissue residue guideline is 0.033 µg/g ww, which is approximately 0.132 µg/g dw, assuming 75% tissue moisture content. Most or all of the mercury present in fish tissue is likely in the form of methylmercury (CCME 2000) and, for the purposes of comparison to guidelines, it has been assumed to be 100% methylmercury. It is unlikely that the current mercury residues in the fish are directly toxic to the fish since Beckvar, Dillon, and Read (2005) estimate that a mercury tissue residue threshold for fish of 0.2 µg/g ww (approximately 0.8 µg/g dw, assuming 75% tissue moisture) is protective against adverse sublethal effects in both juvenile and adult fish. This tissue residue threshold was not exceeded.

The productive capacity in aquatic habitats could also be potentially altered as a result of the Project activities. Acids and metals leaching into aquatic environments can lead to decreased biomass, densities, and diversities in primary and secondary producer communities (Kimmel 1983; McKnight and Feder 1984). Aquatic insects are also affected by low pH, with lethality occurring below a pH of 5.4, and emergence impairment beginning at a pH of 5.9 (Bell 1971; McKean and Nagpal 1991). Sediment quality can be affected by the overlying water quality, and increases in metal concentrations in the water may lead to increased partitioning of those metals into sediments or aquatic biota and potential for adverse effects. Acidic aquatic pH can also lead to the liberation of sediment-bound metals, which can then enter the dissolved phase and be more bioavailable to aquatic organisms resulting in toxicity.

15.7.4.1.2 Process Chemicals

Chemicals used in ore processing or for environmental protection (e.g., water treatment process chemicals) may be present in the LSA during all Project phases and may pose a risk of toxicity to fish and aquatic resources. Metal concentrates produced at the Treaty Process Plant will be present in the LSA during the operation phase. These chemicals may be released in effluent discharged from the TMF or the Mine Site WTP during the normal course of Project activities, which will be considered as part of the effects assessment in this section.

Important or heavily used chemicals that will be used during Project activities include sodium cyanide (gold extraction), potassium amyl xanthate (PAX; ore processing), lime (water treatment), sulphuric acid (water treatment), and flocculants (water treatment). Since the main risk associated with metal concentrates is spills related to traffic accidents or other unusual incidents, this will be addressed in Appendix 22-C, *Highways 37 and 37A Traffic Effects Assessment*, and metal concentrates will not be considered further.

Sodium cyanide will be used as a process chemical in the Treaty Process Plant, and thus may be present in the discharge from the Plant to the TMF. This can be toxic to fish and aquatic invertebrates, and spills of this chemical have caused serious damage to aquatic ecosystems

(Eisler, Clark et al. 1999). Cyanide was included in the predictive water quality model, and the potential for residual effects for cyanide will be based on this data.

PAX is used as a collector in the flotation step of ore processing. There is limited information available on the persistence or toxicity of this chemical in the environment. However, Vigneault, Desforges, and McGeer (2009) report that at concentrations of 0.5 mg/L, PAX can impair algal growth, although an aquatic invertebrate and a macrophyte were shown to be less sensitive.

At low concentrations, lime is used to raise the pH in acidified waterbodies (Hultbert and Andersson 1982), and it may be used if necessary to control ML/ARD along roadways during construction. Lime is also proposed for use in the water treatment processes in the WTP during all phases of Project activity to increase the precipitation and removal of metals from water. At higher concentrations it can be hazardous to aquatic habitat and organisms. The primary way lime affects aquatic habitat is by raising water pH, which can increase the toxicity of ammonia by converting ammonium ions (NH_4^+) to more toxic, uncharged ammonia molecules (NH_3). It can also increase the total dissolved solids in receiving waters, due to increased calcium concentrations. Calcium contributes to water hardness, and for many metals (e.g., cadmium, copper, lead, and nickel) increasing water hardness is associated with decreasing metal toxicity. However, increased total dissolved solids or calcium concentrations can also have adverse effects ranging from impairing growth and reproduction in some invertebrates or macrophytes to decreasing fertilization success in salmonids, as well as mortality at high concentrations (Stekoll et al. 2009; Vigneault, Desforges, and McGeer 2009). Certain macrophyte and aquatic invertebrate species are highly sensitive to liming, and will die when exposed to lime (Ye and Randall 1991; Brandrud 2002). In general, a pH of 9 or more will cause mortality in most fish species (Ye and Randall 1991). When exposed to lower levels of alkalinity, fish experience impaired ammonia excretion and sodium influx that may result in changes to blood ammonia levels (Ye and Randall 1991).

Following the use of lime in the water treatment process, the pH will be decreased again to a neutral level using acid. This can increase the concentration of sulphate, since sulphuric acid will be used in the pH adjustment to neutral levels. Sulphate can cause toxicity to aquatic invertebrates and fish, which may be associated with ionic imbalance (Goodfellow et al. 2000)

Polyacrylamide flocculants may be used as part of the sedimentation and erosion control plans and in the WTP for the Mine Site. The amount of flocculant required will depend on the TSS concentration, but typically the concentrations of flocculant used for sediment control purposes are less than 10 mg/L (Vigneault, Desforges and McGeer 2009). Some flocculants have been shown to cause acute lethality to fish and aquatic life, and toxicity is dependent on the charge associated with the compound (anionic, cationic, non-ionic). Toxicity of these compounds is through their interaction with respiratory surfaces, leading to impaired oxygen exchange and ultimately suffocation. For aquatic invertebrates, flocculants can also interact with sensory surfaces such as antennae, leading to immobilization and death. In fish, cationic flocculants are often associated with the highest toxicity since gills have a negative charge and the flocculant has a positive charge that increases the likelihood of interaction at the gill surface. Anionic or non-ionic flocculants have a much lower toxicity, with LC_{50} values typically greater than

100 mg/L, although some (e.g., MagnaFloc 10) are reported to impair rainbow trout survival at 18 µg/L (Vigneault, Desforges and McGeer 2009).

15.7.4.1.3 Petroleum Products

Potential Project-specific locations and activities where petroleum products may be present include all Project access roads, the transmission line, the TMF, tunnelling and portal development, development of RSFs and pits, camps, construction of the WSD, fuel storage areas, hydroelectric power development, and diversion ditches and tunnels. Release of petroleum products could occur during the construction, operation, and closure phases due to a number of Project activities. Routine Project-related traffic creates a risk of diesel fuel or lubricant entering aquatic habitat, either directly or due to runoff associated with precipitation. Activities involving mechanized equipment in or near waterways, such as road, bridge, dam, or other infrastructure construction and activities during closure and post-closure reclamation can lead to introduction of small amounts of fuel, oil, or petroleum-based lubricants into the aquatic environment.

The potential geographic scope of petroleum product introduction into waterways can range from localized to far-reaching events depending on the amount that is introduced into the aquatic environment and watercourse discharge. The potential for spills and accidents involving large quantities of petroleum products are not explicitly considered here since this will be addressed in Chapter 35, Environmental Effects of Accidents and Malfunctions. The potential for petroleum products to enter waterways during normal Project activities is likely small in geographic scope, since only small quantities in localized areas would be introduced to aquatic environments. Petroleum products can affect fish and aquatic habitat in many ways, including physiological toxicity (lethal or sublethal effects) or behavioural changes in fish and aquatic invertebrates and loss of productive habitat capacity.

Most petroleum products that may enter waterways during normal Project activities (e.g., gasoline, diesel, fuel oil, lubricants) are toxic to fish and can cause mortality at high enough levels (Tagatz 1961; Hedtke and Puglisi 1982; Lockhart, Duncan et al. 1996). Toxicity occurs through the water soluble constituents and emulsions causing damage to gill epithelia, nerve damage, liver damage, and general organ failure (Fryday, Andrew et al. 1996; Omoregie and Ufodike 2000). Disturbances in blood chemistry such as increased haematocrit (percent volume of red blood cells in blood), haemoglobin concentration, erythrocyte counts, plasma glucose, and cortisol, along with variable changes in plasma chloride and potassium levels may occur (Zbanyszek and Smith 1984; Alkindi, Brown et al. 1996). Acute and chronic stress responses, as indicated by alteration in blood chemistry and cortisol production, can lead to behavioural changes such as decreased feeding activity, growth, and changes in swimming behaviour (Struhsaker 1977; Little and DeLonay 1996).

Contamination of the aquatic habitat leading to decreased productive capacity could potentially occur if petroleum products are released to the aquatic environment. Localized contamination of sediments may occur, since most petroleum products have constituents that are hydrophobic and will move from the water to the sediment. Accidental release of petroleum products (e.g., diesel fuel) have been shown to reduce primary and secondary producer densities and alter community structure (Lytle and Peckarsky 2001).

15.7.4.1.4 Nitrogen and Phosphorus

Introduction of nitrogenous compounds and phosphorus into the aquatic environment may occur as a result of Project activities involving nitrogen-based explosives and disposal of effluent from STPs associated with construction and operating camps. The primary nitrogenous compounds that may be a concern include ammonia, nitrate, and nitrite. Although cyanide does contain nitrogen, it was not considered as a nutrient given the low concentrations in the aquatic environment (particularly downstream of the Mine Site where it is below detection limits in the water; Chapter 14) and relatively high concentrations of other forms of available inorganic nitrogen which would greatly reduce the demand for cyanide as a nitrogen source.

Airborne particles of explosive residues, blasting residue leachate, and effluent from STPs entering waterbodies can affect fish and aquatic habitat in several ways. The main concern associated with the introduction of nitrogen or phosphorus into the aquatic environment is eutrophication. Alteration of productive habitat capacity may occur due to changes in nitrogen or phosphorus concentrations, particularly if the aquatic environment is nitrogen-limited or phosphorus-limited and Project activities lead to introduction of the limiting nutrient. The second concern is the toxicity to fish or aquatic life associated with some forms of nitrogenous compounds (e.g., ammonia, nitrate, and nitrite). The geographic scope of effects due to blasting residues and effluent from STPs can range from localized to far-reaching events depending on the amount that is introduced into the aquatic environment.

The explosives to be used at the KSM Project are formulations of ammonium nitrate and fuel oil (ANFO), with some sodium nitrate and ethylene glycol as surfactants (Chapter 4, Project Description). Locations and activities where Project-specific sources of blasting residues may be present include access roads, the TMF, tunnelling and portal development, RSFs, mine pits and block caves, construction of the WSD, hydroelectric power developments, and diversion ditches and tunnels. Blasting residues will be generated during the construction phase for the majority of the above listed Project activities. Blasting residues will also be generated during the operation phase for Project activities associated with continuous blasting such as the pit areas, block caves, and in RSFs for waste rock. The nitrogen in ANFO is in a highly water-soluble form (ammonia and nitrate), and these residues may enter the water after blasting from particulates settling out of the air or during precipitation events as runoff from residue on rocks or other surfaces (Forsynth, Cameron et al. 1995). The accumulation of these residues on disturbed rock material and subsequent nitrogen loading to the aquatic environment will depend on the volume of explosives used.

Potential sources of effluent from STPs containing both nitrogenous compounds and phosphorus include all camps during the construction, operation, and closure phases. Effluent from STPs may have nitrogen (including both ammonia and nitrate) and phosphorus which, if not disposed of properly, can contribute to alterations in productive capacity and eutrophication, as well as the potential for toxicity to aquatic organisms and fish.

Nitrogen loading can increase the potential for eutrophication in aquatic systems if there are sufficient macronutrients (e.g., phosphorus), micronutrients (e.g., iron), and light for primary production, and nitrogen is in limited supply. This could degrade water quality and alter primary producer growth and community composition away from baseline conditions if the system is nitrogen-limited. Community shifts such as these may have a cascading effect, leading to changes in the structure of several successive trophic levels. On a population scale, continued exposure to elevated levels of nutrients could lead to changes in species diversity and abundance relative to control areas (Grigg 1994). In streams, how additional nutrients are manifested in primary productivity can also be affected by water temperature, availability of light, TSS content (which affects availability of light and contributes to scouring), and the flow or gradient of the stream.

Nitrogenous compounds, including ammonia, nitrate, or the oxidative intermediate nitrite, in high enough concentrations can be toxic (lethal) to all life history stages of fish due to gill and other tissue damage (Lewis and Morris 1986; Servizi and Gordon 1990; Camargo, Alonso et al. 2005). The toxicity of total ammonia is pH and temperature dependent, with higher pH and temperature contributing to higher ratios of the more toxic un-ionized ammonia (NH_3), which is reflected in the BC water quality guidelines for this compound.

At lower concentrations, exposure to nitrogenous wastes has been shown to cause sublethal effects, including a general stress response (Wendelaar Bonga 1997) in fish that can lead to sublethal changes in development (Weis and Weis 1989; Weis et al. 1989), decreased growth (Smith and Suthers 1999; Saborido-Rey et al. 2007), and decreased swimming performance (Shingles et al. 2001). As well, chronic exposure can alter immune system function resulting in an increase in the susceptibility of fish to infection (Carballo et al. 1995). Nitrate (10 mg NO_3-N/L) can lead to decreased growth in fish (Camargo, Alonso et al. 2005). Other physiological changes in fish include nerve damage during development, along with damage to muscles and liver. Generally, invertebrates and algae are less sensitive to the toxic effects of nitrogenous compounds (Nordin and Pommen 1986). Early life stages of some invertebrates may experience increased mortality and decreased growth at very high nitrate concentrations (Camargo, Alonso et al. 2005).

The constituents of effluent from STPs have been shown to cause sublethal behavioural effects such as avoidance behaviour (Richardson et al. 2001). As well, increases in parasite load can occur in areas of sewage effluent exposure (Siddall et al. 1994), which can lead to physiological and behavioural changes (Poulin 1995). Effluent from STPs has also been associated with endocrine disruption and reproductive alteration in fish (Jobling et al. 1998).

15.7.4.2 Mitigation for Water Quality Degradation

15.7.4.2.1 Mitigation Measures for Potential Water Quality Degradation Effects

In addition to the specific mitigation measures outlined for each class of chemical in the following sections, a comprehensive Aquatic Effects Monitoring Plan (Section 26.18.12) will be implemented. This monitoring plan will detect alterations to the receiving environment including changes to sediment quality or effects on aquatic life and fish. This plan will include provisions for identification of causes of alteration and implementation of additional mitigation measures or adaptive management strategies if effects are identified.

15.7.4.2.2 Mitigation for Metals

Mitigation for Metals from Non-point Sources

ML/ARD may occur along newly constructed access roads from exposed sulphide-bearing rock alongside rock-cuts. ML/ARD may occur during all phases of the Project and may continue for many years post-closure. Implementing a carefully managed ML/ARD Management Plan (Section 26.14) will reduce the possible ML/ARD release into the aquatic environment, particularly for access roads and other Project infrastructure. This plan will be used in conjunction with other plans (e.g., the Erosion Control Plan, and sedimentation control under the Water Management Plan, Section 26.17) to ensure that ML/ARD is minimized and water and sediment quality are not affected.

PAG rock will not be used in the construction of TMF diversion ditches, and there will be no PAG rock used in the dams. The only exception is the upstream face of the WSD, since water from within the WSF will be passed through the WTP prior to discharge to the environment. Dams will be constructed of non-PAG floatation tailing. CIL tailing will be deposited in the centre of the impoundment (Centre Cell TMF) which will be lined, where it will be covered by water. The dam will be constructed with a compacted till core that will prevent the movement of acid-generating water to the outside face of the dam. Any seepage water that leaves the impoundment will be collected in seepage collection ponds downstream of the dams and will be pumped back into the TMF.

The Water Management Plan (Section 26.17) will be implemented to control water movement in the PTMA, including the diversion of non-contact water away from the TMF. Contact water (i.e., water that has been in contact with Project infrastructure) will be channelled into the TMF.

The ML/ARD Management Plan (Section 26.14) outlines measures that will be implemented to decrease the potential for effects due to acid generation and subsequent mobilization of metals associated with PAG rock.

For the Mine Site components, all PAG rock will be directed to the RSFs. Most of the pit walls, block caves, and rock within the storage facilities will be acid generating, and seepage from the tunnels may also be acidic. The contact water within the tunnel, pits, block caves, ore stockpiles, and RSFs will be collected and diverted to the WSF (creating a point source of acidic water and metals, see below). During closure, the Mitchell Pit, Mitchell Block Cave Mine, and the Iron Cap Block Cave Mine will be flooded to minimize the surface area of the walls exposed to oxidation and the potential for leaching.

The Water Management Plan details the use of diversion tunnels and channels to minimize the amount of non-contact water (i.e., water that has not been in contact with PAG or Project infrastructure) away from the WSF. Currently, the water in Mitchell Creek is naturally acidic with high metal content due to the geology of the watershed (Chapter 14). Water from the Mitchell Creek headwaters will be collected in two separate systems: one for water that has been exposed to the PAG deposits or mine infrastructure (contact water), and the other a diversion system for water that has not been exposed to PAG deposits or mine infrastructure (Section 26.17). Water that has been exposed to PAG and is expected to be acidic with high metal content will be directed toward the WSF and WTP on Mitchell Creek. The Mitchell Diversion Tunnels (MDT) will collect water that is not expected to be acidic. The diverted water from Mitchell Creek headwaters will be directed from the Mitchell watershed to the Sulphurets watershed. Similarly, diversion channels will collect water, primarily from precipitation, and route it away from the catchment of the RSFs and mining areas. The diverted water will be returned to the Mine Site waterways below the WSF and WTP discharge point.

Mitigation for Metals from Point Sources

The ML/ARD Management Plan (Section 26.14) outlines measures that will be implemented to decrease the potential for impacts due to acid generation and subsequent mobilization of metals associated with PAG rock.

Discharge from the TMF may occur during operation, closure, and post-closure. To mitigate the potential for effects from TMF discharges, effluent will be separated into two streams. The poorer quality effluent containing tailing and cyanide from ore processing (cleaner or sulphide tailing) will be stored sub-aqueously (3-m water depth) in the Centre Cell TMF, and will not be discharged. The remaining effluent containing tailing will be stored in either the North Cell or South Cell. Effluent discharge from the North or South cells during the operation and closure phases will be closely managed so it will match the receiving environment hydrology (Chapter 14). Discharges from the TMF will only occur between May and October, with discharge volumes staged to match the hydrological regime of the receiving environment. Seepage and runoff water from each tailing dam will be collected at small downstream seepage recovery dams and pumped back to the TMF.

During the operation phase of the Project, discharge from the TMF will be directed to different receiving environments as part of a water management plan to minimize the potential for impacts to the aquatic environment. One of the goals of the TMF discharge regime was the protection of water quality in Teigen Creek, with populations of all four VC fish species and greater fisheries values as compared to other streams in the area. For a description of annual flows and potential effects to surface water quantity, see Chapter 13. Discharge from the North Cell of the TMF will be initially directed to Treaty Creek, with a shift to discharging to North Treaty Creek at approximately year 25 of the operation phase. After approximately year 45, discharge from the North Cell will be re-directed to South Teigen Creek. For the South Cell, discharge will be to Treaty Creek during the operation phase, with a shift of discharge to North Treaty during the closure phase (approximately Year 55) once water quality in the South Cell is acceptable. During the closure/post-closure phase, the Centre Cell of the TMF will be opened (once water quality is acceptable), diversion structures will be removed, and the hydrological regime out of the TMF to both South Teigen and North Treaty creeks will be returned to near-baseline conditions to the extent possible.

When mining ceases, the carbon-in-leach (CIL) pond containing the cleaner (sulphide) tailing will be capped with a flotation (rougher) tailing layer, and flooded with at least 5 m of water after closure (Section 26.14; Chapter 27). The TMF will be flooded with freshwater from rainfall, snowmelt, and glacier melt, such that the PAG tailing material is enclosed by water in perpetuity. This will minimize the potential for acid generation associated with the tailing material. Implementation of the Water Management Plan (Section 26.17) will ultimately ensure the return of drainage patterns that are more similar to pre-mining configuration, once water quality targets are met within the TMF during the closure or post-closure phases. Water treatment may also be installed at the TMF to ensure that water quality meets targets during closure and post-closure.

For the Mine Site, a number of mitigation measures will be implemented under the ML/ARD Management Plan (Section 26.14). As noted above, water that has been in contact with PAG or mine infrastructure within the catchment area for the WSF will be directed to the WSF. This water may be expected to be acidic and contain higher concentrations of metals. In the Mine Site WTP, a conventional high-density sludge lime water treatment process will be applied to water collected in the WSF to decrease the concentrations of some metals (including selenium), TSS, and some ions, and adjust the pH from acidic to a more neutral pH (Chapter 14). Discharges from the WTP will occur in all phases of the Project year-round and will be closely managed so that they are matched to the receiving environment hydrology to minimize potential for effects in the receiving environment. A seepage pond downstream of the WSF will be constructed, and water collected in this pond will be sent back to the WTP. In addition, treatment of drainage from the Sulphurets Pit (backfilled with Kerr waste rock and covered to reduce infiltration rates) in a specific selenium treatment plant using exchange technology. Following this treatment to reduce selenium concentrations, this effluent will then be pumped to the Mine Site WTP for additional treatment prior to discharge. The potential for effects of discharged water will be monitored regularly through the implementation of an Aquatic Effects Monitoring Plan (Section 26.18.2).

15.7.4.2.3 Mitigation for Process Chemicals

The handling and storage of all process chemicals will follow BMPs, and general transportation, storage, and handling requirements that are outlined in the Dangerous Goods and Hazardous Materials Management Plan (Section 26.7). While spills are not specifically considered in this chapter, the Spill Prevention and Emergency Response Plan (Section 26.10) will be implemented to quickly respond to and mitigate any unintended release or spill of chemicals that may affect the aquatic environment.

The use of cyanide in ore processing means that there may be some cyanide present in the tailing generated in the Treaty Process Plant. Cyanide transportation, storage, and use will be consistent with the International Cyanide Management Code (ICMC 2012) and is discussed in Section 26.7, Dangerous Goods and Hazardous Materials Management Plan. The cyanide-containing tailing released from the Plant will be contained within the lined Centre Cell TMF where seepage can be prevented, and not discharged until post-closure when water quality in the pond is acceptable.

The concentration of the flocculant is expected to be below levels that would cause adverse effects to aquatic life. Flocculant use would likely occur at concentrations of less than 10 mg/L; even if all of this flocculant was assumed to pass directly through the Mine Site WTP or temporary WTPs, it would still be below lethal concentrations for fish and invertebrates. When flocculant use is necessary, compounds with lower toxicity (non-ionic or anionic flocculants) will preferentially be used.

15.7.4.2.4 Mitigation for Petroleum Products

Petroleum products will be in use during construction, operation, and closure phases. To minimize the effects on aquatic life and their habitats, several mitigation measures relating to petroleum products will be required. Mitigation strategies will be tailored to address Project-specific issues associated with petroleum product introduction into aquatic environments. Mitigation objectives outlined in accordance with DFO Land Development Guidelines for the Protection of Aquatic Habitat (DFO 1993), BC MOE Standards and Best Practices for Instream Works (BC MOE 2004), and Pacific Region Operational Statements (DFO 2010) all provide guidelines for the mitigation of petroleum product effects and spills on the aquatic environment.

Petroleum product introduction into the aquatic environment will be mitigated in the LSA and RSA through the implementation of BMPs, particularly in the construction and operation stages. BMPs relating to petroleum spills are described in detail under the Spill Prevention and Emergency Response Plan (Section 26.10) and are discussed in the Fish and Aquatic Habitat Effects Protection and Mitigation Plan (Section 26.18.1). The Spill Prevention and Emergency Response Plan will provide performance-based environmental specifications for preventing and controlling the release of spills during the construction, operation, and closure phases to minimize adverse effects to downstream water quality. These measures will be monitored and modified, as necessary, to ensure compliance with regulatory requirements and BMPs. When in-water work occurs, an Environmental Monitor will be on site monitoring water quality, and appropriate fisheries operating window requirements for fish-bearing streams will be adhered to. In certain circumstances, instream work may need to occur outside of the Least Risk Windows. Therefore, necessary permits will be obtained from appropriate agencies and work will comply with necessary conditions.

Specific BMPs relating to the mitigation and/or minimizing of effects caused by petroleum product introduction into the aquatic environment include environmental monitoring, adhering to appropriate construction operating windows for instream work, spill control measures, and an emergency response plan. Spill control measures will include, but will not be limited to, fuel stored in bermed and lined containment facilities to prevent seepage into the soil, spill kits, equipment maintenance, stream setback distances for construction, and application of a hydrocarbon management plan for fuel use when working within or near streams.

15.7.4.2.5 Mitigation for Nitrogen and Phosphorus

Blasting and discharge of effluent from STPs will occur during the construction, operation, and closure phases. To minimize the effects on aquatic life and their habitats, several mitigation measures relating to blast residues will be required. Mitigation strategies will be tailored to address Project-specific issues associated with blasting residues. Mitigation objectives outlined within Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters (Wright and Hopky 1998), DFO Land Development Guidelines for the Protection of Aquatic Habitat (DFO 1993), BC MOE Standards and Best Practices for Instream Works (BC MOE 2004), and Pacific Region Operational Statements (DFO 2010) all provide guidelines for the mitigation of blast residue effects on the aquatic environment.

Blasting residues will be mitigated in the LSA through the implementation of BMPs, particularly in the construction and operation stages. BMPs relating to blast residues are described in the Explosives Management Plan (Section 26.8), Erosion Control Plan (Section 26.13.2), and the Fish and Aquatic Habitat Effects Protection and Mitigation Plan (Section 26.18.1). The plans will provide performance-based environmental specifications for preventing and controlling the blast residue during the construction and operation phases to minimize adverse effects to downstream water quality. These measures will be monitored and modified, as necessary, to ensure compliance with regulatory requirements and BMPs. When blasting occurs near waterbodies, an Environmental Monitor will be on site monitoring water quality. Blasting residue control measures will include, but will not be limited to, equipment maintenance, site isolation techniques, and stream setback distances for blasting.

The construction of diversion channels surrounding the TMF will intercept surface water and then direct the water to fish-bearing reaches of South Teigen and North Treaty creeks below the dams. These diversion ditches will be lined with excavated and/or blasted rock. The starter dams will be constructed with till material, which will not have blast residue. The rock used to construct the diversion ditches and portions of the TMF dams may contain blast residues. These residues may enter the water during precipitation events as runoff from the dams, or when the diversion ditches are constructed and surface water is directed toward South Teigen and North Treaty creeks. Runoff from the TMF dam will be collected within the seepage ponds below the TMF dams to mitigate runoff effects.

There will be blasting associated with the Mine Site components such as pits, diversion ditches, and diversion tunnels. RSFs, overburden storage areas, diversion ditches, and the WSD will be lined with excavated and/or blast rock. Therefore, the rock material used to construct the diversion ditches, diversion tunnels, dams, and storage areas may contain blast residues. Mitigation and control of residues will vary depending upon the Project component. During the construction phase, aeration systems will be used within the temporary water treatment facilities to increase ammonia volatilization, thereby decreasing loadings generated from explosives use. During operation, diversion ditches carrying contact water from within the pits and RSFs will be directed toward the WSF. Runoff from the WSD will be collected within the seepage ponds below the dam to mitigate runoff effects. Outside of the WSF catchment area, blasting residues will be controlled and mitigated for in diversion ditches and tunnels, through adherence to an Erosion Control Plan (Section 26.13.2), with the use of settling ponds during construction before discharge into Sulphurets Creek.

If further attenuation of water quality parameters is required as demonstrated by the results of the Aquatic Effects Monitoring Plan (Chapter 26, Section 26. 18.2), the WTP effluent may be discharged to a constructed wetland that will drain to lower Mitchell Creek (Figure 4.5-67A). Some attenuation of water quality parameters (i.e., nutrients) is expected. The effects assessment and water quality modelling, however, did not consider this potential reduction in concentration of water quality parameters as the constructed wetland will only be implemented as an adaptive management response and may not be required.

To minimize the effects on aquatic life and their habitats, several mitigation measures relating to sewage effluent will be required. Each temporary construction camp and both of the operating camps will have STPs, with subsequent disposal of the effluent in a manner that is acceptable to regulatory agencies. Effluent quality standards of the Municipal Wastewater Regulation (BC Reg. 87/2012) or the Sewerage System Regulation (BC Reg. 326/2004) will be met, and monitoring programs will be implemented as required by the applicable regulation. BMPs will be followed during the construction, operation, maintenance, and closure of STPs to ensure the protection of aquatic environments.

Effluent from the STPs for most of the construction camps will include ground disposal systems that meet requirements for setback from waterbodies to prevent any effects to surface waters. Secondary-treated effluent from the STPs for camps 4, 9, and 10, and for the Mitchell operating camp will be discharged to Mitchell Creek or Sulphurets Creek; effluent from the STP at Camp 6 will be discharged to Upper Treaty Creek. This is not expected to have an effect outside of the initial dilution zone due to high dilution ratios, existing poor sediment and water quality in these areas, limited aquatic life (periphyton and benthic invertebrates), and the absence of fish in these areas (refer to Sections 15.1.4 and 15.1.5). Secondary-treated effluent from Camp 5 (construction camp) and Treaty operating camp will be discharged within the TMF. Fish or aquatic habitat exposure to sewage effluent spills or leaks to streams are not expected to occur with proper design and engineering of the sewage disposal systems.

15.7.4.3 Potential for Residual Effects

15.7.4.3.1 Potential for Residual Effects due to Metals

Metals from Non-point Sources

By implementing the ML/ARD Management Plan (Section 26.14) and other mitigation measures outlined in Section 15.7.4.2.2, the effects of ML/ARD on fish and aquatic habitat are predicted to be minimal for non-point sources such as access roads. However, localized effects during sporadic events, such as during the time between when ML/ARD release is recognized and when mitigation measures are implemented, cannot be ruled out during any of the phases of the Project. During this time, ML/ARD may be able to enter waterways, resulting in potential effects on aquatic habitat and fish.

Tailing Management Facility Discharges

Discharge from the TMF will occur during the operation, closure, and post-closure phases, and may contain varying concentrations of metals, process chemicals, and unsettled tailing fines. Water quality modelling was conducted to predict the concentrations of the various metals and some process chemicals (e.g., cyanide) due to TMF discharges (Chapter 14; Appendix 14-H). Unless otherwise noted, throughout this section any reference to a predicted metal concentration in water refers to the total metal concentration, and any reference to guidelines means the BC water quality guidelines for the protection of aquatic life (BC MOE 2006a, 2006b). Details of the water quality model, analysis, and comparisons are provided in Chapter 14, Surface Water Quality. Sediment loading assessment was done to determine if unsettled tailing fines were likely to affect sediment quality in areas downstream of the TMF.

In ecological risk assessment, the calculation of a hazard quotient (HQ) can be a useful screening tool for determining the potential for a chemical to cause toxicity in receptors, such as aquatic life or fish, in the receiving environment (US EPA 1998). An HQ is most often calculated as a ratio of the concentration of a chemical (either a measured or predicted concentration) compared to the relevant guideline value. An HQ of greater than 1.0 can indicate that there may be a potential for effects in receptors, while an HQ of less than 1.0 is considered to not carry additional risk of toxicity to receptors. This approach was used to screen for potential residual effects related to discharge from either the TMF or Mine Site WTP (see next section) using predicted water concentrations from the water quality model.

However, during baseline studies of water quality at the KSM Project, it was found that the concentrations for a number of metals exceeded BC water quality guidelines for the protection of aquatic life (Chapter 14). In this case, comparison of predicted concentrations from the water quality model to concentrations specified in the guidelines may not be informative since the HQ during baseline studies would already be greater than 1.0. For these metals, the calculation of an HQ based on background concentrations of the metal can provide a good indicator of the potential for incremental change in potential residual effects that may occur due to Project-related activities.

Mercury and selenium are unique among metals in that their primary route of uptake is through the diet (Chapman et al. 2009; Kidd and Batchelar 2012). This means that increase in water concentration of mercury or selenium relative to baseline concentrations can pose a risk to aquatic organisms since these metals can then be accumulated through the food chain, even if water quality guideline limits are met. This may be a concern in the KSM Project LSA, since whole body fish tissue residues greater than BC tissue residue guideline (BC MOE 2006b) limits were measured during baseline studies for these two metals (Table 15.7-4). For selenium and mercury, increases in water concentration relative to baseline conditions may lead to additional uptake and accumulation via the food chain, which was also considered when assessing the water quality model results.

HQs are only useful as a screening tool to determine the potential for residual effects, and they should not be used to assess the magnitude of potential effects (i.e., an HQ of 8 is not necessarily worse than an HQ of 2; US EPA 1998). For metals where the calculated HQ was greater than 1.0 (based on either guideline limits or background concentrations, whichever is appropriate), more detailed consideration of the potential for residual effects is needed. Factors such as uncertainty in guideline limits (e.g., due to safety factors or the underlying studies used to derive the guidelines), the sensitivity of potential receptors in the receiving environment, or other Project-specific information (e.g., uncertainty in the predicted concentrations or other factors that may affect the metal concentration or toxicity) should be considered when determining the true potential for residual effects due to Project activities.

For the purposes of residual effects assessment, the expected case of the water quality model was considered. These predictions are based on average water chemistry and hydrology and represent the water quality that is most likely to occur during the operation, closure, and post-closure phases of the Project. Water quality predictions based on other scenarios, such as during wet years or dry years, are available in Chapter 14 but are not discussed further in this chapter, and were not assessed for potential residual effects to fish and aquatic habitat.

Concentrations of some water quality parameters, including total chromium, total copper, and total iron, appear to increase above baseline concentrations and water quality guidelines in South Teigen Creek in some months during various Project phases for the expected case (Appendix 14-H). However, flows in South Teigen Creek are predicted to be reduced as a result of operation of the TMF (see Section 15.7.5.1 or Chapter 13). This suggests that the predictions of elevated concentrations of these metals are an artifact of mass balance modelling as the baseline load in the predicted lower flow is calculated in the model to be greater than the baseline concentration. Mitigation including controlling seepage beyond the North Cell seepage collection dam and the commitment to not discharge water to South Teigen Creek until receiving environment targets are met (see Section 26.17, Water Management Plan) will ensure that concentrations of metals in South Teigen Creek will not increase above baseline concentrations.

Downstream of the TMF, the concentration of selenium is expected to be below water quality guidelines. However, in some months it is expected to increase slightly compared to baseline concentrations in North Treaty Creek (NTR2, HQ equals 1.1 to 1.3) and South Teigen Creek (STE3), which are closest to the TMF (Table 15.7.-5) during various phases of the Project. It is possible that these slight increases in predicted selenium water concentrations relative to baseline concentrations in North Treaty or South Teigen creeks may pose a risk to aquatic organisms, since increased uptake may be possible if the additional selenium enters the food chain. However, it is unlikely that fish tissue residues would approach toxicity thresholds, since water selenium concentrations are predicted to be below water quality guidelines in these creeks. Selenium water concentrations in Treaty Creek (TRC2) and Teigen Creek (TEC2) are predicted to remain at or below baseline levels (Table 15.7-5) and well below guideline limits.

Mine Site Water Treatment Plant Discharges

The WSF stores metal-laden, potentially acidic contact water collected throughout the Mine Site. This water is subsequently passed through the WTP, which discharges treated water to Lower Mitchell Creek. Water flows from Mitchell Creek into Sulphurets Creek, then into the Unuk River, and ultimately to the Pacific Ocean. Controlled, staged discharges from the WTP are planned during all Project phases, which have the potential to release metals into the receiving environment.

Water quality modelling was conducted to predict the total concentrations of the various metals (plus concentrations of dissolved aluminum and iron) due to discharges from the WTP (Chapter 14; Appendix 14-H). Unless otherwise noted, throughout this section any reference to a predicted metal concentration in water refers to the total metal concentration, and reference to the guidelines means the BC water quality guidelines for the protection of aquatic life (BC MOE 2006a, 2006b). Details of the water quality model, analysis, and comparisons are provided in Chapter 14. The same screening level approach described in the preceding section (i.e., screening with HQs) for TMF discharges was used in assessing the potential for residual effects due to Mine Site WTP discharges.

Table 15.7-5. Hazard Quotients for Selenium in Water Downstream of the Tailing Management Facility, KSM Project

Year	Month	North Treaty (NTR2)	Treaty (TRC2)	South Teigen (STE3)	Teigen (TEC2)
Operation Years 0 to 50	January	0.9	1.0	1.0	0.8
	February	1.2	1.0	1.0	0.8
	March	0.9	0.9	0.9	0.8
	April	0.9	0.9	1.1	0.8
	May	0.8	1.0	1.3	0.6
	June	0.9	1.0	1.0	0.8
	July	0.8	0.9	0.9	0.7
	August	0.8	1.0	0.8	0.8
	September	0.9	0.5	1.0	0.8
	October	0.9	0.7	1.0	0.7
	November	1.0	0.9	0.9	1.0
	December	1.0	1.0	0.9	0.9
Closure Years 50 to 55	January	1.0	1.0	0.9	0.8
	February	1.3	1.0	0.9	0.8
	March	1.0	0.9	0.8	0.8
	April	0.9	0.9	1.0	0.8
	May	0.8	1.0	1.3	0.6
	June	1.0	0.9	0.9	0.8
	July	0.8	0.8	0.8	0.7
	August	0.8	0.9	0.7	0.8
	September	1.0	0.5	0.9	0.8
	October	1.0	0.6	0.9	0.7
	November	1.0	0.9	0.8	1.0
	December	1.1	1.0	0.8	0.9
Post-closure Years >55	January	1.0	1.0	0.9	0.8
	February	1.3	1.0	0.9	0.7
	March	1.0	0.9	0.7	0.7
	April	1.0	0.9	1.1	0.8
	May	1.0	1.0	1.5	0.7
	June	1.1	0.9	0.9	0.8
	July	0.9	0.6	0.8	0.7
	August	0.9	0.8	0.6	0.8
	September	1.0	0.5	0.8	0.8
	October	1.1	0.6	0.8	0.7
	November	1.1	0.9	0.8	1.0
	December	1.1	1.0	0.8	0.9

Notes:
The HQ provided for each month is the mean HQ for those months for a given phase of Project activities.
Hazard quotients were calculated as base case (mean) predicted concentrations relative to baseline (mean) concentrations.
Selenium water concentrations are predicted to be below water quality guideline (BC MOE 2006a, 2006b) limits in all phases and HQs for predicted concentrations are less than 1.0 relative to guideline limits during all months.

For the purposes of residual effects assessment to fish and aquatic habitat, the expected case of the water quality model was considered. The predictions of the expected case water quality model are based on average water chemistry and hydrology and represent the water quality that is most likely to occur during the operation, closure, and post-closure phases of the Project. Water quality predictions based on other scenarios, such as during wet years or dry years, are available in Chapter 14 but are not discussed further here and were not assessed for potential residual effects to fish and aquatic habitat.

During the construction phase, water quality modelling (Table 14.7-9) indicates that the concentrations of most metals and other parameters in the WSF will be up to an order of magnitude lower than that of the operation phase, and therefore are not considered to have potential for residual effects (Section 14.7.1.2). This assessment from the water quality section (Chapter 14) is carried through to the potential for residual effects to fish and aquatic habitat, so discharges from the WTP during the construction phase are ruled out as having no potential for residual effects. All other phases (operation, closure, and post-closure) were assessed for their potential for residual effects to fish and aquatic habitat.

During the operation, closure, and post-closure phases, following water treatment in the Mine Site WTP, water concentrations of most metals (e.g., arsenic, cadmium, lead, mercury, and others) are expected to decrease as a result of water storage in the WSF followed by water treatment in the WTP, which will have an overall improvement in downstream water quality in relation to baseline conditions in Sulphurets Creek and the Unuk River (see Chapter 14). Over time, this may lead to decreased concentrations of metals in sediments downstream of the Mine Site WTP (see sediment quality modelling below and the discussion of partitioning coefficients between sediment and water).

However, even with the implementation of mitigation measures outlined in Section 15.7.4.2.2, concentrations of a few metals are expected to increase relative to either guideline or background concentrations in the receiving environment downstream of the WSF/WTP (i.e., HQ greater than 1.0), and these metals may pose a risk to aquatic organisms. These metals were also identified in Chapter 14 based on the comparison of water quality model predictions to baseline concentrations or guideline limits using the criterion that metals with HQs greater than 1.0 warrant further consideration to determine if there is true potential for residual effects.

For the waterways downstream of the Mine Site, the water quality model predicts that the water concentrations of dissolved aluminum, copper, total iron, and selenium may increase above both guideline and background concentrations under normal Project activities in some areas of Sulphurets Creek and the Unuk River (Chapter 14). Concentrations of these and all other metals are predicted to be below BC water quality guidelines at the UR2 site on the Unuk River, located near the border with the United States. Since all metal concentrations were predicted to meet guideline limits for freshwater at this point, there is no risk of concentrations being greater than water quality guidelines in the marine environment since marine water quality guidelines are generally the same or higher than the respective freshwater guideline limits. Therefore, effects of metals on the marine receiving environment where the Unuk River meets the Pacific Ocean are not considered further in this assessment.

Concentrations of dissolved aluminum were predicted to be periodically elevated at the SC3 site on Sulphurets Creek downstream of the Mine Site WTP, in December of each phase with an HQ of 1.3 or 1.4 (Appendix 14-H). The HQs upstream on Sulphurets Creek at SC2 and downstream in the Unuk River at both UR1 and UR2 were all less than 1.0, indicating that residual effects in these areas are unlikely. As discussed in Chapter 14, given the circum-neutral pH of Sulphurets Creek, natural attenuation processes (including precipitation of aluminum oxyhydroxides) are likely to reduce dissolved aluminum concentrations to below the water quality guideline (Langmuir 1997). Therefore, dissolved aluminum was not considered to contribute to potential residual effects to fish and aquatic habitat.

The concentration of total iron at SC2 was predicted to be elevated only during December of the closure phase (HQ of 1.1). However, dissolved iron had an HQ of less than 0.3, indicating that it would be below guideline limits or baseline concentrations. The BC MOE technical appendix document for total iron indicates that the guideline of "1 mg/L may be overly protective" and that exceedance of the total iron guideline without exceedance of the dissolved iron guideline is of lower concern than the converse (Phippen et al. 2008). Since most of the projected total iron concentrations are only slightly above guideline limits (i.e., an HQ of 1.1), occur sporadically, are localized to the stream monitoring sites closest to the Mine Site WTP, and do not extend to the site slightly farther downstream (SC3), and since dissolved iron does not exceed guideline limits, sublethal effects to fish or aquatic habitat are predicted to be minimal. Therefore total iron was not considered to contribute to the potential for residual effects to fish and aquatic habitat.

For copper at SC2 (closure phase), SC3 (closure and post-closure phases), and UR2 (operation, closure, and post-closure), HQs were 1.1 during December only (Chapter 14). Further investigation indicated that these predictions may be a result of uncertainties in the model due to monthly inputs in flow and concentration values (Chapter 14). In addition, the potential for residual effects for copper is likely overestimated, since the mass balance model was based on the conservative assumption that water hardness would remain the same as during baseline studies. This is not expected to be the case, since calcium concentrations downstream of the Mine Site WTP are predicted to increase as a result of lime use in the WTP. Copper toxicity decreases with increasing water hardness, which is reflected by the hardness-dependent BC water quality guideline for copper (Singleton 1987). Therefore, copper was determined to be unlikely to contribute to a residual effect and was eliminated from further consideration of residual effects.

Mercury and selenium are unique among metals in that their primary route of uptake is through the diet (Chapman et al 2009; Kidd and Batchelar 2012). This means that increases in water concentration of mercury or selenium over baseline concentrations can pose a risk to aquatic organisms since these metals can then be accumulated through the food chain, even if water quality guideline limits are met. This may be a concern in the KSM Project LSA, since whole body fish tissue residues greater than BC tissue residue guideline limits were measured during baseline studies for these two metals (Table 15.7-4).

As noted in Table 15.7-4, whole body fish tissue mercury levels were elevated in some fish collected from the Unuk River (UR1) during baseline studies. Mercury concentrations are not expected to increase as a result of Project activities on the Mine Site and will remain below baseline concentrations throughout the modelled time frame under normal conditions at the four sites downstream of the Mine Site WTP. Accordingly, fish tissue mercury concentrations would not be expected to increase.

Downstream of the WTP, the concentration of selenium is expected to be higher than water quality guidelines at the SC2 and SC3 sites and sporadically at the UR1 site during all phases of the Project. It is predicted to meet water quality guidelines at the UR2 site just before the United States border during all phases of the Project. Selenium concentrations in water are predicted to be greater than the baseline water concentrations at all four sites (SC2, SC3, UR1, and UR2) during all phases of the Project. Table 15.7-6 provides a summary of the hazard quotients for selenium compared to both guideline and baseline concentrations.

Table 15.7-6. Hazard Quotients of Selenium Downstream of the Mine Site, KSM Project

		Sulphurets (SC2) Selenium		Sulphurets (SC3) Selenium		Unuk River (UR1) Selenium		Unuk River (UR2) Selenium	
Year	**Month**	**Guideline**	**Baseline**	**Guideline**	**Baseline**	**Guideline**	**Baseline**	**Guideline**	**Baseline**
Operation Years 0 to 50	January	1.95	1.66	1.6	2.8	0.9	1.5	0.5	1.5
	February	2.03	1.73	1.8	2.1	1.0	1.4	0.5	1.4
	March	2.09	1.57	1.8	4.4	0.9	1.1	0.5	1.3
	April	2.26	1.48	1.4	3.2	0.8	1.0	0.5	1.1
	May	2.22	1.14	1.8	3.9	0.7	1.2	0.5	1.1
	June	2.75	2.53	2.4	6.0	1.0	2.3	0.6	1.5
	July	2.54	1.70	2.4	3.3	1.2	1.4	0.6	1.7
	August	2.11	3.49	1.8	4.5	1.1	3.2	0.7	2.9
	September	1.76	2.36	1.7	1.3	1.2	1.5	0.7	1.3
	October	2.55	2.02	2.4	3.2	1.1	1.9	0.5	1.7
	November	2.51	2.12	2.2	5.5	1.0	1.5	0.5	1.5
	December	2.65	1.98	2.5	5.0	1.1	1.6	0.6	1.3
Closure Years 50 to 55	January	1.9	1.6	1.5	2.6	0.8	1.3	0.4	1.4
	February	2.3	1.9	1.9	2.3	1.0	1.5	0.5	1.4
	March	2.4	1.8	2.1	5.0	1.0	1.2	0.6	1.4
	April	2.8	1.8	1.8	4.2	0.9	1.1	0.5	1.2
	May	2.9	1.5	2.4	5.1	0.9	1.4	0.6	1.2
	June	3.5	3.2	3.0	7.5	1.2	2.7	0.7	1.7
	July	3.3	2.2	3.0	4.2	1.4	1.7	0.7	1.9
	August	2.6	4.3	2.2	5.4	1.3	3.6	0.7	3.3
	September	1.4	1.9	1.4	1.1	1.0	1.3	0.5	1.1
	October	1.4	1.1	1.4	1.8	0.7	1.1	0.4	1.1
	November	1.9	1.6	1.6	4.2	0.7	1.2	0.4	1.3
	December	2.4	1.8	2.3	4.5	1.0	1.4	0.5	1.2

(continued)

Table 15.7-6. Hazard Quotients of Selenium Downstream of the Mine Site, KSM Project (completed)

		Sulphurets (SC2) Selenium		Sulphurets (SC3) Selenium		Unuk River (UR1) Selenium		Unuk River (UR2) Selenium	
Year	Month	Guideline	Baseline	Guideline	Baseline	Guideline	Baseline	Guideline	Baseline
Post-closure Years >55	January	1.5	1.3	1.2	2.2	0.7	1.2	0.4	1.2
	February	1.8	1.5	1.6	1.9	0.9	1.3	0.4	1.2
	March	1.9	1.4	1.7	4.0	0.9	1.0	0.5	1.2
	April	2.2	1.5	1.3	3.2	0.8	0.9	0.5	1.1
	May	2.3	1.2	1.8	3.9	0.7	1.2	0.5	1.1
	June	2.9	2.7	2.6	6.3	1.1	2.4	0.6	1.6
	July	2.5	1.7	2.4	3.3	1.2	1.4	0.6	1.7
	August	2.0	3.3	1.8	4.3	1.0	3.0	0.6	2.8
	September	1.8	2.4	1.8	1.4	1.2	1.5	0.7	1.4
	October	2.7	2.2	2.6	3.4	1.2	2.0	0.6	1.8
	November	2.2	1.9	1.9	4.9	0.9	1.4	0.5	1.4
	December	2.4	1.8	2.3	4.7	1.1	1.5	0.5	1.3

Notes:
The hazard quotient (HQ) provided for each month is the average HQ for those months for a given phase of Project activities.
HQs were calculated as base case (average) predicted concentrations relative to BC water quality guidelines for the protection of aquatic life (Guideline; BC MOE 2006a, 2006b) or baseline (mean) concentrations (Baseline; Chapter 14).

Based on the initial HQ screening and the subsequent individual assessments of the metals with HQs greater than 1.0 (i.e., dissolved aluminum, copper, and total iron), selenium is the only metal that was identified as having the potential for residual effects in the water downstream of the Mine Site WTP.

Sediment Quality Assessment

Discharges from the TMF or WTP have the potential to alter sediment quality, which may in turn affect aquatic organisms or fish that live in, on, or near the sediment. Determination of the potential effects to sediment quality by discharges was assessed based on: 1) the potential loadings of total metals; and 2) consideration of the partitioning coefficients (K_d) between sediment and water under baseline conditions. TSS was used as a surrogate of the potential for metal loading to sediments downstream of the TMF or WTP discharge points, since a proportion of the total metal concentrations measured in water are associated with or bound to the TSS. Partitioning coefficients are useful for describing the general relationship between concentrations of dissolved metals in water and sediments measured in the sediment. A summary of the results are presented below, with the details of the methodology and results provided in a technical memo in Appendix 15-L.

Effects to Sediment Quality from Tailing Management Facility Discharges

TSS was used as a surrogate to determine the potential for TSS-bound metals to change the physical and chemical properties of sediments downstream of the TMF. The potential for effects to Teigen Creek was not modelled because there are no discharges to the creek during the

Project's operation phase, and because baseline TSS in the creek was lower than the TSS estimated in TMF or diversion channel discharges (Chapter 14). To assess the effects of introducing unsettled fine tailing particles (TSS) on the sediment in Treaty Creek, baseline sediment loadings were calculated ("baseline scenario") and compared to the estimated sediment loadings during the Project operation phase ("mine scenario"). The total sediment loads at the TRC2 site in Treaty Creek were estimated using mean baseline monthly TSS and mean stream discharge rates (modelled data) measured over four years (2007 through 2011) for all upstream areas that may contribute loading to the site. For the baseline scenario this included inputs from North Treaty Creek, Upper Treaty Creek, and the catchment area for TRC2 (the area not included in the other two inputs).

For the mine scenario, inputs included the same sites as in the baseline scenario, plus potential additional inputs from diversion structures and the TMF discharge. For the mine scenario, the monthly flow rate for these areas during the Project operation phase was based on modelled hydrology data (Appendix 15-L; Chapter 13). For the sites included in the baseline scenario, TSS was assumed to be unchanged due to mining activities and therefore was considered to be the same as the baseline for those sites. TSS of the diversion water was estimated to be 20 mg/L in the wintertime and 75 mg/L in the summertime. The TSS of the TMF discharge was assumed to meet the requirements of the MMER (SOR/2002-222) and potential discharge permits, and therefore a conservative estimate of 15 mg/L was used in determining the TSS mass loadings from the TMF.

For Treaty Creek, the TSS loading calculations indicate that the TSS input to the TCR2 site is predicted to decrease during the Project operation phase compared to baseline conditions (see details in Appendix 15-L). This is because the discharge from the TMF is expected to meet the requirements for less than 15 mg/L TSS in the effluent, and TSS controls will be used in diversion structures, which will decrease the load of suspended solids compared to the background concentrations of TSS. Results indicate that the monthly TSS load will be reduced by approximately 3% (winter) to 11% (summer) during the Project operation phase relative to baseline conditions as a result of the controlled TSS inputs from the TMF and diversions.

Based on these findings, Project activities are not expected to increase sediment loading to downstream areas. Therefore, sediment metal concentrations are not predicted to increase the deposition of TSS-bound metals since TSS concentrations are predicted to decrease. It is possible that the sediment loading downstream in Sulphurets Creek will decrease as a result of TSS control measures that will be implemented at the WTP and the diversion structures.

Effects to Sediment Quality from Water Treatment Plant Discharges

Similar procedures were used to develop an estimate of sediment loading to Sulphurets Creek at the SC2 site, downstream of the Mine Site WTP discharge point (Appendix 15-L).

To assess the effect of introducing fine tailing particles on the sediment in Sulphurets Creek at the SC2 site, baseline sediment loadings were calculated ("baseline scenario") and compared to the estimated sediment loadings during mining ("mine scenario"). For the baseline scenario, the total sediment loads at the SC2 site were estimated using mean baseline monthly TSS measured at each site and mean stream discharge rates (measured or modelled; Chapter 13) at upstream sites (GC1 on Gingras Creek; MC2 on Mitchell Creek; SC1 on Upper Sulphurets Creek; catchment area of SC2). For the mine scenario, these same sites were included plus potential additional inputs from the McTagg Twinned Diversion Tunnels (MTDT), the MDT, and the WTP discharge.

The mine scenario considered the modelled average monthly discharge rates that were predicted for each of the locations (Chapter 13). For the mine scenario, the TSS for the sites included in the baseline scenario were assumed to be unchanged due to Project activities and therefore are the same as the TSS used in the baseline scenario. TSS of water in the diversion tunnels were estimated to be 20 mg/L in the wintertime and 75 mg/L in the summertime. The TSS of the WTP discharge were assumed to meet the requirements of the MMER (SOR/2002-222) and potential discharge permits, and therefore a conservative estimate of 15 mg/L was used in determining the TSS mass loadings from the WTP.

The TSS loading calculations indicate that the TSS loads at SC2 are predicted to decrease during the operation phase of the Project compared to baseline conditions (see details in Appendix 15-L). This is because the discharge from the WTP is expected to meet the requirements for less than 15 mg/L TSS in the effluent, and TSS controls will be used in diversion structures, which will decrease the load of suspended solids compared to the background concentrations of TSS. Results indicate that the monthly TSS load will be reduced by 30% on average in the winter to 56% in the summer during the Project operation phase relative to baseline conditions as a result of the controlled TSS inputs from the TMF and diversions.

Based on these findings, Project activities are not expected to increase sediment loading to downstream areas. It is possible that the sediment loading downstream in Sulphurets Creek will decrease as a result of TSS control measures that will be implemented at the WTP and the diversion structures.

Partitioning Coefficients for Selected Sites Downstream of the Tailing Management Facility or Mine Site Water Treatment Plant

Partitioning coefficients (K_d) can be used to describe the relationship between the concentration of dissolved metals in surface water and the metals in bed sediments. These were calculated for key receiving environments downstream of the TMF (NTR2, TRC2, STE3, and TEC2) and the Mine Site WTP (SC2, SC3, UR1, and UR2) using paired baseline sediment and water chemistry data collected in December 2012. The K_d was only calculated when both the mean sediment and water metal concentrations were above detection limits; these results are provided in Appendix 15-L. The K_d was positive for each metal suggesting that, at the time of sampling, sediment would be a sink for dissolved metals (i.e., gradient for metal movement from water to sediment). The K_d for a metal was often similar between sampling sites downstream of the TMF and the Mine Site WTP, even though the underlying sediment and water chemistry differed.

The use of the K_d oversimplifies the complex relationships between sediment and water metal chemistry and does not incorporate movement of metals between other compartments such as TSS, organic carbon, or sediment pore water. However, based on the K_d from baseline studies, it is likely that the sediment metal concentrations will follow water concentrations (i.e., if water concentrations go down, sediment concentrations will also go down and vice versa).

15.7.4.3.2 Potential for Residual Effects due to Process Chemicals

Residual effects associated with flocculant use in sedimentation ponds or in the Mine Site WTP are not expected to occur if mitigation measures are implemented and BMPs are followed, since the concentrations of flocculant would not be high enough to cause toxic effects in the aquatic receiving environment. The pilot WTP used up to 6 mg/L of flocculant during optimization testing, but suggested that the actual concentrations of flocculant that would be used in the Mine Site WTP would be less than 1 mg/L (Appendix 4-S), which is lower than expected toxic effects levels (see Section 15.7.4.1.2). A similar conclusion can be made for PAX (used in ore processing) and would not be discharged at concentrations expected to cause an effect in aquatic organisms. Use of these chemicals would not be expected to result in potential residual effects on fish or aquatic habitat.

Residual effects of other process chemicals can be determined based on the water quality model results (Chapter 14; Appendix 14-H). Cyanide, used only in the Treaty Ore Preparation Complex, is predicted to meet BC water quality guidelines at all of the sites downstream of the TMF discharge on South Teigen (STE3), Teigen (TEC2), North Treaty (NTR2), or Treaty (TRC2) creeks during any of the phases of the Project. This is because degradation of cyanide and further dilution of any cyanide-containing effluent in the TMF (e.g., dilution by water in the receiving environment or precipitation) will occur by the time the effluent discharged from the TMF reaches those sites. Thus, cyanide use is not expected to result in the potential for residual effects.

Lime and sulphuric acid will be used in the Mine Site WTP to neutralize the pH before discharge. In the effluent discharged from the WTP, the primary constituents discharged due to this treatment will be calcium and sulphate, respectively. While lime may also be used in other areas of the LSA to address localized issues with the potential for ML/ARD, the Mine Site WTP will be the primary source for introduction of these chemicals to the aquatic environment, and the residual effects assessment will be based on this discharge.

Both calcium and sulphate are expected to be present at high concentrations (up to 1,200 mg/L for each) in the effluent from the WTP (Chapter 14; Appendix 14-H). There are no BC water quality guidelines for calcium; therefore, only comparison to baseline concentrations can be done. Predictions from the water quality model indicate that, under the expected case, calcium concentrations are expected to be periodically increased relative to background concentrations (10 to 30%) at the sites on Sulphurets Creek (SC2 and SC3) and at or below background concentrations at sites on the Unuk River (UR1 and UR2; Chapter 14; Appendix 14-H). For sulphate, the draft BC water quality guideline concentration is 270 mg/L (Meays and Nordin, 2012). Under the expected case, the water quality model prediction indicates that sulphate concentrations will be below the guideline limits of 270 mg/L at all downstream sites. Thus, calcium and sulphate content in the water as a result of lime and sulphuric acid use is not expected to result in the potential for residual effects.

15.7.4.3.3 Potential for Residual Effects due to Petroleum Products

Mitigation measures for the introduction of petroleum products into aquatic environments are outlined in Section 15.7.4.2.4. However, there is still the possibility that localized introduction of small amounts of petroleum products may occur, such as during activities using mechanized equipment in or near waterways due to incidental contact of water or sediment with equipment, or during the time between when a spill or leak is identified and mitigated through the implementation of the Spill Prevention and Emergency Response Plan (Section 26.10). Potential effects associated with petroleum spills that surpass the mitigation strategies are expected to have a residual effect.

15.7.4.3.4 Potential for Residual Effects due to Nitrogen and Phosphorus

There are three main potential effects from introducing nitrogenous compounds and phosphorus into the aquatic environment: toxicity, increasing the primary production (eutrophication), and altering primary producer communities. The potential for toxic effects associated with nitrogenous compounds on aquatic life can be determined based on predictions made by the water quality model compared to BC water quality guidelines (Chapter 14; Appendix 14-H). The potential for alteration in productive capacity due to nutrients can be estimated based on comparison of nutrient loading, trophic status, and other factors during baseline compared to the different phases of Project activities.

Potential for Residual Effects due to Toxicity

The water quality model included the effluent from the STPs at the two operating camps as direct inputs to SC2 for the Mitchell operating camp and the North Cell TMF for the Treaty operating camp (Chapter 14). Most of the blasting residues that could enter aquatic environments within the LSA will be present in areas within the catchment for the TMF in the PTMA and the Mine Site WTP, and this has also been included as an input into the water quality model. Therefore, the bulk of the input of nitrogen and phosphorus during Project operation, closure, and post-closure is captured in the model predictions under the various chemicals associated with the nitrogen cycle (ammonia, nitrate, and nitrite) and total phosphorus. The water quality model predicts water concentrations after all preventive mitigation measures have been applied; therefore, any compounds that are identified by the model as having concentrations greater than guideline limits downstream of the TMF or Mine Site WTP will be considered as having residual effects.

For sites downstream of the TMF, the water quality model (expected case) predicts that concentrations of ammonia and nitrate will be lower than guideline limits at all sites during all the years modelled (up to 100 years). Nitrite concentrations are predicted to be greater than BC water quality guidelines in years 35 to 45 at the NTR2 site on North Treaty Creek, but not at the TRC2 site on Treaty Creek (Chapter 14). Similarly, nitrite concentrations are expected to be greater than guideline limits at the STE3 site on South Teigen Creek in years 45 to 50, but not at the TEC2 site on Teigen Creek. Nitrite is an intermediate nitrogen species in the oxidation of ammonia to nitrate and is modelled as 2% of the total nitrogen load from explosives. Nitrite concentrations are likely over-estimated, as nitrite is rapidly oxidized to nitrate and concentrations of nitrite are usually lower under oxygenated conditions (Mortonson 1980; Wetzel 2001) than predicted by the conservative mass-balance modelling approach. Therefore, the potential for nitrite toxicity was considered not significant.

For the Mine Site WTP, the water quality model (expected case) predicts that all forms of nitrogenous compounds (ammonia, nitrate, and nitrite) will be below water quality guidelines at all downstream sites during all the years modelled (up to 100 years). Thus no toxicity is predicted for fish due to nitrogenous compounds from either blasting residues or STP effluent downstream of the Mine Site in Sulphurets Creek or in Unuk River.

Potential for Residual Effects due to Nutrient Loading

Effect of Total Phosphorus on Trophic Status

While there are no BC water quality guidelines for phosphorus, CCME does provide some guidance on total phosphorus in Canadian streams and lakes by defining trigger ranges based on trophic status (CCME 2004). The CCME guidance document suggests that increases in the concentration of phosphorus that are greater than the upper limit of the trigger range during baseline conditions should be considered to be at risk for effects. A comparison of trophic status (trigger ranges) of streams at sites downstream of the TMF (NTR2 and STE3) and the Mine Site WTP (SC2, SC3, UR1, and UR2) using total phosphorus water concentrations during baseline studies and during Project phases is provided in Table 15.7-7. For the purposes of this assessment, water quality data from the model was averaged for each phase of Project activity, which were defined as the operation phase from years 0 to 50, closure phase from years 50 to 55, and post-closure phase from years 55 to 100.

The comparison provided in Table 15.7-7 shows that, generally, the concentration of phosphorus will remain the same or decrease during the operation, closure, or post-closure phases. For the sites downstream of the TMF, there are a few sporadic months in which the trophic status of the stream site is expected to change to a higher level. For STE3 on South Teigen Creek, the trophic status for this site between November and February is predicted to increase from ultra-oligotrophic during baseline to oligotrophic during the closure and post-closure phase. Similarly, for NTR2 on North Treaty Creek, the trophic status from December to February in the post-closure phase is predicted to move from oligotrophic to mesotrophic. These changes in the phosphorus-based trophic status during the winter at any site would not likely increase primary production (the production of organic carbon over time) since primary producer photosynthesis would be light limited (short photoperiods) with reduced metabolic rates (low temperatures) during this season. Baseline studies show there is plenty of phosphorus for growth during the winter (Chapter 14; Appendix 14-A), yet primary producer standing stocks remain low. Consequently, increases in winter phosphorus levels will have a limited influence on winter trophic status of Project streams, and is therefore considered insignificant.

However, NTR2 trophic status in the operation and post-closure phase (but not closure) is predicted to increase in July from oligotrophic to mesotrophic, which has some potential to cause changes in primary producer standing stocks. The effect is sporadic (July only) and results in an increase in total phosphorus concentrations from 0.0089 mg/L in baseline studies to 0.0102 mg/L (operation phase) or 0.0139 mg/L (post-closure). Since the effective increase in total phosphorus concentration is not large and the concentration during baseline studies is just below the lower end of the mesotrophic range (0.010 mg/L), this change was not considered significant.

Table 15.7-7. Trophic Status of Streams during Baseline Compared to KSM Project Phases

Area	Site	Month	Total Phosphorus Concentration (mg/L), By Phase of Operations							
			Baseline	Trophic Status	Operations	Trophic Status	Closure	Trophic Status	Post-Closure	Trophic Status
Downstream of TMF	STE3	January	0.0035	Ultra-oligotrophic	0.0017	Ultra-oligotrophic	0.0047	Oligotrophic	0.0052	Oligotrophic
		February	0.0039	Ultra-oligotrophic	0.0025	Ultra-oligotrophic	0.0047	Oligotrophic	0.0051	Oligotrophic
		March	0.0044	Oligotrophic	0.0031	Ultra-oligotrophic	0.0047	Oligotrophic	0.0051	Oligotrophic
		April	0.0036	Ultra-oligotrophic	0.0011	Ultra-oligotrophic	0.0045	Oligotrophic	0.0049	Oligotrophic
		May	0.0198	Mesotrophic	0.0057	Oligotrophic	0.0143	Mesotrophic	0.0155	Mesotrophic
		June	0.0137	Mesotrophic	0.0011	Ultra-oligotrophic	0.0292	Meso-eutrophic	0.0314	Meso-eutrophic
		July	0.0076	Oligotrophic	0.0037	Ultra-oligotrophic	0.0149	Mesotrophic	0.0162	Mesotrophic
		August	0.0173	Mesotrophic	0.0078	Oligotrophic	0.0034	Ultra-oligotrophic	0.0041	Oligotrophic
		September	0.0261	Meso-eutrophic	0.0177	Mesotrophic	0.0089	Oligotrophic	0.0100	Oligotrophic
		October	0.0261	Meso-eutrophic	0.0258	Meso-eutrophic	0.0053	Oligotrophic	0.0061	Oligotrophic
		November	0.0037	Ultra-oligotrophic	0.0019	Ultra-oligotrophic	0.0044	Oligotrophic	0.0050	Oligotrophic
		December	0.0036	Ultra-oligotrophic	0.0018	Ultra-oligotrophic	0.0049	Oligotrophic	0.0055	Oligotrophic
	TEC2	January	0.0047	Oligotrophic	0.0043	Oligotrophic	0.0047	Oligotrophic	0.0052	Oligotrophic
		February	0.0047	Oligotrophic	0.0044	Oligotrophic	0.0047	Oligotrophic	0.0051	Oligotrophic
		March	0.0046	Oligotrophic	0.0044	Oligotrophic	0.0047	Oligotrophic	0.0051	Oligotrophic
		April	0.0050	Oligotrophic	0.0042	Oligotrophic	0.0045	Oligotrophic	0.0049	Oligotrophic
		May	0.0175	Mesotrophic	0.0144	Mesotrophic	0.0143	Mesotrophic	0.0155	Mesotrophic
		June	0.0324	Meso-eutrophic	0.0299	Meso-eutrophic	0.0292	Meso-eutrophic	0.0314	Meso-eutrophic
		July	0.0155	Mesotrophic	0.0150	Mesotrophic	0.0149	Mesotrophic	0.0162	Mesotrophic
		August	0.0055	Oligotrophic	0.0030	Ultra-oligotrophic	0.0034	Ultra-oligotrophic	0.0041	Oligotrophic
		September	0.0111	Mesotrophic	0.0088	Oligotrophic	0.0089	Oligotrophic	0.0100	Oligotrophic
		October	0.0057	Oligotrophic	0.0050	Oligotrophic	0.0053	Oligotrophic	0.0061	Oligotrophic
		November	0.0044	Oligotrophic	0.0041	Oligotrophic	0.0044	Oligotrophic	0.0050	Oligotrophic
		December	0.0050	Oligotrophic	0.0046	Oligotrophic	0.0049	Oligotrophic	0.0055	Oligotrophic
	NTR2	January	0.0058	Oligotrophic	0.0065	Oligotrophic	0.0062	Oligotrophic	0.0110	Mesotrophic
		February	0.0068	Oligotrophic	0.0076	Oligotrophic	0.0075	Oligotrophic	0.0117	Mesotrophic
		March	0.0044	Oligotrophic	0.0050	Oligotrophic	0.0043	Oligotrophic	0.0096	Oligotrophic
		April	0.0049	Oligotrophic	0.0056	Oligotrophic	0.0050	Oligotrophic	0.0099	Oligotrophic
		May	0.0424	Eutrophic	0.0416	Eutrophic	0.0459	Eutrophic	0.0412	Eutrophic
		June	0.0233	Meso-eutrophic	0.0242	Meso-eutrophic	0.0260	Meso-eutrophic	0.0266	Meso-eutrophic
		July	0.0089	Oligotrophic	0.0102	Mesotrophic	0.0098	Oligotrophic	0.0139	Mesotrophic
		August	0.0109	Mesotrophic	0.0117	Mesotrophic	0.0123	Mesotrophic	0.0160	Mesotrophic
		September	0.0156	Mesotrophic	0.0163	Mesotrophic	0.0169	Mesotrophic	0.0192	Mesotrophic
		October	0.0097	Oligotrophic	0.0046	Oligotrophic	0.0010	Ultra-oligotrophic	0.0019	Ultra-oligotrophic
		November	0.0050	Oligotrophic	0.0056	Oligotrophic	0.0049	Oligotrophic	0.0097	Oligotrophic
		December	0.0060	Oligotrophic	0.0069	Oligotrophic	0.0066	Oligotrophic	0.0114	Mesotrophic
	TRC2	January	0.0142	Mesotrophic	0.0142	Mesotrophic	0.0144	Mesotrophic	0.0147	Mesotrophic
		February	0.0170	Mesotrophic	0.0172	Mesotrophic	0.0173	Mesotrophic	0.0175	Mesotrophic
		March	0.0044	Oligotrophic	0.0044	Oligotrophic	0.0044	Oligotrophic	0.0052	Oligotrophic
		April	0.0419	Eutrophic	0.0414	Eutrophic	0.0426	Eutrophic	0.0419	Eutrophic
		May	0.1970	Hyper-eutrophic	0.1957	Hyper-eutrophic	0.2022	Hyper-eutrophic	0.1949	Hyper-eutrophic
		June	0.1520	Hyper-eutrophic	0.1529	Hyper-eutrophic	0.1550	Hyper-eutrophic	0.1539	Hyper-eutrophic
		July	0.1718	Hyper-eutrophic	0.1698	Hyper-eutrophic	0.1693	Hyper-eutrophic	0.1744	Hyper-eutrophic
		August	0.3235	Hyper-eutrophic	0.3180	Hyper-eutrophic	0.3202	Hyper-eutrophic	0.3246	Hyper-eutrophic
		September	0.4485	Hyper-eutrophic	0.4405	Hyper-eutrophic	0.4499	Hyper-eutrophic	0.4519	Hyper-eutrophic
		October	0.1776	Hyper-eutrophic	0.1763	Hyper-eutrophic	0.1777	Hyper-eutrophic	0.1753	Hyper-eutrophic
		November	0.0170	Mesotrophic	0.0171	Mesotrophic	0.0172	Mesotrophic	0.0174	Mesotrophic
		December	0.0152	Mesotrophic	0.0153	Mesotrophic	0.0154	Mesotrophic	0.0157	Mesotrophic

(continued)

Table 15.7-7. Trophic Status of Streams during Baseline Compared to KSM Project Phases (completed)

Area	Site	Month	Total Phosphorus Concentration (mg/L), By Phase of Operations							
			Baseline	Trophic Status	Operations	Trophic Status	Closure	Trophic Status	Post-Closure	Trophic Status
Downstream of Mine Site WTP	SC2	January	0.0244	Meso-eutrophic	0.0336	Meso-eutrophic	0.0205	Meso-eutrophic	0.0224	Meso-eutrophic
		February	0.0552	Eutrophic	0.0599	Eutrophic	0.0516	Eutrophic	0.0500	Eutrophic
		March	0.0421	Eutrophic	0.0290	Meso-eutrophic	0.0184	Mesotrophic	0.0195	Mesotrophic
		April	0.0612	Eutrophic	0.0493	Eutrophic	0.0430	Eutrophic	0.0411	Eutrophic
		May	0.7188	Hyper-eutrophic	0.4751	Hyper-eutrophic	0.4882	Hyper-eutrophic	0.4599	Hyper-eutrophic
		June	0.3637	Hyper-eutrophic	0.1306	Hyper-eutrophic	0.0211	Meso-eutrophic	0.0219	Meso-eutrophic
		July	0.3590	Hyper-eutrophic	0.3163	Hyper-eutrophic	0.3327	Hyper-eutrophic	0.2854	Hyper-eutrophic
		August	0.2564	Hyper-eutrophic	0.1781	Hyper-eutrophic	0.1754	Hyper-eutrophic	0.1679	Hyper-eutrophic
		September	0.2757	Hyper-eutrophic	0.0614	Eutrophic	0.0472	Eutrophic	0.0585	Eutrophic
		October	0.2070	Hyper-eutrophic	0.1392	Hyper-eutrophic	0.1189	Hyper-eutrophic	0.1277	Hyper-eutrophic
		November	0.0940	Eutrophic	0.0438	Eutrophic	0.0133	Mesotrophic	0.0275	Meso-eutrophic
		December	0.0486	Eutrophic	0.0472	Eutrophic	0.0296	Meso-eutrophic	0.0377	Eutrophic
Downstream of Mine Site WTP	SC3	January	0.0174	Mesotrophic	0.0246	Meso-eutrophic	0.0130	Mesotrophic	0.0151	Mesotrophic
		February	0.0208	Meso-eutrophic	0.0222	Meso-eutrophic	0.0126	Mesotrophic	0.0138	Mesotrophic
		March	0.0333	Meso-eutrophic	0.0214	Meso-eutrophic	0.0118	Mesotrophic	0.0131	Mesotrophic
		April	0.0171	Mesotrophic	0.0073	Oligotrophic	0.0012	Ultra-oligotrophic	0.0010	Ultra-oligotrophic
		May	0.3198	Hyper-eutrophic	0.1035	Hyper-eutrophic	0.0895	Eutrophic	0.0855	Eutrophic
		June	0.3570	Hyper-eutrophic	0.1583	Hyper-eutrophic	0.0572	Eutrophic	0.0562	Eutrophic
		July	0.4675	Hyper-eutrophic	0.4286	Hyper-eutrophic	0.4533	Hyper-eutrophic	0.3979	Hyper-eutrophic
		August	0.1983	Hyper-eutrophic	0.1301	Hyper-eutrophic	0.1233	Hyper-eutrophic	0.1213	Hyper-eutrophic
		September	0.6903	Hyper-eutrophic	0.5177	Hyper-eutrophic	0.5573	Hyper-eutrophic	0.5128	Hyper-eutrophic
		October	0.1997	Hyper-eutrophic	0.1403	Hyper-eutrophic	0.1231	Hyper-eutrophic	0.1303	Hyper-eutrophic
		November	0.1063	Hyper-eutrophic	0.0630	Eutrophic	0.0394	Eutrophic	0.0488	Eutrophic
		December	0.0619	Eutrophic	0.0613	Eutrophic	0.0477	Eutrophic	0.0528	Eutrophic
Downstream of Mine Site WTP	UR1	January	0.0086	Oligotrophic	0.0118	Mesotrophic	0.0061	Oligotrophic	0.0072	Oligotrophic
		February	0.0086	Oligotrophic	0.0089	Oligotrophic	0.0043	Oligotrophic	0.0051	Oligotrophic
		March	0.0161	Mesotrophic	0.0108	Mesotrophic	0.0065	Oligotrophic	0.0072	Oligotrophic
		April	0.0161	Mesotrophic	0.0126	Mesotrophic	0.0104	Mesotrophic	0.0104	Mesotrophic
		May	0.1822	Hyper-eutrophic	0.1070	Hyper-eutrophic	0.1023	Hyper-eutrophic	0.1006	Hyper-eutrophic
		June	0.1513	Hyper-eutrophic	0.1264	Hyper-eutrophic	0.0363	Eutrophic	0.0362	Eutrophic
		July	0.0733	Eutrophic	0.0574	Eutrophic	0.0527	Eutrophic	0.0471	Eutrophic
		August	0.1512	Hyper-eutrophic	0.1149	Hyper-eutrophic	0.1106	Hyper-eutrophic	0.1102	Hyper-eutrophic
		September	0.5710	Hyper-eutrophic	0.4750	Hyper-eutrophic	0.4928	Hyper-eutrophic	0.4725	Hyper-eutrophic
		October	0.0865	Eutrophic	0.0646	Eutrophic	0.0545	Eutrophic	0.0610	Eutrophic
		November	0.0318	Meso-eutrophic	0.0169	Mesotrophic	0.0081	Oligotrophic	0.0122	Mesotrophic
		December	0.0210	Meso-eutrophic	0.0202	Meso-eutrophic	0.0141	Mesotrophic	0.0173	Mesotrophic
Downstream of Mine Site WTP	UR2	January	0.0059	Oligotrophic	0.0025	Ultra-oligotrophic	0.0010	Ultra-oligotrophic	0.0010	Ultra-oligotrophic
		February	0.0069	Oligotrophic	0.0041	Oligotrophic	0.0018	Ultra-oligotrophic	0.0021	Ultra-oligotrophic
		March	0.0079	Oligotrophic	0.0054	Oligotrophic	0.0034	Ultra-oligotrophic	0.0038	Ultra-oligotrophic
		April	0.0079	Oligotrophic	0.0066	Oligotrophic	0.0057	Oligotrophic	0.0058	Oligotrophic
		May	0.0851	Eutrophic	0.0549	Eutrophic	0.0526	Eutrophic	0.0523	Eutrophic
		June	0.1453	Hyper-eutrophic	0.1750	Hyper-eutrophic	0.0968	Eutrophic	0.0960	Eutrophic
		July	0.0460	Eutrophic	0.0383	Eutrophic	0.0356	Eutrophic	0.0341	Meso-eutrophic
		August	0.1335	Hyper-eutrophic	0.1132	Hyper-eutrophic	0.1108	Hyper-eutrophic	0.1105	Hyper-eutrophic
		September	0.2796	Hyper-eutrophic	0.2211	Hyper-eutrophic	0.2228	Hyper-eutrophic	0.2200	Hyper-eutrophic
		October	0.0770	Eutrophic	0.0679	Eutrophic	0.0639	Eutrophic	0.0656	Eutrophic
		November	0.0127	Mesotrophic	0.0069	Oligotrophic	0.0033	Ultra-oligotrophic	0.0050	Oligotrophic
		December	0.0059	Oligotrophic	0.0054	Oligotrophic	0.0028	Ultra-oligotrophic	0.0043	Oligotrophic

Baseline water quality data was compiled from all samples collected at each site between 2007 and 2011

For determining total phosphorus concentrations based on water quality model predictions, the operations phase was defined as years 0 to 50, closure phase as years 50 to 55, and post-closure as years 55 to 200

Downstream of the Mine Site WTP on Sulphurets Creek (SC2 and SC3) and the Unuk River (UR1 and UR2), total phosphorus concentrations are predicted to decrease during the operation, closure, and post-closure phases relative to the baseline conditions. The decrease in phosphorus will generally occur across all seasons, and the only month with a predicted increase is January (sites SC3 and UR1, operation phase) when primary production would be minimal and little growth would be expected due to low light and temperature conditions. Although baseline total phosphorus levels are hyper-eutrophic (greater than 0.1 mg total phosphorus/L) downstream of the Mine Site, periphyton biomass is consistently low, with concentrations of less than 0.05 µg chlorophyll *a*/cm^2 (Appendices 15-B and 15-D). These very low periphyton levels suggest that the trophic status of Sulphurets Creek is not driven by phosphorus supply, and thus the future predicted changes in phosphorus concentration are considered insignificant.

Nutrient Loading

Changes in nitrogen levels can also affect productive capacity at concentrations below the guideline limits. The potential for residual effects due to nutrient loading was evaluated quantitatively by comparing calculated nutrient loading rates during baseline conditions to predicted nutrient loading rates during the different phases of Project activities at locations downstream of both the Mine Site (sites SC2, SC3, UR1, and UR2) and the TMF (STE3, TEC2, NTR2 and TRC2).

Since discharges from the TMF will be phased, nutrient loading will vary over time for both Teigen and Treaty creeks. Nutrient loading at each site was determined by grouping phases with similar hydrological regimes together, rather than by phase of Project activities. For Teigen Creek, nutrient loading was calculated using data from the STE3 water quality sampling site and the NTWM-H1 hydrometric station for both baseline and projected cases. For Treaty Creek, nutrient loading was calculated using data from the NTR2 water quality sampling site and the STWM-H1 hydrometric station. These sites were selected because the water quality and hydrometric stations were located near each other and they would best represent inputs from the areas most affected by the TMF.

Data from the water quality model were used to predict concentrations (Appendix 14-H), and hydrological modelling was used to estimate stream discharges at the same stations (Appendix 13-B). Nutrient loading was calculated on a monthly basis using the mean concentration at a water quality sampling site downstream of the potential point sources (i.e., TMF or WTP) in mg/L and average water flows in L/day to provide an estimate of nutrient input per day for both baseline and during each grouping of years predicted to have similar hydrology.

The results of this assessment are provided in summary form in Table 15.7-8, with spreadsheets showing the details of the calculations provided in Appendix 15-M.

At STE3 in South Teigen Creek, loading of all forms of nitrogen is predicted to decrease during the Project operation phase (years 0 to 45). This is likely a result of water diversion during the operation phase and no discharges to this site from the TMF during this time, resulting in an overall lower stream discharge at this site.

Table 15.7-8. Predicted Change in Nitrogen and Phosphorus Load Downstream of the TMF or Mine Site, KSM Project

Processing and Tailing Management Area

		Years 0 - 45, Change in Load				Years >45, Change in Load			
Creek	**Month**	**NO_3**	**NO_2**	**NH_4**	**Total P**	**NO_3**	**NO_2**	**NH_4**	**Total P**
South	January	0.8	0.8	0.8	0.3	0.9	24.0	1.2	1.4
Teigen	February	0.7	0.8	0.8	0.4	0.9	23.8	1.2	1.3
Creek	March	0.7	0.8	0.8	0.5	0.8	27.5	1.2	1.4
	April	0.0	0.8	0.8	0.2	0.0	27.6	1.2	0.7
(STE3 site)	May	0.9	0.8	0.8	0.2	1.0	23.7	1.1	0.4
	June	0.9	0.8	0.5	0.1	1.1	18.6	0.9	0.2
	July	0.8	0.8	0.7	0.4	4.1	14.4	0.9	1.0
	August	0.5	0.8	0.6	0.4	1.8	12.5	0.7	0.7
	September	0.4	0.8	0.8	0.6	1.1	14.1	1.0	0.8
	October	0.3	0.8	0.8	0.8	0.7	16.4	1.1	1.1
	November	0.7	0.8	0.8	0.4	0.9	17.4	1.2	1.5
	December	0.8	0.8	0.8	0.4	0.9	19.0	1.2	1.4

		Years 0 - 45, Change in Load				Years 45-55, Change in Load				Years >55, Change in Load			
Creek	**Month**	**NO_3**	**NO_2**	**NH_4**	**Total P**	**NO_3**	**NO_2**	**NH_4**	**Total P**	**NO_3**	**NO_2**	**NH_4**	**Total P**
Teigen	January	1.0	1.0	1.0	0.9	1.0	1.0	1.0	0.9	1.1	1.1	1.1	1.1
Creek	February	1.0	0.9	0.9	0.9	1.0	1.0	1.0	0.9	1.0	1.0	1.0	1.0
	March	0.9	1.0	1.0	0.9	1.0	1.0	1.0	0.9	1.0	1.0	1.0	1.0
(TEC2 site)	April	0.8	1.0	0.9	0.8	0.8	1.0	0.9	0.8	1.0	1.0	1.0	1.0
	May	0.9	1.0	1.0	0.8	1.0	1.0	1.0	0.8	1.0	1.0	1.0	1.0
	June	0.9	1.0	1.0	3.5	1.0	1.0	1.0	3.7	1.0	1.0	1.0	1.0
	July	1.0	1.0	1.0	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	August	0.9	1.0	0.8	0.5	1.0	1.0	0.8	0.5	1.0	1.0	1.0	1.0
	September	1.0	1.0	0.9	0.8	1.0	1.0	0.9	0.8	1.0	1.0	1.0	1.0
	October	1.0	1.0	1.0	0.8	1.0	1.0	1.0	0.9	1.1	1.1	1.1	1.1
	November	0.9	1.0	1.0	0.9	1.0	1.0	1.0	0.9	1.1	1.1	1.1	1.1
	December	1.0	1.0	1.0	0.9	1.0	1.0	1.0	0.9	1.1	1.1	1.1	1.1

		Years 0 - 24, Change in Load				Years 25-30 and 45-50, Change in Load				Years 30-44, Change in Load			
Creek	**Month**	**NO_3**	**NO_2**	**NH_4**	**Total P**	**NO_3**	**NO_2**	**NH_4**	**Total P**	**NO_3**	**NO_2**	**NH_4**	**Total P**
North Treaty	January	1.0	1.0	1.0	1.0	1.3	1.3	1.3	1.3	0.9	80.9	2.5	1.6
Creek	February	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.8	75.6	2.2	1.4
	March	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	0.9	91.5	2.5	1.7
(NTR2 site)	April	1.0	1.0	1.0	1.0	1.3	1.3	1.3	1.3	1.0	89.9	2.3	1.6
	May	1.0	1.0	1.0	1.0	0.3	0.3	0.3	0.3	0.8	79.4	2.1	0.9
	June	0.9	1.0	1.0	7.7	0.0	0.0	0.0	0.3	0.8	62.1	1.8	1.1
	July	0.8	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.8	60.7	1.5	1.5
	August	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.2	15.6	1.4	1.3
	September	0.8	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.1	58.6	2.1	1.1
	October	0.9	1.0	1.0	0.8	0.1	0.1	0.1	0.1	0.8	69.7	2.3	0.3
	November	0.9	0.9	0.9	0.9	0.4	0.4	0.4	0.4	0.8	74.5	2.5	1.7
	December	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	81.6	2.6	1.7
		Years 51-55, Change in Load				**Years >55, Change in Load**							
	Month	**NO_3**	**NO_2**	**NH_4**	**Total P**	**NO_3**	**NO_2**	**NH_4**	**Total P**				
	January	0.7	0.7	0.7	0.8	1.0	1.1	1.0	1.9				
	February	0.6	0.7	0.7	0.7	0.9	1.0	0.9	1.6				
	March	0.7	0.7	0.7	0.7	1.0	1.1	1.0	2.2				
	April	0.8	0.7	0.7	0.7	1.0	1.1	1.0	2.0				
	May	0.7	0.7	0.7	0.8	0.8	1.2	1.0	1.0				
	June	0.6	0.7	0.7	0.8	1.0	1.1	1.0	1.2				
	July	0.1	0.7	0.7	0.8	2.9	1.1	0.8	1.5				
	August	0.1	0.8	0.8	0.8	3.3	1.0	1.0	1.4				
	September	0.0	0.7	0.7	0.8	0.8	1.0	1.0	1.2				
	October	0.6	0.7	0.7	0.1	1.0	1.1	1.0	0.2				
	November	0.6	0.7	0.7	0.7	0.8	1.1	1.0	1.9				
	December	0.7	0.7	0.7	0.7	1.0	1.1	1.0	1.9				

		Years 0-24, Change in Load				Years 25-30, Change in Load				Years 30-45, Change in Load			
Creek	**Month**	**NO_3**	**NO_2**	**NH_4**	**Total P**	**NO_3**	**NO_2**	**NH_4**	**Total P**	**NO_3**	**NO_2**	**NH_4**	**Total P**
Treaty Creek	January	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	8.1	1.0	1.0
	February	1.0	1.0	1.0	1.0	0.9	1.0	1.0	1.0	0.9	8.8	1.1	1.0
(TRC2 site)	March	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	10.8	1.2	1.1
	April	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	10.3	1.0	1.0
	May	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	5.1	1.4	1.0
	June	2.1	2.3	2.2	1.0	1.5	3.6	1.4	1.0	1.0	7.8	1.1	1.0
	July	35.0	8.3	19.5	1.0	27.6	14.6	8.8	1.0	17.9	8.3	7.6	1.0
	August	49.7	5.2	14.9	1.0	41.5	11.4	6.7	1.0	4.4	4.9	1.8	1.0
	September	19.3	4.9	10.4	1.0	13.3	7.9	4.1	1.0	11.7	6.9	4.8	1.0
	October	4.9	3.3	9.4	1.0	4.0	5.1	4.3	1.0	3.2	6.7	4.2	1.0
	November	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	6.0	1.1	1.0
	December	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	7.8	1.1	1.0
		Years 45-50, Change in Load				**Years 51-56, Change in Load**				**Years >56, Change in Load**			
	Month	**NO_3**	**NO_2**	**NH_4**	**Total P**	**NO_3**	**NO_2**	**NH_4**	**Total P**	**NO_3**	**NO_2**	**NH_4**	**Total P**
	January	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	February	0.9	1.0	1.0	1.0	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	March	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.2	1.0	1.0	1.0	1.2
	April	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	May	0.9	1.0	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.1	1.0
	June	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	July	16.9	1.1	6.8	1.0	9.6	1.0	1.6	1.0	1.3	1.0	1.0	1.0
	August	1.7	1.0	1.1	1.0	8.7	1.0	1.2	1.0	1.2	1.0	1.0	1.0
	September	9.7	1.0	3.8	1.0	3.1	1.0	1.1	1.0	1.0	1.0	1.0	1.0
	October	3.3	1.0	4.0	1.0	1.6	1.0	1.2	1.0	1.0	1.0	1.0	1.0
	November	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	December	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

NO_3 = nitrate, NO_2 = nitrate, NH_4 = ammonia, CN = cyanide, Total P = total phosphorus **(continued)**

Change in the nutrient load was calculated for each time frame of Project activites for each location relative to the baseline nutrient load (see Appendix 15-M)

All data is shown as the ratio between predicted load and baseline load

The grouping of years for loading calculations was based on hydrological data (i.e. changes in predicted stream discharge) rather than phases of Project activities

Table 15.7-8. Change in Nitrogen and Phosphorus Load Downstream of the TMF or Mine Site, KSM Project (continued)

Mine Site

		Years 0-10, Change in Load				Years 10-30, Change in Load				Years 30-50, Change in Load			
Creek	**Month**	**NO_3**	**NO_2**	**NH_4**	**Total P**	**NO_3**	**NO_2**	**NH_4**	**Total P**	**NO_3**	**NO_2**	**NH_4**	**Total P**
Sulphurets	January	11.0	0.1	19.6	2.3	3.3	1.1	4.5	1.3	0.6	1.0	0.9	0.8
Creek	February	13.6	0.1	10.4	1.5	4.6	1.1	3.0	1.0	0.6	0.9	1.0	0.8
	March	10.2	0.1	15.7	1.3	3.4	1.1	3.3	0.7	0.5	1.0	0.9	0.3
(SC2 site)	April	6.5	0.2	19.3	1.2	2.4	1.1	3.0	0.8	0.7	1.0	1.0	0.6
	May	7.4	0.2	21.1	0.8	3.2	1.1	3.7	0.6	0.6	1.1	2.0	0.6
	June	20.5	0.2	45.1	0.2	12.1	1.2	13.5	0.7	0.6	1.3	9.9	0.1
	July	76.4	0.1	53.4	0.9	33.6	1.1	17.9	0.9	0.7	1.0	13.3	0.9
	August	76.1	0.1	33.5	0.7	56.9	1.0	20.1	0.7	0.7	1.0	8.4	0.7
	September	42.8	0.1	32.8	0.2	18.1	1.0	11.6	0.2	0.5	1.1	5.9	0.2
	October	16.5	0.2	44.7	0.7	10.4	1.1	23.3	0.7	0.6	1.2	14.3	0.7
	November	17.6	0.2	47.7	0.7	6.1	1.2	13.1	0.4	0.5	1.1	6.0	0.4
	December	12.6	0.2	29.6	1.3	5.5	1.2	9.8	1.0	0.7	1.0	2.5	0.7

	Years 50-60, Change in Load				Years >55, Change in Load			
Month	**NO_3**	**NO_2**	**NH_4**	**Total P**	**NO_3**	**NO_2**	**NH_4**	**Total P**
January	0.6	0.9	0.9	0.8	0.6	1.0	0.9	0.8
February	0.6	1.0	0.9	0.8	0.6	1.0	0.9	0.8
March	0.5	1.0	0.9	0.4	0.5	1.1	0.9	0.4
April	0.7	1.0	0.9	0.6	0.7	1.1	0.9	0.6
May	0.6	1.0	0.8	0.6	0.6	1.1	0.8	0.6
June	0.6	1.1	1.0	0.1	0.7	1.1	1.0	0.1
July	0.7	1.0	0.7	0.8	0.7	1.0	0.7	0.8
August	0.7	1.0	0.7	0.6	0.7	1.0	0.8	0.7
September	0.5	0.9	0.7	0.2	0.5	0.9	0.8	0.2
October	0.6	0.9	0.9	0.5	0.6	0.9	0.9	0.6
November	0.5	1.0	0.9	0.2	0.5	1.1	0.9	0.3
December	0.6	1.0	0.9	0.6	0.6	1.1	0.9	0.7

		Years 0-10, Change in Load				Years 10-30, Change in Load				Years 30-50, Change in Load			
Creek	**Month**	**NO_3**	**NO_2**	**NH_4**	**Total P**	**NO_3**	**NO_2**	**NH_4**	**Total P**	**NO_3**	**NO_2**	**NH_4**	**Total P**
Sulphurets	January	6.8	1.2	15.5	2.3	2.5	1.0	4.0	1.3	0.7	1.0	0.9	0.8
Creek	February	7.4	1.2	12.3	1.9	3.0	1.0	3.7	1.0	0.7	0.9	1.0	0.5
	March	6.0	1.3	12.0	1.2	2.5	1.1	2.9	0.6	0.7	1.0	0.9	0.3
(SC3 site)	April	10.3	1.3	14.5	1.3	3.9	1.1	2.8	0.3	0.4	1.0	1.0	0.1
	May	5.4	1.3	23.5	0.5	2.7	1.2	4.5	0.3	0.8	1.2	2.3	0.3
	June	20.9	1.1	29.6	0.3	11.8	1.2	8.7	0.8	0.6	1.2	6.4	0.2
	July	54.0	1.0	49.1	1.0	23.2	1.1	16.1	1.0	0.8	1.0	11.7	0.9
	August	48.7	1.0	40.7	0.7	35.4	1.0	23.6	0.7	0.8	1.0	9.6	0.6
	September	30.7	1.2	16.2	0.7	13.3	1.0	6.1	0.7	0.7	1.0	3.4	0.7
	October	9.6	1.1	13.1	0.7	6.3	1.0	7.3	0.7	0.7	1.1	4.7	0.7
	November	10.5	1.3	38.0	0.7	4.1	1.1	11.2	0.5	0.7	1.1	5.1	0.5
	December	8.3	1.2	24.4	1.2	4.0	1.1	8.5	1.0	0.7	1.0	2.2	0.8

	Years 50-60, Change in Load				Years >60, Change in Load			
Month	**NO_3**	**NO_2**	**NH_4**	**Total P**	**NO_3**	**NO_2**	**NH_4**	**Total P**
January	0.7	0.9	0.9	0.7	0.7	1.0	0.9	0.8
February	0.7	0.9	0.9	0.5	0.8	1.0	0.9	0.6
March	0.7	0.9	0.9	0.3	0.7	1.1	0.9	0.4
April	0.4	1.0	0.9	0.1	0.4	1.1	0.9	0.1
May	0.7	1.1	1.0	0.3	0.8	1.2	1.1	0.3
June	0.6	1.0	0.9	0.1	0.7	1.1	1.0	0.2
July	0.7	0.9	0.7	0.8	0.8	1.0	0.8	0.9
August	0.8	0.9	0.9	0.6	0.8	1.0	1.0	0.6
September	0.6	0.9	0.9	0.7	0.7	1.0	0.9	0.7
October	0.7	0.9	0.9	0.6	0.7	1.0	0.9	0.6
November	0.7	0.9	0.9	0.4	0.7	1.1	0.9	0.4
December	0.7	1.0	0.9	0.7	0.8	1.1	0.9	0.8

		Years 0-10, Change in Load				Years 10-30, Change in Load				Years 30-50, Change in Load			
Creek	**Month**	**NO_3**	**NO_2**	**NH_4**	**Total P**	**NO_3**	**NO_2**	**NH_4**	**Total P**	**NO_3**	**NO_2**	**NH_4**	**Total P**
Unuk River	January	4.7	1.1	3.8	2.5	1.9	1.1	1.6	1.3	0.9	1.0	1.0	0.8
	February	4.8	1.1	6.5	2.1	2.1	1.0	2.3	1.0	0.9	1.0	1.0	0.4
UR1 site	March	3.9	1.1	6.1	1.2	1.8	1.0	1.8	0.7	0.8	1.0	1.0	0.3
	April	3.1	1.1	5.4	1.1	1.6	1.0	1.5	0.8	0.9	1.0	1.0	0.6
	May	3.2	1.1	8.7	0.7	1.8	1.1	2.1	0.6	0.9	1.1	1.4	0.6
	June	8.6	1.0	14.9	0.4	5.2	1.1	4.8	1.6	0.9	1.1	3.7	0.3
	July	26.4	1.0	35.1	0.8	11.7	1.0	11.8	0.8	0.9	1.0	8.8	0.7
	August	30.1	1.0	22.2	0.8	22.2	1.0	13.2	0.8	0.9	1.0	5.7	0.7
	September	15.8	1.1	8.3	0.8	7.1	1.0	3.5	0.8	0.8	1.0	2.1	0.8
	October	5.3	1.0	9.7	0.7	3.7	1.0	5.5	0.7	0.9	1.0	3.7	0.7
	November	5.3	1.1	14.0	0.7	2.4	1.0	4.5	0.5	0.9	1.0	2.4	0.4
	December	4.2	1.1	10.1	1.2	2.3	1.0	3.8	1.0	0.9	1.0	1.5	0.8

	Years 50-60, Change in Load				Years >60, Change in Load			
Month	**NO_3**	**NO_2**	**NH_4**	**Total P**	**NO_3**	**NO_2**	**NH_4**	**Total P**
January	0.8	1.0	0.9	0.7	0.9	1.0	1.0	0.8
February	0.8	1.0	0.9	0.5	0.9	1.0	1.0	0.6
March	0.8	1.0	0.9	0.4	0.8	1.0	1.0	0.4
April	0.9	1.0	1.0	0.6	0.9	1.0	1.0	0.6
May	0.9	1.0	1.0	0.6	0.9	1.1	1.0	0.6
June	0.8	1.0	1.0	0.2	0.9	1.0	1.0	0.2
July	0.9	1.0	1.0	0.7	0.9	1.0	1.0	0.6
August	0.9	1.0	1.0	0.7	0.9	1.0	1.0	0.7
September	0.8	1.0	0.9	0.8	0.8	1.0	1.0	0.8
October	0.9	1.0	0.9	0.6	0.9	1.0	1.0	0.7
November	0.9	1.0	1.0	0.3	0.9	1.0	1.0	0.4
December	0.9	1.0	1.0	0.7	0.9	1.0	1.0	0.8

NO_3 = nitrate, NO_2 = nitrate, NH_4 = ammonia, CN = cyanide, Total P = total phosphorus **(continued)**

Change in the nutrient load was calculated for each time frame of Project activites for each location relative to the baseline nutrient load (see Appendix 15-M)

All data is shown as the ratio between predicted load and baseline load

The grouping of years for loading calculations was based on hydrological data (i.e. changes in predicted stream discharge) rather than phases of Project activities

Table 15.7-8. Change in Nitrogen and Phosphorus Load Downstream of the TMF or Mine Site, KSM Project (completed)

Mine Site (Cont'd)

		Years 0-10, Change in Load				Years 10-30, Change in Load				Years 30-50, Change in Load			
Creek	**Month**	NO_3	NO_2	NH_4	Total P	NO_3	NO_2	NH_4	Total P	NO_3	NO_2	NH_4	Total P
Unuk River	January	1.2	1.0	5.1	1.2	0.3	1.0	1.9	0.3	0.0	1.0	1.0	0.2
	February	1.6	1.0	3.8	1.3	0.8	1.0	1.6	0.6	0.4	1.0	1.0	0.2
UR2 site	March	2.1	1.1	3.4	1.2	1.3	1.0	1.4	0.7	0.9	1.0	1.0	0.4
	April	1.6	1.0	2.7	1.1	1.2	1.0	1.2	0.8	1.0	1.0	1.0	0.7
	May	1.4	1.0	4.1	0.7	1.2	1.0	1.4	0.6	1.0	1.0	1.2	0.6
	June	3.0	1.0	5.6	0.7	2.1	1.0	2.3	2.0	1.0	1.0	1.9	0.7
	July	7.9	1.0	11.1	0.8	3.9	1.0	4.2	0.9	1.0	1.0	3.3	0.8
	August	11.1	1.0	12.9	0.8	8.4	1.0	7.9	0.9	0.9	1.0	3.6	0.8
	September	5.6	1.0	9.8	0.8	2.9	1.0	4.0	0.8	1.0	1.0	2.4	0.8
	October	2.0	1.0	6.8	0.9	1.6	1.0	4.0	0.9	1.0	1.0	2.8	0.9
	November	2.1	1.0	6.2	0.8	1.3	1.0	2.4	0.5	1.0	1.0	1.6	0.5
	December	1.9	1.0	4.8	1.3	1.4	1.0	2.2	1.0	1.0	1.0	1.2	0.6

		Years 50-60, Change in Load				Years >60, Change in Load			
Creek	**Month**	NO_3	NO_2	NH_4	Total P	NO_3	NO_2	NH_4	Total P
	January	0.0	1.0	1.0	0.2	0.0	1.1	1.1	0.2
	February	0.4	1.0	1.0	0.3	0.4	1.0	1.0	0.3
	March	0.9	1.0	1.0	0.4	0.9	1.0	1.0	0.5
	April	1.0	1.0	1.0	0.7	1.0	1.0	1.0	0.7
	May	1.0	1.0	1.0	0.6	1.0	1.0	1.0	0.6
	June	1.0	1.0	1.0	0.7	1.0	1.0	1.0	0.7
	July	1.0	1.0	0.9	0.8	1.0	1.0	0.9	0.7
	August	0.9	1.0	1.0	0.8	1.0	1.0	1.0	0.8
	September	0.9	1.0	0.9	0.8	1.0	1.0	0.9	0.8
	October	1.0	1.0	1.0	0.8	1.0	1.0	1.0	0.8
	November	1.0	1.0	1.0	0.3	1.0	1.0	1.0	0.4
	December	1.0	1.0	1.0	0.6	1.0	1.0	1.0	0.7

NO_3 = nitrate, NO_2 = nitrate, NH_4 = ammonia, CN = cyanide, Total P = total phosphorus

Change in the nutrient load was calculated for each time frame of Project activites for each location relative to the baseline nutrient load (see Appendix 15-M)

All data is shown as the ratio between predicted load and baseline load

The grouping of years for loading calculations was based on hydrological data (i.e. changes in predicted stream discharge) rather than phases of Project activities

In the closure and post-closure phases, once water management returns the flows to approximately baseline levels, the loading of ammonia and phosphorus downstream of the TMF is predicted to remain near (slightly above or below) baseline levels. For nitrate, loads are predicted to increase by approximately two- to four-fold during summer months (July and August). Nitrite loads are predicted to substantially increase relative to baseline levels during these phases. However, such elevated nitrite loading is likely an artifact of the water quality model in which nitrite is modelled as 2% of the total nitrogen load from explosives (Chapter 14). Nitrite concentrations are likely over-estimated because nitrite is rapidly oxidized to nitrate and concentrations of nitrite are usually far lower under oxygenated conditions (Mortonson 1980; Wetzel 2001) than those predicted by the conservative mass-balance modelling approach.

Similarly to South Teigen, nitrite loading is predicted to increase in North Treaty Creek (site NTR2) relative to background loading during years in which TMF discharge is directed to the creek. This will occur during years 30 to 44 of the operation phase and also during post-closure. Nitrate is also predicted to be higher than background concentrations in the post-closure phase (years greater than 55). Relative to baseline, total phosphorus loading is not predicted to increase substantially in most of the years examined, except possibly in the post-closure phase when loading may increase slightly in the winter months.

All forms of inorganic nitrogen are predicted to increase relative to baseline loading during the first 30 years of operation at both sites on Sulphurets Creek (SC2 and SC3) as well as the Unuk River sites (UR1 and UR2). The magnitude of the increase in loading due to Project activities generally diminishes at the downstream sites from SC3 to UR1 to UR2 as dilution due to higher stream discharge decreases the concentrations of the nutrients. The increase in nitrate loading is greatest during the first years of the Project operation phase, and is predicted to decrease to below baseline levels after 30 years once mining shifts to underground activities. The concentration of ammonia is predicted to be higher than baseline for up to Year 50, after which it diminishes to baseline levels.

Phosphorus loadings are predicted to be higher at the Sulphurets Creek and Unuk River sites between December and April during the first five years, but decrease to values near or below baseline loadings by Year 30. During the freshet, summer, and early fall, phosphorus loadings are predicted to be lower than baseline values.

Influence of Nutrient Loading on Primary Producer Community Structure

Changes in nutrient supply can alter primary productivity in aquatic habitats as well as shift the composition of the community from one group of algae to another. These shifts in community composition can have trophic implications due to the dietary preferences of higher trophic levels and influence the transfer of energy up the food web. Such effects are termed “bottom-up”, referring to nutrients and primary producers forming the bottom of the food web. Not only can the supply of nutrients have bottom-up effects, but the ratio of nutrients may also be important. A commonly cited adverse effect is the selection of cyanobacteria by low nitrogen to phosphorus ratios. It is unlikely that the predicted changes in nutrient concentrations due to Project activities, and their ratios, will select for cyanobacteria communities. Cyanobacteria are generally thought to have an advantage in periphyton communities when nitrogen to phosphorus ratios are low, due to their ability to use atmospheric nitrogen (N_2) for growth. The baseline and predicted nitrogen to phosphorus ratios in watersheds downstream from both the Mine Site WTP and the TMF are presented in Table 15.7-9.

Table 15.7-9. Nitrogen to Phosphorus Ratios During Baseline and Various Years of the KSM Project

	South Teigen (STE3)			Teigen Creek (TEC2)			
Months	**Baseline**	**Years 0 to 45**	**Years >45**	**Baseline**	**Years 0-45**	**Years 45-56**	**Years >56**
January	71 :1	164 :1	54 :1	83 :1	92 :1	92 :1	92 :1
February	71 :1	115 :1	52 :1	82 :1	88 :1	88 :1	88 :1
March	70 :1	89 :1	47 :1	81 :1	85 :1	85 :1	85 :1
April	69 :1	12 :1	16 :1	158 :1	152 :1	152 :1	152 :1
May	41 :1	153 :1	97 :1	26 :1	31 :1	31 :1	31 :1
June	30 :1	457 :1	156 :1	4 :1	1 :1	1 :1	1 :1
July	2 :1	4 :1	6 :1	3 :1	4 :1	4 :1	4 :1
August	1 :1	2 :1	3 :1	7 :1	13 :1	13 :1	13 :1
September	1 :1	1 :1	2 :1	9 :1	12 :1	12 :1	12 :1
October	1 :1	0.5 :1	1 :1	24 :1	28 :1	28 :1	28 :1
November	45 :1	84 :1	31 :1	59 :1	64 :1	64 :1	64 :1
December	58 :1	123 :1	42 :1	65 :1	70 :1	70 :1	70 :1

	North Treaty (NTR2)					
Months	**Baseline**	**Years 0 to 24**	**Years 25-30 + 45-50**	**Years 30-44**	**Years 51-56**	**Years >56**
January	120 :1	118 :1	118 :1	77 :1	108 :1	60 :1
February	86 :1	83 :1	83 :1	58 :1	72 :1	47 :1
March	150 :1	150 :1	150 :1	92 :1	151 :1	67 :1
April	367 :1	365 :1	365 :1	243 :1	420 :1	188 :1
May	42 :1	42 :1	42 :1	39 :1	38 :1	36 :1
June	17 :1	2 :1	2 :1	15 :1	13 :1	15 :1
July	6 :1	5 :1	5 :1	8 :1	2 :1	11 :1
August	5 :1	5 :1	5 :1	5 :1	2 :1	9 :1
September	9 :1	7 :1	7 :1	5 :1	1 :1	6 :1
October	42 :1	51 :1	51 :1	158 :1	332 :1	205 :1
November	112 :1	108 :1	108 :1	62 :1	95 :1	49 :1
December	114 :1	113 :1	113 :1	72 :1	102 :1	58 :1

	Treaty Creek (TRC2)						
Months	**Baseline**	**Years 0 to 24**	**Years 25-30**	**Years 30-45**	**Years 45-50**	**Years 50-55**	**Years >56**
January	30 :1	30 :1	29 :1	29 :1	29 :1	29 :1	29 :1
February	8 :1	8 :1	7 :1	8 :1	7 :1	7 :1	8 :1
March	98 :1	98 :1	97 :1	86 :1	97 :1	82 :1	80 :1
April	24 :1	25 :1	24 :1	25 :1	25 :1	24 :1	24 :1
May	5 :1	5 :1	4 :1	5 :1	4 :1	4 :1	4 :1
June	2 :1	4 :1	3 :1	2 :1	2 :1	2 :1	2 :1
July	0.3 :1	11 :1	9 :1	6 :1	5 :1	3 :1	0.4 :1
August	0.1 :1	3 :1	3 :1	0.3 :1	0.1 :1	1 :1	0.1 :1
September	0.1 :1	2 :1	1 :1	1 :1	1 :1	0.3 :1	0.1 :1
October	1 :1	4 :1	3 :1	3 :1	3 :1	1 :1	1 :1
November	15 :1	14 :1	14 :1	14 :1	14 :1	14 :1	14 :1
December	18 :1	17 :1	17 :1	17 :1	17 :1	17 :1	17 :1

(continued)

Table 15.7-9. Nitrogen to Phosphorus Ratios During Baseline and Various Years of the KSM Project (completed)

Months	Baseline	Years 0-10	Years 10-30	Years 30-50	Years 50-60	Years >60
	Sulphurets Creek (SC2)					
January	8 :1	41 :1	22 :1	6 :1	6 :1	6 :1
February	3.1 :1	27 :1	14 :1	2 :1	2 :1	2 :1
March	5.6 :1	43 :1	28 :1	8 :1	8 :1	7 :1
April	6.6 :1	36 :1	20 :1	8 :1	8 :1	8 :1
May	0.5 :1	5 :1	2 :1	0.5 :1	0.5 :1	0.5 :1
June	0.4 :1	38 :1	7 :1	3 :1	5 :1	4 :1
July	0.2 :1	14 :1	6 :1	0.5 :1	0.1 :1	0.1 :1
August	0.1 :1	14 :1	10 :1	1 :1	0.2 :1	0.2 :1
September	0.2 :1	37 :1	18 :1	1 :1	1 :1	1 :1
October	0.8 :1	20 :1	13 :1	1 :1	1 :1	1 :1
November	2.0 :1	51 :1	32 :1	4 :1	6 :1	4 :1
December	4.3 :1	42 :1	25 :1	4 :1	5 :1	4 :1
	Sulphurets Creek (SC3)					
Months	**Baseline**	**Years 0-10**	**Years 10-30**	**Years 30-50**	**Years 50-60**	**Years >60**
January	16 :1	47 :1	31 :1	14 :1	16 :1	14 :1
February	12 :1	47 :1	36 :1	19 :1	17 :1	15 :1
March	10 :1	50 :1	38 :1	24 :1	21 :1	18 :1
April	10 :1	85 :1	127 :1	85 :1	81 :1	87 :1
May	1 :1	15 :1	12 :1	4 :1	4 :1	4 :1
June	0.4 :1	25 :1	6 :1	2 :1	2 :1	2 :1
July	0.2 :1	9 :1	4 :1	0.4 :1	0.1 :1	0.1 :1
August	0.2 :1	17 :1	12 :1	1 :1	0.3 :1	0.3 :1
September	0.1 :1	4 :1	2 :1	0.2 :1	0.1 :1	0.1 :1
October	1 :1	18 :1	12 :1	2 :1	2 :1	2 :1
November	2 :1	37 :1	20 :1	4 :1	5 :1	4 :1
December	4 :1	32 :1	18 :1	4 :1	5 :1	4 :1
	Unuk River (UR1)					
Months	**Baseline**	**Years 0-10**	**Years 10-30**	**Years 30-50**	**Years 50-60**	**Years >60**
January	27 :1	51 :1	39 :1	28 :1	32 :1	28 :1
February	24 :1	55 :1	51 :1	52 :1	44 :1	37 :1
March	16 :1	51 :1	43 :1	38 :1	34 :1	30 :1
April	16 :1	44 :1	32 :1	24 :1	23 :1	22 :1
May	2 :1	8 :1	5 :1	3 :1	3 :1	3 :1
June	1 :1	20 :1	3 :1	3 :1	3 :1	3 :1
July	1 :1	32 :1	13 :1	2 :1	1 :1	1 :1
August	0.3 :1	10 :1	7 :1	1 :1	0.3 :1	0.3 :1
September	0.2 :1	3 :1	1 :1	0.2 :1	0.2 :1	0.2 :1
October	2 :1	16 :1	11 :1	3 :1	3 :1	3 :1
November	6 :1	48 :1	32 :1	13 :1	19 :1	15 :1
December	11 :1	40 :1	27 :1	14 :1	14 :1	13 :1
	Unuk River (UR2)					
Months	**Baseline**	**Years 0-10**	**Years 10-30**	**Years 30-50**	**Years 50-60**	**Years >60**
January	60 :1	67 :1	61 :1	12 :1	12 :1	12 :1
February	49 :1	63 :1	69 :1	103 :1	85 :1	71 :1
March	41 :1	69 :1	77 :1	98 :1	89 :1	81 :1
April	41 :1	60 :1	57 :1	57 :1	55 :1	54 :1
May	7 :1	14 :1	13 :1	11 :1	11 :1	11 :1
June	1 :1	6 :1	2 :1	2 :1	2 :1	2 :1
July	3 :1	26 :1	12 :1	4 :1	3 :1	4 :1
August	0.5 :1	6 :1	5 :1	0.7 :1	0.6 :1	0.6 :1
September	0.5 :1	4 :1	2 :1	0.7 :1	0.6 :1	0.6 :1
October	4 :1	10 :1	8 :1	5 :1	5 :1	5 :1
November	26 :1	72 :1	69 :1	54 :1	78 :1	63 :1
December	60 :1	87 :1	85 :1	91 :1	103 :1	81 :1

The nitrogen to phosphorus (N:P, in molar concentrations) ratio was calculated based on the nutrient loads in Table 15.7-8

The grouping of years for loading calculations was based on hydrological data (i.e. changes in predicted stream discharge) rather than phases of Project activities

During the growing season of July to September, baseline nitrogen:phosphorus ratios are less than 10:1, and often less than 1:1 (Table 15.7-9), yet the periphyton community is dominated by diatoms in the watersheds downstream from both the Mine Site WTP and the TMF (Appendices 15-B and 15-D). Stelzer and Lamberti (2001) showed that although the composition of the periphyton community does change with changes in nutrient ratios, diatoms continued to dominate the community in a temperate experimental stream even at low nitrogen:phosphorus ratios. The predicted increases in inorganic nitrogen species and decreases in phosphorus, both increasing the predicted nitrogen:phosphorus ratio, would likely continue to favour the growth of diatoms, and a shift in community structure due to increases in the nitrogen:phosphorus ratio is unlikely.

Furthermore, secondary producers (organisms that graze on periphyton and macrophytes) exert strong effects on stream primary producers and often control community structure (known as "top-down" regulation; Feminella & Hawkins 1995). The predicted continued presence of secondary producers and stream invertebrates would maintain the baseline trophic interactions and may serve to preserve primary producer community structure.

Primary Producer Biomass and Production

The predicted increase in nitrogenous nutrients (primarily ammonia and nitrate) downstream from the TMF and Mine Site WTP could increase primary production within the streams. Increases in nutrient concentrations are associated with overall increases in instream primary producer biomass (Biggs 2000). Biomass accrual is more strongly influenced by the length of time between high flow events than by increases in the concentration of nutrients (Biggs 2000). The relatively short growing season between the freshet and the high-precipitation autumn season in the high-altitude streams in the LSA will likely mitigate some of the increases in biomass due to nutrient loading. In addition, the stimulation of primary producer growth by nutrient additions depends on the nutritional requirements of the primary producers (i.e., if they are deficient in nitrogen or phosphorus or both), and stream water concentrations of nutrients are not necessarily good predictors of nutritional requirements (Francoeur et al. 1999). The predicted increases in inorganic nitrogen nutrients therefore will likely increase primary producer biomass, although the magnitude of the effect is difficult to predict.

Furthermore, secondary producers may control the overall biomass (Feminella and Hawkins 1995). The established communities of EPT found in the streams downstream of both the Mine Site WTP (greater than or equal to 80% of the community at UR1 in 2009, for example; Appendix 15-D) and the TMF would likely expand in response to increases in available primary producers biomass and could efficiently transfer the increased primary production to higher trophic levels.

Summary of Potential for Residual Effects due to Nitrogen and Phosphorus

If the mitigation measures outlined in Section 15.7.4.2.5 are all implemented and followed, potential effects caused by nitrogenous blasting residue and sewage (nitrogen and phosphorus) still may not be fully mitigated on aquatic organisms or habitat. Most of the potential input of nitrogen and phosphorus from these sources will be captured with the catchments for the TMF and Mine Site WTP. Therefore the water quality model predictions (Chapter 14; Appendix 14-H), which predict water quality *after mitigation measures have been applied*, can be used to directly assess potential effects associated with nitrogen and phosphorus.

The potential for toxicity associated with nitrogenous compounds is based on whether predicted concentrations of ammonia or nitrate will meet water quality guidelines for the protection of aquatic life. Downstream of both the TMF and the Mine Site WTP, ammonia and nitrate are predicted to remain below water quality guidelines.

Compared to baseline loading, the nitrogen and phosphorus loading rates during different phases of the Project were predicted to change for areas downstream of the TMF and Mine Site WTP discharges (Table 15.7-8). This has the potential to affect both trophic status of the receiving environment (Table 15.7-7) and primary production; thus, there is some potential for residual effects due to nutrient loading.

15.7.4.3.5 Summary of Potential for Residual Effects due to Water Quality Degradation

Potential residual effects may occur due to water quality degradation resulting from Project components in various phases of the Project for bull trout, Dolly Varden, rainbow trout/steelhead, Pacific salmon, and aquatic habitat.

The following potential effects and pathways were assessed:

- toxicity or alteration of aquatic habitat due to metal exposure from non-point sources (e.g., ML/ARD generation associated with construction and infrastructure development);
- toxicity to fish and aquatic organisms or alteration of aquatic habitat due to metal or process chemical exposure associated with TMF discharge or seepage from the TMF;
- toxicity or alteration of aquatic habitat due to metal or process chemical exposure associated with the Mine Site WTP discharge or seepage from the WSF;
- toxicity or alteration of aquatic habitat due to introduction of petroleum products into aquatic environments during normal Project activities;
- toxicity due to introduction of nitrogenous compounds associated with blasting residues or sewage; and
- alteration of aquatic resources and potential for eutrophication associated with blasting residues or sewage.

A summary of the potential residual effects associated with water quality degradation are presented in Table 15.7-10.

15.7.4.4 Bull Trout: Potential Residual Effects due to Water Quality Degradation

Bull trout only inhabit the PTMA portion of the LSA. Bull trout may be affected by changes to water quality that may occur due to construction, operation, or maintenance of the TCAR, the transmission line, and camps since the species is present in Teigen and Treaty creeks and the Bell-Irving River. Bull trout may also be affected by water quality changes associated with TMF discharges (potential point source of metals, process chemicals, and nitrogenous compounds; non-point sources of petroleum products and nitrogenous compounds) during the operation, closure, and post-closure phases. While fish are not necessarily in the areas where the Project components are physically located (e.g., fish were not found above the cascades on Sulphurets Creek), chemicals introduced to the water in these areas can be carried downstream to areas where fish are found.

Table 15.7-10. Potential Residual Effects on Fish and Aquatic Habitat Valued Components due to Water Quality Degradation

Valued Component	Timing Start	Project Area(s)	Component(s)	Description of Effect due to Component(s)	Type of Project Mitigation	Project Mitigation Description	Potential Residual Effect	Description of Residuals
Dolly Varden Aquatic Habitat	Construction Operation Closure Post Closure	Processing and Tailing Management Area	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC	Toxicity or alteration of aquatic habitat due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	ARD rock utilized on inside of dam only; Effluent Monitoring Plan; ML/ARD Management Plan; Erosion Control Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	ARD rock utilized on inside of dam; seepage pond water collection and return to TMF; Implement and adhere to applicable environmental management plans	Yes	Sublethal toxic effects on fish; Toxicity to aquatic invertebrates and loss of productive habitat capacity
Bull trout Dolly Varden Rainbow trout Pacific salmon Aquatic Habitat	Construction Operation Closure Post Closure	Processing and Tailing Management Area	Treaty Creek Access Road; Mitchell-Treaty Tunnel	Toxicity or alteration of aquatic habitat due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Effluent Monitoring Plan; ML/ARD Management Plan; Erosion Control Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Selection of road alignment and tunnel portals minimizing high potential areas for ML/ARD; Water and sediment quality maintenance; Implement and adhere to applicable environmental management plan	Yes	Sublethal toxic effects on fish; Toxicity to aquatic invertebrates and loss of productive habitat capacity
Bull trout Dolly Varden Rainbow trout Pacific salmon Aquatic Habitat	Operation Closure Post-closure	Processing and Tailing Management Area	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Seepage Collection Ponds; Concentrate Storage and Loadout	Toxicity or alteration of aquatic habitat due to metals or process chemical exposure downstream of the TMF associated with scheduled discharge or seepage from the TMF	TMF discharges paced with hydrology of receiving enviroment; no discharges during low flow periods of the receiving environment; water from seepage collection ponds returned to TMF; Proper storage standards for chemicals; water treatment during post-closure if necessary to ensure water quality targets are met; implement ML/ARD Management Plan, Spill Containment and Emergency Response Plan, Effluent Monitoring Plan, and Aquatic Effects Monitoring Plan	Direct discharges from TMF to Treaty Creek during operations phase; proper storage of process chemicals and metal concentrates; initiation of water treatment during post-closure if necessary to achieve water quality targets; Implement and adhere to applicable environmental management plans	Yes	Sublethal toxic effects on fish; Toxicity to aquatic invertebrates and loss of productive habitat capacity
Bull trout Dolly Varden Rainbow trout Pacific salmon Aquatic Habitat	Construction Operation Closure	Processing and Tailing Management Area	Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road	Toxicity or alteration of aquatic habitat due to introduction of petroleum products into aquatic environment during normal Project activities	Adhere to DFO's operational statements; Spill Containment and Emergency Response Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize petroleum product entry to water bodies; Adhere to DFO's operational statements; Adhere to appropriate construction operating window for instream work; Adhere to the Spill Containment and Emergency Response Plan; Spill kits, Equipment maintenance, Stream setback distances, Water quality maintenance	Yes	Sublethal toxic effects on fish; Toxicity to aquatic invertebrates and loss of productive habitat capacity
Dolly Varden Aquatic Habitat	Construction Operation Closure	Processing and Tailing Management Area	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility	Toxicity or alteration of aquatic habitat due to introduction of petroleum products into aquatic environment during normal Project activities (associated with TMF)	Adhere to DFO's operational statements;Spill Containment and Emergency Response Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize petroleum product entry to water bodies; Adhere to DFO's operational statements; Adhere to appropriate construction operating window for instream work; Adhere to the Spill Containment and Emergency Response Plan; Spill kits, Equipment maintenance, Stream setback distances, Water quality maintenance	Yes	Sublethal toxic effects on fish; Toxicity to aquatic invertebrates and loss of productive habitat capacity

(continued)

Table 15.7-10. Potential Residual Effects on Fish and Aquatic Habitat Valued Components due to Water Quality Degradation (continued)

Valued Component	Timing Start	Project Area(s)	Component(s)	Description of Effect due to Component(s)	Type of Project Mitigation	Project Mitigation Description	Potential Residual Effect	Description of Residuals
Dolly Varden Aquatic Habitat	Construction Operation Closure	Processing and Tailing Management Area	South Cell Tailing Management Facility; Treaty OPC; Camp 5: Treaty Plant; Treaty Operations Camps	Toxicity due to introduction of nitrogenous compounds associated with blasting residue or sewage	DFO Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters; Erosion Control Plan; Municipal Wastewater Regulation, with associated monitoring program; Industry Standards for Wastewater Treatment; Fish and Aquatic Habitat Protection and Mitigation Plan	Adhere to DFO's operational statements; Use of best management practices to minimize blast residue entry to water bodies; Use of best management practices and industry wastewater treatment standards to treat effluent (secondary treatment) and minimize effluent entry to water bodies; Site isolation; Seepage collection pond collecting run-off; Water quality maintenance; Implement and adhere to applicable management and monitoring plans	Yes	Sublethal toxic effects on fish; Toxicity to aquatic invertebrates and loss of productive habitat capacity
Aquatic Habitat	Construction Operation Closure	Processing and Tailing Management Area	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Camp 5: Treaty Plant; Treaty Operations Camps; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Treaty Creek Access Road; Mitchell-Treaty Tunnel; Construction Access Adit; Mitchell-Treaty Tunnel Saddle Area; Camp 6: Treaty Saddle	Alteration of aquatic resources and potential for eutrophication associated with blasting residue or sewage	DFO Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters; Erosion Control Plan; Sewerage System Regulation; Industry Standards for Wastewater Treatment; Fish and Aquatic Habitat Protection and Mitigation Plan	Adhere to DFO's operational statements; Use of best management practices to minimize blast residue entry to water bodies; Use of best management practices and industry wastewater treatment standards to treat effluent and minimize effluent entry to water bodies; Site isolation; Seepage collection pond collecting run-off; Water quality maintenance; Implement and adhere to applicable management and monitoring plans	Yes	Increased nutrients, eutrophication, decreased productive habitat capacity
Dolly Varden Rainbow trout Pacific salmon Aquatic Habitat	Construction Operation Closure Post Closure	Mine Site	Coulter Creek Access Corridor	Toxicity or alteration of aquatic habitat due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Effluent Monitoring Plan; ML/ARD Management Plan; Erosion Control Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Selection of road alignment minimizing high potential areas for ML/ARD; Water and sediment quality maintenance; Implement and adhere to applicable environmental management and monitoring plans	Yes	Sublethal toxic effects on fish; Toxicity to aquatic invertebrates and loss of productive habitat capacity
Dolly Varden Rainbow trout Pacific salmon Aquatic Habitat	Construction	Mine Site	Water Storage Facility; Water Storage Dam; Water Treatment Plant; Water Treatment & Energy Recovery Area	Toxicity or alteration of aquatic habitat due to metals or process chemical exposure downstream of the Mine Site WTP associated with scheduled discharge or seepage from the Mine Site WTP	ML/ARD Management Plan; Water Treatment; Effluent Monitoring Plan; Aquatic Effects Monitoring Plan	Collection of all contact water from within the Mine Site catchment area and diversion of contact water to the WTP; treat contaminated water prior to discharge; Discharges from WSF/WTP phased to match hydrological regime; collection of seepage water in teh seepage collection pond below the WSD; return of seepage water to the WSF/WTP; Implement and adhere to applicable environmental management and monitoring plans	Yes	Sublethal toxic effects on fish; Toxicity to aquatic invertebrates and loss of productive habitat capacity

(continued)

Table 15.7-10. Potential Residual Effects on Fish and Aquatic Habitat Valued Components due to Water Quality Degradation (continued)

Valued Component	Timing Start	Project Area(s)	Component(s)	Description of Effect due to Component(s)	Type of Project Mitigation	Project Mitigation Description	Potential Residual Effect	Description of Residuals
Dolly Varden Rainbow trout Pacific salmon Aquatic Habitat	Operation Closure Post-Closure	Mine Site	Water Storage Facility; Water Storage Dam; Water Treatment Plant; Water Treatment & Energy Recovery Area	Toxicity or alteration of aquatic habitat due to metals or process chemical exposure downstream of the Mine Site WTP associated with scheduled discharge or seepage from the Mine Site WTP	ML/ARD Management Plan; Water Treatment; Effluent Monitoring Plan; Aquatic Effects Monitoring Plan	Collection of all contact water from within the Mine Site catchment area and diversion of contact water to the WTP; treat contaminated water prior to discharge; Discharges from WSF/WTP phased to match hydrological regime; collection of seepage water in teh seepage collection pond below the WSD; return of seepage water to the WSF/WTP; Implement and adhere to applicable environmental management and monitoring plans	Yes	Sublethal toxic effects on fish; Toxicity to aquatic invertebrates and loss of productive habitat capacity
Dolly Varden Rainbow trout Pacific salmon Aquatic Habitat	Construction Operation Closure	Mine Site	Coulter Creek Access Corridor; Camp 7: Unuk North; Camp 8: Unuk South	Toxicity or alteration of aquatic habitat due to introduction of petroleum products into aquatic environment during normal Project activities	Adhere to DFO's operational statements; Spill Containment and Emergency Response Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize petroleum product entry to water bodies; Adhere to DFO's operational statements; Adhere to appropriate construction operating window for instream work; Adhere to the Spill Containment and Emergency Response Plan; Spill kits, Equipment maintenance, Stream setback distances, Water quality maintenance	Yes	Sublethal toxic effects on fish; Toxicity to aquatic invertebrates and loss of productive habitat capacity
Aquatic Habitat	Construction Operation Closure	Mine Site	Camp 4: Mitchell North; Camp 9: Mitchell Initial: Camp 10: Mitchell Secondary; Mitchell Operating Camp; WSD, WSF, WTP; McTagg Energy Recovery Facility	Toxicity or alteration of aquatic habitat due to introduction of petroleum products into aquatic environment during normal Project activities	Spill Containment and Emergency Response Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices to minimize petroleum product entry to water bodies; Adhere to the Spill Containment and Emergency Response Plan; Spill kits, Equipment maintenance, Stream setback distances, Water quality maintenance	Yes	Increased toxicity in aquatic invertebrates and loss of productive habitat capacity
Dolly Varden Rainbow trout Pacific salmon	Construction	Mine Site	Coulter Creek Access Corridor; Camp 3: Eskay Staging; Camp 7: Unuk North; Camp 8: Unuk South	Toxicity due to introduction of nitrogenous compounds associated with blasting residue or sewage	DFO Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters; Erosion Control Plan; Sewerage System Regulation; Industry Standards for Wastewater Treatment; Fish and Aquatic Habitat Protection and Mitigation Plan	Adhere to DFO's operational statements; Use of best management practices to minimize blast residue entry to water bodies; Use of best management practices and industry wastewater treatment standards to treat effluent; discharge of effluent to ground disposal; Site isolation; meet setback distances to water bodies; Water quality maintenance; Implement and adhere to applicable management and monitoring plans	Yes	Sublethal toxic effects on fish; Toxicity to aquatic invertebrates and loss of productive habitat capacity

(continued)

Table 15.7-10. Potential Residual Effects on Fish and Aquatic Habitat Valued Components due to Water Quality Degradation (completed)

Valued Component	Timing Start	Project Area(s)	Component(s)	Description of Effect due to Component(s)	Type of Project Mitigation	Project Mitigation Description	Potential Residual Effect	Description of Residuals
Aquatic Habitat	Construction Operation Closure	Mine Site	Coulter Creek Access Corridor; Explosives Manufacturing Facility; Camp 3: Eskay Staging; Camp 7: Unuk North; Camp 8: Unuk South; Camp 4: Mitchell North; Camp 9: Mitchell Initial; Camp 10: Mitchell Secondary; Mitchell Operating Camp	Toxicity due to introduction of nitrogenous compounds associated with blasting residue or sewage	Explosives Act; DFO Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters; Erosion Control Plan; Sewerage System Regulation; Municipal Wastewater Regulation and associated monitoring program; Industry Standards for Wastewater Treatment; Fish and Aquatic Habitat Protection and Mitigation Plan	Use of best management practices and industry standards on storage, manufacturing and transportation of explosives to minimize residue entry to water bodies; Adhere to DFO's operational statements; Use of best management practices to minimize blast residue entry to water bodies; Use of best management practices and industry wastewater treatment standards to treat effluent; Site isolation; meet setback distances to water bodies; Water quality maintenance; Implement and adhere to applicable management and monitoring plans	Yes	Increased effects in aquatic invertebrates and loss of productive habitat capacity
Aquatic Habitat	Construction Operation Closure	Mine Site	Coulter Creek Access Corridor; Explosives Manufacturing Facility; Camp 3: Eskay Staging; Camp 4: Mitchell North; Camp 7: Unuk North; Camp 8: Unuk South; Camp 9: Mitchell Initial; Camp 10: Mitchell Secondary; Mitchell Operating Camp	Alteration of aquatic resources and potential for eutrophication associated with blasting residue or sewage	DFO Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters; Erosion Control Plan; Sewerage System Regulation; Industry Standards for Wastewater Treatment; Fish and Aquatic Habitat Protection and Mitigation Plan	Adhere to DFO's operational statements; Use of best management practices to minimize blast residue entry to water bodies; Use of best management practices and industry wastewater treatment standards to treat effluent and minimize effluent entry to water bodies; Site isolation; Seepage collection pond collecting run-off; Water quality maintenance; Implement and adhere to applicable management and monitoring plans	Yes	Increased nutrients, eutrophication, decreased productive habitat capacity

Bull trout do not inhabit streams in the other areas of the Project and thus will not be affected by water quality changes in the Mine Site.

The mitigation measures outlined in Section 15.7.4.2 will substantially decrease the potential for residual effects on bull trout. However, even after all mitigation measures have been applied, there is still some potential for residual effects remaining for the following pathways, effects, and phases:

- toxicity due to metal exposure from non-point sources (e.g., ML/ARD generation associated with construction and infrastructure development) during all phases of the Project;
- toxicity due to metals or process chemical exposure downstream of the TMF associated with scheduled discharge or seepage from the TMF during operation, closure, and post-closure; and
- toxicity due to introduction of petroleum products into the aquatic environment during normal Project activities in construction, operation, and closure.

A summary of the potential residual effects on bull trout associated with water quality degradation are presented in Table 15.7-10.

15.7.4.5 Dolly Varden: Potential Residual Effects due to Water Quality Degradation

Dolly Varden is the only fish species that occurs in nearly all streams in the LSA, except upstream of the cascade in Sulphurets Creek. Therefore, the potential for residual effects due to water quality degradation from both point and non-point sources may occur in a number of areas.

Project components include access roads, transmission lines, camps, RSFs, pits, hydropower tunnels, the Mitchell-Treaty Twinned Tunnels (MTT), and discharges from the TMF, the WSF, and the WTP. Dolly Varden may also be affected by water quality changes associated with TMF or Mine Site WTP discharges (potential point sources of metals and process chemicals) during the operation, closure, and post-closure phases. While fish are not necessarily in the areas where the Project components are physically located (e.g., fish were not found above the cascades on Sulphurets Creek), chemicals introduced to the water in these areas can be carried downstream to areas where fish are found. The potential for residual effects may occur during the construction, operation, closure, and post-closure phases for many of these Project components.

The mitigation measures outlined in Section 15.7.4.2 will substantially decrease the potential for residual effects on Dolly Varden. However, even after all mitigation measures have been applied there is still some potential for residual effects remaining for the following pathways and effects:

- toxicity due to metal exposure from non-point sources (e.g., ML/ARD generation associated with construction and infrastructure development) during all phases of the Project;
- toxicity due to metals or process chemical exposure downstream of the TMF associated with scheduled discharge or seepage from the TMF during operation, closure, and post-closure;

- toxicity due to metals or process chemical exposure downstream of the Mine Site WTP associated with scheduled discharge or seepage from the Mine Site WTP during operation, closure, and post-closure;
- toxicity due to introduction of petroleum products into the aquatic environment during normal Project activities in construction, operation, and closure; and
- toxicity due to introduction of nitrogenous compounds associated with blasting residues or sewage during the construction, operation, and closure phases of the Project in the PTMA.

A summary of the potential residual effects on Dolly Varden associated with water quality degradation are presented in Table 15.7-10.

15.7.4.6 Rainbow Trout/Steelhead: Potential Residual Effects due to Water Quality Degradation

Rainbow trout/steelhead are present in South Teigen Creek (below the cascades; Reach 1), Teigen Creek, Treaty Creek, the Bell-Irving River, and the Unuk River. They were not found in North Treaty or Sulphurets creeks. Potential residual effects due to water quality degradation from both point and non-point sources may be associated with access roads, transmission lines, camps, RSFs, pits, hydropower tunnels, and the MTT. Rainbow trout/steelhead may also be affected by water quality changes associated with TMF or Mine Site WTP discharges (potential point sources of metals and process chemicals) during the operation, closure, and post-closure phases. While fish are not necessarily in the areas where the Project components are physically located (e.g., fish were not found above the cascades on Sulphurets Creek), chemicals introduced to the water in these areas can be carried downstream to areas where fish are found.

The mitigation measures outlined in Section 15.7.4.2 will substantially decrease the potential for residual effects on rainbow trout/steelhead. However, even after all mitigation measures have been applied there is still some potential for residual effects remaining for the following pathways and effects:

- toxicity due to metal exposure from non-point sources (e.g., ML/ARD generation associated with construction and infrastructure development) during all phases of the Project;
- toxicity due to metals or process chemical exposure downstream of the TMF associated with scheduled discharge or seepage from the TMF during operation, closure, and post-closure;
- toxicity due to metals or process chemical exposure downstream of the Mine Site WTP associated with scheduled discharge or seepage from the Mine Site WTP during operation, closure, and post-closure; and
- toxicity due to introduction of petroleum products into the aquatic environment during normal Project activities in construction, operation, and closure.

A summary of the potential residual effects on rainbow trout/steelhead associated with water quality degradation are presented in Table 15.7-10.

15.7.4.7 Pacific Salmon: Potential Residual Effects due to Water Quality Degradation

Pacific salmon are present in Teigen Creek, Treaty Creek, the Bell-Irving River, and the Unuk River. Pacific salmon are not present in South Teigen, North Treaty, or Sulphurets creeks. Potential residual effects to Pacific salmon may occur due to water quality degradation from both point and non-point sources associated with access roads, transmission lines, camps, RSFs, pits, hydropower tunnels, and the MTT. Pacific salmon may also be affected by water quality changes associated with TMF or Mine Site WTP discharges (potential point sources of metals and process chemicals) during the operation, closure, and post-closure phases. While fish are not necessarily in the areas where the Project components are physically located (e.g., fish were not found above the cascades on Sulphurets Creek), chemicals introduced to the water in these areas can be carried downstream to areas where fish are found.

The mitigation measures outlined in Section 15.7.4.2 will substantially decrease the potential for residual effects to Pacific salmon. However, even after all mitigation measures have been applied there is still some potential for residual effects, which are the same as previously described for rainbow trout/steelhead (Section 15.7.4.6).

A summary of the potential residual effects on Pacific salmon associated with water quality degradation are presented in Table 15.7-10.

15.7.4.8 Aquatic Habitat: Potential Residual Effects due to Water Quality Degradation

Aquatic habitat was defined earlier as including sediment, aquatic resources (e.g., periphyton and benthic invertebrates), and fish habitat (i.e., waterways, fish passage, and riparian habitat). Aquatic habitat is located throughout all waterbodies (e.g., creeks, streams, rivers, and lakes) in the LSA and RSA, and can include both fish-bearing and non-fish-bearing waterbodies. Aquatic habitat in the Mine Site, specifically the non-fish-bearing reaches of waterways above the cascades on Lower Sulphurets Creek (approximately 500 m upstream of the confluence with the Unuk River), are also included. Therefore, the potential for residual effects due to water quality degradation from both point and non-point sources may occur in a number of areas. Aquatic habitat may be affected by changes in water quality associated with the construction, operation, maintenance, and closure components related to access roads, transmission lines, tunnels, pits, quarries, construction camps, the TMF, the WTP/WSF, and hydropower facilities.

The mitigation measures outlined in Section 15.7.4.2 will substantially decrease the potential for residual effects on aquatic habitat. However, even after all mitigation measures have been applied there is still some potential for residual effects remaining for the following pathways and effects:

- toxicity due to metal exposure from non-point sources (e.g., ML/ARD generation associated with construction and infrastructure development) during all phases of the Project;
- toxicity due to metals or process chemical exposure downstream of the TMF associated with scheduled discharge or seepage from the TMF during operation, closure, and post-closure;

- toxicity due to metals or process chemical exposure downstream of the Mine Site WTP associated with scheduled discharge or seepage from the Mine Site WTP during operation, closure, and post-closure;
- toxicity due to introduction of petroleum products into the aquatic environment during normal Project activities in construction, operation, and closure;
- toxicity due to introduction of nitrogenous compounds associated with blasting residues or sewage during the construction, operation, and closure phases of the Project; and
- alteration of aquatic resources and potential for eutrophication associated with blasting residues or sewage during the construction, operation, and closure phases of the Project.

A summary of the potential residual effects on aquatic habitat associated with water quality degradation are presented in Table 15.7-10.

15.7.5 Habitat Loss and Alteration

15.7.5.1 Effect of Habitat Loss and Alteration

Fish habitat loss refers to removing or physically altering aspects of the environment that are directly or indirectly used by fish. More specifically, fish habitat loss can refer to the removal of riparian and instream habitat, the loss of fish habitat productive capacity, restricting fish passage, and the alteration of water quantity. Project-specific fish habitat loss will be caused through the construction and operation of the TMF, access roads or transmission lines that cross streams and rivers, and dams.

In addition, there are areas where Project activities may have similar effects in non-fish-bearing waterways, and these will be discussed as aquatic habitat loss and alteration. In these areas, sediment quality, periphyton, and/or aquatic invertebrates could be affected, and aquatic habitat alteration may lead to effects on productive capacity. Project-specific aquatic habitat loss or alteration may occur as a result of Project infrastructure development and operation (access roads, transmission lines, TMF, mine pits, RSFs, energy recovery facilities) or water quantity changes (diversion, staged discharges from the TMF and WTP).

15.7.5.1.1 Fish Habitat Loss and Alteration due to Project Infrastructure – Linear Development

Linear developments such as access roads and a transmission line are proposed for the Project. These developments include the CCAR and TCAR, and a transmission line within the Treaty Creek watershed. Project access roads that will cross streams and rivers, with their associated bridges and culvert installations, will cause a loss of fish habitat for certain stream crossings. These fish habitat losses will require an authorization under the *Fisheries Act* (1985) to permit the destruction or disruption of fish habitat.

In some instances, stream crossings associated with roads have historically acted as barriers to fish passage, isolating populations and hindering migration to key habitats, such as spawning grounds or overwintering habitat (Furniss et al. 1991). Poorly designed or installed stream crossings can impede fish movement, lead to erosion that affects downstream habitat by introducing excess quantities of fine sediment, and alter stream channel morphology. These alterations to streams can ultimately lead to road failure and elevated road maintenance costs.

Fish habitat includes both instream and riparian habitat values. Instream habitat consists of any part of a stream that is below the mean annual high water mark (HWM). The HWM is typically a natural line or “mark” impressed on the bank or shore, indicated by erosion, shelving, changes in soil characteristics, destruction of terrestrial vegetation, or other distinctive physical characteristics. This definition generally corresponds to the 1:5 flood interval or corresponding elevation (DFO 2010). For this assessment, instream habitat was conservatively considered to be any part of the stream below the 1 in 100-year flood (Q100) elevation because the professional surveyors who assessed the crossing locations surveyed Q100, not HWM. Therefore, calculations of habitat lost represent the area of the alteration below Q100 flood elevation.

A summary of fish habitat and fisheries data at stream crossings resulting in habitat loss is presented in Tables 15.7-11 and 15.7-12. Table 15.7-11 presents crossing habitat details such as location, channel measurements, channel characteristics (bed substrate and morphology), habitat types (e.g., riparian vegetation), and habitat quality. Table 15.7-12 presents fish-bearing status and fish species present for each watercourse. Watercourses were sampled to confirm fish presence (Appendices 15-A, 15-C, 15-E, 15-G, and 15-I). Historical fish presence data were used, if available.

Eight fish-bearing crossings will result in habitat loss for the proposed TCAR. For the CCAR, five fish-bearing crossings will result in habitat loss. Road right-of-way was considered 30-m wide for this assessment. The majority of stream crossings will result in habitat loss primarily due to the use of rip-rap below the Q100 flood elevation to protect bridge abutments. This habitat loss determination is preliminary because HWM elevation data will be surveyed prior to construction. The area of fish habitat affected below the HWM will be calculated depending upon site-specific conditions.

Ten fish-bearing crossings will result in habitat loss for the proposed transmission line. For transmission line crossings, riparian function will be impaired during the construction and maintenance phases. The riparian zone was considered 15 m from the bankfull width for this effects assessment. A riparian width of 15 m for habitat loss/alteration determination was selected based upon riparian widths stated in the DFO’s Land Development Guidelines for the Protection of Aquatic Habitat (1993) and DFO's guidelines on Riparian Areas and Revegetation (DFO 2013). For this assessment, stream crossings that possessed shrub riparian vegetation were not considered habitat loss because shrubs meet clearance standards for overhead transmission lines. Stream crossings that possessed deciduous and/or coniferous trees as riparian habitat with alluvium banks were considered a habitat loss.

Dolly Varden is the dominant fish species to be affected by habitat loss. A minor amount of coho salmon habitat will be lost at the Coulter Creek, Unuk River, and Bell-Irving River crossings. None of these crossings will result in the loss of critical coho salmon fish habitat. A minor amount of chinook salmon habitat will be lost at the Unuk and Bell-Irving River crossings. None of these crossings will result in the loss of critical or spawning chinook salmon habitat.

Table 15.7-11. Fish-bearing Stream Crossing Habitat Data for Streams Resulting in Habitat Loss

					Location		Channel Measurements				Channel Characteristics		Habitat		Habitat Quality		
Road	Waterbody Name	Habitat Type	Infrastructure Type	Stream Class	Easting	Northing	Mean Channel Width (m)	Mean Gradient (%)	Mean Residual Pool Depth (m)	Mean Bankfull Depth (m)	Dominant Substrate	Morphology	Dominant Cover Type	Riparian Vegetation Type	Over-wintering	Rearing	Spawning
Coulter Creek	2060	Stream	Culvert	S3	407703	6266547	1.9	0.5	-	0.3	F	RP	OV	C	F	G	N
Access Road	Coulter Creek - 2061	Stream	Bridge	S2	407561	6266553	16.0	1.5	0.6	-	G	RP	LWD	C	G	G	G
	2063	Stream	Bridge	S2	407277	6265832	12.7	3.5	0.3	-	G	RP	LWD	C	P	F	N
	2064	Stream	Bridge	S4	407274	6265770	1.4	14.0	0.2	0.3	C	SP	OV	C	P	F	N
	Unuk River - 1025	Stream	Bridge	S1	408275	6263910	71.0	1.0	-	1.9	G	RP	LWD	C	G	G	P
	5008	Stream	Culvert	S4	408373	6263805	0.8	5.0	0.1	0.2	F	RP	U	C	P	G	F
	5007	Stream	Bridge	S2	408404	6263727	9.7	1.0	0.2	0.4	G	RP	LWD	C	G	G	G
Treaty Creek	100	Stream	Bridge, Transmission Line	S1	457091	6270729	63.3	19.0	-	3.0	C	RP	B	S	P	F	P
Access Road	108	Stream	Culvert, Transmission Line	S3	449782	6270082	2.0	24.0	0.2	0.4	C	CP	SWD	C	P	F	P
	114	Stream	Bridge, Transmission Line	S2	448987	6270402	15.5	20.0	-	0.6	B	CP	B	D, M	P	F	P
	204	Stream	Culvert, Transmission Line	S4	455882	6270066	0.3	18.0	0.4	0.1	C	CP	SWD,OV	S,C	P	P	P
	205	Stream	Culvert, Transmission Line	S4	455723	6270012	0.4	15.0	-	0.1	C	CP	OV	S,M	P	P	P
	209	Stream	Culvert, Transmission Line	S4	455448	6269847	0.9	9.0	-	8.7	C	CP	SWD,OV	M	P	F	P
	243	Stream	Bridge	S3	443508	6272703	2.1	18.0	0.1	0.5	C	CP	SWD	C	P	G	F
	244	Stream	Bridge, Transmission Line	S2	452180	6269610	5.5	18.0	-	1.2	C	CP	OV	C	P	F	P
	210	Stream	Bridge, Transmission Line	S3	455190	6269430	4.0	16.0	-	-	-	CP	OV	M	P	F	P
	North Treaty Creek - 4011	Stream	Bridge, Transmission Line	S2	447556	6271912	8.9	2.7	-	1.1	B	CP	B	D	G	F	P
	Bell Irving River - 4004	Stream	Bridge	S1	460039	6272653	70.0	0.5	-	-	G	RP	SWD	M	G	G	F
	Bell Irving River - 4005	Stream	Transmission Line	S1	460325	6272531	65.0	0.5	-	-	G	RP	SWD	M	G	G	F
	Glacier Creek - 4006	Stream	Transmission Line	S3	460192	6273853	3.0	14.0	0.2	0.6	C	CP	LWD	D	F	P	P

Dashes indicate not applicable or no data available.

Dominant Substrate:
F = fines
C = cobble
B = boulder
G = gravel

Morphology:
CP = cascade pool
RP = riffle pool
SP = step pool
LC = large channel

Riparian Vegetation Type:
D = deciduous
C = coniferous
S = shrubs
G = grass
M = mixed

Habitat:
G = good
P = poor
F = fair
N = none

Table 15.7-12. Individual Fish-bearing Stream Crossing Fisheries Data for Streams Resulting in Habitat Loss

					Year Sampled					Fish		Habitat Loss Determination	
Road	Waterbody Name	Habitat Type	Infrastructure Type	Stream Class	2008	2009	2010	2011	2012	Fish Bearing Status	Species Present	Access Road	Transmission Line
Coulter Creek	2060	Stream	Culvert	S3	X	X				Confirmed	CO, DV	Yes	NA
Access Road	Coulter Creek - 2061	Stream	Bridge	S2	X	X				Confirmed	CO, DV	Yes	NA
	2063	Stream	Bridge	S2	X	X				Confirmed	DV, CO, CCT	Yes	NA
	Unuk River - 1025	Stream	Bridge	S1	X	X				Confirmed	CO, CH, SK, DV, CCT	Yes	NA
	5008	Stream	Culvert	S4		X				Default	DV*	Yes	NA
Treaty Creek	100	Stream	Bridge, Transmission Line	S1					X	Default	DV*	Yes	No
Access Road	108	Stream	Culvert, Transmission Line	S3					X	Default	RB, DV*	Yes	Yes
	114	Stream	Bridge, Transmission Line	S2			X	X		Confirmed	DV	No	Yes
	204	Stream	Culvert, Transmission Line	S4					X	Default	DV*	Yes	Yes
	205	Stream	Culvert, Transmission Line	S4					X	Default	DV*	Yes	Yes
	209	Stream	Culvert, Transmission Line	S4					X	Default	DV*	Yes	Yes
	244	Stream	Bridge, Transmission Line	S2			X			Confirmed	RB, DV	No	Yes
	210	Stream	Bridge, Transmission Line	S3					X	Confirmed	RB, DV	Yes	Yes
	North Treaty Creek - 4011	Stream	Bridge, Transmission Line	S2	X	X				Confirmed	DV, MWF	Yes	Yes
	Bell Irving River - 4004	Stream	Bridge	S1		X	X			Confirmed	BT, CH, CO, DV, MWF, SK, RB	Yes	NA
	Bell Irving River - 4005	Stream	Transmission Line	S1		X	X			Confirmed	BT, CH, CO, DV, MWF, SK, RB	NA	Yes
	Glacier Creek - 4006	Stream	Transmission Line	S2			X			Confirmed	DV	NA	Yes

Species: BT = bull trout; CH = Chinook salmon; CO = coho salmon; DV = Dolly Varden; MWF = mountain whitefish; SK = sockeye salmon; RB = rainbow trout/steelhead
Astericks indicates species not confirmed but likely present based upon habitat characteristics
NA = not applicable

Project access roads are expected to remove 1,108 m^2 of fish habitat due to the installation of bridge piers, culverts, and rip-rap (Table 15.7-13). The transmission line will not produce a loss and alteration of instream habitat; however, 9,000 m^2 of riparian habitat will be altered due to the clearing of vegetation for the alignment (Table 15.7-14). Habitat loss is also summarized in Table 15.7-15.

15.7.5.1.2 Fish Habitat Loss and Alteration due to Project Infrastructure – Tailing Management Facility Development

TMF infrastructure such as the North and Southeast dams, Saddle dams, seepage dams, TMF waste piles, and Treaty Creek pipeline outlet will cause a loss of fish habitat in Treaty, North Treaty, and South Teigen watersheds. These fish habitat losses will require an authorization under Section 35 of the *Fisheries Act* (1985) to permit the harmful alteration, destruction, or disruption (HADD) of fish habitat. Furthermore, the deposition of deleterious substances within the TMF and seepage ponds will cause a loss of fish habitat in North Treaty and South Teigen watersheds. Section 36(1) of MMER(SOR/2002-222) governs compensation for the loss of fish habitat within the TMF and seepage ponds.

Instream habitat consists of any part of a stream that is below the mean annual HWM. To assess habitat loss due to the TMF development, instream habitat was conservatively considered to be any part of the stream below the HWM because the professional field biologist measured bankfull width for individual streams. This differed from the linear development assessment discussed above where the Q100 level was used to delineate instream habitat.

A detailed summary of fish habitat data within the TMF is presented in the HADD Fish Habitat Compensation Plan (Appendix 15-R) and MMER Fish Habitat Compensation Plan (Appendix 15-Q) in Tables 4.2-1 to 4.2-10. These tables present stream and wetland habitat details such as channel measurements, channel characteristics (bed substrate and morphology), habitat types (e.g., riparian vegetation), and habitat quality. Section 15.1.4.4.2 describes fish habitat within the TMF.

Dolly Varden is the only species present within the TMF. A total of 69 fish-bearing streams and 6 fish-bearing wetlands will lose habitat in the proposed TMF development. The overall loss of fish habitat is expected to total 129,105 m^2 (12.9 ha), of which 117,549 m^2 (11.7 ha) is stream fish habitat (91%; Table 15.7-16), and 11,556 m^2 (1.2 ha) is wetland fish habitat (9%; Tables 15.7-15 and 15.7-17).

A total area of 89,590 m^2 (8.96 ha) of fish habitat will be lost from South Teigen and North Treaty watersheds as a result of the deposit of deleterious substances into the proposed TMF and seepage collection ponds (Table 15.7-15). A total area of 39,515 m^2 (3.95 ha) of fish habitat will be lost from TMF and seepage pond dams, TMF waste piles, and Treaty Creek pipeline outlet.

In addition to the direct loss of habitat, the proposed dams will prevent fish movement to upper reaches of North Treaty and South Teigen watersheds. Specifically, the reach in South Teigen Creek between the falls and the seepage collection dam will be isolated. This reach of South Teigen Creek is limited in low gradient tributaries that Dolly Varden use as spawning habitat (Appendix 15-C). Rearing and overwintering habitat are not limited in the mainstem reaches (Appendix 15-C). Therefore, the long-term longevity and/or abundance of this isolated Dolly Varden population may decline due to the loss of tributary spawning habitat in the upper watershed.

Table 15.7-13. Access Road Stream Habitat Loss Summary

Road	Waterbody Name	Project Infrastructure	Habitat Type	Area Loss (m^2)
Coulter Creek Access Road	2063	Bridge	Stream	30
	Unuk River - 1025	Bridge	Stream	220
	5008	Culvert	Stream	16
	2060	Culvert	Stream	57
	Coulter Creek - 2061	Bridge	Stream	60
Treaty Creek Access Road	100	Bridge	Stream	150
	108	Culvert	Stream	40
	204	Culvert	Stream	6
	205	Culvert	Stream	8
	209	Culvert	Stream	18
	210	Culvert	Stream	45
	North Treaty Creek - 4011	Bridge	Stream	210
	Bell Irving River - 4004	Bridge	Stream	248
Total				**1,108**

Table 15.7-14. Transmission Line Riparian Habitat Loss Summary

Project Infrastructure	Waterbody Name	Habitat Type	Area Loss (m^2)
Transmission Line	108	Stream	900
	114	Stream	900
	204	Stream	900
	205	Stream	900
	209	Stream	900
	244	Stream	900
	210	Stream	900
	North Treaty Creek - 4011	Stream	900
	Bell Irving River - 4005	Stream	900
	Glacier Creek - 4006	Stream	900
Total			**9,000**

Table 15.7-15. KSM Project Fish Habitat Loss Summary

		Habitat		Habitat Loss	
Infrastructure	**Total Area**	**Stream**	**Wetland**	**MMER Plan (Tailing)**	**HADD Plan (Infrastructure)**
Access Roads	1,108	1,108	-	NA	1,108
Transmission Line	9,000	9,000	-	NA	9,000
TMF	129,105	117,549	11,556	89,590	39,515
Water Quantity Loss	4210.7	4210.7	-	NA	4210.7
Total	143,424	131,868	11,556	89,590	53,834

Dash indicates not present
NA = not applicable

Table 15.7-16. Dolly Varden Stream Habitat Loss Summary

Watershed	Project Infrastructure	Waterbody Name	Area Loss (m^2)
South Teigen	TMF Dam	1002	46.0
South Teigen	TMF Dam	1003	78.7
South Teigen	TMF Dam	1004	985.1
South Teigen	TMF Waste Pile	1012	432.0
South Teigen	TMF Waste Pile	1013	28.0
South Teigen	TMF Waste Pile	1014	35.8
South Teigen	TMF Waste Pile	1015	67.5
South Teigen	TMF Waste Pile	1016	1,794.0
South Teigen	TMF Waste Pile	1017	245.0
South Teigen	TMF Waste Pile	1018	36.0
South Teigen	TMF Dam	1027	101.5
South Teigen	TMF Dam	1029	750.0
South Teigen	TMF Dam	1030	1,566.0
South Teigen	TMF Dam	1110	656.3
South Teigen	TMF Dam	1150	64.5
South Teigen	TMF Dam	1151	25.5
South Teigen	TMF Dam	1152	29.3
South Teigen	TMF Waste Pile	1088	40.0
South Teigen	TMF Dam	1090	14.0
South Teigen	TMF Dam	1091	32.8
South Teigen	TMF Waste Pile	1207	30.0
South Teigen	TMF Dam	1205	86.8
North Treaty	TMF Dam	1051	124.7
North Treaty	TMF Dam	1052	32.7
North Treaty	TMF Dam	1053	162.0
North Treaty	TMF Dam	1082	279.8
North Treaty	TMF Dam	1072	121.6
North Treaty	TMF Dam	1059	300.6
North Treaty	TMF Dam	1070	20.3
South Teigen	TMF Dam	South Teigen - Reach 8	1,600.0
South Teigen	TMF Dam	South Teigen - Reach 7	1,566.0
South Teigen	TMF Dam	South Teigen - Reach 6	2,277.0
South Teigen	TMF Dam/Waste Pile	South Teigen - Reach 5	9,202.1
South Teigen	TMF Dam	South Teigen - Reach 4	8,275.9
South Teigen	Seepage Dam	South Teigen - Reach 4	2,152.7
North Treaty	TMF Dam	North Treaty - Reach 2	3,136.5
North Treaty	TMF Dam	North Treaty - Reach 1	1,958.0
North Treaty	Seepage Dam	North Treaty - Reach 1	746.6
Treaty	Pipeline Outlet	Treaty Creek - 1	100.0

(continued)

Table 15.7-16. Dolly Varden Stream Habitat Loss Summary (continued)

Watershed	Project Infrastructure	Waterbody Name	Area Loss (m^2)
South Teigen	Tailing	1005	174.8
South Teigen	Tailing	1006	188.0
South Teigen	Tailing	1007 A	61.1
South Teigen	Tailing	1007 B	321.4
South Teigen	Tailing	1008	231.4
South Teigen	Tailing	1009	19.5
South Teigen	Tailing	1010	2,300.2
South Teigen	Tailing	1011 A	259.9
South Teigen	Tailing	1011 B	90.5
South Teigen	Tailing	1012	572.4
South Teigen	Tailing	1019 A	1,237.5
South Teigen	Tailing	1019 B	275.0
South Teigen	Tailing	1021	209.6
South Teigen	Tailing	1022	439.3
South Teigen	Tailing	1023 A	253.1
South Teigen	Tailing	1023 B	64.2
South Teigen	Tailing	1025	578.3
South Teigen	Tailing	1026	175.0
South Teigen	Tailing	1028	325.5
South Teigen	Tailing	1029	594.0
South Teigen	Tailing	1030	2,985.8
South Teigen	Tailing	1150	677.0
South Teigen	Tailing	1206	59.3
North Treaty	Tailing	1054	209.4
North Treaty	Tailing	1055	222.8
North Treaty	Tailing	1056	65.7
North Treaty	Tailing	1057	40.6
North Treaty	Tailing	1059	1,497.2
North Treaty	Tailing	1060	2,535.1
North Treaty	Tailing	1061	22.6
North Treaty	Tailing	1062	293.2
North Treaty	Tailing	1063	10.5
North Treaty	Tailing	1064	20.0
North Treaty	Tailing	1065	44.9
North Treaty	Tailing	1066	14.9
North Treaty	Tailing	1067	141.8
North Treaty	Tailing	1068	70.0
North Treaty	Tailing	1069	4.8

(continued)

Table 15.7-16. Dolly Varden Stream Habitat Loss Summary (completed)

Watershed	Project Infrastructure	Waterbody Name	Area Loss (m^2)
North Treaty	Tailing	1070	29.2
North Treaty	Tailing	1071	13.0
North Treaty	Tailing	1072	315.1
North Treaty	Tailing	1081	106.9
North Treaty	Tailing	1082	1,839.8
North Treaty	Tailing	1083	54.8
North Treaty	Tailing	1084	166.4
North Treaty	Tailing	1085	57.9
North Treaty	Tailing	1086	97.3
North Treaty	Tailing	1087	246.7
North Treaty	Tailing	1089	36.0
North Treaty	Tailing	1101	7.0
South Teigen	Tailing	South Teigen - Reach 8	4,864.0
South Teigen	Tailing	South Teigen - Reach 6	3,896.0
South Teigen	Tailing	South Teigen - Reach 5	9,871.3
South Teigen	Tailing	South Teigen - Reach 4	10,891.0
South Teigen	Tailing	South Teigen - Reach 4 (seepage pond)	12,304.4
North Treaty	Tailing	North Treaty - Reach 1	6,358.0
North Treaty	Tailing	North Treaty - Reach 2	9,906.9
Total			117,548.8

Table 15.7-17. Dolly Varden Wetland Habitat Loss Summary

Watershed	Project Infrastructure	Waterbody Name	Area Loss (m^2)
South Teigen	Dam	STW2	314
South Teigen	Tailing	STW1	1,544
South Teigen	Tailing	STW3	309
North Treaty	Tailing	NTW1	4,421
North Treaty	Tailing	NTW2	4,344
North Treaty	Tailing	NTW3	624
Total			11,556

15.7.5.1.3 Fish Habitat Loss and Alteration due to Tailing Management Facility Water Management – South Teigen and North Treaty Creeks

North Treaty and South Teigen creeks are tributaries of Treaty and Teigen creeks, respectively. The TMF is situated within the watershed of these creeks. Potential changes in stream flow in South Teigen and North Treaty creeks due to the TMF development were assessed quantitatively.

Methods

The physical fish habitat analyses in this study follow the BC Instream Flow Assessment Methods (Lewis et al. 2004). This includes:

- identifying the watercourses and reaches of concern;
- identifying target species and their life stages of concern;
- collecting data regarding preferred habitat conditions (i.e., habitat suitability criteria) for concerned life stages of target species and surveying cross-sections along the streams of interest;
- specifying stream flows before and after development of the Project;
- performing hydraulic analysis to identify hydraulic parameters at all cross-sections for both the baseline and developed flow rates in the streams; and
- integrating results of the hydraulic analysis with habitat suitability criteria to estimate weighted usable habitat before and after development of the Project.

South Teigen Creek is divided into two reaches based on stream morphological characteristics. Reach 1 is outside of the TMF and downstream of a 2.5-m falls. Reach 2 is between the toe of the seepage dam and the falls. The length of mesohabitat units within the stream reaches (which are macrohabitat units) are summarized in Table 15.7-18.

Table 15.7-18. Length of Mesohabitat Units in each Macrohabitat

Macrohabitat	Mesohabitat Unit Length (m)			
	Riffle	Cascade	Pool	Glide
North Treaty Creek - Reach 1	58	109	27	0
North Treaty Creek - Reach 0	35	1,631	106	0
South Teigen Creek – Reach 1	214	1,820	107	0
South Teigen Creek – Reach 2	142	1,063	213	0

The *British Columbia Instream Flow Guidelines for Fish* (Lewis et al. 2004) support a two-tiered process: first, instream flow thresholds, followed by instream flow assessment methods. The instream flow thresholds serve as a coarse filter using hydrological data only, and indicate that instream flow reductions are of potential concern (i.e., potential HADD). The thresholds are determined by comparing the discharge hydrograph for developed conditions to the flow thresholds for the stream. There is a potential for a HADD if the developed conditions fall below the threshold values, and if this is the case, the second-tier instream flow assessment must be conducted.

Instream flow thresholds were determined for South Teigen and North Treaty creeks. The BC instream flow thresholds require 20 years of daily stream flow data to determine monthly minimum flows. Twenty years of historic stream flow data does not exist for any of these watersheds; therefore, historic stream flow data were simulated using a linked groundwater/surface hydrology model using 25 years of climate data. This model was calibrated with stream flow data collected from various gauging stations established in these watersheds (Appendix 15-O).

North Cell TMF changes in monthly discharge of South Teigen Creek during TMF construction, operation, and closure (years 0 to 45, years 46 to 56, and years greater than 56) were predicted by the calibrated groundwater/discharge model. The South Cell TMF changes in monthly discharge of North Treaty Creek during TMF construction, operation, and closure (years 0 to 24, years 25 to 30, years 30 to 45, years 46 to 56, and years greater than 56) were predicted by the same methods as discussed above.

The instream flow thresholds calculated from the modelled data indicate that the TMF developed conditions will fall below the threshold for South Teigen and North Treaty creeks. For South Teigen Creek, the TMF developed conditions will be below the threshold in all months for years 0 to 45, except September (Table 15.7-19). For North Treaty Creek, TMF developed conditions will be below the threshold in all months for years 51 to 56 (Table 15.7-20). Therefore, the conditions of the first tier were not satisfied for both creeks, and a second-tier instream flow assessment must be conducted.

Table 15.7-19. Comparison of Instream Flow Thresholds, based on Hatfield et al. 2003, and Proposed Operational Flows for South Teigen Creek (NTWM-H1)

Month	Flow Threshold (m^3/s)	Baseline Flow (m^3/s)	Operational Flow (m^3/s)					
			Years 0-24	Years 25-30	Years 30-45	Years 45-50	Years 51-56	Years >56
Jan	0.39	0.30	0.25	0.25	0.25	0.32	0.32	0.31
Feb	0.54	0.27	0.21	0.21	0.21	0.27	0.27	0.26
Mar	0.65	0.29	0.24	0.24	0.24	0.30	0.30	0.29
Apr	1.14	0.63	0.51	0.51	0.51	0.63	0.63	0.60
May	4.28	4.03	3.29	3.29	3.29	3.96	3.96	3.62
June	6.95	7.76	6.21	6.21	6.21	7.62	7.62	7.12
July	5.43	5.11	4.24	4.24	4.24	5.24	5.24	5.16
Aug	2.86	3.00	2.49	2.49	2.49	3.02	3.02	2.97
Sep	2.67	3.98	3.23	3.23	3.23	3.90	3.90	3.75
Oct	3.17	2.61	2.16	2.16	2.16	2.71	2.71	2.68
Nov	1.50	1.15	0.94	0.94	0.94	1.22	1.22	1.24
Dec	0.16	0.56	0.47	0.47	0.47	0.59	0.59	0.59
MAD		2.47	2.02	2.02	2.02	2.48	2.48	2.38

MAD = mean annual discharge

For the second-tier assessment, North Cell TMF changes in monthly discharge of South Teigen Creek were compared to the instream flow threshold techniques for BC (Hatfield et al. 2003) under baseline conditions. The South Cell TMF changes in monthly discharge of North Treaty Creek were predicted by the same methods as discussed above. The following sections provide the results of the second-tier assessment.

Table 15.7-20. Comparison of Instream Flow Thresholds, based on Hatfield et al. 2003, and Proposed Operational Flows for North Treaty Creek (STWM-H1)

Month	Flow Threshold (m^3/s)	Baseline Flow (m^3/s)	Operational Flow (m^3/s)					
			Years 0-24	Years 25-30	Years 30-45	Years 45-50	Years 51-56	Years 57+
Jan	0.41	0.24	0.23	0.19	0.28	0.19	0.17	0.24
Feb	0.51	0.27	0.25	0.20	0.29	0.20	0.18	0.25
Mar	0.64	0.28	0.27	0.22	0.32	0.22	0.20	0.28
Apr	1.23	0.72	0.69	0.56	0.79	0.56	0.50	0.71
May	2.84	3.22	3.10	2.46	3.41	2.46	2.26	3.27
June	3.26	4.08	3.88	3.09	4.41	3.09	2.85	4.12
July	2.65	2.75	2.65	2.16	3.12	2.16	1.93	2.62
Aug	1.42	1.45	1.39	1.13	1.60	1.13	1.02	1.34
Sep	1.28	1.55	1.48	1.21	1.67	1.21	1.08	1.48
Oct	1.37	1.06	1.02	0.83	1.23	0.83	0.74	1.05
Nov	0.82	0.50	0.47	0.39	0.60	0.39	0.35	0.49
Dec	0.52	0.35	0.34	0.27	0.42	0.27	0.24	0.35
MAD		1.37	1.31	1.06	1.51	1.06	0.96	1.35

MAD = mean annual discharge

Target Species

Dolly Varden is the only species present in Reach 2 of South Teigen Creek and North Treaty Creek. Dolly Varden, bull trout, mountain whitefish, and rainbow trout are present in Reach 1 of the South Teigen Creek. However, the abundance of bull trout, mountain whitefish, and rainbow trout was low compared to Dolly Varden in Reach 1 of South Teigen Creek. Therefore, Dolly Varden was selected as the target species for this physical habitat effect study due to its abundance in the baseline study area.

The life stages of concern for Dolly Varden in the South Teigen and North Treaty creeks include adult spawning in October, summer low flow for parr in August, and overwintering habitat for parr and adults. To evaluate effects on Dolly Varden summer parr-rearing habitat, the month of August was selected as a critical period in South Teigen and North Treaty creeks because of low flow and greater water temperatures. To evaluate effects on Dolly Varden adult spawning habitat, the month of October was selected as a critical period in North Treaty Creek because this is when spawning occurs in the mainstem. Overwintering, although considered as a life stage of concern, was not modelled. Hydraulic modelling, and hence physical habitat estimations, during the winter is not as reliable because open-water conditions are not in place. Therefore, physical habitat estimation studies have been limited to the critical periods (i.e., August and October).

Physical Habitat Suitability Criteria

Physical habitat models integrate hydraulic parameters of the flow with other conditions such as substrate composition and cover, which are important to fish species. The Habitat Suitability

Indices (HSI) of microhabitat units in streams are evaluated using available depth, velocity, substrate, and cover preferences for different life stages of target species. These preferences are referred to as Habitat Suitability Criteria (HSC) for the target species.

Depth and velocity HSC for Dolly Varden were extracted from the Washington Department of Fish and Wildlife and Ecology (2008), converted to the metric system, and are shown in Figure 15.7-1. There are no peer-reviewed depth and velocity HSC for Dolly Varden in BC; therefore, the Washington HSC was used because the data were from coastal environments similar to the LSA and RSA.

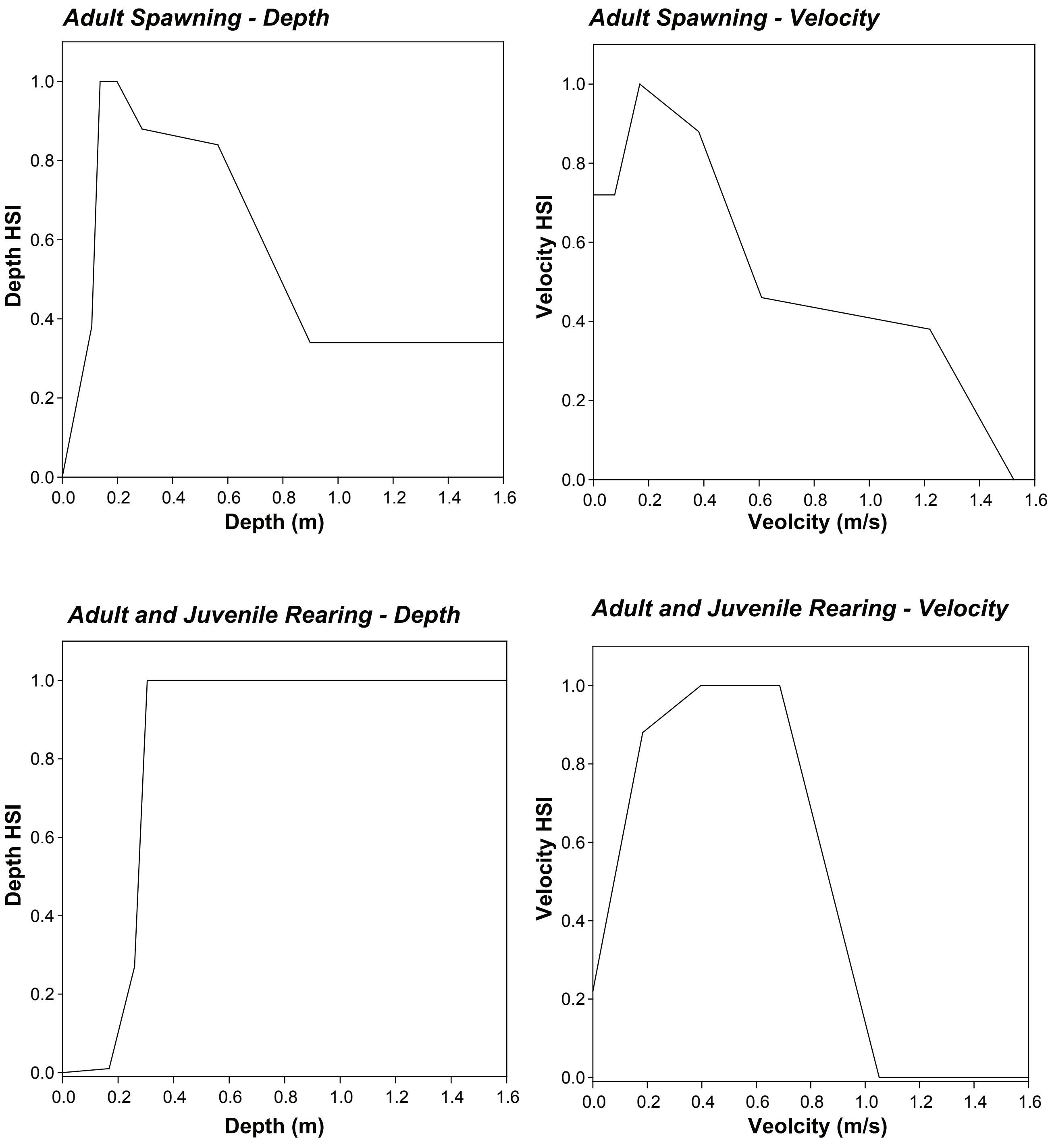
Cross-section Surveys

During the fish habitat surveys for the KSM Project, three sets of surveys were conducted for 15 cross-sections on North Treaty Creek and 10 of the 22 surveyed cross-sections on South Teigen Creek. Ten of the remaining 12 cross-sections on the South Teigen Creek were surveyed twice and two cross-sections were surveyed once. Transects 1 to 17 on the South Teigen Creek were in Reach 2, and transects 18 to 22 were in Reach 1. During the surveys, cross-sections were divided into multiple segments in which water depth and flow velocity were measured. Selection of transects was primarily based on fisheries criteria. Cross-section surveys included the wetted area of the stream only, i.e., the extent of the cross-sections was limited to the water surface at the time of each survey. Using available site visit photos, these geometry data were extrapolated beyond the water surface. Whenever multiple surveys were available for one cross-section, the most recent survey was preferred because it represented the most updated geomorphology of the streams unless errors were visible in the more recent survey. Details about selected geometry and observed data at each cross-section on the North Treaty and South Teigen creeks are provided in Tables 15.7-21 and 15.7-22, respectively.

Flow Data

Through the 2007 to 2011 KSM Project surface water quantity baseline program, baseline hydrometric data was collected for specific streams, rivers, and lakes within the LSA and RSA. At each site, hydrometric stations recorded water level data during open-water periods to monitor surface water flows to characterize hydrologic variation in these waterbodies.

A total of nine hydrometric stations operated in the Teigen-Treaty drainages during the baseline monitoring program, with seven active stations in 2011. Hydrometric stations were in sub-basins ranging in size from 12.5 km^2 at station NTWM-H3 to 432 km^2 at station TC-H1. The average glacier coverage of all other stations in the Teigen-Treaty drainages was 3.5%, resulting in hydrographs characterized by freshet peaks in mid to late April, followed by a steady decline in discharge until fall precipitation supplemented flows. Streams generally returned to base flow levels in late October or early November. Average surface water runoff within the Teigen-Treaty drainages ranged from 1,129 mm at station STWM-H2 (0% glacier coverage) to 2,442 mm at station TC-H1 (25% glacier coverage).



Note: Adapted from Washington Department of Fish and Wildlife (2008)

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Dolly Varden Health Suitability Indices for Depth and Velocity Preferences

Figure 15.7-1

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Table 15.7-21. Available Data for Cross-sections on North Treaty Creek

Transect #	Hydraulic Type	Number of Surveys	Selected Survey (mon-yy)	Observed Data	
				Stage (m)	Discharge (m^3/s)
1	Pool	3	Sep-10	0.43	0.31
2	Cascade	3	Sep-10	0.40	0.23
3	Riffle	3	Sep-10	0.21	0.16
4	Riffle	3	Sep-10	0.31	0.17
5	Pool	3	Sep-09[1]	0.47	0.35
6	Cascade	3	Sep-10	0.26	0.24
7	Pool	3	Sep-10	0.50	0.29
8	Riffle	3	Sep-10	0.33	0.20
9	Cascade	3	Sep-10	0.18	0.16
10	Cascade	3	Sep-10	0.29	0.21
11	Pool	3	Sep-10	0.69	0.17
12	Riffle	3	Sep-10	0.38	0.22
13	Riffle	3	Sep-10	0.40	0.19
14	Cascade	3	Sep-10	0.26	0.22
15	Pool	3	Sep-10	0.78	0.27

[1] Geometry of the September 2010 survey was similar to that of the September 2009 survey. However, measured discharge in 2010 was too low to calibrate the hydraulic model. Therefore, September 2009 data were selected for calibration purposes.

Table 15.7-22. Available Data for Cross-sections on South Teigen Creek

Transect #	Hydraulic Type	Number of Surveys	Selected Survey (mon-yy)	Observed Data	
				Stage (m)	Discharge (m^3/s)
1 (Reach 2)	Pool	3	Sep-10[1]	0.87	1.45
2 (Reach 2)	Cascade	3	Aug-09[2]	0.43	0.89
3 (Reach 2)	Cascade	1	Aug-09[3]	0.50	0.93
4 (Reach 2)	Cascade	3	Sep-10	0.46	1.08
5 (Reach 2)	Pool	3	Sep-10	0.54	1.11
6 (Reach 2)	Riffle	1	Aug-09[4]	0.41	1.18
7 (Reach 2)	Pool	3	Sep-10	0.62	1.04
8 (Reach 2)	Cascade	3	Sep-10	0.47	0.94
9 (Reach 2)	Cascade	3	Sep-10	0.52	1.09
10 (Reach 2)	Pool	3	Sep-10	0.98	0.94
11 (Reach 2)	Cascade	3	Sep-10	0.40	0.91
12 (Reach 2)	Riffle	2	Aug-09[5]	0.52	1.05
13 (Reach 2)	Pool	3	Sep-10	1.01	1.31
14 (Reach 2)	Cascade	2	Sep-10	0.40	0.85
15 (Reach 2)	Cascade	2	Sep-10	0.38	1.41
16 (Reach 2)	Pool	2	Sep-10	0.78	0.89
17 (Reach 2)	Cascade	2	Sep-10	0.58	1.09
18 (Reach 1)	Cascade	2	Sep-10	0.47	0.94
19 (Reach 1)	Cascade	2	Sep-09[6]	0.74	1.03
20 (Reach 1)	Cascade	2	Sep-10	0.46	1.15

(continued)

Table 15.7-22. Available Data for Cross-sections on South Teigen Creek (completed)

Transect #	Hydraulic Type	Number of Surveys	Selected Survey (mon-yy)	Observed Data	
				Stage (m)	Discharge (m^3/s)
21 (Reach 1)	Cascade	2	Sep-10	0.37	1.08
22 (Reach 1)	Cascade	2	Sep-10	0.33	1.22

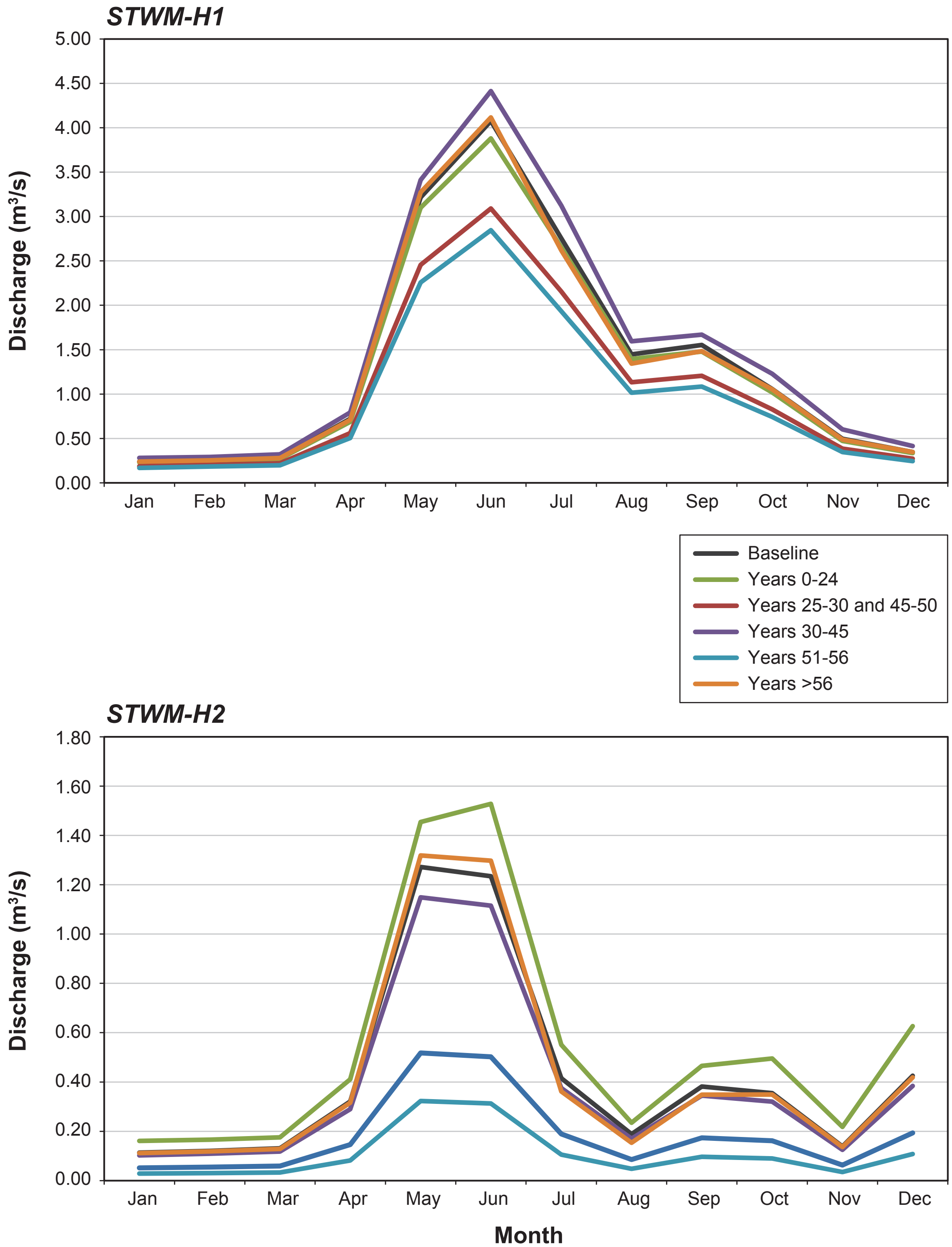
[1] One error in depth measurement was identified. After correction, the September 2010 data were used.
[2] The September 2010 survey included a couple of depth measurement errors that could not be corrected. The August 2009 survey flow rate was similar to that of the September 2010 data and therefore was selected.
[3] Only one set of survey data (i.e., August 2009) is available.
[4] Only one set of survey data (i.e., August 2009) is available.
[5] Includes two surveys: August 2009 and September 2009. The geometry data were similar; however, discharge measurements were different (1.05 m^3/s in August 2009 and 0.76 m^3/s in September 2009). The September 2009 data included several zero-valued velocity measurements, which may have resulted in underestimating the discharge. Therefore, only the August 2009 data were used here.
[6] The September 2010 data may have had a potential depth measurement error and could not be calibrated with the hydraulic model.

Key hydrometric stations in the Teigen-Treaty drainages that were used to estimate the discharge at the surveyed instream flow transects included STWM-H1 and STWM-H2 on North Treaty Creek, and NTWM-H1 and NTWM-H2 on South Teigen Creek. Average monthly baseline discharges at these stations are presented in Appendix 15-N. In addition, the average monthly flows at different phases of development of the Project were estimated based on the water management simulations. These average monthly discharges are summarized in Appendix 15-N and illustrated in Figures 15.7-2 and 15.7-3.

Given the average monthly discharges calculated from the available hydrometric data, the average monthly discharge at the surveyed cross-sections can be estimated. For this purpose, transects that have similar drainage areas are grouped together, and therefore, have similar estimated discharges. These estimates for both baseline and developed conditions are presented in Appendix 15-N, where average monthly baseline flows and operational flows for the months of interest (i.e., August and October) at all transects are highlighted. The patterns of change in the average monthly flows are shown in Figure 15.7-4.

Hydraulic Modelling

A wide range of modelling approaches is available for estimating hydraulic parameters of streams (e.g., flow depth, velocity, and shear stress). For this assessment, individual cross-section analysis was conducted. In this method, it was assumed that a cross-section represented the hydraulic characteristics of a river reach where the flow was close to a uniform pattern and was not affected by downstream back water. WinXSPRO, developed by the US Department of Agriculture, is a software package designed to analyze stream channel cross-section data. The model requires cross-sectional data and water surface slope (and in some cases the Manning's roughness coefficient) to estimate hydraulic parameters at individual cross-sections. Accurate results may be achieved if cross-sections are selected in high-gradient streams (gradient greater than 0.01) and the flow is close to uniform. However, it can be used as an approximate assessment in other conditions.



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Average Monthly Discharges in North Treaty Creek (STWM-H1 and STWM-H2) for Baseline and Tailing Management Facility Developed Conditions

Figure 15.7-2

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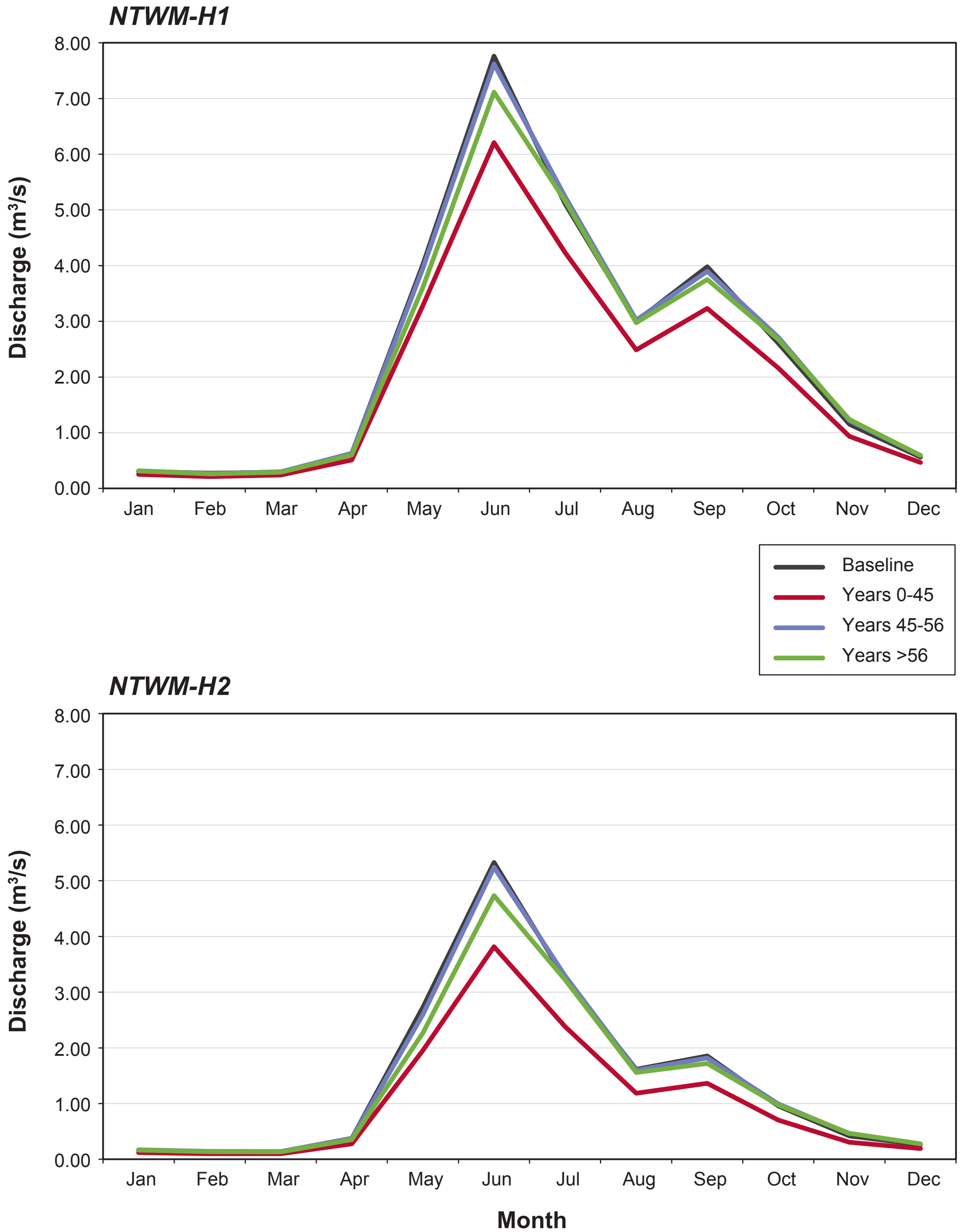
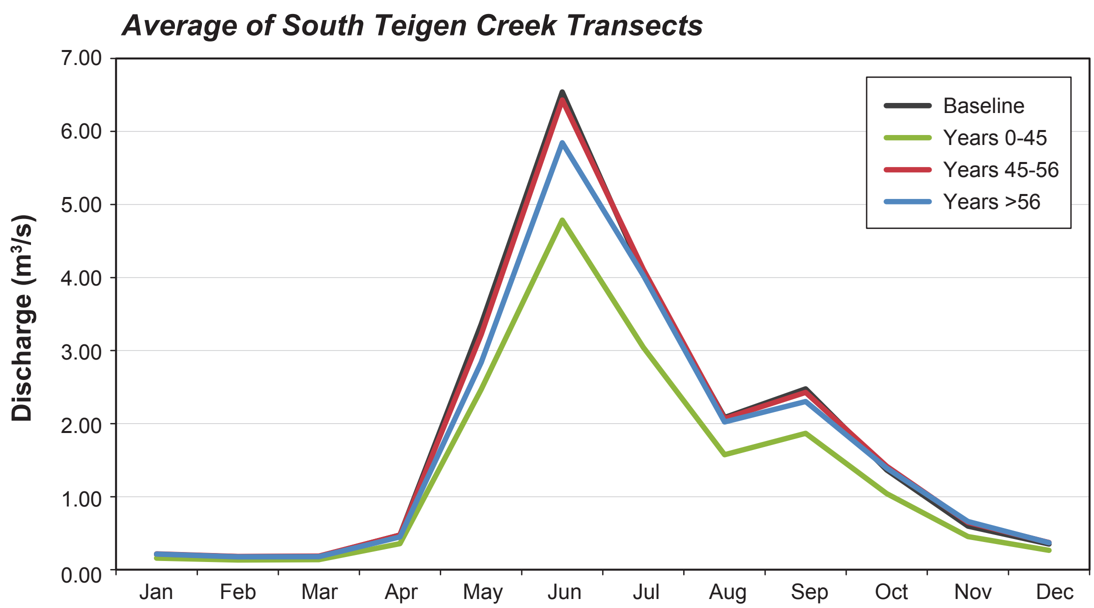
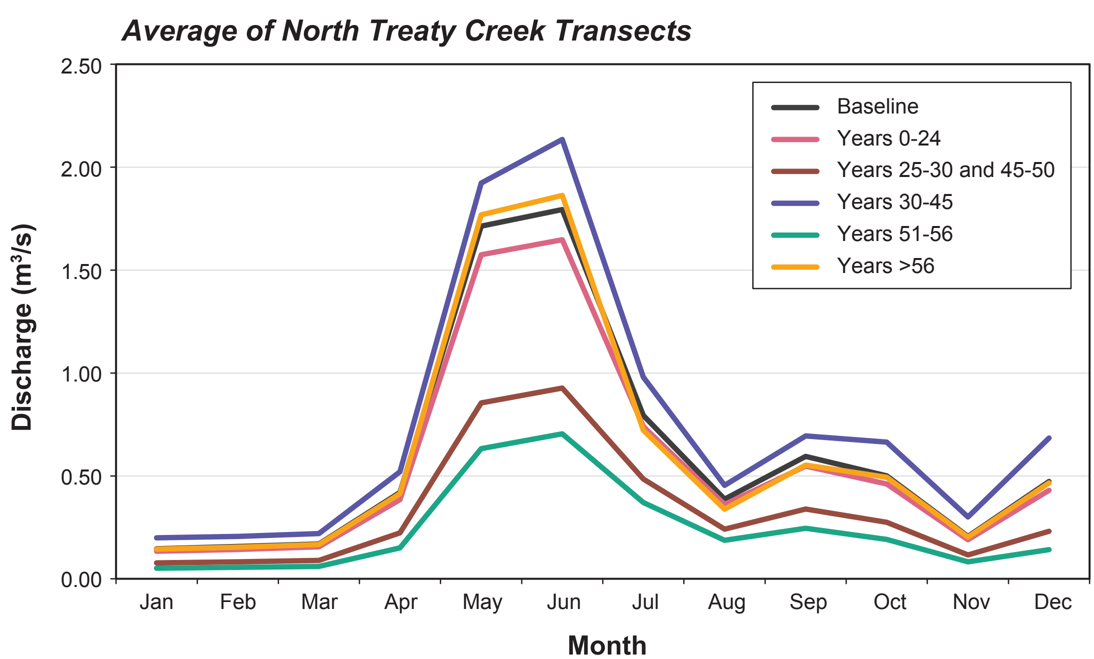


Figure 15.7-3

Average Monthly Discharges in South Teigen Creek (NTWM-H1 and NTWM-H2) for Baseline and Tailing Management Facility Developed Conditions





Baseline and Tailing Management Facility Developed Flows for Mean of all Transects on the North Treaty and South Teigen Creeks

Figure 15.7-4

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The hydraulic model was calibrated and the calibration was successful for 10 of 15 transects on North Treaty Creek, and 14 of 22 transects on South Teigen Creek. Calibrated parameters for all cross-sections are summarized in Appendix 15-N for North Treaty and South Teigen creeks.

Weighted Usable Habitat

The BC Instream Flow Assessment Methods (Lewis at al. 2004) suggests dividing each transect into several segments (or cells). Given the suitability criteria (Figure 15.7-1), and simulated values of depth, velocity, and width of each cell, the weighted usable width (WUW) for Dolly Varden for each transect was calculated.

Knowing the value of Dolly Varden WUW at all cross-sections, one can calculate the weighted usable area (WUA) of stream reaches by multiplying the WUW and the length of the reach. Comparing the WUA of the baseline and developed conditions provides a quantified measure to estimate the effects of the Project on physical fish habitat in North Treaty and South Teigen creeks.

Results

For those cross-sections where the model is calibrated, WinXSPRO provided estimated hydraulic parameters for a range of flow rates. These parameters included maximum depth, average depth, hydraulic radius, wetted area, wetted perimeter, surface width, average velocity, and bed shear stress for a range of flow rates. These results are provided in Appendix 15-N and may be used to estimate the effects of stream flow changes on the hydraulic parameters that are considered to be important physical habitat characteristics. Based on these results, water levels at each transect in the months of August and October were plotted for both baseline and developed conditions (Appendix 15-N).

Estimated WUW of all transects for both baseline and developed conditions in the months of August and October are in Appendix 15-N. Having the estimated average WUW changes (Appendix 15-N) and length of mesohabitat units (Table 15.7-18), one may assess the change in WUA from baseline to predicted development periods. Tables 15.7-23, 15.7-24, and 15.7-25 summarize these changes for different mesohabitat types in the North Treaty and South Teigen creeks in the months of August and October.

Table 15.7-23. Estimated Dolly Varden Habitat Effect on Weighted Usable Area in North Treaty Creek (Reach 1)

Month	TMF Phase (years)	Mesohabitat Unit		WUA		
		Type	Length (m)	Baseline (m^2)	Developed (m^2)	Change (%)
August	0 - 24	Riffles	58	113.2	106.8	-5.7
		Cascades	109	74.9	66.3	-11.5
		Pools	27	81.4	78.9	-3.1
October	0 - 24	Riffles	58	202.7	198.4	-2.1
		Cascades	109	286.5	284.1	-0.8
		Pools	27	97.3	95.6	-1.8

(continued)

Table 15.7-23. Estimated Dolly Varden Habitat Effect on Weighted Usable Area in North Treaty Creek (Reach 1; completed)

Month	TMF Phase (years)	Mesohabitat Unit Type	Length (m)	WUA Baseline (m^2)	Developed (m^2)	Change (%)
August	25 - 30 and 45 - 50	Riffles	58	113.2	83.2	-26.5
		Cascades	109	74.9	36.5	-51.3
		Pools	27	81.4	55.9	-31.3
October	25 - 30 and 45 - 50	Riffles	58	202.7	171.8	-15.2
		Cascades	109	286.5	280.4	-2.1
		Pools	27	97.3	92.1	-5.3
August	30 - 45	Riffles	58	113.2	123.8	9.4
		Cascades	109	74.9	109.5	46.2
		Pools	27	81.4	88.2	8.3
October	30 - 45	Riffles	58	202.7	214.3	5.7
		Cascades	109	286.5	270.7	-5.5
		Pools	27	97.3	104.2	7.1
August	51 - 56	Riffles	58	113.2	53.3	-52.9
		Cascades	109	74.9	17.1	-77.1
		Pools	27	81.4	36.4	-55.2
October	51 - 56	Riffles	58	202.7	148.1	-26.9
		Cascades	109	286.5	264.1	-7.8
		Pools	27	97.3	86.9	-10.7
August	> 56	Riffles	58	113.2	103.6	-8.5
		Cascades	109	74.9	61.3	-18.1
		Pools	27	81.4	76.1	-6.5
October	> 56	Riffles	58	202.7	203.0	0.1
		Cascades	109	286.5	290.7	1.5
		Pools	27	97.3	97.3	0.0

Table 15.7-24. Estimated Dolly Varden Habitat Effect on Weighted Usable Area in North Treaty Creek (Reach 0)

Month	TMF Phase (years)	Mesohabitat Unit Type	Length (m)	WUA Baseline (m^2)	Developed (m^2)	Change (%)
August	0 - 24	Riffles	35	68.3	64.4	-5.7
		Cascades	1,631	1,117.2	988.7	-11.5
		Pools	106	319.6	309.7	-3.1

(continued)

Table 15.7-24. Estimated Dolly Varden Habitat Effect on Weighted Usable Area in North Treaty Creek (Reach 0; completed)

		Mesohabitat Unit		WUA		
Month	**TMF Phase (years)**	**Type**	**Length (m)**	**Baseline (m^2)**	**Developed (m^2)**	**Change (%)**
October	0 - 24	Riffles	35	122.2	119.6	-2.1
		Cascades	1,631	4,289.5	4,255.2	-0.8
		Pools	106	381.9	375.0	-1.8
August	25 - 30 and 45 - 50	Riffles	35	68.3	50.2	-26.5
		Cascades	1,631	1,117.2	544.1	-51.3
		Pools	106	280.9	193.0	-31.3
October	25 - 30 and 45 - 50	Riffles	35	122.2	103.6	-15.2
		Cascades	1,631	4,289.5	4,199.4	-2.1
		Pools	106	381.9	361.7	-5.3
August	30 - 45	Riffles	35	68.3	74.7	9.4
		Cascades	1,631	1,117.2	1,633.3	46.2
		Pools	106	319.6	346.1	8.3
October	30 - 45	Riffles	35	122.2	129.2	5.7
		Cascades	1,631	4,289.5	4,053.6	-5.5
		Pools	106	381.9	409.0	7.1
August	51 - 56	Riffles	35	68.3	32.2	-52.9
		Cascades	1,631	1,117.2	255.8	-77.1
		Pools	106	319.6	143.2	-55.2
October	51 - 56	Riffles	35	122.2	89.3	-26.9
		Cascades	1,631	4,289.5	3,954.9	-7.8
		Pools	106	381.9	341.0	-10.7
August	> 56	Riffles	35	68.3	62.5	-8.5
		Cascades	1,631	1,117.2	915.0	-18.1
		Pools	106	319.6	298.8	-6.5
October	> 56	Riffles	35	122.2	122.3	0.1
		Cascades	1,631	4,289.5	4,353.8	1.5
		Pools	106	381.9	381.9	0.0

Table 15.7-25. Estimated Dolly Varden Habitat Effect on Weighted Usable Area in South Teigen Creek

Month	TMF Phase (years)	Reach	Mesohabitat Unit		WUA		
			Type	Length (m)	Baseline (m^2)	Developed (m^2)	Change (%)
August	0 - 45	Reach 2	Riffles	142	681.1	537.3	-21.1
			Cascades	1,063	6,137.3	5,303.7	-13.6
			Pools	213	1,268.1	1,027.1	-19.0
		Reach 1	Riffles	214	1,026.4	809.7	-21.1*
			Cascades	1,820	11,696.5	10,278.5	-12.1
			Pools	107	637.0	516.0	-19.0*
October	0 - 45	Reach 2	Riffles	142	483.1	533.9	10.5
			Cascades	1,063	4,345.4	4,564.3	5.0
			Pools	213	997.5	953.7	-4.4
		Reach 1	Riffles	214	728.1	804.6	10.5*
			Cascades	1,820	9,311.4	8,903.8	-4.4
			Pools	107	501.1	479.1	-4.4*
August	45 - 56	Reach 2	Riffles	142	681.1	681.1	0.0
			Cascades	1,063	6,137.3	6,088.9	-0.8
			Pools	213	1,268.1	1,257.2	-0.9
		Reach 1	Riffles	214	1,026.4	1,026.4	0.0*
			Cascades	1,820	11,696.5	11,696.5	0.0
			Pools	107	637.0	631.6	-0.9*
October	45 - 56	Reach 2	Riffles	142	483.1	475.1	-1.6
			Cascades	1,063	4,345.4	4,287.1	-1.3
			Pools	213	997.5	992.4	-0.5
October (cont'd)	45 - 56	Reach 1	Riffles	214	728.1	716.1	-1.6*
			Cascades	1,820	9,311.4	9,405.1	1.0
			Pools	107	501.1	498.5	-0.5*
August	> 56	Reach 2	Riffles	142	681.1	679.7	-0.2
			Cascades	1,063	6,137.3	6,055.2	-1.3
			Pools	213	1,268.1	1,255.2	-1.0
		Reach 1	Riffles	214	1,026.4	1,024.3	-0.2*
			Cascades	1,820	11,696.5	11,638.8	-0.5
			Pools	107	637.0	630.6	-1.0*
October	> 56	Reach 2	Riffles	142	483.1	475.1	-1.6
			Cascades	1,063	4,345.4	4,328.3	-0.4
			Pools	213	997.5	997.5	0.0
		Reach 1	Riffles	214	728.1	716.1	-1.6*
			Cascades	1,820	9,311.4	9,242.5	-0.7
			Pools	107	501.1	501.1	0.0*

*** indicates estimated based on Reach 2 results**

Estimated effects on WUA (Tables 15.7-23, 15.7-24, and 15.7-25) were based on the average WUW changes in each reach. Variability of these estimates is demonstrated in Figures 15.7-5 to 15.7-9. Here, a range of WUA variability is shown for different mesohabitat types within each reach. In this assessment, individual estimated WUWs within a reach were used along with the average values.

<u>Discussion</u>

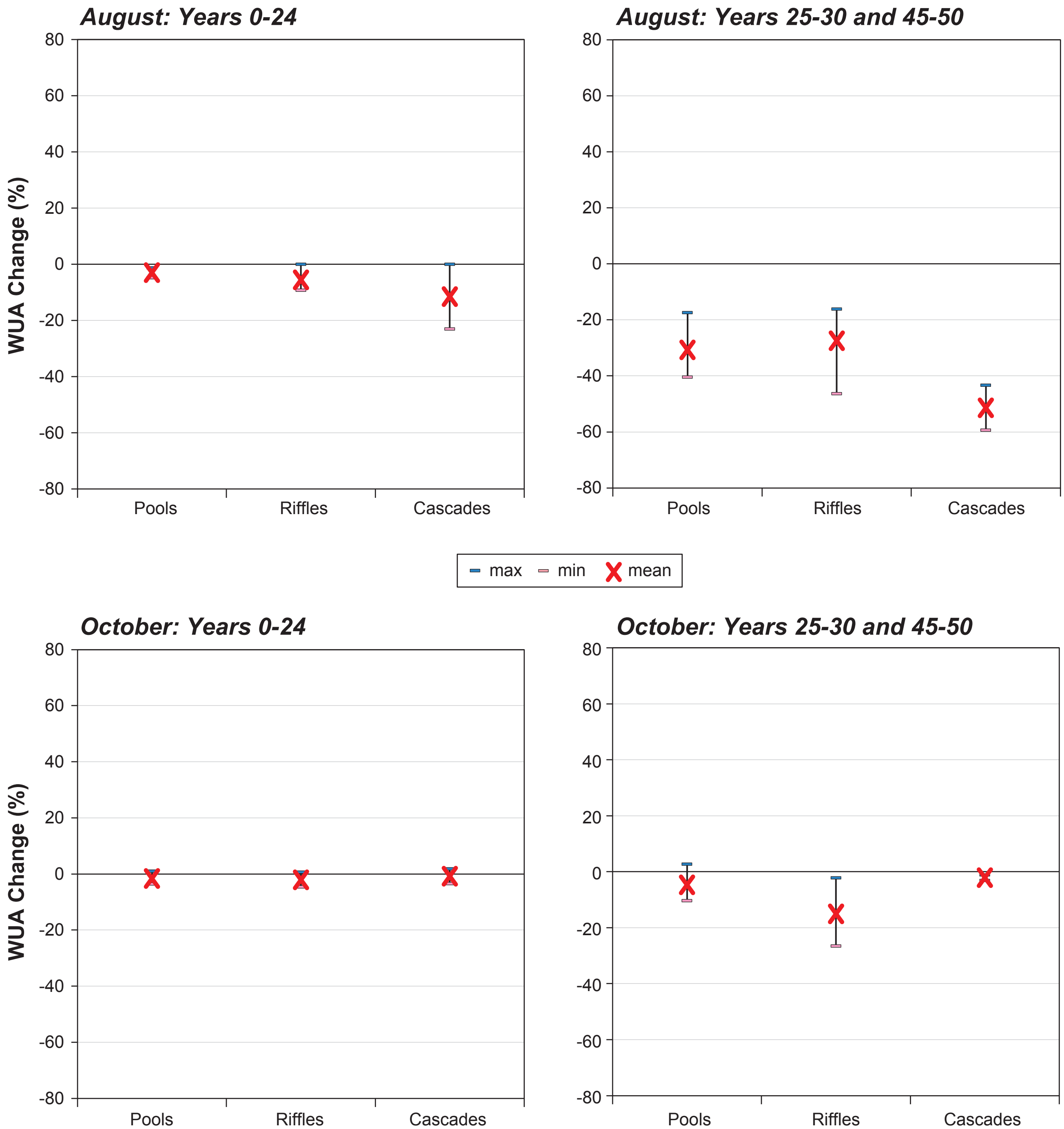
<u>North Treaty Creek</u>

The mean annual discharge (MAD) in North Treaty Creek upstream of the Tumbling Creek confluence (Reach 1; STWM-H2) is predicted to change measurably over the duration of TMF development. Similarly, the MAD in North Treaty Creek downstream of the Tumbling Creek confluence (Reach 0; STWM-H1) is predicted to change measurably over the duration of TMF development. For Reach 1, MAD is predicted to vary between increases of 27% in years 30 to 45 and a reduction of 75% in years 51 to 56 (Figures 15.7-2 and 15.7-4). Mean monthly discharge changes followed a similar pattern that varies over the duration of TMF development, with a relatively even distribution of discharge increases and reductions throughout the months. For Reach 0, MAD is predicted to vary between increases of 10% in years 30 to 45 and a reduction of 30% in years 51 to 56 (Figures 15.7-2 and 15.7-4). As MAD changes, so does the suitability or area of Dolly Varden habitat.

To evaluate effects on Dolly Varden summer parr-rearing habitat, the month of August was selected as a critical period. WUA of Dolly Varden habitat depends on the habitat unit type. Cascade habitat units will be affected by changes in discharge to a greater degree than riffles and pools habitats units (Tables 15.7-17 and 15.7-18). Riffle habitat units will be affected more than pool habitat units. Based upon baseline observations, Dolly Varden parr use pool and cascade habitats more frequently than riffles, which are typically occupied by Dolly Varden fry.

To evaluate effects on Dolly Varden adult spawning habitat, the month of October was selected as a critical period. Dolly Varden use riffle habitat units for spawning. The WUA results indicated that riffle habitat units will be affected by changes in discharge to a greater degree than cascade and pool habitat units (Tables 15.7-23 and 15.7-24).

The predicted changes in North Treaty Creek discharge would result in fish habitat loss and alteration. These fish habitat losses will require an authorization under the *Fisheries Act* (1985) to permit the destruction or disruption of fish habitat. To quantify the changes in fish habitat area, weighted usable area calculations were used from the TMF development stage “worst-case scenario” (i.e., greatest fish habitat effect period) for the month of August (i.e., month of greatest fish habitat effect compared to October). For North Treaty Creek, the worst-case scenario was determined to be years 51 to 56, which predicted discharge reductions of 75% for Reach 1 and 30% for Reach 0 during the month of August. This represents a fish habitat loss area of 163 m^2 in Reach 1, and 1,074 m^2 in Reach 0 (Tables 15.7-26 and 15.7-15).



SEABRIDGE GOLD
KSM PROJECT

Estimated Dolly Varden Habitat Impact Variability on Weighted Useable Area in North Treaty Creek in August and October (Years 0-24, 25-30, and 45-50)

Figure 15.7-5

Rescan™
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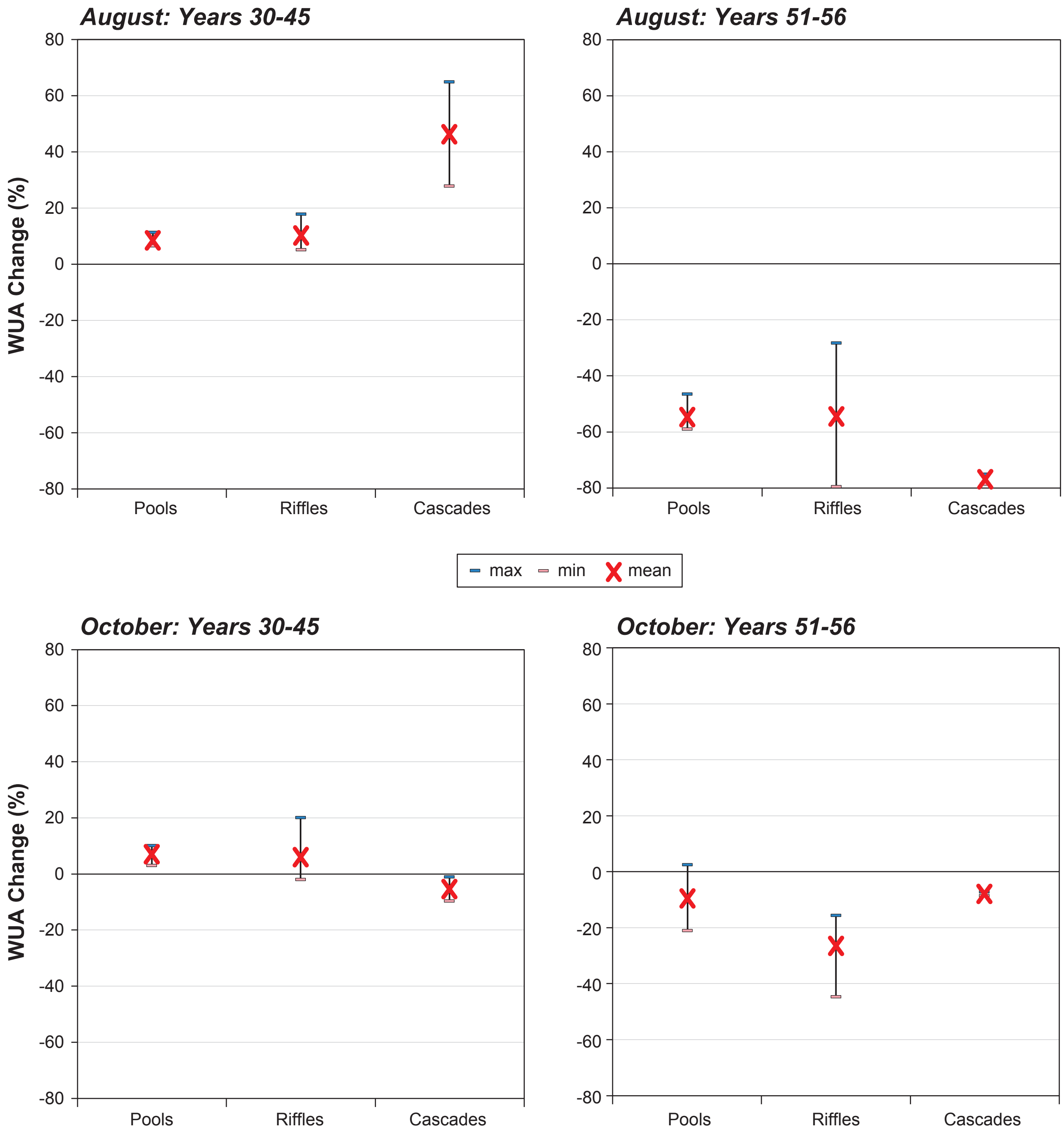
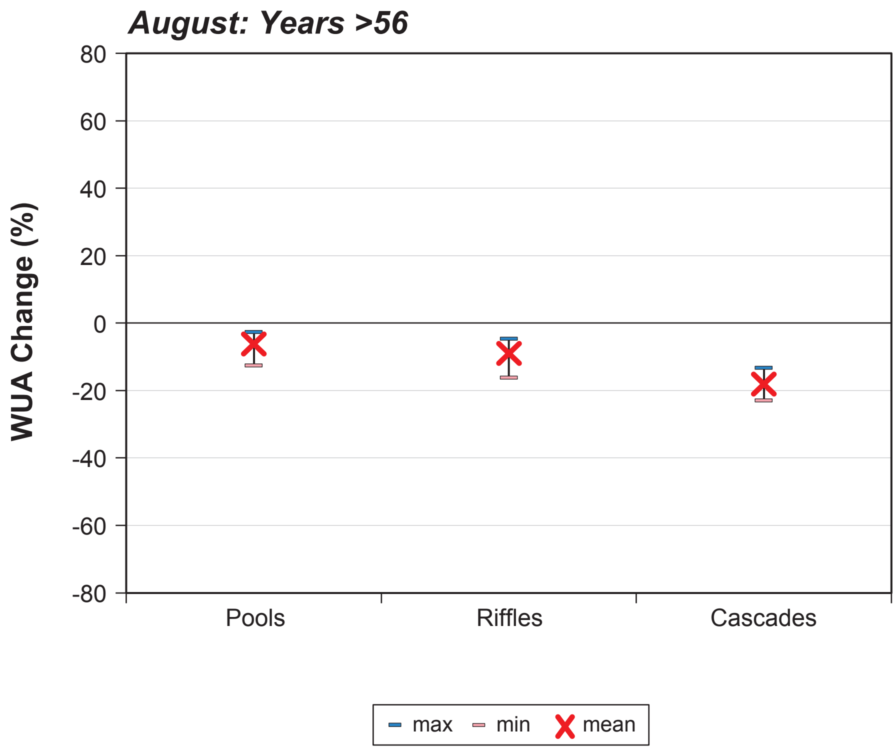


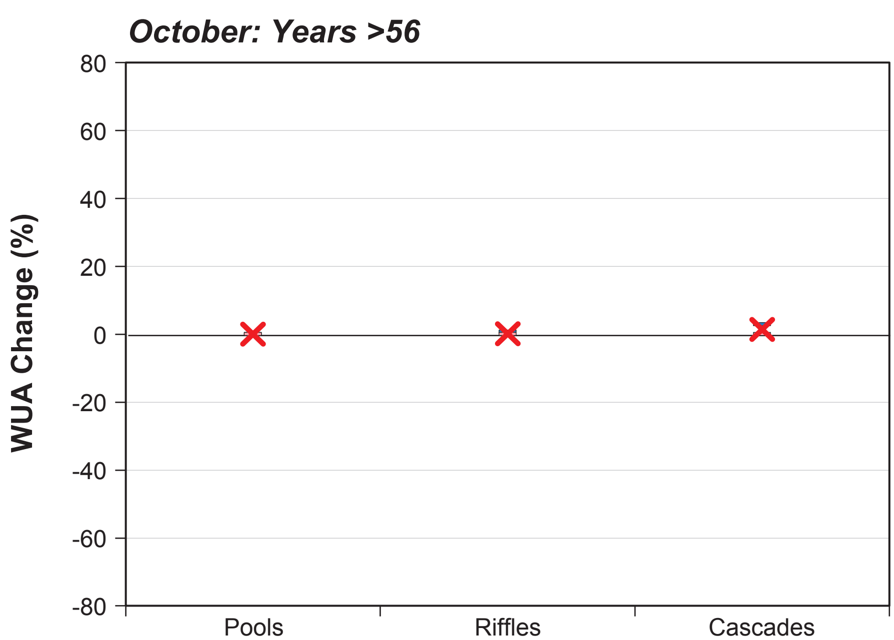
SEABRIDGE GOLD
KSM PROJECT

Estimated Dolly Varden Habitat Impact Variability on Weighted Useable Area in North Treaty Creek in August and October (Years 30-45 and 51-56)

Figure 15.7-6

Rescan Engineers & Scientists





SEABRIDGE GOLD
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Estimated Dolly Varden Habitat Impact Variability on Weighted Useable Area in North Treaty Creek in August and October (Year >56)

Figure 15.7-7

Rescan
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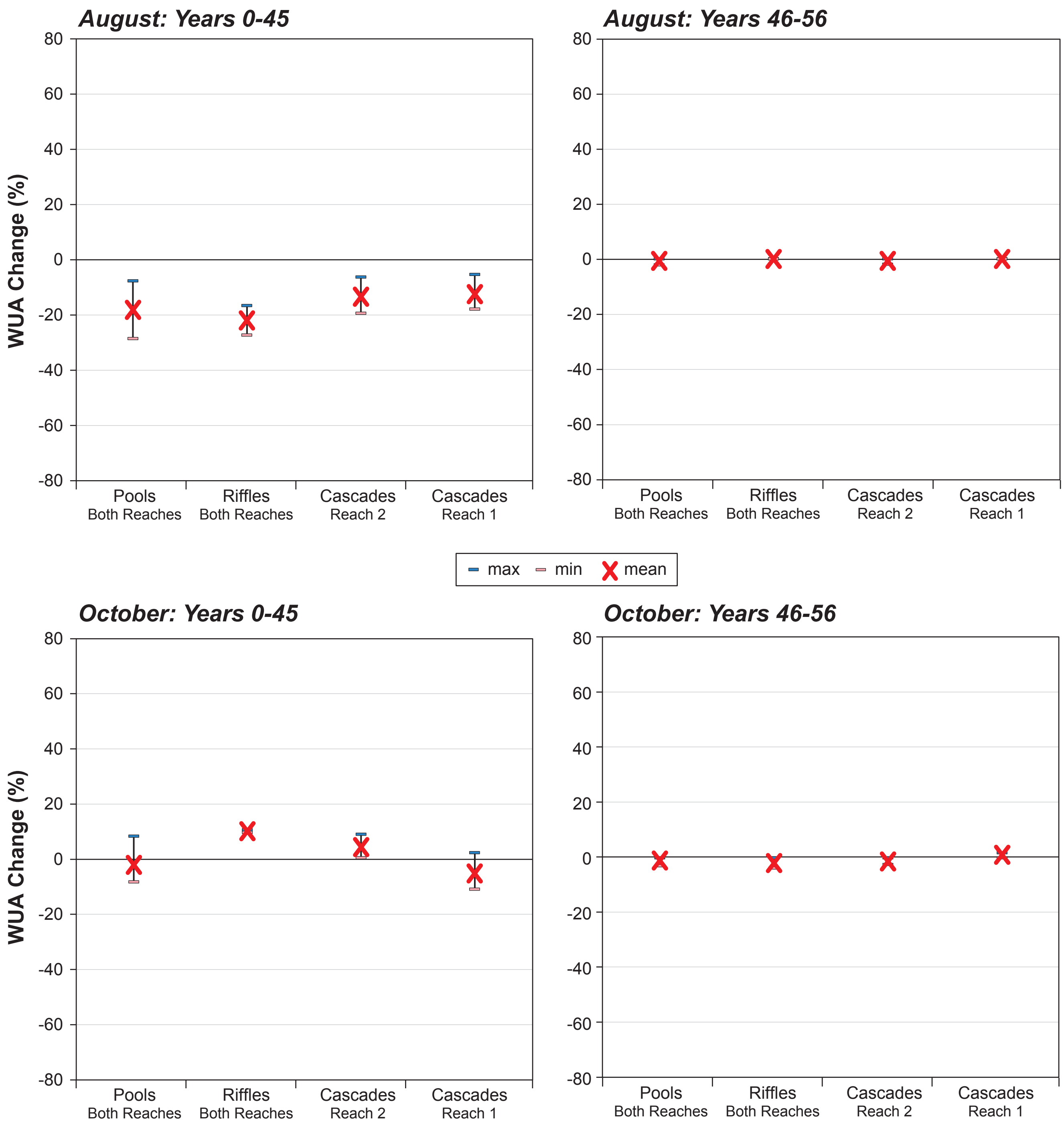
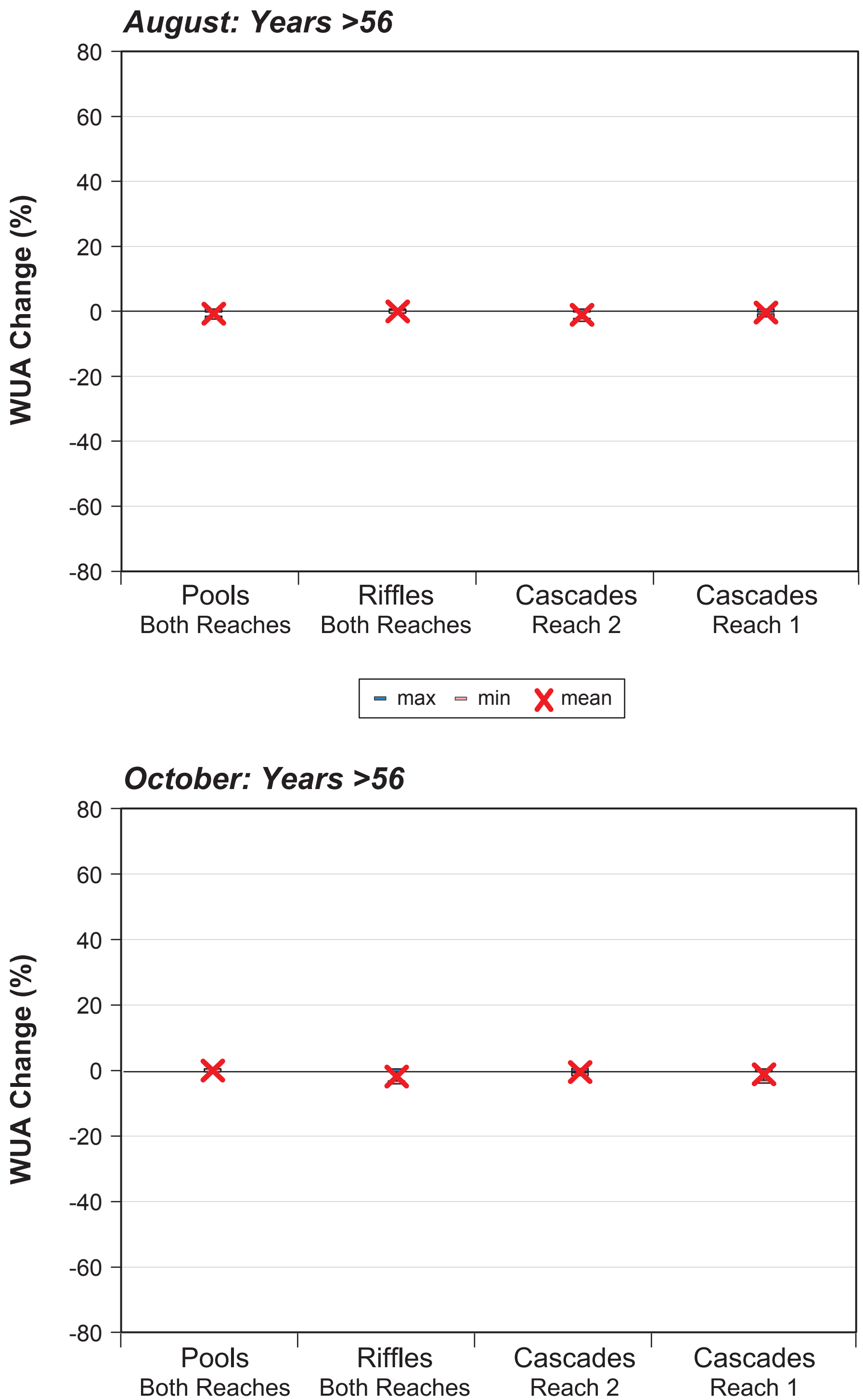


Estimated Dolly Varden Habitat Impact Variability on Weighted Useable Area in South Teigen Creek in August and October (Years 0-45 and 46-56)

Figure 15.7-8



SEABRIDGE GOLD
KSM PROJECT

Estimated Dolly Varden Habitat Impact Variability on Weighted Useable Area in South Teigen Creek in August and October (Years >56)

Figure 15.7-9

Rescan
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Table 15.7-26. Fish Habitat Loss Summary for North Treaty and South Teigen Creeks

Watercourse	Month	TMF Phase (year)	Reach	Mesohabitat Unit	Habitat Loss Area (m^2)
South Teigen	August	0 - 45	Reach 2	Riffles	143.8
				Cascades	833.6
				Pools	241.0
			Reach 1	Riffles	216.7
				Cascades	1,418.0
				Pools	121.0
North Treaty	August	51 - 56	Reach 1	Riffles	59.9
				Cascades	57.8
				Pools	45.0
			Reach 0	Riffles	36.1
				Cascades	861.4
				Pools	176.4

South Teigen Creek

The MAD in South Teigen Creek downstream of the falls to Teigen Creek confluence (Reach 1; NTWM-H1) is predicted to change measurably over the duration of TMF development. Similarly, the MAD in South Teigen Creek upstream of the falls to the TMF (Reach 2; NTWM-H2) is predicted to change measurably over the duration of TMF development. For Reach 1, MAD is predicted to decrease by 18% in years 0 to 45 to 0.3% reductions in years 45 to 56 (Figures 15.7-3 and 15.7-4). Mean monthly discharge changes followed a similar pattern that varies over the duration of TMF development, with a relatively even distribution of discharge increases and reductions throughout the months. For Reach 2, MAD is predicted to decrease by 27% in years 0 to 45 to 1% reductions in years 45 to 56 (Figures 15.7-3 and 15.7-4).

To evaluate effects on Dolly Varden summer parr-rearing habitat, the month of August was selected as a critical period. During years 0 to 45, riffle habitat units will be affected the greatest by changes in discharge relative to that of cascade and pool habitat units. Pool habitat units will be more affected than cascade habitat units. During years 45 to 56, all habitat units demonstrate relatively the same change (plus or minus 1%). Based upon baseline observations, Dolly Varden parr use pool and cascade habitats more frequently than riffles, which are typically occupied by Dolly Varden fry.

To evaluate effects on Dolly Varden adult spawning habitat, the month of October was selected as a critical time period. Dolly Varden use riffle habitat units for spawning; however, suitable spawning habitat is limited within South Teigen Creek because discharge is high and Dolly Varden have not been observed spawning in the creek. The WUA results indicate that riffle habitat units will be affected the greatest by changes in discharge relative to that of cascade and pool habitat units (Table 15.7-25).

The resulting predicted changes in South Teigen Creek discharge would result in fish habitat loss and alteration. These fish habitat losses will require an authorization under the *Fisheries Act*

(1985) to permit the destruction or disruption of fish habitat. To quantify the changes in fish habitat area, WUA calculations were used from the TMF development stage worst-case scenario (i.e., greatest fish habitat effect period) for the month of August (i.e., month of greatest fish habitat effect compared to October). For South Teigen Creek, the worst-case scenario was determined to be years 0 to 45, which predicted discharge reductions of 17% for Reach 1 and 27% for Reach 2 in August. This represents a fish habitat loss area of 1,756 m^2 in Reach 1 and 1,218 m^2 in Reach 2 (Tables 15.7-26 and 15.7-15).

15.7.5.1.4 Fish Habitat Loss and Alteration due to Tailing Management Facility Water Management – Teigen and Treaty Creeks

Hydrology

Potential changes in stream flow in Teigen and Treaty creeks due to the TMF development were assessed quantitatively. North Cell TMF changes in monthly discharge of Teigen Creek, during TMF construction, operation, and closure (years 0 to 45, 45 to 56, and greater than 56), were predicted by the calibrated groundwater/discharge model by comparing to the range of natural variability in mean monthly flows at various locations in Teigen Creek under baseline conditions. The South Cell TMF changes in monthly discharge of Treaty Creek, during TMF construction, operation, and closure (years 0 to 24, 25 to 30, 30 to 45, 46 to 56, and greater than 56), were predicted by the same methods as discussed above.

Key hydrometric stations in Teigen and Treaty creeks were used to calculate MAD and mean monthly discharge. The average monthly flows at different phases of development of the Project were calculated based on the water management simulations. Teigen and Treaty average monthly discharges are summarized in Tables 15.7-27 and 15.7-28.

Table 15.7-27. Comparison of Baseline and Proposed Operational Flows for Teigen Creek (TGN-H1)

	Baseline	Years 0-45		Years 45-56		Years >56	
	Flow (m^3/s)	Flow (m^3/s)	Change from Baseline (%)	Flow (m^3/s)	Change from Baseline (%)	Flow (m^3/s)	Change from Baseline (%)
Jan	1.8	1.72	-4.10%	1.82	1.10%	1.81	0.80%
Feb	1.86	1.76	-5.30%	1.84	-0.80%	1.84	-1.30%
Mar	1.98	1.9	-4.10%	1.99	0.70%	1.98	0.00%
Apr	4.63	4.42	-4.50%	4.62	-0.20%	4.58	-1.10%
May	22.88	21.86	-4.40%	22.78	-0.40%	22.31	-2.50%
June	31.48	29.96	-4.80%	31.34	-0.40%	30.85	-2.00%
July	18.12	17.37	-4.10%	18.23	0.60%	18.16	0.30%
Aug	9.98	9.57	-4.10%	10	0.20%	9.96	-0.20%
Sep	13.34	12.73	-4.50%	13.27	-0.50%	13.15	-1.40%
Oct	9.71	9.3	-4.10%	9.8	1.00%	9.77	0.60%
Nov	4.26	4.06	-4.50%	4.31	1.40%	4.33	1.70%
Dec	2.43	2.33	-4.10%	2.46	1.40%	2.46	1.30%
MAD	10.2	9.75	-4.50%	10.21	0.00%	10.1	-1.00%

Table 15.7-28. Comparison of Baseline and Proposed Operational Flows for Treaty Creek (TC-H1)

	Baseline	Years 0-24		Years 25-30		Years 30-45		Years 45-50		Years 51-56		Years >56	
Month	**Flow (m^3/s)**	**Flow (m^3/s)**	**Change from Baseline (%)**	**Flow (m^3/s)**	**Change from Baseline (%)**	**Flow (m^3/s)**	**Change from Baseline (%)**	**Flow (m^3/s)**	**Change from Baseline (%)**	**Flow (m^3/s)**	**Change from Baseline (%)**	**Flow (m^3/s)**	**Change from Baseline (%)**
Jan	5.21	5.20	-0.2%	5.25	0.8%	5.25	1.8%	5.16	-1.0%	5.24	0.6%	5.21	0.0%
Feb	5.34	5.33	-0.2%	5.37	0.6%	5.37	0.9%	5.28	-1.1%	5.36	0.4%	5.33	-0.2%
Mar	5.57	5.57	0.0%	5.61	0.7%	5.61	2.1%	5.52	-0.9%	5.61	0.7%	5.57	0.0%
Apr	14.50	14.47	-0.2%	14.56	0.4%	14.56	1.0%	14.36	-1.0%	14.56	0.4%	14.49	-0.1%
May	37.61	37.50	-0.3%	37.81	0.5%	37.80	1.0%	36.87	-2.0%	37.78	0.5%	37.67	0.2%
Jun	62.70	63.65	1.5%	63.07	0.6%	63.21	1.0%	61.66	-1.7%	62.96	0.4%	62.75	0.1%
Jul	77.77	78.57	1.0%	78.27	0.6%	78.53	2.0%	77.62	-0.2%	77.88	0.1%	77.65	-0.2%
Aug	60.88	61.10	0.4%	61.07	0.3%	61.07	0.7%	60.63	-0.4%	60.88	0.0%	60.78	-0.2%
Sep	50.00	50.32	0.6%	50.27	0.5%	50.28	1.0%	49.67	-0.7%	50.08	0.2%	49.92	-0.2%
Oct	30.28	30.56	0.9%	30.57	1.0%	30.61	1.8%	30.10	-0.6%	30.45	0.6%	30.28	0.0%
Nov	18.99	19.02	0.2%	19.13	0.7%	19.13	1.7%	18.88	-0.6%	19.07	0.4%	18.98	-0.1%
Dec	12.33	12.32	-0.1%	12.40	0.6%	12.40	1.5%	12.26	-0.6%	12.38	0.4%	12.33	0.0%
MAD	**31.77**	**31.97**	**0.6%**	**31.95**	**0.6%**	**31.99**	**1.3%**	**31.50**	**-1.6%**	**31.85**	**0.3%**	**31.75**	**-0.1%**

MAD = mean annual discharge

Based on long-term synthetic data at Station TC-H1 (1968-2010)

A comparison of predicted monthly discharges in Teigen Creek indicates that monthly discharge will be reduced with small variations between 5.3% and 4.1% during years 0 to 45 (Table 15.7-27). Monthly discharge during years 45 to 56 and years greater than 56 will have even smaller variations from an increase of 1.7% to a reduction of 2.5%.

A comparison of predicted discharges in Treaty Creek indicates that mean annual discharge will be increased (with small variations) by 1.3% during years 0 to 45, reduced by 1.6% in years 45 to 50 (Table 15.7-28).

Instream flow thresholds were determined for Teigen and Treaty creeks. The BC instream flow thresholds require 20 years of daily stream flow data from which to determine monthly minimum flows. Twenty years of historical stream flow data does not exist for any of these watersheds, therefore, historical stream flow data were simulated using a linked groundwater/surface hydrology model using 25 years of climate data. This model was calibrated with stream flow data collected from various gauging stations established in these watersheds (Appendix 15-P).

Table 15.7-29 presents baseline mean monthly discharges and instream threshold monthly discharges for Teigen and Treaty creeks. In all months, except May and June, the instream flow threshold guidelines exceed baseline mean monthly discharges. Therefore, according to the threshold guidelines, water reductions would be acceptable only during the months of May and June (freshet). However, the small variations in monthly discharge (-4.5%) fall within baseline natural variability in Teigen Creek. Based upon this analysis, effects to fish and fish habitat such as chinook salmon spawning and rearing habitat, are not expected. Therefore, the low flow variations in Teigen Creek will not require an authorization under the *Fisheries Act* (1985) to permit the destruction or disruption of fish habitat.

Table 15.7-29. Monthly Flow Discharge Thresholds for Teigen and Treaty Creeks as Determined Using the Guidelines in Hatfield et al. (2003)

Creek	Month	Mean Baseline Flow (m^3/s)	Instream Flow Threshold (m^3/s)	Ratio of Instream Flow Threshold to Mean Monthly Baseline Flow
Teigen	Jan	1.16	1.48	127.0%
	Feb	1.16	1.58	136.0%
	March	1.06	1.58	149.0%
	April	2.77	3.75	135.5%
	May	18.47	17.40	94.2%
	June	33.78	26.56	78.6%
	July	12.75	13.13	102.9%
	Aug	6.31	7.24	114.7%
	Sept	11.83	13.05	110.3%
	Oct	9.86	10.78	109.3%
	Nov	4.14	5.73	138.5%
	Dec	1.85	2.35	127.5%

(continued)

Table 15.7-29. Monthly Flow Discharge Thresholds for Teigen and Treaty Creeks as Determined Using the Guidelines in Hatfield et al. (2003; completed)

Creek	Month	Mean Baseline Flow (m^3/s)	Instream Flow Threshold (m^3/s)	Ratio of Instream Flow Threshold to Mean Monthly Baseline Flow
Treaty	Jan	5.21	7.34	141.0%
	Feb	5.34	11.32	211.8%
	March	5.57	11.63	208.7%
	April	14.50	17.79	122.7%
	May	37.61	39.14	104.1%
	June	62.70	54.54	87.0%
	July	77.77	66.26	85.2%
	Aug	60.88	57.78	94.9%
	Sept	50.00	48.00	96.0%
	Oct	30.28	31.28	103.3%
	Nov	18.99	24.07	126.7%
	Dec	12.33	19.68	159.6%

Teigen: Based on hydrometric monitoring during 2008 to 2011.
Treaty: Based on long-term synthetic data at Station TC-H1 (1968 to 2010).

Table 15.7-29 presents baseline mean monthly discharges and instream threshold monthly discharges for Treaty Creek. In all months, except between June and September, the instream flow threshold guidelines exceed baseline mean monthly discharges. Therefore, according to the threshold guidelines, water reductions would be acceptable only between June and September. However, the small variations in monthly discharge (1.6%) fall within baseline natural variability in Treaty Creek. Based upon this analysis, effects to fish and fish habitat are not expected. Therefore, the low flow variations in Treaty Creek will not require an authorization under the *Fisheries Act* (1985) to permit the destruction or disruption of fish habitat.

<u>Sediment Transport</u>

The governing conditions of the physical processes in streams, and hence their morphology are the magnitude, frequency, and duration of water supplied from upstream; the volume, frequency, and size of sediment delivered to the channel; the nature of the materials through which the channel flows; the local geological history of the riverine landscape (which influences valley slope and channel confinement); the local climate and vegetation (which influences riparian vegetation, which in turn affects bank strength and roughness, and in-channel wood); and land use in the drainage basin (Church 1992; Buffington et al. 2003). Dams can alter the ability of the channel to transport sediment and the amount of sediment available for transport, and the volume and timing of water.

The effect of the downstream interruption of sediment and water on channel processes can vary depending upon the size of the dam impoundment, management of water diversion channels, position of the dam within the watershed relative to sediment sources, and on the geology and hydrology of the watershed (Pitlick and Wilcock 2001). Consequently, this interruption can lead to potential effects on sediment transport and recruitment for fish spawning (Hauer et al. 2011; Kondolf and Ramirez 1996). Where abundant natural sources of sediment exist (bank erosion, hillslope processes, and tributary inputs) below dams, the channel may show a net aggradation of sediments if peak flows are drastically reduced (Pitlick and Wilcock 2001). Alternatively, where limited sources of sediment are available below dams, the channel may experience net degradation, and hence reduced usable spawning habitat.

Sediment storage and transport to downstream reaches varies depending upon the location of the channel within the drainage network and the channel morphology. Schumm (1977) divided the drainage network into erosion, transport, and deposition reaches, which proceed downstream from the headwaters to the drainage basin outlet. The morphology of the channel depended upon the materials through which it flows. Schumm (1985) suggested three categories: bedrock, semi-controlled, and alluvial. Bedrock channels are fixed, have relatively high sediment transport capacities relative to supply, and are stable over time. Semi-controlled channels are only controlled locally by bedrock, colluvial, or non-erodible alluvial material. Alluvial channels are composed of material in both the bed and banks that have been transported by the channel; these channels can be confined or unconfined. The morphology of alluvial channels is a direct consequence of sediment transport and sedimentation (Church 2006).

Montgomery and Buffington (1997) recognized five distinct alluvial reach morphologies: cascade, step-pool, plane bed, pool-riffle, and dune ripple. In the baseline study area, only the first four morphologies have been observed. Cascade channels generally occur on steep slopes (greater than 0.065), are narrowly confined valley walls, and are characterized by bed material consisting of cobbles and boulders. The larger particle size means that the substrates are effectively immobile during typical flows and only become mobilized during infrequent (e.g., greater than 50 year) high flow events. Cascade reaches have a high sediment transport capacity relative to sediment supply, and these reaches serve as sediment transport zones that rapidly deliver sediment to lower gradient channel reaches (Montgomery and Buffington 1997; Bisson et al. 2006). Step-pool channels tend to occur in slopes ranging from 0.03 to 0.065, and consist of longitudinal steps formed by large clasts organized into discrete channel-spanning accumulations that separate pools containing finer material. Similar to cascade channels, the step-pool morphology is associated with higher gradients, small width to depth rations, and pronounced valley confinements. Plane-bed or rapid channels occur in gradients of 0.015 to 0.03, in either unconfined or confined valleys, and are generally featureless in that they lack bedforms. In contrast, riffle-pool channels less than 0.015 are typically transport limited (Montgomery and Buffington 1997; Bisson et al. 2006).

Watershed sediment sources, hydrology, and channel morphology conditions for South Teigen Creek, as explained below, indicate that North dam construction, operation, and closure will not measurably alter sediment transport to lower reaches of South Teigen Creek and Teigen Creek. Consequently, chinook salmon spawning habitat will not be altered in Teigen Creek (Figure 15.1-4). The upper reach of South Teigen Creek possesses a confined cascade-pool morphology, which transports sediment (i.e., gravels) to the lower gradient riffle-pool reach. This riffle-pool reach is located within the TMF. Since riffle-pool reaches are transport limited

(Montgomery and Buffington 1997), downstream transport of sediment to higher gradient cascade-pool reaches of South Teigen Creek and Teigen Creek is low.

Geomorphology mapping and field investigations indicated that numerous sediment sources (i.e., hillslope/bank erosion and tributaries) are present downstream of the proposed North dam. Flow alterations in South Teigen Creek during TMF operation are not expected to reduce sediment transport/recruitment, or lead to sediment aggregation in downstream reaches because peak flows will be maintained within the creek. It is expected that the proposed water management of the TMF diversion channels will provide sufficient discharge and allow for natural variation in the South Teigen Creek hydrograph to maintain natural channel processes for fish and aquatic habitat.

Furthermore, geomorphologic mapping and field investigations indicated that abundant sediment supply (i.e., primary sources) is present in Teigen Creek to maintain high quality chinook spawning habitat. The Teigen Creek reach upstream of the South Teigen Creek confluence is a low gradient depositional reach with abundant gravel recruitment from bank and hillslope erosion. The presence of a high concentration of chinook salmon redds confirms this statement (Figure 15.1-4). The section of Teigen Creek immediately downstream of the South Teigen Creek confluence is a higher gradient transport reach that carries gravels further downstream. The presence of a high concentration of chinook salmon redds further downstream confirms this statement (Figure 15.1-4).

Consequently, TMF development will not measurably alter sediment sources or supply to downstream reaches of South Teigen and Teigen creeks, or chinook salmon spawning habitat in Teigen Creek. Therefore, the low flow variations in Teigen Creek will not require an authorization under the *Fisheries Act* (1985) to permit the destruction or disruption of fish habitat.

15.7.5.1.5 Aquatic Habitat Loss and Alteration due to Tailing Management Facility Water Management

Potential Effects

Water management can affect productive capacity of non-fish aquatic life in two ways. First, water management affects discharge rates and can therefore alter wetted width availability for aquatic life colonization at different times of the year. For example, decreased water flow in the summer could decrease aquatic habitat available for periphyton and aquatic invertebrates, while in the winter, decreased flow rates could lead to increased ice formation, which could build up and block flows in diversion channels or low-flow streams. In the other extreme, increases in water flow can cause scouring and bank erosion, which may also decrease productivity as potential aquatic habitats are altered. Instream primary producer biomass is strongly correlated with the number of days between flood events greater than three times the median flow (Biggs 2000), and water management can affect the return period of flood events.

Second, management of discharge rates can alter nutrient loading rates since the introduction of nutrients to a flowing aquatic environment is largely dependent on discharge rates and nutrient concentrations. For example, a decrease in water flow alone, even if concentrations of nutrients remain the same, can lead to decreased productive capacity in the primary producers since fewer nutrients would be delivered. Similarly, increases in nutrient delivery due to increased water flow or nutrient concentrations could increase productive capacity. Comparison of nutrient loading rates under baseline conditions and predicted conditions can provide insight into potential effects of water management regimes, which was addressed in Sections 15.7.4.1.4 (general information), 15.7.4.2.5 (mitigation measures), and 15.7.4.3.4 (potential for residual effects).

Riparian habitat will also be removed from streams in the North Treaty and South Teigen watersheds due to the development of the TMF. Riparian vegetation provides numerous functions including shading, stabilizing stream banks, controlling sediments, contributing LWD and organic litter, and regulating composition of nutrients. Losing riparian function can lead to fish habitat loss and alteration. Salmonid food webs receive important energy subsidies from terrestrial inputs of invertebrates and nutrients falling into streams from riparian vegetation (Wipfli and Gregovich 2002; Allan, Wipfli et al. 2003). Clearing riparian vegetation removes this resource over short distances and can affect the productive capacity of stream habitat over moderate distances. In small headwater streams, riparian vegetation moderates the amount of solar radiation that reaches the stream channel, thereby dampening seasonal and diel fluctuations in stream temperature (Beschta, Bilby et al. 1987) and controlling primary productivity. In winter, streamside vegetation provides insulation from radiative and convective heat losses, which helps reduce the frequency of anchor ice formation. Thus, riparian vegetation tends to moderate stream temperatures year-round.

The effectiveness of riparian vegetation in providing shade to the stream channel depends on local topography, channel orientation and width, forest composition, and stand age and density (Beschta, Bilby et al. 1987). In smaller streams, removing riparian vegetation increases light intensity, which stimulates the growth of benthic algae (Gregory 1980; Murphy, Hawkins et al. 1981; Shortreed and Stockner 1983; Murphy, Heifetz et al. 1986). In contrast, energy inputs from allochthonous sources decrease after removal of riparian vegetation (Gregory, Larnberti et al. 1987; Bilby and Bisson 1992). Macroinvertebrate communities respond to these changes in food sources. Herbivorous invertebrates, particularly those that scrape algae from the substrate, are expected to become more abundant, while those species that feed on detritus (i.e., shredders, filterers, and collector-gatherers) typically decline in numbers (Hawkins, Murphy et al. 1982; Beschta, Boyle et al. 1995). The abundance of invertebrate predators has been shown to increase in response to increased secondary production in streams in the Oregon Cascades (Murphy, Hawkins et al. 1981; Hawkins, Murphy et al. 1982). Therefore, removing streamside vegetation may also increase the amount of solar radiation reaching the stream, influencing primary production, and boosting the short-term productivity of the habitat. Studies of deforestation have shown that periphyton biomass increases with decreasing shade (Kiffney, Richardson et al. 2003), macroinvertebrate density increases (Carlson, Andrus et al. 1990), and Dolly Varden abundance increases (Keith, Bjornn et al. 1998).

Riparian vegetation contributes quantities of organic litter to low- and mid-order streams. This litter constitutes an important food resource for aquatic communities (Naiman, Beechie et al. 1992). The quality, quantity, and timing of litter delivered to the stream channel depends on the vegetation type (i.e., coniferous versus deciduous), stream orientation, side slope angle, stream width, and the amount of stream meander (Cummins, Botkin et al. 1994). In conifer-dominated riparian zones, 40 to 50% of the organic litter consists of low quality cones and wood, which may take several years to decades to be processed. In contrast, high quality material from deciduous forests may decay within a year. Although conifers have the greater standing biomass, shrub- and herb-dominated riparian assemblages provide more input in many streams (Gregory, Swanson et al. 1991). Over 80% of the deciduous inputs, primarily leaves, are delivered during a six to eight week period in the fall (Naiman, Beechie et al. 1992), while coniferous inputs are delivered throughout the year (Cummins, Botkin et al. 1994).

Riparian vegetation increases stream bank stability and resistance to erosion via two mechanisms. First, roots from woody and herbaceous vegetation bind soil particles together, helping to maintain bank integrity during erosive high stream flow events (Swanson, Gregory et al. 1982). Roots promote the formation of undercut banks, an important habitat characteristic for many salmonids (Murphy and Meehan 1991). In wide valleys where stream channels are braided, meandering, or highly mobile, the zone of influence of root structure is greater.

LWD provide long-term nutrient storage and substrate for aquatic invertebrates; moderates flow disturbances; increases retention of allochthonous inputs, water, and nutrients; and provides refugia for aquatic organisms during high- and low-flow events (Bisson, Bilby et al. 1987). The ability of large wood to perform these functions depends in part on the size and type of wood. In general, the larger the size of the debris, the greater its stability in the stream channel, because higher flows are needed to displace larger pieces (Bilby and Ward 1989). In small, steep headwater streams (first and second order) large volumes of stable LWD tend to dominate hydraulic processes. The stepped channel profile, created by LWD, increases the frequency and volume of pools, decreases the effective streambed gradient, and increases the retention of organic material and nutrients within the system, thus facilitating biological processing (Bisson, Bilby et al. 1987).

Woody debris within the channel increases velocity heterogeneity and habitat complexity by physically obstructing the stream flow, creating small pools and short riffles (Swanston 1991). Diverted currents create pools (plunge, lateral, and backwater) and riffles, flush sediments, and scour stream banks to create undercut banks (Cummins, Botkin et al. 1994). In sediment-poor systems, LWD retains gravels that are essential for spawning salmonids. In mid-order streams, LWD functions primarily to increase channel complexity and flow heterogeneity. LWD is important in pool formation in mid-sized streams; however, these are more likely to be debris-scour pools than plunge pools. In these high-order streams, LWD increases channel complexity by creating side channels, backwaters, and ponds.

During Project construction, diversion tunnels, channels, and ditches on both the northeast and southwest sides of the TMF will be constructed to collect water from drainage areas above the TMF, which will effectively cut off water flow to downstream areas that fall within the TMF. Riparian vegetation to protect against temperature increases will be planted around these channels and ditches, and they may offer some new aquatic habitat for colonization during the construction and operation phases. During closure and post-closure, diversion structures on the northeast side of the TMF will be decommissioned, and drainage of these areas will resume into the reclaimed TMF. At this time, aquatic habitat and non-fish aquatic life that was established during construction and operation will be eliminated as more natural drainage patterns are resumed, except the TMF will be converted from a wetland and stream habitat to a lake-type habitat. In addition, the two seepage recovery ponds located downstream of the dam will be developed, as far as possible, into small lakes suitable for aquatic invertebrates. Once the diversion structures are breached on the northeast side of the reclaimed TMF there will be less downstream drift of benthic invertebrates and organic matter since it could be retained behind the dam. However, drift of benthic invertebrates from the upstream drainage area will contribute to colonization of the reclaimed TMF with non-fish aquatic life.

Assessment

TMF water management may have some minor effects on the aquatic productive capacity (Section 15.7.4.3.4). The North Treaty and South Teigen Creeks are predicted to have small decreases in nutrient loading, likely within the natural variation of the system (Table 15.7-8) combined with lower overall discharges (Tables 15.7-18 and 15.7-19). Lower discharges and lower nutrient concentrations may therefore reduce primary production, but that decrease will be likely offset by increases in primary production rates due to temperature increases (discussed in Section 15.7.5.1.6). The balance between the decrease in nutrients and increase in temperature is uncertain. However, the return period for flooding events is not likely to be affected by TMF water management, since discharges will follow the natural hydrography. Treaty Creek is predicted to experience negligible changes in discharge due to TMF water management. Combined with higher predicted nutrient loading, periphyton productivity on the scale of the entire stream is predicted to increase, but again, this effect will likely be tempered by the relatively short accrual duration for periphyton biomass. Overall periphyton biomass will likely continue to be controlled by the duration of accrual between flooding events, similar to the baseline conditions.

15.7.5.1.6 Fish and Aquatic Habitat Loss and Alteration due to Tailing Management Facility Water Management – Water Temperature

Potential Effects

In regard to salmonid community response, increases in surface water temperature beyond diurnal or seasonal averages have the potential to accelerate embryo development; alter the timing of emergence, growth, and downstream migration of juveniles; reduce metabolic efficiencies of food conversion into growth (i.e., due to thermal stress and oxygen deficiency); alter adult spawning migration and spawning timing; increase susceptibility to disease; and shift the competitive advantage of salmonids over non-salmonid species (Hicks et al. 1991; De Staso III and Rahel 1994; Flebbe 1994; Dickerson and Vinyard 1999). Sublethal temperature effects are also related to metabolic inefficiencies, susceptibility to disease and toxic effects of pollutants, behavioural patterns, intra- and inter-specific competition, predator-prey relationships, community composition, and parasite-host relationships (Oliver and Fidler 2001).

A lower survival for stream resident trout may also occur if the period of tributary rearing is reduced by accelerated growth, yet the habitat requirements of smaller-sized fish are unavailable in mainstem channels. The greater dilemma for stream resident species may be related to summer temperatures near their upper tolerance limits that force individuals to seek cooler refuges that exhibit a lower capability for food and shelter when compared to the more productive reaches (Vannote et al. 1980).

Water temperature increases have generally positive effects on the growth of periphyton under the conditions expected (Francoeur, Biggs et al. 1999). Increases in temperature increase the photosynthetic rate of stream periphyton (Q_{10} equals 2.5; Morin, Lamoureux et al. 1999), and reductions to growth rate and photosynthesis of temperate periphyton species are often observed at temperatures greater than 30°C (DeNicola 1996). Increases in temperature can also exacerbate the effects of nutrient limitation (Francoeur, Biggs et al. 1999) by increasing the demand for nitrogen and phosphorus in response to enhanced photosynthesis, protein synthesis (nitrogen), and respiration (phosphorus). Increases in temperature may also select for different algal groups, with diatoms favoured at temperatures less than 20°C, xanthophytes favoured between 20 and 30°C, and cyanobacteria dominant at temperatures above 30°C (DeNicola 1996).

With respect to aquatic insect community response, temperature fluctuations beyond threshold levels can have an effect on diapause induction (i.e., as a function of endocrine processes; Vannote and Sweeney 1980), hatching success (i.e., decreases at low or high extremes; Elliott and Humpesch 1980), larval growth, adult size, and fecundity (i.e., both temperature and nutrition influence on the rate of feeding, assimilation and respiration, food conversion efficiencies, and enzymatic kinetics; Anderson and Cummins 1979; Vannote and Sweeney 1980; Sweeney and Vannote 1981). In addition, temperature fluctuations can have an effect on voltinism (i.e., number of generations per year based on larval growth rate; Newell and Minshall 1978) and timing of adult emergence (i.e., premature or delayed depending on temperature increase or decrease; Sweeney and Vannote 1981).

Assessment

Dolly Varden is the only species present in Reach 2 of South Teigen Creek and in North Treaty Creek. Dolly Varden, bull trout, mountain whitefish, and rainbow trout are present in Reach 1 of South Teigen Creek. However, bull trout, mountain whitefish, and rainbow trout are of low abundance relative to Dolly Varden abundance in Reach 1 of South Teigen Creek. Furthermore, Dolly Varden is the dominant species present in Treaty Creek. Based upon literature review, optimal temperature ranges were selected for Dolly Varden life history stages (Oliver and Fidler 2001). These life history stages are egg incubation, summer rearing, and spawning. In addition, critical lethal temperatures were selected for Dolly Varden life history stages (Oliver and Fidler 2001). Optimal and critical temperatures for Dolly Varden are presented in Table 15.7-30. In cases where Dolly Varden temperatures were not available, bull trout temperatures were used because they occupy similar thermal regimes.

Table 15.7-30. Dolly Varden Optimal and Critical Temperatures

Temperature Category	Life History Stage Temperature (°C)		
	Egg Incubation	Summer Rearing	Spawning
Optimal Range	2 - 6	8 - 16	5 - 9
Critical Range	8 - 10	20	16 - 19

Weekly mean temperatures for South Teigen and North Treaty creeks from August 2009 to August 2010 are shown in Figures 15.7-10 and 15.7-11, respectively. The annual and seasonal temperature profile is similar between watersheds.

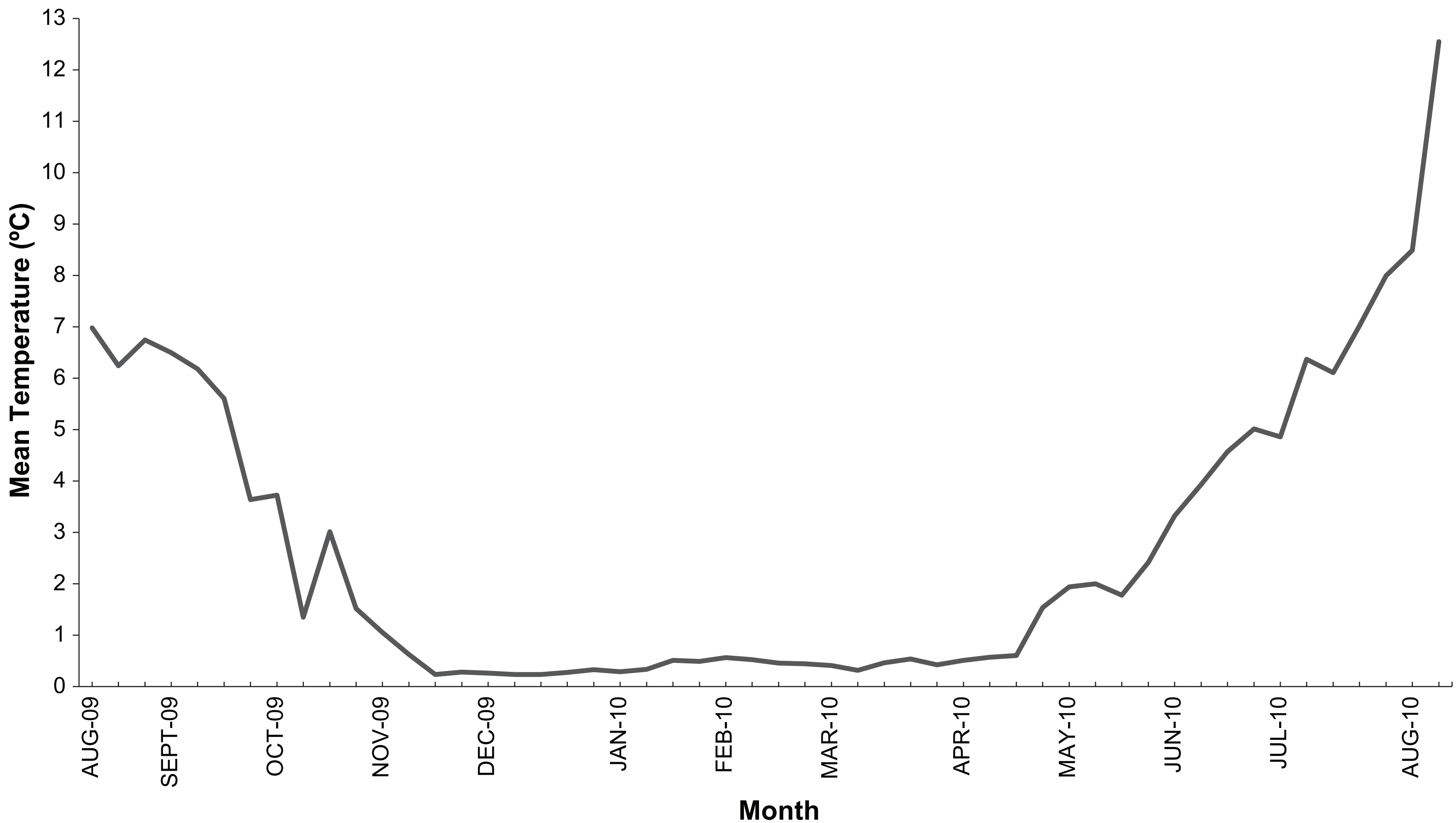

Figure 15.7-10

SEABRIDGE GOLD
KSM PROJECT

Weekly Mean Temperatures for South Teigen Creek from August 2009 to August 2010

Rescan
Engineers & Scientists

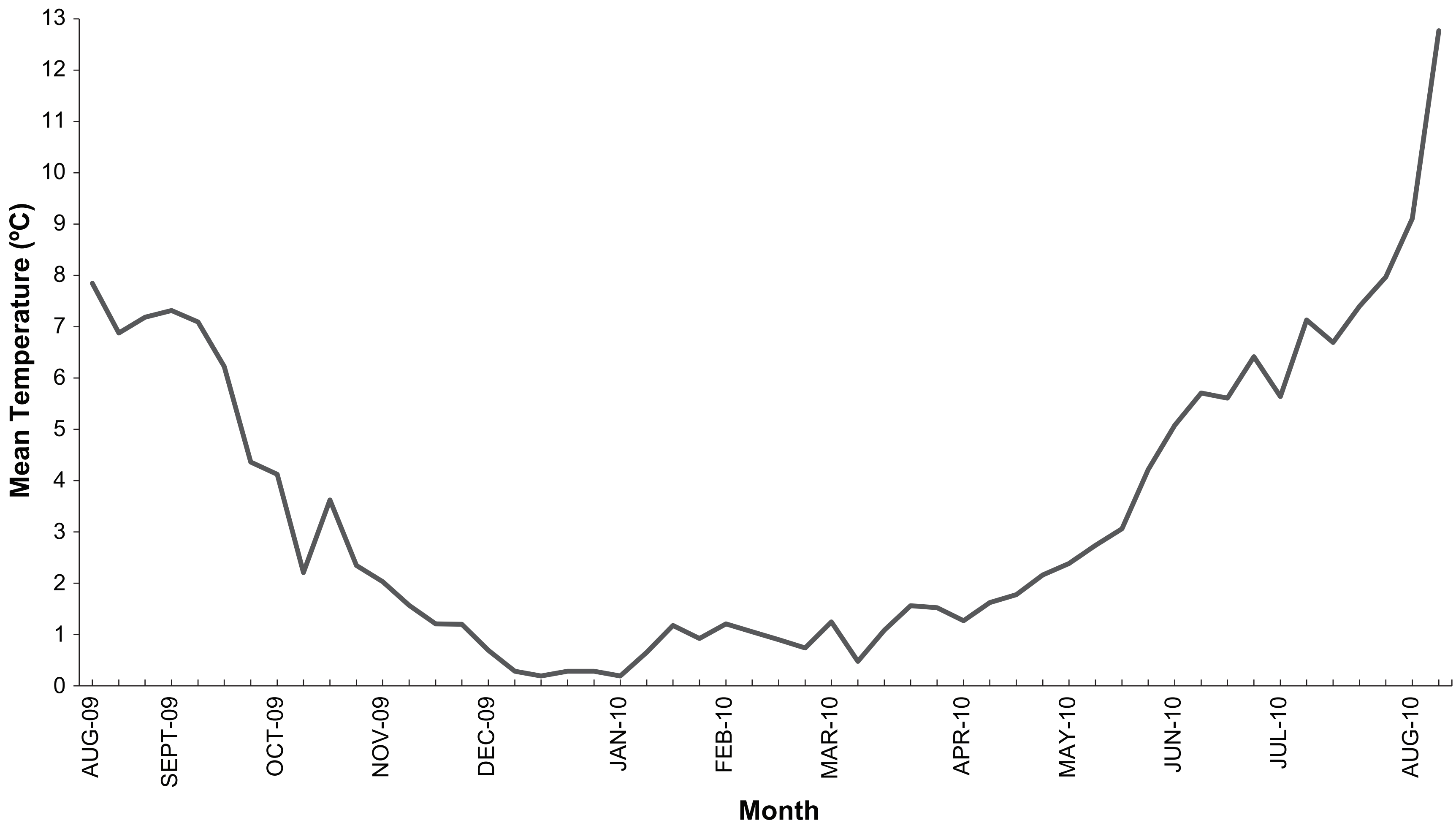

Figure 15.7-11

SEABRIDGE GOLD
KSM PROJECT

Weekly Mean Temperatures for North Treaty Creek from August 2009 to August 2010

Rescan Engineers & Scientists

Diversion ditches can alter water temperatures in downstream receiving environments through the removal of riparian vegetation resulting in increased solar radiation. There are no lakes, a small surface area of open water wetlands, and shallow residual pool depths in the Upper South Teigen and North Treaty watersheds, which provide minimal water retention, solar radiation, and warming over the summer months. Similarly, the diversion ditches around the TMF will provide minimal water retention for significant solar radiation and warming over the summer months. Therefore, changes in water temperature in South Teigen and North Treaty creeks because of the diversions are not predicted to occur. Impoundment of watercourses, such as the proposed TMF, creates a large surface area, which is subject to increased solar radiation. The increased solar radiation will result in increased surface water temperatures within the TMF. The impoundment effect of the TMF could alter water temperature in downstream receiving environments by three pathways and timelines:

- Pathway 1: TMF discharging water into North Treaty Creek during years 30 to 45 and greater than 56;
- Pathway 2: TMF discharging water into South Teigen Creek during years greater than 45; and
- Pathway 3: TMF discharging water into Treaty Creek during years 0 to 56.

Potential changes in water temperature of downstream receiving environments were assessed quantitatively through an analysis of proposed TMF discharge volumes. For each pathway, maximum monthly TMF discharge volumes were compared to predicted receiving environment stream discharge volumes for the month of August, October, and April. The month of August represents the warmest mean monthly stream temperature for rearing Dolly Varden in South Teigen, North Treaty, and Treaty creeks. The month of October represents when Dolly Varden are spawning in South Teigen and North Treaty creeks. The month of April represents the warmest mean monthly stream temperature for incubating eggs in South Teigen and North Treaty creeks. Dolly Varden do not spawn or incubate eggs in Treaty Creek, therefore are excluded from the analysis. It is assumed that the greatest effects on fish would occur during these months, since downstream receiving environments are already at their warmest.

Tables 15.7-31 to 15.7-33 present a comparative analysis of TMF discharge volumes and receiving environment discharge volumes for North Treaty, South Teigen, and Treaty creeks.

Based upon baseline water temperature data, mean water temperature in North Treaty Creek ranges from 0.3°C in December to 8.9°C in August. The TMF discharges into North Treaty Creek during years 30 to 45 and greater than 56. For years 30 to 45, the TMF maximum discharge volume varies between 23.3% in August and 39.6% in October of the mean monthly creek discharge (Table 15.7-31). During April the TMF discharge will contribute 28.4% of the mean monthly creek discharge. For years greater than 56, the maximum discharge volume varies between 47.2% in July and 84.5% in April of the mean monthly creek discharge. During August and October the TMF discharge will contribute 52.6% and 73.1% of the mean monthly creek discharge. Depending upon the TMF surface water temperature, it is possible that the TMF discharge water will increase ambient water temperatures in North Treaty Creek. Water temperatures would have to increase by 8°C during August, 6°C during October, and 4°C during April to place Dolly Varden outside of their optimal temperature range for growth and survival (Table 15.7-30).

Table 15.7-31. Percent Difference in Max Monthly Discharge in North Treaty Creek

Month	Mean Baseline Temperature (℃)	Years 30-45 Discharge (m^3/s)	Years 30-45 Mean Monthly Discharge (m^3/s)	Years 30-45 Max Monthly Discharge (m^3/s)	Years 30-45 Max Difference (%)	Years > 56 Discharge (m^3/s)	Years > 56 Mean Monthly Discharge (m^3/s)	Years > 56 Max Monthly Discharge (m^3/s)	Years > 56 Max Difference (%)
January	0.7	0.28	0.08	0.09	32.2	0.24	0.15	0.15	63.1
February	1.0	0.29	0.08	0.08	29.0	0.25	0.14	0.15	58.3
March	1.1	0.32	0.09	0.10	31.0	0.28	0.19	0.19	69.3
April	1.7	0.79	0.21	0.22	28.4	0.71	0.59	0.60	84.5
May	3.2	3.41	1.00	1.07	31.4	3.27	2.15	2.17	66.3
June	5.7	4.41	1.36	1.46	33.1	4.12	2.59	2.61	63.5
July	7.1	3.12	0.70	0.75	24.0	2.62	1.24	1.24	47.2
August	8.9	1.6	0.35	0.37	23.3	1.34	0.70	0.70	52.6
September	6.6	1.67	0.54	0.58	34.6	1.48	0.98	0.98	65.9
October	3.2	1.23	0.45	0.49	39.6	1.05	0.77	0.77	73.1
November	1.5	0.6	0.19	0.21	34.4	0.49	0.33	0.33	67.9
December	0.3	0.42	0.11	0.12	29.0	0.35	0.20	0.20	57.1

Highlighted rows represent the warmest mean monthly stream temperature for Dolly Varden rearing (August), spawning (October), and egg incubation (April)

Table 15.7-32. Percent Difference in Max Monthly Discharge in South Teigen Creek

Month	Mean Baseline Temperature (℃)	Years > 45 Discharge (m^3/s)	Years > 45 Mean Monthly Discharge (m^3/s)	Years > 45 Max Monthly Discharge (m^3/s)	Years > 45 Max Difference (%)
January	0.4	0.32	0.11	0.17	52.2
February	0.5	0.27	0.10	0.16	57.9
March	0.4	0.30	0.12	0.18	61.4
April	0.7	0.63	0.28	0.42	66.2
May	2.1	3.96	1.36	2.05	51.8
June	4.3	7.62	1.84	2.77	36.3
July	6.7	5.24	1.02	1.53	29.1
August	8.2	3.02	0.53	0.80	26.5
September	5.9	3.90	0.76	1.13	29.0
October	2.5	2.71	0.60	0.90	33.3
November	0.5	1.22	0.26	0.38	31.4
December	0.3	0.59	0.15	0.23	38.3

Highlighted rows represent the warmest mean monthly stream temperature for Dolly Varden rearing (August), spawning (October), and egg incubation (April)

Table 15.7-33. Percent Difference in Max Monthly Discharge in Treaty Creek

Month	Years 0-24				Years 25-30				Years 30-45				Years 45-50				Years 51-56			
	Discharge (m^3/s)	Mean Monthly Discharge (m^3/s)	Max Monthly Discharge (m^3/s)	Max Difference (%)	Discharge (m^3/s)	Mean Monthly Discharge (m^3/s)	Max Monthly Discharge (m^3/s)	Max Difference (%)	Discharge (m^3/s)	Mean Monthly Discharge (m^3/s)	Max Monthly Discharge (m^3/s)	Max Difference (%)	Discharge (m^3/s)	Mean Monthly Discharge (m^3/s)	Max Monthly Discharge (m^3/s)	Max Difference (%)	Discharge (m^3/s)	Mean Monthly Discharge (m^3/s)	Max Monthly Discharge (m^3/s)	Max Difference (%)
January	2.72	0.00	0.00	-	2.76	0.08	0.09	3.3	2.76	0.00	0.00	-	2.66	0.00	0.00	-	2.75	0.09	0.10	3.7
February	2.49	0.00	0.00	-	2.52	0.07	0.08	3.3	2.52	0.00	0.00	-	2.43	0.00	0.00	-	2.51	0.08	0.10	3.9
March	2.54	0.00	0.00	-	2.58	0.08	0.10	3.9	2.58	0.00	0.00	-	2.48	0.00	0.00	-	2.57	0.11	0.13	5.1
April	6.38	0.00	0.00	-	6.45	0.19	0.22	3.5	6.45	0.00	0.00	-	6.24	0.00	0.00	-	6.45	0.31	0.37	5.7
May	22.93	0.03	0.20	0.9	23.12	0.89	1.07	4.6	23.11	0.00	0.00	-	22.18	0.00	0.00	-	23.10	0.98	1.18	5.1
June	42.66	1.51	1.76	4.1	43.02	1.44	1.62	3.8	43.16	0.24	0.32	0.7	41.61	0.19	0.47	1.1	42.91	1.23	1.46	3.4
July	43.46	0.74	0.79	1.8	43.96	0.95	1.07	2.4	44.23	0.31	0.33	0.7	43.32	0.26	0.28	0.7	43.58	0.63	0.76	1.7
August	33.96	0.19	0.24	0.7	34.16	0.37	0.37	1.1	34.15	0.00	0.00	-	33.71	0.00	0.00	-	33.96	0.35	0.42	1.2
September	24.03	0.46	0.51	2.1	24.30	0.60	0.73	3.0	24.31	0.15	0.18	0.7	23.70	0.09	0.11	0.5	24.11	0.52	0.63	2.6
October	18.29	0.30	0.36	2.0	18.58	0.46	0.55	2.9	18.62	0.10	0.11	0.6	18.11	0.09	0.11	0.6	18.46	0.43	0.52	2.8
November	7.96	0.00	0.00	-	8.10	0.17	0.21	2.5	8.10	0.00	0.00	-	7.85	0.00	0.00	-	8.04	0.44	0.53	6.6
December	3.76	0.00	0.00	-	3.83	0.10	0.12	3.2	3.83	0.00	0.00	-	3.69	0.00	0.00	-	3.81	0.36	0.47	12.3

Dashes indicate not applicable

Highlighted rows represent the warmest mean monthly stream temperature for Dolly Varden rearing (August), spawning (October), and egg incubation (April)

Based upon baseline water temperature data, mean water temperature in South Teigen Creek ranges from 0.3°C in December to 8.2 °C in August. The TMF discharges into South Teigen Creek during years greater than 45. For years greater than 45, the TMF maximum discharge volume varies between 26.5% in August and 66.2% in April of the mean monthly creek discharge (Table 15.7-32). During October the TMF discharge will contribute 33.3% of the mean monthly creek discharge. Depending upon the TMF surface water temperature, it is possible that the TMF discharge water will increase ambient water temperatures in South Teigen Creek. Water temperatures would have to increase by 8°C during August, 6°C during October, and 5°C during April to place Dolly Varden outside of their optimal temperature range for growth and survival (Table 15.7-30).

Continuous baseline water temperature data are not available for Treaty Creek. Spot measurements indicate that Treaty Creek is colder than North Treaty and South Teigen creeks due to its highly glaciated headwaters; however, for the purposes of this assessment the South Teigen temperature data were adopted. The TMF discharges into Treaty Creek throughout the TMF development stages. TMF maximum discharge volume varies between 0.5% in September (years 45 to 50) and 12.3% in December (years 51 to 56) of the mean monthly creek discharge (Table 15.7-33).

During August, the TMF discharge will only contribute between 0.7% and 1.2% of the mean monthly creek discharge (all stages of discharge). Therefore, minor contribution of TMF water is highly unlikely to increase ambient water temperatures in Treaty Creek. Water temperatures would have to increase by 8°C during August to place Dolly Varden outside of their optimal temperature range (Table 15.7-30); which is highly unlikely to occur and have a negligible effect.

Similar to the case with fish, the temperature increases due to input of TMF discharges in South Teigen, North Treaty, or Treaty Creeks will likely have negligible adverse effects on aquatic invertebrates and periphyton. The organisms that colonize these areas have the ability to withstand large variation in water temperature on an annual basis (i.e., eurythermal), between just above 0°C in the winter and 8 to 9°C in the summer. A doubling of summertime temperatures to 16°C would still be less than the 30°C level that can reduce periphyton primary production. Enhanced primary production due to higher summertime temperatures could lead to the accumulation of primary producer biomass in the streams most influenced by TMF discharges. However, as discussed for nutrient loading, the accumulation of periphyton biomass is likely also controlled by secondary producers and by the biomass accrual period between flood events, and these two processes may act opposite to the effects of temperature.

Species composition, distribution, or density of aquatic life can vary from year to year, and factors such as flow, sediment quality, or nutrient loading will have a greater effect on community composition than slight alterations in water temperature. In addition, since aquatic invertebrates are not thermo-regulators, increased ambient water temperatures are associated with an increase in metabolic rate and, generally, an increase in productive capacity of a system (reviewed in Oliver and Fidler 2001). Overall, a slight increase in water temperature would not be expected to decrease productive capacity, and fish prey availability should remain relatively unchanged or will increase in abundance.

15.7.5.1.7 *Aquatic Habitat Loss and Alteration due to Mine Site Infrastructure and Water Management*

Potential Effects

The potential for alterations in productive capacity due to Mine Site water management occurs in all phases of Project activities. The diversion ditches and pipelines, MDT and MTDT, and the Mine Site WSF and WTP may alter aquatic habitat in the non-fish-bearing McTagg, Mitchell, and Gingras creeks and reaches of Sulphurets Creek above the cascades. Non-contact surface runoff water from the McTagg and Mitchell watersheds will be collected in diversion ditches and pipelines and discharged untreated to Mitchell Creek below the WSF via the WSF bypass pipeline. Water from McTagg Creek will be diverted around the McTagg RSF and downstream mine facilities into Gingras Creek through the MTDT. Untreated non-contact water from the Mitchell Glacier and areas upstream of the Mitchell Pit will be diverted into Sulphurets Lake through the MDT, while contact water from this area will be collected separately and directed into the WSF and subsequently through the WTP. In addition, all surface water that has been in contact with the various mine pits, RSFs, or other infrastructure will be diverted into the WSF for processing in the WTP.

Mine water management, with the diversions, WSF, and water treatment, could have several potential effects on downstream aquatic habitats. First, they will cause the loss of instream and riparian habitat within McTagg and Mitchell creeks due to water diversions (these areas will become RSFs), in Gingras Creek due to water diversion from McTagg and to the McTagg Power Plant, and in Lower Mitchell Creek due to discharge from the WTP. Second, the WTP will alter the water quality entering Sulphurets Creek.

The riparian area, aquatic habitat, and aquatic biology present in McTagg Creek will be progressively eliminated when the various stages (1 to 3) of the McTagg Diversion Tunnel are constructed at consecutively higher elevations on McTagg Creek. Water from McTagg Creek and any suspended sediment or aquatic life it contains will be directed into Gingras Creek. However, the overall implication of diversion of McTagg Creek and loss of aquatic habitat are minimal since baseline studies indicated that there were low levels of aquatic life present in this creek (MCTR site; Section 15.1.5.2; Appendices 15-B and 15-D). During Stage 1 of tunnel development, the increased flow in Lower Gingras Creek may result in scouring of the creek bed and an associated decrease in riparian areas, sediments, and aquatic life. By Stage 2 of MDT construction, some or all of the flow diverted from McTagg Creek will be used to generate hydroelectric power in the McTagg Power Plant near the outlet of Gingras Creek. In addition, some of the flow may be diverted from Gingras Creek to the McTagg penstock during the wintertime to increase the potential for hydropower generation. The scouring effect on Gingras Creek of the diverted water from McTagg will then be diminished except during high water flow (e.g., freshet, storm events). During the winter, it is possible that Gingras Creek will experience lower than normal flows as a result of diversions to the Power Plant. Thus, the longer-term effects on Gingras Creek may be transient or seasonal.

The Mitchell Glacier melt water and other non-contact water from the Mitchell Pit area will be diverted into Sulphurets Lake and will follow the natural discharge regime. This increase in natural discharge regime could alter the aquatic habitat and productive capacity in the non-fish-bearing reaches of Upper Sulphurets Creek above the confluence with Mitchell Creek. However, the change in discharge volume is not expected to be significant in Sulphurets Creek at the SC2 site since the diverted water would normally have arrived at this same location (i.e., from Mitchell Creek). Due to the diversion of non-contact water to Sulphurets Creek, the overall flow of water in Upper Mitchell Creek above the WSF will be reduced. However, the effects of the decreased discharge are minimal since the aquatic habitat and productivity of Mitchell Creek (MC-1) was very low during baseline studies (Section 15.1.5.2; Appendices 15-B and 15-D).

The WSF, which will act as a large sedimentation pond, will alter aquatic habitat in Sulphurets Creek by potentially decreasing the input of organic matter, benthic invertebrates, and sediments from this catchment area into Sulphurets Creek. It is difficult to predict the net change in organic matter loadings and invertebrate drift to Sulphurets Creek. However, there is generally low organic matter or nutrients and low productive capacity in terms of aquatic life in McTagg and Mitchell creeks. In addition, there is a 9.5-km section of Sulphurets Creek and associated riparian area between the WTP discharge point and the fish-bearing section of Sulphurets Creek. There are also the upper reaches of Sulphurets Creek (which will include the diverted water from Upper Mitchell Creek), Upper Gingras Creek, Ted Morris Creek, and Joe Mandy Creek, and their respective watersheds that contribute organic matter, nutrients, and benthic invertebrate drift to the lower portion of Sulphurets Creek and the Unuk River. Inputs from these other watersheds are sufficient to support the periphyton and benthic communities, although some minor reductions in productive capacity could occur.

The WSF will act as a sedimentation pond and settling of suspended solids will decrease the movement of sediments from the Mitchell watershed and the McTagg RSF into Sulphurets Creek (Section 15.7.4.3.1). It will also decrease the effects associated with the naturally high TSS content in Mitchell Creek (e.g., scouring, blockage of light for primary producers, and transport of TSS-bound metals). However, there is the potential for the facility to cause sediment starvation in Sulphurets Creek. Sediment starvation can lead to scouring and removal of riparian and pool habitat, and subsidence and disappearance of wetlands and lowering of the water table (Jha 2003). It is expected that the upper reaches of Sulphurets Creek, Upper Gingras Creek, Ted Morris Creek, and Joe Mandy Creek and their respective watersheds will contribute sediments to the lower portion of Sulphurets Creek and the Unuk River. These other watersheds should supply sufficient sediments to the lower portions of Sulphurets Creek to maintain the aquatic habitat, although some alterations could occur.

Assessment

An estimate of aquatic habitat lost to Project infrastructure on the Mine Site was made by determining the total stream length lost due to Mitchell and McTagg RSFs, the WSF, diversion of McTagg Creek to Gingras Creek, and loss of flow to Mitchell Creek during times of low discharge (winter) from the WTP. Stream length was used to estimate aquatic habitat loss, as detailed cross-sections of the affected areas were not done during baseline studies since these areas are non-fish-bearing. The length of open diversion channels and ditches in this area was also determined since they may, over time, provide some new aquatic habitat that could be recolonized.

Aquatic habitat of streams and tributaries were classified as either lost to the Mine Site (red on Figure 15.7-12) or as being diverted in diversion tunnels, channels, or ditches (blue on Figure 15.7-12). The aquatic habitat in the mainstems of McTagg Creek and much of Upper Mitchell Creek will be lost under the RSFs or other mine infrastructure (e.g., pits), as will the portion of the unnamed tributaries below the diversion tunnels, channels, or ditches. Aquatic habitat above the diversion structures will remain intact. The stream lengths associated with the various losses or gains in aquatic habitat are summarized in Table 15.7-34. A loss of 97,441 m of stream length may occur as a result of Project infrastructure development and operation, which represents just under 30% of all stream length in the Mine Site (Table 15.7-34). However, open diversion channels, ditches, and spillways will also be created as part of Mine Site infrastructure, and will add approximately 17,267 m of potential aquatic habitat. Overall, the net loss of aquatic habitat due to Mine Site infrastructure is then 80,174 m, or approximately 25% of the total stream length.

Table 15.7-34. Non Fish-bearing Aquatic Habitat Loss in the KSM Project Mine Site

Creek	Lost/Not Lost	Length (m)	Proportion of Total (%)
Gingras	Total Length	13,362	-
	Length Lost	1,720	12.9
	Length Unaffected	11,642	87.1
Mitchell	Total Length	74,606	-
	Length Lost	48,303	64.7
	Length Unaffected	26,303	35.3
McTagg	Total Length	61,331	-
	Length Lost	15,725	25.6
	Length Unaffected	45,606	74.4
Sulphurets	Total Length	178,299	-
	Length Lost	31,693	17.8
	Length Unaffected	146,606	82.2
Mine Site (all streams)	Total Length	327,598	-
	Length Lost	97,441	29.7
	Length Unaffected	230,157	70.3
Open Water Diversion Structures[1]		17,267	-
Net Loss of Aquatic Habitat[2]			24.5

[1] Includes diversion ditches, channels and spillways that will not be reclaimed during closure/post-closure.
[2] Net loss of aquatic habitat was calculated as total stream length lost in Mine Site - total length of non-reclaimed open water diversion structures divided by the total length of streams in Mine Site x 100.

While the loss of aquatic habitat may appear high on a local level, in a broader context, these habitats are not unique to the region. In addition, during baseline studies these areas were found to have low productive capacity, with low or very low abundance and diversity of both periphyton and aquatic invertebrates (Table 15.1-7; Appendices 15-B and 15-D). Sediments in these areas often had concentrations of metals that were greater than sediment quality guidelines (Tables 15.1-8 and 15.1-9; Appendices 15-B and 15-D).

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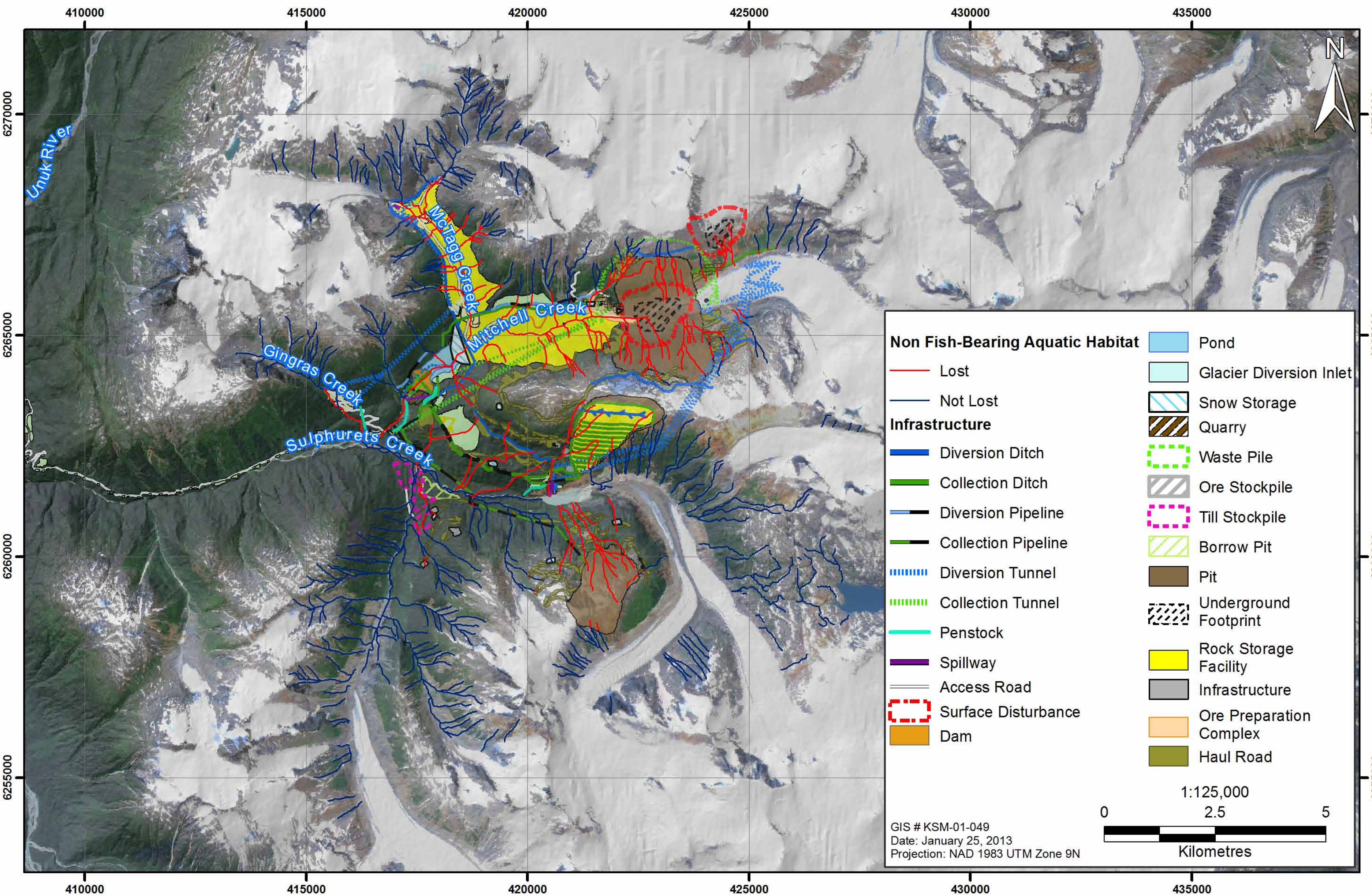

Figure 15.7-12

SEABRIDGE GOLD
KSM PROJECT

Non-fish-bearing Aquatic Habitat Loss in the KSM Project Mine Site

Figure 15.7-12

Rescan
Engineers & Scientists

15.7.5.1.8 Fish Habitat Loss and Alteration due to Mine Site Infrastructure and Water Management - Sulphurets Creek

Hydrology

Potential changes in stream flow in the lower fish-bearing reach of Sulphurets Creek (downstream of the cascade) due to Mine Site development were assessed quantitatively. Changes in monthly discharge of Sulphurets Creek during mine construction, operation, and closure (years 0 to 10, 11 to 25, 26 to 30, 31 to 50, 51 to 56, and greater than 56), were predicted by the calibrated groundwater/discharge model at Site SC3 (lower fish bearing reach of Sulphurets Creek) under baseline conditions.

Hydrometric stations in Sulphurets Creek were used to calculate the MAD and mean monthly discharge. The annual flows at different phases of development of the Project were calculated based on the water management simulations. A comparison of predicted discharges in Sulphurets Creek indicates that the MAD will be increased and decreased by less than 1.0% during all phases of Mine Site development, except years 51 to 56 (Table 15.7-35). During these years, the pits will fill with water resulting in the annual discharge to the lower fish-bearing reach of Sulphurets Creek being reduced by 8.2%.

Table 15.7-36 presents baseline mean monthly discharges (MMDs) and instream threshold monthly discharges for Sulphurets Creek. In all months, except between June and September, the BC instream flow threshold guidelines exceed baseline MMDs. Therefore, according to the threshold guidelines, water reductions would be acceptable only between June and September. However, the small variations in monthly discharge fall within baseline natural variability in Sulphurets Creek during the short temporal water quantity loss period of years 51 to 56. Furthermore, baseline fish and fish habitat data indicates that Dolly Varden fish populations residing in the lower reach of Sulphurets Creek is marginal due to low catch-per-unit-effort compared to other surrounding waterbodies, naturally poor water quality, high sediment loads, high velocity, and low amount of cover for fish. Based upon this analysis, effects on fish and fish habitat are not expected. Therefore, the low flow variations in Sulphurets Creek will not require an authorization under the *Fisheries Act* (1985) to permit the destruction or disruption of fish habitat.

15.7.5.2 Mitigation for Habitat Loss and Alteration

15.7.5.2.1 Fish Habitat Loss and Alteration due to Project Infrastructure – Linear Development

To mitigate fish habitat and passage effects related to the Project access roads, the majority of fish-bearing stream crossings will follow DFO's operational statements for clear-span bridges. There are no restrictions on timing for the construction of clear-span structures because they do not involve in-water work. Efforts will be undertaken to minimize potential effects from the Project on fish habitat and passage, and to avoid fish habitat loss. If any in-water work within fish-bearing streams should occur, an Environmental Monitor will be on site monitoring water quality. Appropriate fisheries operating windows for fish-bearing streams will be adhered to (Section 26.19.1). Alternatively, appropriate permits will be acquired for out-of-window activities. Fish habitat loss is expected to occur for certain stream crossings, and the extent of fish habitat loss is summarized in Section 15.7.5.1 (Table 15.7-15).

Table 15.7-35. Comparison of Baseline and Proposed Operational Flows for Sulphurets Creek (SC3)

	Baseline	Years 0-10		Years 11-25		Years 26-30		Years 31-50		Years 51-56		Years >56	
Month	**Flow (m^3/s)**	**Flow (m^3/s)**	**Change from Baseline (%)**	**Flow (m^3/s)**	**Change from Baseline (%)**	**Flow (m^3/s)**	**Change from Baseline (%)**	**Flow (m^3/s)**	**Change from Baseline (%)**	**Flow (m^3/s)**	**Change from Baseline (%)**	**Flow (m^3/s)**	**Change from Baseline (%)**
Jan	2.85	2.55	-10.5%	2.51	-11.9%	2.50	-12.3%	2.51	-11.9%	2.29	-19.6%	2.56	-10.2%
Feb	2.46	2.13	-13.4%	2.10	-14.6%	2.10	-14.6%	2.14	-13.0%	1.94	-21.1%	2.15	-12.6%
Mar	2.48	2.23	-10.1%	2.20	-11.3%	2.20	-11.3%	2.25	-9.3%	2.05	-17.3%	2.25	-9.3%
Apr	5.07	4.85	-4.3%	4.81	-5.1%	4.81	-5.1%	4.81	-5.1%	4.58	-9.7%	4.86	-4.1%
May	16.48	18.06	9.6%	18.03	9.4%	18.00	9.2%	17.93	8.8%	16.22	-1.6%	17.82	8.1%
Jun	38.86	41.12	5.8%	41.01	5.5%	40.92	5.3%	40.71	4.8%	37.28	-4.1%	40.57	4.4%
Jul	61.73	63.24	2.4%	62.91	1.9%	62.86	1.8%	62.43	1.1%	58.22	-5.7%	62.65	1.5%
Aug	59.50	59.14	-0.6%	58.69	-1.4%	58.58	-1.5%	58.19	-2.2%	54.25	-8.8%	58.55	-1.6%
Sep	39.50	38.41	-2.8%	38.09	-3.6%	38.02	-3.7%	37.73	-4.5%	34.77	-12.0%	37.98	-3.8%
Oct	18.20	17.39	-4.5%	17.32	-4.8%	17.31	-4.9%	17.18	-5.6%	15.93	-12.5%	17.25	-5.2%
Nov	7.70	7.15	-7.1%	7.11	-7.7%	7.10	-7.8%	7.06	-8.3%	6.69	-13.1%	7.13	-7.4%
Dec	4.03	3.76	-6.7%	3.73	-7.4%	3.72	-7.7%	3.71	-7.9%	3.53	-12.4%	3.77	-6.5%
MAD	**21.57**	**21.67**	**0.5%**	**21.54**	**-0.1%**	**21.51**	**-0.3%**	**21.39**	**-0.8%**	**19.81**	**-8.2%**	**21.46**	**-0.5%**

MAD = mean annual discharge

Table 15.7-36. Monthly Flow Discharge Thresholds for Sulphurets Creek as Determined using the Guidelines in Hatfield et al. (2003)

Month	Mean Baseline Flow* (m^3/s)	Instream Flow Threshold (m^3/s)	Ratio of Instream Flow Threshold to Mean Monthly Baseline Flow
Jan	2.85	4.93	173.2%
Feb	2.46	4.04	164.0%
Mar	2.48	3.98	160.5%
Apr	5.07	7.90	155.9%
May	16.48	20.26	122.9%
June	38.86	35.60	91.6%
July	61.73	53.03	85.9%
Aug	59.50	52.48	88.2%
Sep	39.50	37.49	94.9%
Oct	18.20	20.24	111.2%
Nov	7.70	12.66	164.3%
Dec	4.03	6.03	149.8%

*** Based on long-term synthetic data at Station SC-H1 (1968 to 2010)**

As part of the design for the Project, consideration has been given in the selection of access road and transmission line routes that avoid or minimize the number and potential effects on crossings of fish-bearing watercourses. These efforts and future detailed designs will include:

- selecting alignments that, where practical, minimize the number of watercourse crossings required;
- avoiding parallel road and transmission line alignment directly adjacent to watercourses where practical;
- selecting laydown areas outside of riparian zones;
- selecting structure placements and designs that minimize loss or disturbance to riparian vegetation (e.g., higher structures allow for wider span lengths);
- designing and constructing road approaches so that they are perpendicular to watercourses to minimize loss or disturbance to riparian vegetation; and
- avoiding structures or access roads on meander bends, braided streams, alluvial fans, active floodplains, unstable slopes, or any other area that is inherently unstable and may result in erosion and scouring of the stream bed.

Vegetation within the access roads will be initially removed to facilitate the construction. For the transmission line, selected timber will be removed in a manner that avoids removal of understory vegetation to the extent practical. Some vegetation within the riparian management area (i.e., 15 m from the top of bank of a watercourse) will be removed at watercourse crossing locations along the alignments, but efforts will be made to retain shrubs while ensuring that adequate electrical clearances are met for the transmission line. Following transmission line construction, exposed or disturbed soils will be re-vegetated.

There are no DFO operational statements that specifically deal with the removal of riparian vegetation (i.e., 15 m from the top of bank of a watercourse) for transmission line projects of this scope and magnitude. DFO's operational statement for overhead line construction (DFO 2010) applies specifically to transmission lines with voltage less than 60 kV. However, the Project will use general guiding principles from this operational statement including:

- conducting work activities (i.e., equipment access, construction of transmission structures, and conductor stringing) in a manner that minimizes riparian vegetation effects and maintains fish habitat and stream bank integrity;
- retaining shrubs or grass species in riparian zones;
- where practical, modifying riparian cover by hand (if machinery must be used, it will be operated on land [above the HWM] and in a manner that minimizes disturbance to the banks of the waterbody); and
- preserving root structure and stability of topped trees located on the bank of a waterbody, ensuring that the root structure and stability are maintained, to help bind the soil and encourage rapid colonization of low-growing plant species.

The Fish and Aquatic Habitat Effects Protection and Mitigation Plan (Section 26.18.1) provides mitigation measures for work in riparian areas for linear project types.

15.7.5.2.2 Fish Habitat Loss and Alteration due to Project Infrastructure – Tailing Management Facility Development

Fish habitat loss within the TMF is unavoidable. The extent of fish habitat loss is summarized in Section 15.7.5.1. Prior to TMF construction, an intensive fish salvage program will be implemented within the TMF watercourses. The details of the Fish Salvage Plan are summarized in Chapter 26 (Section 26.18.3). To mitigate fish habitat loss downstream (i.e., South Teigen and North Treaty creeks) of the TMF dams, the following mitigation measures will be adhered to during construction, operation, and closure:

- the Environmental Monitor will monitor water quality when there is in-water work within fish-bearing streams;
- appropriate fisheries operating windows for fish-bearing streams will be adhered to (Section 26.18.1);
- appropriate permits will be acquired for out-of-window activities;
- water diversion structures will be used to divert dirty water from the work zone to a sediment control area;
- during TMF development, water flow will be reduced at a gradual rate as to not strand fish downstream;
- silt fencing, geotextile cloth, hay bales, berms, or other sediment control structures will be installed;

- constructed ponds will be allowed to settle before connecting to the stream;
- constructed dams will be graded at a stable slope; and
- dam materials denuded of vegetation will be stabilized using temporary erosion control blankets, biodegradable mats, planted vegetation, or other erosion control techniques.

The Fish and Aquatic Habitat Effects Protection and Mitigation Plan provides mitigation measures for instream work.

15.7.5.2.3 Fish Habitat Loss and Alteration due to Tailing Management Facility Water Management – South Teigen and North Treaty Creeks

As part of the design for the Project, consideration was given to TMF water management to minimize effects in South Teigen and North Treaty creeks. These efforts included:

- designing diversion ditches to minimize water loss;
- altering diversion ditch flow patterns to coincide with the various phases of TMF development; and
- rotating the TMF to discharge into Treaty and North Treaty creeks during TMF operation.

Fish habitat loss downstream of the TMF, in South Teigen and North Treaty creeks, due to TMF water management is unavoidable. The extent of fish habitat loss is summarized in Section 15.7.5.1 (Table 15.7-15).

15.7.5.2.4 Fish Habitat Loss and Alteration due to Tailing Management Facility Water Management – Teigen and Treaty Creeks

As part of the design for the Project, consideration was given to TMF water management to minimize effects in Teigen and Treaty creeks. These efforts included:

- designing diversion ditches to minimize water loss;
- altering diversion ditch flow patterns to coincide with the various phases of TMF development; and
- rotating the TMF to discharge into Treaty and North Treaty creeks during TMF operation.

Fish habitat changes in Teigen and Treaty creeks, due to TMF water management, are negligible. Sediment supply and transport of gravels into Teigen Creek due to TMF water management are negligible. The extent of changes in water discharge volumes is summarized in Section 15.7.5.1, and will not require an authorization under the *Fisheries Act* (1985). A chinook salmon monitoring program in Teigen Creek will be developed and will be implemented for the first 10 years of the TMF operation phase to monitor the predicted results of the effects assessment (Section 26.19.2).

15.7.5.2.5 Aquatic Habitat Loss and Alteration due to Tailing Management Facility Water Management

As described above for fish, productive capacity during the Project construction and operation phases will also be reduced in South Teigen and North Treaty Creeks due to TMF construction (loss of area) and water management (loss of flow). Mitigation measures to minimize effects on productive capacity include:

- designing diversion ditches to minimize water loss;
- altering diversion ditch flow patterns to coincide with the various phases of TMF development; and
- rotating the TMF to discharge into Treaty and North Treaty creeks during TMF operation.

Although the water diversions will maintain some water flow in these creeks, nutrient inputs from the wetland area (lost to the TMF, see Chapter 16, Wetlands) surrounding these creeks will be lost, and there will likely be some effect to the productive capacity in these creeks. The proportion of nutrients contributed by the wetlands to the water flowing in South Teigen and North Treaty creeks is currently not known, so the magnitude of nutrient loss cannot be quantified. For Teigen and Treaty creeks, water management in the PTMA is not expected to have significant effects on discharge rates, thus water volume is not likely to cause changes to productive capacity.

The mitigation measures outlined above for loss of fish habitat due to TMF water management in Teigen and Treaty creeks also apply to productive capacity in these creeks. There may be some limited effect to the productive capacity in Teigen and Treaty creeks due to changes in nutrient loading, which may also affect community composition. The Aquatic Effects Monitoring Plan (Section 26.18.2) will be implemented; it will include triggers for risk assessment of potential effects, ensure detection of measureable alterations in productive capacity, allow for identification of potential causes, and include the provision of additional mitigation or adaptive management strategies.

15.7.5.2.6 Fish and Aquatic Habitat Loss and Alteration due to Tailing Management Facility Water Management – Water Temperature

Water temperature changes in Treaty Creek, due to TMF water management, are negligible. Water temperature changes in North Treaty and South Teigen creeks, due to TMF water management, are considered low; however, there is a level of uncertainty with respect to the TMF surface water temperature. The extent of TMF discharge volumes is summarized in Section 15.7.5.1, and will not require an authorization under the *Fisheries Act* (1985). The diversion ditches will be planted with riparian vegetation to provide streamside shading and to mitigate for increases in direct solar heating and large fluctuations in stream temperature. A water temperature monitoring program in South Teigen, Teigen, North Treaty, and Treaty creeks will be developed; and will be implemented for the first six years of the TMF operation phase to monitor the predicted results of the effects assessment.

15.7.5.2.7 Aquatic Habitat Loss and Alteration due to Mine Site Infrastructure and Water Management

As a result of Project activities including development of the Mitchell Pit, Mitchell and McTagg RSFs, and the McTagg Power Plant, non-fish-bearing aquatic habitat will be lost under the Mine Site. This includes loss of both sediment and non-fish aquatic life (periphyton and aquatic invertebrates), although baseline studies show there is currently low productive capacity in this area. Mitigation includes the diversion of non-contact water from the Upper Mitchell Creek watershed and glacier to Sulphurets Lake and from McTagg Creek watershed and glacier to Gingras Creek; however, loss of non-fish-bearing aquatic habitat from Mine Site infrastructure is unavoidable.

15.7.5.2.8 Fish Habitat Loss and Alteration due to Mine Site Infrastructure and Water Management – Sulphurets Creek

Project activities including development of the pits and RSFs will alter water management within the Sulphurets Creek watershed. However, fish habitat changes in Sulphurets Creek will be negligible due to Mine Site water management. The extent of changes in water discharge volumes is summarized in Section 15.7.5.1 and will not require an authorization under the *Fisheries Act* (1985).

15.7.5.3 Potential for Residual Effects

Table 15.7-37 presents potential residual effects on the aquatic habitat VC due to aquatic habitat loss and alteration.

15.7.5.4 Aquatic Habitat: Potential Residual Effects due to Habitat Loss and Alteration

The primary goal of mitigation strategies is to prevent effects to fish and aquatic habitat. Mitigation strategies include adhering to DFO operational statements, the Erosion Control Plan (Section 26.13.2), the Spill Prevention and Emergency Response Plan (Section 26.10), and the Aquatic Effects Monitoring Plan (Section 26.18.2), and to using BMPs. Although these mitigations and BMPs are effective in minimizing fish and aquatic habitat loss and alteration, these strategies may not fully prevent all effects on aquatic habitat. Thus, some residual effects due to decreases in stream productive capacity are expected to occur due to the construction, operation, and closure of Project components in the PTMA and Mine Site. The significance of the residual effects is discussed in subsequent sections.

During the construction phase, aquatic habitats in the LSA may be affected by components such as the construction of access roads, tunnels, TMF, WTP/WSF, and transmission line. During operation and mine closure, aquatic habitats may be affected by the TMF, RSFs, WSD, and the WTP/WSF.

Certain Project components will result in fish habitat loss and/or alteration. These Project components include access roads, the transmission line, the TMF, TMF dams, and water quantity loss in South Teigen and North Treaty creeks. Other components will result in loss of non-fish-bearing aquatic habitat including Mine Site access roads, McTagg and Mitchell RSFs, mine pits, WSF/WTP, the WSF dam, and water diversions (water quantity loss or gain).

Table 15.7-37. Potential Residual Effects on the Aquatic Habitat Valued Component due to Habitat Loss and Alteration

Valued Component	Timing Start	Project Area(s)	Component(s)	Description of Effect due to Component(s)	Type of Project Mitigation	Project Mitigation Description	Potential Residual Effect	Description of Residuals
Aquatic Habitat	Construction Operation Closure	Mine Site	Coulter Creek Access Corridor	Loss of instream and riparian habitat at stream crossings	DFO Clear Span Bridge Operational Statement; Fish Habitat Compensation Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Adhere to DFO's operational statements; Implement Fish Habitat Compensation Plan	Yes	Temporal residuals related to timing of habitat destruction and habitat creation
Aquatic Habitat	Construction Operation Closure	Mine Site	McTagg and Mitchell RSF; Mine Site WSF/WTP; Energy Recovery Facility (McTagg Power Plant); McTagg Twinned Diversion Tunnels and various diversion channels and ditches	Loss of aquatic habitat productive capacity within McTagg, Mitchell, and Gingras, and non-fish bearing reaches of Sulphurets Creek due to infrastructure development and diversion of water	Water Management Plan; Water diversions tunnels between McTagg (to Gingras) Creek and Mitchell Creek to Sulphurets Lake will collect non-contact water	Manage water according to design plans; Adhere to minimum instream flow thresholds for aquatic habitat (for fish-less streams) where possible	Yes	Decrease in the productive capacity of aquatic habitat within non-fish bearing reaches of Mitchell, McTagg, Gingras, and Sulphurets Creeks
Aquatic Habitat	Construction Operation Closure	Processing and Tailing Management Area	Treaty Creek Access Road	Loss of instream and riparian habitat at stream crossings	DFO Clear Span Bridge Operational Statement; Fish Habitat Compensation Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Adhere to DFO's operational statements; Implement Fish Habitat Compensation Plan	Yes	Temporal residuals related to timing of habitat destruction and habitat creation
Aquatic Habitat	Construction Operation Closure	Processing and Tailing Management Area	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility	Loss of aquatic life and instream and riparian habitat within the TMF footprint of South Teigen and North Treaty Watersheds	Fish Habitat Compensation Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Implement Fish Habitat Compensation Plan	Yes	Temporal residuals related to timing of habitat destruction and habitat creation
Aquatic Habitat	Construction Operation Closure	Processing and Tailing Management Area	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; East Catchment Diversion	Loss of aquatic life and instream habitat within South Teigen and North Treaty Creeks, downstream of the TMF dams, related to water quantity loss	Fish Habitat Compensation Plan; Fish and Aquatic Habitat Protection and Mitigation Plan; Water Management Plan	Implement Fish Habitat Compensation Plan; Manage water according to design plans	Yes	Temporal residuals related to timing of habitat destruction and habitat creation
Aquatic Habitat	Construction Operation Closure	Processing and Tailing Management Area	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; East Catchment Diversion	Loss instream habitat within Teigen Creek, downstream of the TMF dams, related to water quantity loss	Water Management Design; Teigen Creek Chinook Salmon Monitoring Program	Implement Teigen Creek Chinook Salmon Monitoring Program; Manage water according to design plans	Yes	Minor changes in downstream discharge volumes

(continued)

Table 15.7-37. Potential Residual Effects on the Aquatic Habitat Valued Component due to Habitat Loss and Alteration (completed)

Valued Component	Timing Start	Project Area(s)	Component(s)	Description of Effect due to Component(s)	Type of Project Mitigation	Project Mitigation Description	Potential Residual Effect	Description of Residuals
Aquatic Habitat	Construction Operation Closure	Processing and Tailing Management Area	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; East Catchment Diversion	Loss instream habitat within Treaty Creek, downstream of the TMF dams, related to water quantity loss	Water Management Design	Manage water according to design plans	Yes	Minor changes in downstream discharge volumes
Aquatic Habitat	Construction Operation Closure	Processing and Tailing Management Area	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; East Catchment Diversion	Loss of aquatic habitat productive capacity within South Teigen and North Treaty Creeks, downstream of the TMF dams, related to loss of upper watershed	Fish Habitat Compensation Plan; Water Management Plan; Water diversions tunnels, channels and ditches to collect non-contact water from watersheds above the TMF	Implement Fish Habitat Compensation Plan; Manage water according to design plans	Yes	Decrease in the productive capacity of aquatic habitat within South Teigen and North Treaty Creeks
Aquatic Habitat	Construction Operation Closure	Processing and Tailing Management Area	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; East Catchment Diversion	Change in instream habitat sediment supply within South Teigen and Teigen creeks downstream of the TMF dams	Water Management Design; Teigen Creek Chinook Salmon Monitoring Program	Implement Teigen Creek Chinook Salmon Monitoring Program; Manage water according to design plans	Yes	Minor changes in downstream discharge volumes
Aquatic Habitat	Construction Operation Closure	Processing and Tailing Management Area	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; East Catchment Diversion	Change in water temperatures within South Teigen, North Treaty and Treaty creeks downstream of the TMF dam	Water Management Design; Water Temperature Monitoring Program	Implement Water Temperature Monitoring Program; Manage water according to design plans	Yes	Minor changes in downstream discharge volumes

Fish and fish habitat are protected under a variety of federal and provincial regulatory acts and principles. The *Fisheries Act* (1985) prohibits the loss of fish habitat through physical, chemical, or biological means. Under Section 35(2) of the *Fisheries Act* (1985), any project or activity that causes fish habitat loss requires an authorization from DFO, and a fish habitat compensation plan must be developed. The MMER (SOR/2002-222), enacted in 2002, was developed under Section 36 of the *Fisheries Act* (1985) to regulate the deposit of tailing and other waste matter produced during mining activities into natural fish-bearing waters. These regulations, administered by Environment Canada, are for both new and existing mines. If a developer proposes to use a natural fish-bearing waterbody for tailing management, a fish habitat compensation plan must be developed to ensure that no net loss of fish habitat results from the use of this waterbody. Therefore, two separate fish habitat compensation plans were developed to compensate for fish habitat loss as a result of the Project (Appendices 15-Q and 15-R). The compensation plans were developed according to DFO's policy of a 2:1 habitat gain to loss ratio to ensure certainty of success and maintain the overall net productive capacity.

Potential residual effects for fish habitat loss were identified and carried through the habitat loss and alteration assessment, even though the fish habitat compensation plan will effectively compensate for fish habitat loss. Potential residual effects may be caused by the timing of fish habitat destruction (for Project infrastructure) and habitat creation, resulting in a temporal residual effect. The significance of the residual effects is discussed in subsequent sections for both aquatic and fish habitat loss and alteration.

15.8 Significance of Residual Effects for Fish and Aquatic Habitat

All five of the fish and aquatic habitat VCs may experience residual effects, as described in this section.

15.8.1 Residual Effect Descriptors for Fish and Aquatic Habitat

Standard descriptors used in the assessment of potential residual effects are shown in Table 15.8-1.

Sections 15.8.2 and 15.8.3 assess the risk of potential Project-related effects on each VC. All fish species VCs were grouped together because of similarities in residual effects. The assessment considered results of fish and aquatic baseline studies, feedback received during the pre-Application stage from review participants, regional planning documents, and scientific literature. The duration and frequency of each potential effect was considered when determining the potential effects of greatest concern. For example, an effect that occurs continuously beyond the life of the Project is likely to be of greater concern than a short-term effect that is confined to a discrete time period. Each section is subdivided according to the issues determined to be of concern for that VC. Within each section, the extent and significance of both positive and adverse potential effects of the Project on fish and aquatic VCs are predicted and discussed. A detailed description of the effects assessment methodology, logic, variables, and descriptors used in the assessment of the Project are provided in Chapter 5.

Population-level effects resulting from the combined effects of habitat loss and mortality (direct and indirect) could occur. Multiple effects may combine to produce a greater effect, as one effect may weaken the resilience of a VC to a subsequent or concurrent effect. The predicted “overall significance” of potential effects on each VC is assessed within each section.

15.8.2 Residual Effects Assessment for Fish Valued Components (Bull Trout, Dolly Varden, Rainbow Trout/Steelhead, and Pacific Salmon)

Tables 15.8-2 to 15.8-5 summarize the assessment of potential residual effects for all VC fish species. Several potential residual effects were identified that could affect fish in the LSA. These potential residual effects include direct mortality, noise, erosion and sedimentation, and water quality degradation (metals from point sources, metals and process chemicals from the TMF or Mine Site WTP, petroleum products, and nitrogen or phosphorus). Each of these potential residual effects is discussed below in relation to fish VCs and their geographic distribution in the LSA and RSA.

15.8.2.1 Direct Mortality

Direct mortality is described in detail in Section 15.7.1. Direct mortality causing tissue damage and direct mortality for fish at all life stages may be associated with the construction, operation, and closure of access roads, transmission lines, TMF, and other infrastructure in the PTMA and Mine Site. This effect can be caused by direct contact of heavy equipment, dewatering activities during construction, and fish stranding during flow reductions. For example, heavy equipment contacting instream substrate can cause direct mortality to incubating fish eggs. The magnitude of all effects associated with direct mortality will be low because events will be localized and geographically isolated. In addition, direct mortality events will be of short duration and occur sporadically.

Since the timing and duration of events causing direct mortality is short, this effect can be reversed relatively quickly (e.g., reversible short-term) and the VC will be able to respond and adapt (e.g., context is low). If the appropriate management plans (e.g., the Fish and Aquatic Habitat Protection and Mitigation Plan and the Fish Salvage Plan) are adhered to, the probability of occurrence is low (with high confidence). Thus, considering the above description of direct mortality and mechanisms, direct mortality was assessed as **not significant - minor** for fish in the LSA and RSA.

15.8.2.1.1 Tailing Management Facility Fish Salvage Effects and Mitigation

Proposed activities associated with the Project will result in a loss of fish habitat in North Treaty and South Teigen creeks. As a mitigation measure, it is proposed that Dolly Varden from the proposed TMF will be relocated from North Treaty and South Teigen creeks to the mainstem of Treaty Creek. Potential effects of the relocation include transportation of disease between populations, interspecific competition between introduced individuals and other species, lack of available habitat or productive capacity in the receiving waterbody, increased risk of hybridization, and injury to fish during relocation activities. Each potential effect and mitigation measure is summarized below.

Relocated fish will be released in the Treaty Creek mainstem where Dolly Varden are currently present. No fish will be released in any other waterbody. The relocation will not result in the introduction of species to an area in which they do not currently reside.

Table 15.8-1. Definitions of Significance Criteria for Fish and Aquatic Habitat Residual Effects

Timing *What phase of the Project is the effect associated with?*	**Magnitude** *(negligible, low, medium, high)*	**Geographic Extent** *(local, landscape, regional, beyond regional)*	**Duration** *(short-term, medium-term, long-term, far future)*	**Frequency** *(once, sporadic, regular, continuous)*	**Reversibility** *(reversible short-term, reversible long-term, or irreversible)*	**Context** *(ecological resilience and/or unique attributes)* *(low, neutral, high)*	**Probability** *(low, medium, high)*	**Confidence** *(low, medium, high)*	**Significance** *(Not Significant: minor, moderate; Significant: major)*	**Follow-up Monitoring** *(Not required, required)*
Construction	**Negligible.** There is no detectable change from baseline conditions.	**Local.** The effect is limited to the project footprint.	**Short term**. The effect lasts approximately 1 year or less.	**Once.** The effect occurs once during any phase of the project.	**Reversible short-term:** An effect that can be reversed relatively quickly.	**Low**. The valued component is considered to have little to no unique attributes and/or there is high resilience to imposed stresses.	**Low.** An effect is unlikely but could occur.	**Low** (< 50% confidence). The cause-effect relationship between the project and its interaction with the environment is poorly understood; data for the project area may be incomplete; uncertainty associated with synergistic and/or additive interactions between environmental effects may exist. High degree of uncertainty.	**Not Significant (minor).** Residual effects have no or low magnitude, local geographical extent, short or medium-term duration, and occur intermittently, if at all. There is a high level of confidence in the conclusions. The effects on the VC (at a population or species level) are indistinguishable from background conditions (i.e., occur within the range of natural variation as influenced by physical, chemical, and biological processes). Land use management objectives will be met. Follow-up monitoring is optional.	**Not Required**
Operations	**Low.** The magnitude of effect differs from the average value for baseline conditions, but is within the range of natural variation and well below a guideline or threshold value.	**Landscape.** An effect extends beyond the project footprint to a broader watershed area.	**Medium term.** The effect lasts from 1 – 11 years.	**Sporadic.** The effect occurs at sporadic or intermittent intervals during any phase of the project.	**Reversible long-term:** An effect that can be reversed after many years.	**Neutral.** The valued component is considered to have some unique attributes, and/or there is neutral (moderate) resilience to imposed stresses.	**Medium.** An effect is likely but may not occur.	**Medium.** (50 – 80% confidence): The cause-effect relationship between the project and its interaction with the environment is not fully understood, or data for the project area is incomplete: moderate degree of uncertainty.	**Not Significant (moderate).** Residual effects have medium magnitude, local, landscape or regional geographic extent, are short-term to chronic (i.e., may persist into the far future), and occur at all frequencies. Residual effects on VCs are distinguishable at the population, community, and/or ecosystem level. Ability of meeting land use management objectives may be impaired. Confidence in the conclusions is medium or low. The probability of the effect occurring is low or medium. Follow-up monitoring of these effects may be required.	**Required**
Closure	**Medium.** The magnitude of effect differs from the average value for baseline conditions and approaches the limits of natural variation, but below or equal to a guideline or threshold value.	**Regional.** The effect extends across the Regional Study Area.	**Long term.** The effect lasts between 12 and 70 years.	**Regular.** The effect occurs on a regular basis during any phase of the project.	**Irreversible.** The effect cannot be reversed.	**High.** The valued component is considered to be unique, and/or there is low resilience to imposed stresses.	**High**. An effect is highly likely to occur.	**High**. There is greater than 80% confidence in understanding the cause-effect relationship between the project and its interaction with the environment, and all necessary data is available for the project area. There is a low degree of uncertainty.	**Significant (Major).** Residual effects have high magnitude, regional or beyond regional geographic extent, are chronic (i.e., persist into the far future), and occur at all frequencies. Residual effects on VCs are consequential (i.e., structural and functional changes in populations, communities and ecosystems are predicted). Ability to meet land use management objectives is impaired. Probability of the effect occurring is medium or high. Confidence in the conclusions can be high, medium, or low. Follow-up monitoring is required.	
Post-closure	**High.** The magnitude of effect is predicted to differ from baseline conditions and exceed guideline or threshold values so that there will be a detectable change beyond the range of natural variation (i.e., change of state from baseline conditions).	**Beyond Regional**. The effect extends possibly across or beyond the province.	**Far Future. The** effect lasts more than 70 years.	**Continuous.** An effect occurs constantly during any phase of the Project.						

Table 15.8-2. Summary of Residual Effects on Bull Trout

Description of Residual Effect	Project Component(s)	Timing of Effect	Magnitude	Extent	Duration	Frequency	Reversibility	Context	Likelihood of Effects: Probability	Likelihood of Effects: Confidence Level	Significance Determination	Follow-up Monitoring
Blunt tissue trauma causing mortality to all fish life stages	Treaty Creek Access Road	Construction	Low	Local	Short	Sporadic	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Blunt tissue trauma causing mortality to all fish life stages	Treaty Creek Access Road	Operations	Low	Local	Short	Sporadic	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Blunt tissue trauma causing mortality to all fish life stages	Treaty Creek Access Road	Closure	Low	Local	Short	Sporadic	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Noise causing sub-lethal effects, decreased feeding efficiency and habitat avoidance	Treaty Creek Access Road	Construction	Negligible	Local	Short	Sporadic	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Treaty Creek Access Road; North Cell Tailing Management Facility; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction	Construction	Low	Landscape	Medium	Sporadic	Reversible long-term	Neutral	Medium	High	Not Significant (Minor)	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Treaty Creek Access Road; North Cell Tailing Management Facility; South Cell Tailing Management Facility; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction	Operations	Low	Landscape	Medium	Sporadic	Reversible long-term	Neutral	Medium	High	Not Significant (Minor)	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Treaty Creek Access Road; North Cell Tailing Management Facility; South Cell Tailing Management Facility	Closure	Negligible	Landscape	Short	Sporadic	Reversible long-term	Neutral	Medium	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Treaty Creek Access Road; Mitchell-Treaty Tunnel	Construction	Low	Landscape	Short	Sporadic	Reversible long-term	High	Low	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Treaty Creek Access Road; Mitchell-Treaty Tunnel	Operations	Low	Landscape	Short	Sporadic	Reversible long-term	High	Low	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Treaty Creek Access Road; Mitchell-Treaty Tunnel	Closure	Low	Landscape	Short	Sporadic	Reversible long-term	High	Low	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Treaty Creek Access Road; Mitchell-Treaty Tunnel	Post-closure	Low	Landscape	Short	Sporadic	Reversible long-term	High	Low	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metals or process chemical exposure downstream of the TMF associated with scheduled discharge or seepage from the TMF	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Seepage Collection Ponds; Concentrate Storage and Loadout	Operations	Medium	Landscape	Long	Sporadic	Reversible long-term	Neutral	Low	Medium	Not Significant (Minor)	Required
Sublethal toxicity due to metals or process chemical exposure downstream of the TMF associated with scheduled discharge or seepage from the TMF	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Seepage Collection Ponds; Concentrate Storage and Loadout	Closure	Medium	Landscape	Medium	Sporadic	Reversible long-term	Neutral	Low	Medium	Not Significant (Minor)	Required
Sublethal toxicity due to metals or process chemical exposure downstream of the TMF associated with scheduled discharge or seepage from the TMF	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Seepage Collection Ponds; Concentrate Storage and Loadout	Post-closure	Medium	Landscape	Long	Sporadic	Reversible long-term	Neutral	Low	Medium	Not Significant (Minor)	Required
Toxicity due to introduction of petroleum products into aquatic environment during normal Project activities	Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road	Construction	Low	Landscape	Short	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of petroleum products into aquatic environment during normal Project activities	Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road	Operations	Low	Landscape	Short	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of petroleum products into aquatic environment during normal Project activities	Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road	Closure	Low	Landscape	Short	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road	Construction	Medium	Landscape	Medium	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion;Treaty Creek Access Road	Operations	Medium	Landscape	Long	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion;Treaty Creek Access Road	Closure	Low	Landscape	Short	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required

Table 15.8-3. Summary of Residual Effects on Dolly Varden

Description of Residual Effect	Project Component(s)	Timing of Effect	Magnitude	Extent	Duration	Frequency	Reversibility	Context	Likelihood of Effects: Probability	Likelihood of Effects: Confidence Level	Significance Determination	Follow-up Monitoring
Blunt tissue trauma causing mortality to all fish life stages	Coulter Creek Access Corridor; Treaty Creek Access Road; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Construction	Low	Local	Short	Sporadic	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Blunt tissue trauma causing mortality to all fish life stages	Coulter Creek Access Corridor; Treaty Creek Access Road; South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Operations	Low	Local	Short	Sporadic	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Blunt tissue trauma causing mortality to all fish life stages	Coulter Creek Access Corridor; Treaty Creek Access Road; South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Closure	Low	Local	Short	Sporadic	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Noise causing sub-lethal effects, decreased feeding efficiency and habitat avoidance	Coulter Creek Access Corridor; Treaty Creek Access Road; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Construction	Negligible	Local	Short	Sporadic	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Noise causing sub-lethal effects, decreased feeding efficiency and habitat avoidance	South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Operations	Negligible	Local	Short	One-time	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction	Construction	Low	Landscape	Medium	Sporadic	Reversible long-term	Neutral	Medium	High	Not Significant (Minor)	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37	Operations	Low	Landscape	Medium	Sporadic	Reversible long-term	Neutral	Medium	High	Not Significant (Minor)	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; South Cell Tailing Management Facility; East Catchment Diversion	Closure	Low	Landscape	Short	Sporadic	Reversible long-term	Neutral	Medium	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Treaty Creek Access Road; Mitchell-Treaty Tunnel; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC	Construction	Low	Landscape	Short	Sporadic	Reversible long-term	High	Low	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Treaty Creek Access Road; Mitchell-Treaty Tunnel; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC	Operations	Low	Landscape	Short	Sporadic	Reversible long-term	High	Low	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Treaty Creek Access Road; Mitchell-Treaty Tunnel; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC	Closure	Low	Landscape	Short	Sporadic	Reversible long-term	High	Low	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Treaty Creek Access Road; Mitchell-Treaty Tunnel; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC	Post-closure	Low	Landscape	Short	Sporadic	Reversible long-term	High	Low	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metals or process chemical exposure downstream of the TMF associated with scheduled discharge or seepage from the TMF	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Seepage Collection Ponds; Concentrate Storage and Loadout	Operations	Medium	Landscape	Long	Sporadic	Reversible long-term	Neutral	Low	Medium	Not Significant (Minor)	Required
Sublethal toxicity due to metals or process chemical exposure downstream of the TMF associated with scheduled discharge or seepage from the TMF	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Seepage Collection Ponds; Concentrate Storage and Loadout	Closure	Medium	Landscape	Medium	Sporadic	Reversible long-term	Neutral	Low	Medium	Not Significant (Minor)	Required
Sublethal toxicity due to metals or process chemical exposure downstream of the TMF associated with scheduled discharge or seepage from the TMF	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Seepage Collection Ponds; Concentrate Storage and Loadout	Post-closure	Medium	Landscape	Long	Sporadic	Reversible long-term	Neutral	Low	Medium	Not Significant (Minor)	Required
Toxicity due to metals or process chemical exposure downstream of the Mine Site WTP associated with scheduled discharge or seepage from the Mine Site WTP	Water Storage Facility; Water Storage Dam; Water Treatment Plant; Water Treatment & Energy Recovery Area; McTagg RSF; Mitchell RSF; Mitchell Ore Preparation Complex; Mitchell Pit; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Operations	High	Regional	Long	Continuous	Reversible long-term	High	Medium	Medium	Not Significant (Moderate)	Required
Toxicity due to metals or process chemical exposure downstream of the Mine Site WTP associated with scheduled discharge or seepage from the Mine Site WTP	Water Storage Facility; Water Storage Dam; Water Treatment Plant; Water Treatment & Energy Recovery Area; McTagg RSF; Mitchell RSF; Mitchell Ore Preparation Complex; Mitchell Pit; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Closure	High	Regional	Medium	Continuous	Reversible long-term	High	Medium	Medium	Not Significant (Moderate)	Required

(continued)

Table 15.8-3. Summary of Residual Effects on Dolly Varden (completed)

Description of Residual Effect	Project Component(s)	Timing of Effect	Magnitude	Extent	Duration	Frequency	Reversibility	Context	Likelihood of Effects: Probability	Likelihood of Effects: Confidence Level	Significance Determination	Follow-up Monitoring
Toxicity due to metals or process chemical exposure downstream of the Mine Site WTP associated with scheduled discharge or seepage from the Mine Site WTP	Water Storage Facility; Water Storage Dam; Water Treatment Plant; Water Treatment & Energy Recovery Area; McTagg RSF; Mitchell RSF; Mitchell Ore Preparation Complex; Mitchell Pit; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Post-closure	High	Regional	Far future	Continuous	Reversible long-term	High	Medium	Medium	Not Significant (Moderate)	Required
Toxicity due to introduction of petroleum products into aquatic environment during normal Project activities	Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road; Camp 4: Mitchell North; Camp 9: Mitchell Initial: Camp 10: Mitchell Secondary; Mitchell Operating Camp; WSD, WSF, WTP; McTagg Energy Recovery Facility	Construction	Low	Landscape	Short	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of petroleum products into aquatic environment during normal Project activities	Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road; Camp 4: Mitchell North; Camp 9: Mitchell Initial: Camp 10: Mitchell Secondary; Mitchell Operating Camp; WSD, WSF, WTP; McTagg Energy Recovery Facility	Operations	Low	Landscape	Short	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of petroleum products into aquatic environment during normal Project activities	Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road; Camp 4: Mitchell North; Camp 9: Mitchell Initial: Camp 10: Mitchell Secondary; Mitchell Operating Camp; WSD, WSF, WTP; McTagg Energy Recovery Facility	Closure	Low	Landscape	Short	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road	Construction	Medium	Landscape	Medium	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road	Operations	Medium	Landscape	Long	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road	Closure	Low	Landscape	Short	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required

Table 15.8-4. Summary of Residual Effects on Rainbow Trout/Steelhead

Description of Residual Effect	Project Component(s)	Timing of Effect	Magnitude	Extent	Duration	Frequency	Reversibility	Context	Likelihood of Effects: Probability	Likelihood of Effects: Confidence Level	Significance Determination	Follow-up Monitoring
Blunt tissue trauma causing mortality to all fish life stages	Coulter Creek Access Corridor; Treaty Creek Access Road; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Construction	Low	Local	Short	Sporadic	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Blunt tissue trauma causing mortality to all fish life stages	Coulter Creek Access Corridor; Treaty Creek Access Road; South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Operations	Low	Local	Short	Sporadic	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Blunt tissue trauma causing mortality to all fish life stages	Coulter Creek Access Corridor; Treaty Creek Access Road; South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Closure	Low	Local	Short	Sporadic	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Noise causing sub-lethal effects, decreased feeding efficiency and habitat avoidance	Coulter Creek Access Corridor; Treaty Creek Access Road; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Construction	Negligible	Local	Short	Sporadic	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Noise causing sub-lethal effects, decreased feeding efficiency and habitat avoidance	South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Operations	Negligible	Local	Short	One-time	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction	Construction	Low	Landscape	Medium	Sporadic	Reversible long-term	Neutral	Medium	High	Not Significant (Minor)	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37	Operations	Low	Landscape	Medium	Sporadic	Reversible long-term	Neutral	Medium	High	Not Significant (Minor)	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; South Cell Tailing Management Facility; East Catchment Diversion	Closure	Negligible	Landscape	Short	Sporadic	Reversible long-term	Neutral	Medium	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Treaty Creek Access Road; Mitchell-Treaty Tunnel; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC	Construction	Low	Landscape	Short	Sporadic	Reversible long-term	High	Low	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Treaty Creek Access Road; Mitchell-Treaty Tunnel; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC	Operations	Low	Landscape	Short	Sporadic	Reversible long-term	High	Low	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Treaty Creek Access Road; Mitchell-Treaty Tunnel; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC	Closure	Low	Landscape	Short	Sporadic	Reversible long-term	High	Low	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Treaty Creek Access Road; Mitchell-Treaty Tunnel; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC	Post-closure	Low	Landscape	Short	Sporadic	Reversible long-term	High	Low	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metals or process chemical exposure downstream of the TMF associated with scheduled discharge or seepage from the TMF	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Seepage Collection Ponds; Concentrate Storage and Loadout	Operations	Medium	Landscape	Long	Sporadic	Reversible long-term	Neutral	Low	Medium	Not Significant (Minor)	Required
Sublethal toxicity due to metals or process chemical exposure downstream of the TMF associated with scheduled discharge or seepage from the TMF	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Seepage Collection Ponds; Concentrate Storage and Loadout	Closure	Medium	Landscape	Medium	Sporadic	Reversible long-term	Neutral	Low	Medium	Not Significant (Minor)	Required
Sublethal toxicity due to metals or process chemical exposure downstream of the TMF associated with scheduled discharge or seepage from the TMF	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Seepage Collection Ponds; Concentrate Storage and Loadout	Post-closure	Medium	Landscape	Long	Sporadic	Reversible long-term	Neutral	Low	Medium	Not Significant (Minor)	Required
Toxicity due to metals or process chemical exposure downstream of the Mine Site WTP associated with scheduled discharge or seepage from the Mine Site WTP	Water Storage Facility; Water Storage Dam; Water Treatment Plant; Water Treatment & Energy Recovery Area; McTagg RSF; Mitchell RSF; Mitchell Ore Preparation Complex; Mitchell Pit; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Operations	High	Regional	Long	Continuous	Reversible long-term	High	Medium	Medium	Not Significant (Moderate)	Required
Toxicity due to metals or process chemical exposure downstream of the Mine Site WTP associated with scheduled discharge or seepage from the Mine Site WTP	Water Storage Facility; Water Storage Dam; Water Treatment Plant; Water Treatment & Energy Recovery Area; McTagg RSF; Mitchell RSF; Mitchell Ore Preparation Complex; Mitchell Pit; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Closure	High	Regional	Medium	Continuous	Reversible long-term	High	Medium	Medium	Not Significant (Moderate)	Required

(continued)

Table 15.8-4. Summary of Residual Effects on Rainbow Trout/Steelhead (completed)

									Likelihood of Effects			
Description of Residual Effect	Project Component(s)	Timing of Effect	Magnitude	Extent	Duration	Frequency	Reversibility	Context	Probability	Confidence Level	Significance Determination	Follow-up Monitoring
Toxicity due to metals or process chemical exposure downstream of the Mine Site WTP associated with scheduled discharge or seepage from the Mine Site WTP	Water Storage Facility; Water Storage Dam; Water Treatment Plant; Water Treatment & Energy Recovery Area; McTagg RSF; Mitchell RSF; Mitchell Ore Preparation Complex; Mitchell Pit; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Post-closure	High	Regional	Far future	Continuous	Reversible long-term	High	Medium	Medium	Not Significant (Moderate)	Required
Toxicity due to introduction of petroleum products into aquatic environment during normal Project activities	Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road; Camp 4: Mitchell North; Camp 9: Mitchell Initial: Camp 10: Mitchell Secondary; Mitchell Operating Camp; WSD, WSF, WTP; McTagg Energy Recovery Facility	Construction	Low	Landscape	Short	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of petroleum products into aquatic environment during normal Project activities	Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road; Camp 4: Mitchell North; Camp 9: Mitchell Initial: Camp 10: Mitchell Secondary; Mitchell Operating Camp; WSD, WSF, WTP; McTagg Energy Recovery Facility	Operations	Low	Landscape	Short	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of petroleum products into aquatic environment during normal Project activities	Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road; Camp 4: Mitchell North; Camp 9: Mitchell Initial: Camp 10: Mitchell Secondary; Mitchell Operating Camp; WSD, WSF, WTP; McTagg Energy Recovery Facility	Closure	Low	Landscape	Short	Sporadic	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road	Construction	Medium	Landscape	Short	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road	Operations	Medium	Landscape	Short	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road	Closure	Low	Landscape	Short	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required

Table 15.8-5. Summary of Residual Effects on Pacific Salmon

Description of Residual Effect	Project component (s)	Timing of Effect	Magnitude	Extent	Duration	Frequency	Reversibility	Context	Likelihood of Effects: Probability	Likelihood of Effects: Confidence Level	Significance Determination	Follow-up Monitoring
Blunt tissue trauma causing mortality to all fish life stages	Coulter Creek Access Corridor; Treaty Creek Access Road; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Construction	Low	Local	Short	Sporadic	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Blunt tissue trauma causing mortality to all fish life stages	Coulter Creek Access Corridor; Treaty Creek Access Road; South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Operations	Low	Local	Short	Sporadic	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Blunt tissue trauma causing mortality to all fish life stages	Coulter Creek Access Corridor; Treaty Creek Access Road; South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Closure	Low	Local	Short	Sporadic	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Noise causing sub-lethal effects, decreased feeding efficiency and habitat avoidance	Coulter Creek Access Corridor; Treaty Creek Access Road; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Construction	Negligible	Local	Short	Sporadic	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Noise causing sub-lethal effects, decreased feeding efficiency and habitat avoidance	South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Operations	Negligible	Local	Short	One-time	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction	Construction	Low	Landscape	Medium	Sporadic	Reversible long-term	Neutral	Medium	High	Not Significant (Minor)	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12:	Operations	Low	Landscape	Medium	Sporadic	Reversible long-term	Neutral	Medium	High	Not Significant (Minor)	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; South Cell Tailing Management Facility; East Catchment Diversion	Closure	Negligible	Landscape	Short	Sporadic	Reversible long-term	Neutral	Medium	High	Not Significant (Minor)	Not Required

(completed)

Table 15.8-5. Summary of Residual Effects on Pacific Salmon (continued)

Description of Residual Effect	Project Component(s)	Timing of Effect	Magnitude	Extent	Duration	Frequency	Reversibility	Context	Likelihood of Effects: Probability	Likelihood of Effects: Confidence Level	Significance Determination	Follow-up Monitoring
Sublethal toxicity due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Treaty Creek Access Road; Mitchell-Treaty Tunnel; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC	Construction	Low	Landscape	Short	Sporadic	Reversible long-term	High	Low	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Treaty Creek Access Road; Mitchell-Treaty Tunnel; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC	Operations	Low	Landscape	Short	Sporadic	Reversible long-term	High	Low	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Treaty Creek Access Road; Mitchell-Treaty Tunnel; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC	Closure	Low	Landscape	Short	Sporadic	Reversible long-term	High	Low	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Treaty Creek Access Road; Mitchell-Treaty Tunnel; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC	Post-closure	Low	Landscape	Short	Sporadic	Reversible long-term	High	Low	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metals or process chemical exposure downstream of the TMF associated with scheduled discharge or seepage from the TMF	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Seepage Collection Ponds; Concentrate Storage and Loadout	Operations	Negligible	Landscape	Long	Sporadic	Reversible long-term	Neutral	Low	Medium	Not Significant (Minor)	Required
Sublethal toxicity due to metals or process chemical exposure downstream of the TMF associated with scheduled discharge or seepage from the TMF	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Seepage Collection Ponds; Concentrate Storage and Loadout	Closure	Negligible	Landscape	Medium	Sporadic	Reversible long-term	Neutral	Low	Medium	Not Significant (Minor)	Required
Sublethal toxicity due to metals or process chemical exposure downstream of the TMF associated with scheduled discharge or seepage from the TMF	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Seepage Collection Ponds; Concentrate Storage and Loadout	Post-closure	Negligible	Landscape	Long	Sporadic	Reversible long-term	Neutral	Low	Medium	Not Significant (Minor)	Required
Toxicity due to metals or process chemical exposure downstream of the Mine Site WTP associated with scheduled discharge or seepage from the Mine Site WTP	Water Storage Facility; Water Storage Dam; Water Treatment Plant; Water Treatment & Energy Recovery Area; McTagg RSF; Mitchell RSF; Mitchell Ore Preparation Complex; Mitchell Pit; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Operations	High	Regional	Long	Regular	Reversible long-term	High	Medium	Medium	Not Significant (Moderate)	Required

(completed)

Table 15.8-5. Summary of Residual Effects on Pacific Salmon (continued)

Description of Residual Effect	Project Component(s)	Timing of Effect	Magnitude	Extent	Duration	Frequency	Reversibility	Context	Likelihood of Effects: Probability	Likelihood of Effects: Confidence Level	Significance Determination	Follow-up Monitoring
Toxicity due to metals or process chemical exposure downstream of the Mine Site WTP associated with scheduled discharge or seepage from the Mine Site WTP	Water Storage Facility; Water Storage Dam; Water Treatment Plant; Water Treatment & Energy Recovery Area; McTagg RSF; Mitchell RSF; Mitchell Ore Preparation Complex; Mitchell Pit; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Closure	High	Regional	Medium	Regular	Reversible long-term	High	Medium	Medium	Not Significant (Moderate)	Required
Toxicity due to metals or process chemical exposure downstream of the Mine Site WTP associated with scheduled discharge or seepage from the Mine Site WTP	Water Storage Facility; Water Storage Dam; Water Treatment Plant; Water Treatment & Energy Recovery Area; McTagg RSF; Mitchell RSF; Mitchell Ore Preparation Complex; Mitchell Pit; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Post-closure	High	Regional	Far future	Regular	Reversible long-term	High	Medium	Medium	Not Significant (Moderate)	Required
Toxicity due to introduction of petroleum products into aquatic environment during normal Project activities	Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road; Camp 4: Mitchell North; Camp 9: Mitchell Initial: Camp 10: Mitchell Secondary; Mitchell Operating Camp; WSD, WSF, WTP; McTagg Energy Recovery Facility	Construction	Low	Landscape	Short	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of petroleum products into aquatic environment during normal Project activities	Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road; Camp 4: Mitchell North; Camp 9: Mitchell Initial: Camp 10: Mitchell Secondary; Mitchell Operating Camp; WSD, WSF, WTP; McTagg Energy Recovery Facility	Operations	Low	Landscape	Short	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of petroleum products into aquatic environment during normal Project activities	Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road; Camp 4: Mitchell North; Camp 9: Mitchell Initial: Camp 10: Mitchell Secondary; Mitchell Operating Camp; WSD, WSF, WTP; McTagg Energy Recovery Facility	Closure	Low	Landscape	Short	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required

(completed)

Table 15.8-5. Summary of Residual Effects on Pacific Salmon (completed)

Description of Residual Effect	Project Component(s)	Timing of Effect	Magnitude	Extent	Duration	Frequency	Reversibility	Context	Likelihood of Effects: Probability	Likelihood of Effects: Confidence Level	Significance Determination	Follow-up Monitoring
Toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road	Construction	Medium	Landscape	Medium	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road	Operations	Medium	Landscape	Long	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road	Closure	Low	Landscape	Short	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required

The transmission of fish parasites or other types of disease carried by transported fish can have affects on local fish populations (Gaughan 2002; Ruesink et al. 1995). The relocation of individuals can introduce novel pathogens to a previously-unexposed population or increase the density of existing pathogens. The relocation of fish from North Treaty Creek and South Teigen Creek may also transport pathogens to the receiving population in Treaty Creek.

The risk of pathogen introduction is low when fish are relocated within a watershed (Williams et al. 1998). North Treaty Creek discharges into Treaty Creek, and it is likely that the two waterbodies will have similar pathogen types. South Teigen Creek is not a tributary of Treaty Creek, however, the Treaty Creek and Teigen Creek watersheds are closely linked by the Bell-Irving River.

During fish salvage, individual fish will be measured to obtain basic information regarding length and weight, providing an opportunity to inspect the salvaged fish for evidence of disease or parasites. A biologist will be involved in all salvage activities and any fish showing evidence of disease or external parasites will be inspected. Professional judgment will be used to determine the risks of relocating diseased fish or fish with high parasite loads, and fish with a high risk of serving as a vector will not be released.

Dolly Varden, bull trout, rainbow trout, and mountain whitefish are present in the Treaty Creek mainstem. Sympatric fish species often compete for food, space, or other resources, with negative effects to one or both populations (Connell 1983). Relocating Dolly Varden from other areas will result in an increased density of Dolly Varden in Treaty Creek relative to other fish species. Increased interspecific competition from Dolly Varden could have negative effects on the other fish species present.

Treaty Creek is a good candidate for a receiving habitat for relocated Dolly Varden due to the species composition. Dolly Varden are currently the most common species in Treaty Creek so the introduction of new individuals will not likely cause major changes to the fish community composition.

Rainbow trout are the second most common species in Treaty Creek (Appendix 15-C). Interspecific competition between rainbow trout and Dolly Varden has been observed, but where the two species exist sympatrically, rainbow trout outcompete Dolly Varden (Baxter et al. 2004). In general, Dolly Varden and trout species show high plasticity in their feeding strategies, and niche partitioning reduces the direct competition and reduces density compensation (Andrusak et al. 1971; Hume and Northcote 1985; Hindar et al. 1988; Dolloff and Reeves 1990).

There is little information available regarding possible interspecific competition between Dolly Varden and mountain whitefish (IDFG 2007). However, mountain whitefish habitat preference is for deep channels and pools, in contrast with the smaller streams preferred by Dolly Varden, and therefore, little interspecific competition is expected (IDFG 2007; McPhail 2007).

Bull trout were observed at very low densities in Treaty Creek (Appendix 15-C). Bull trout and Dolly Varden occupy similar niches in regard to habitat and food preferences (McPhail 2007). Where bull trout and Dolly Varden exist sympatrically, there is evidence of niche partitioning between the two species to reduce the effects of competition (Hagen and Taylor 2001).

The presence of suitable, available habitat for all life stages is an important factor in successful translocation of fish (Williams et al. 1988). Dolly Varden life history requires a variety of habitat types for spawning, juvenile rearing, and adult rearing (McPhail 2007). Insufficient habitat for any life stage will limit population growth and potentially result in a genetic bottleneck that will increase the loss of genetic diversity and contribute to genetic drift. Fish populations relocated long distances may lack the appropriate life history traits or behaviour necessary to survive in the area to which they are released (Williams et al. 1988).

Dolly Varden are known to hybridize with other char species, primarily bull trout (McPhail 2007). Dolly Varden and bull trout hybridize in many areas where the two species occur sympatrically. Hybridization can result in loss of genetic information and reduced hybrid fitness (Hagen and Taylor 2001).

Treaty Creek is an ideal system for release due to the healthy existing population of Dolly Varden and its proximity to the salvage areas. The presence of existing members of the species indicates appropriate habitat for all life stages. The risk of an unsuccessful transfer due to differences in life history traits or behaviour has been mitigated by identifying a nearby waterbody for release, as the Treaty Creek, North Treaty Creek, and South Teigen Creek populations are genetically similar, and the three waterbodies have similar climate and habitat attributes (Appendix 15-C). Relocations over short distances and between similar populations and geographic areas are more likely to be successful, because closely related populations are more likely to have similar habitat requirements (Williams 1988).

The risks of hybridization will be mitigated by releasing the salvaged fish into Treaty Creek. Bull trout population densities are low in Treaty Creek, reducing the risk of hybridization (Appendix 15-C). Dolly Varden and bull trout both naturally occur in Treaty Creek, and there is some evidence of behavioural adjustments to minimize hybridization in some areas where the two species' ranges overlap (Hagen and Taylor 2001). Genetic analysis of Dolly Varden in the Treaty Creek watershed did not show any evidence of hybridization with bull trout (Appendix 15-C).

The capture, handling, and transportation of fish can induce a stress response that should be minimized when relocating fish (Williams et al. 1988). The physiological changes associated with stress can negatively affect fish health, growth, and behaviour (Barton 2002). There is also the potential for physical injury or mortality due to electrofishing activities or rough or inexperienced handling of fish.

Fish capture and handling will be undertaken under the supervision of a professional biologist with experience in fish handling techniques. Fish will not be handled more than is necessary and will be captured and handled following established protocols designed to minimize injury and stress to captured fish. Fish will be transported in an aerated live well as quickly as is feasible.

Fish will be released in a low velocity area so that they can recover from the stress of the relocation.

15.8.2.2 Noise

Noise, as a potential effect on fish, is described in detail in Section 15.7.2. Noise causing sublethal effects, decreased feeding efficiency, and habitat avoidance may occur during construction of the access roads and the TMF. Blasting and other construction related activities can produce noise that may affect fish at various life stages. The magnitude of all effects associated with noise will be negligible because events will be localized and geographically isolated. In addition, noise events will be of short duration and will occur sporadically during Project construction. Since the timing and duration of most noise events will be short, this effect can be reversed relatively quickly (e.g., reversible short-term), and the VC will be able to respond and adapt to this stressor (e.g., context is low). If the appropriate management plans (e.g., Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters [Wright and Hopkey 1998]; Fish and Aquatic Habitat Protection and Mitigation Plan; and setback distances) are adhered to, the probability of occurrence is low (with high confidence).

Thus, considering the above description of noise, potential effects on fish in the LSA and RSA were assessed as **not significant-minor**.

15.8.2.3 Erosion and Sedimentation

Section 15.7.3 describes erosion and sedimentation and its general effects on fish and fish habitat. Sedimentation generated by the Project may cause several effects on fish. Potential effects include the smothering of eggs, decreased feeding efficiency due to reduced water quality, habitat avoidance, smothering of aquatic invertebrates and fish food sources, and loss of productive habitat capacity. Sedimentation effects may occur during the construction, operation, and closure of the access roads, transmission line, and TMF. The magnitude of all effects associated with erosion and sedimentation will be low. The extent of the residual sediment effect will be landscape as the sediments are flushed downstream. Erosion events, should they occur, will be of medium-term duration (effect lasts from one to five years) and would occur sporadically during all Project phases. The effects of erosion and sedimentation cannot be easily reversed, thus reversal will occur over many years (reversible long-term). Furthermore, fish may not be able to fully respond or adapt to the effects of erosion and sedimentation, thus context (or resiliency) was assessed as neutral. If, however, the appropriate management plans (e.g., the Erosion Control Plan, the Fish and Aquatic Habitat Protection and Mitigation Plan, and BMPs for erosion and sedimentation) are adhered to, the probability of erosion and sedimentation causing effects is likely, but should not occur.

Thus, considering the above description, the effects of erosion and sedimentation on fish in the LSA and RSA were assessed as **not significant-minor**.

15.8.2.4 Water Quality Degradation

15.8.2.4.1 Metals and Process Chemicals

Metals and process chemicals and their potential effects on fish are discussed in Sections 15.7.4.1.1 and 15.7.4.1.2. Mitigation of such effects are described in Sections 15.7.4.2.1 (general), 15.7.4.2.2 (metal-specific), and 15.7.4.2.3 (process chemical–specific). Assessment of whether there is the potential for residual effects related to metals and process chemicals is discussed in Sections 15.7.3.1 and 15.7.3.2. Two principal sources of metals and one principal source of process chemicals may occur due to Project development and have a potential residual effect on fish.

First, ML/ARD may be produced due to the exposure of rock following Project-related construction and blasting activities. At these sites, exposed acid-generating rock may produce acidic runoff and metal leachates that flow into fish-bearing waterbodies. For ML/ARD produced in areas outside of the catchment for the Mine Site WSF/WTP or the TMF in the PTMA, this pathway for metal introduction into the aquatic environment is considered as a non-point source in the following paragraphs.

A second pathway for metals to enter the aquatic environment is through the discharge or seepage of effluent from the TMF or the Mine Site WSF/WTP. The TMF collects and stores the slurry (tailing solids and supernatant) from the Treaty Process Plant, and may contain both metals and process chemicals. The Mine Site WSF/WTP collects and treats water from throughout the Mine Site that has been in contact with mine pits, RSFs, and other areas where PAG rock may have been exposed during construction or Project activities. These facilities collect potentially metal-bearing water into one place, which is then discharged to the environment at one or more discharge points (i.e., point sources).

Effluent discharged from these components may also include process chemicals such as cyanide (TMF), calcium (from lime use at the Mine Site WTP), or sulphate (from sulphuric acid used at the Mine Site WTP). Since these process chemicals are a constituent of the effluent and were included in the water quality model predictions, they are considered in this section together with metals from point sources (i.e., either TMF or Mine Site WTP discharges). Some of the ML/ARD produced during road and infrastructure construction may occur within the catchment areas for the Mine Site WTP or the TMF, and are therefore captured in the water quality model predictions for metal concentrations in receiving environments downstream of these point sources.

Metals from Non-point Sources

Once initiated, the generation of ML/ARD from exposed PAG rock may continue for decades. All fish species may be at risk of toxicity due to metals from non-point sources, such as ML/ARD from road and infrastructure construction, since they may be found in waterways near road construction. In addition, while fish are not necessarily in areas where Project components are physically located (e.g., fish were not found above the cascades on Sulphurets Creek), acidic runoff or metals introduced to the water in these areas (outside of the catchment for the Mine Site WSF/WTP or TMF in the PTMA) can be carried downstream to areas where fish are found.

During the construction of the access roads, tunnels, and diversions, ML/ARD due to untreated leachate from exposed PAG rock reaching fish-bearing waterbodies has the potential to cause toxic effects to fish. Effective mitigation, through the implementation of the ML/ARD Management Plan (Section 26.14), the Erosion Control Plan (Section 26.13.2), the Fish and Aquatic Habitat Effects Protection and Mitigation Plan (Section 26.19.1), and the Aquatic Effects Monitoring Plan (Section 26.18.2) will substantially minimize effects of ML/ARD associated with non-point sources to fish, although some limited risk remains.

Due to the mitigation, management, and monitoring strategies, it is likely that the potential for effects will be limited to a localized area that is just outside of the Project footprint (i.e., the aquatic environment adjacent to a Project road footprint; landscape geographic extent) and will only occur for short durations before the problem is identified and mitigated. Since the duration of ML/ARD introduction into the aquatic environment is likely short, and the ML/ARD introduction to the aquatic environment will likely be slow and further mitigated by dilution in the flowing water of potentially affected waterways, the magnitude of potential effects was assessed as low. The ML/ARD Management Plan addresses how PAG rock will be handled and indicates that mitigation measures would be applied as appropriate, so the frequency of potential effects was assessed as sporadic. Should toxicity due to ML/ARD occur, the effects will dissipate through long-term, natural processes (reversible in the long term). Resiliency was assessed as low because the early life history stages of salmonids are particularly sensitive to toxicity and cannot easily adapt (i.e., habitat avoidance) to toxic environmental conditions (high context). However, if the appropriate management and monitoring plans are adhered to, the overall probability of ML/ARD toxicity to fish was assessed as low, with high confidence. Thus, potential effects associated with ML/ARD from non-point sources was assessed as **not significant - minor** for all fish species.

<u>Tailing Management Facility Discharges</u>

Discharge from the TMF has the potential to introduce metals and other chemicals that can cause toxicity to fish in downstream environments, which could affect all four VC fish species. While fish are not necessarily in the immediate area where the TMF discharge will occur, metals and other chemicals introduced to the water in these areas can be carried downstream to areas where fish are found. Table 15.1-4 summarizes where fish were located during baseline studies, which provides guidance when assessing whether fish are within areas that may be affected by TMF discharge.

Assessment for potential residual effects associated with TMF discharge was done using calculated HQs followed by individual assessment of metals where the HQ was greater than 1.0. Data from the expected case of the water quality model indicates that water quality downstream of the TMF is expected to be lower than BC water quality guidelines for most metals. However, as discussed in Section 15.7.4.3.1, selenium and mercury are unique among metals since their primary route of uptake is through the diet and since they have the potential to bioaccumulate. They were therefore also assessed relative to baseline concentrations. While these metals are predicted to remain below water quality guideline concentrations, and mercury is predicted to remain below baseline levels, there are some periods in which water concentrations of selenium may be greater than concentrations measured during baseline studies (HQ greater than 1.0; see Table 15.7-5).

Selenium is expected to increase slightly compared to baseline concentrations in North Treaty Creek (NTR2) and South Teigen Creek (STE3), which are closest to the TMF (Table 15.7.-5) during some months in various phases of the Project. Selenium water concentrations in Treaty (TRC2) and Teigen (TEC2) creeks are predicted to remain at or below baseline levels (Table 15.7-5). These slight increases in North Treaty or South Teigen creeks may pose a risk to fish, since increased uptake may be possible if the additional selenium enters the food chain either due to increased tissue residues or increased biomass (due to increased nutrient loading) of prey items.

Currently, Dolly Varden collected during baseline studies downstream of the proposed TMF had selenium whole body concentrations that are greater than BC tissue residue guideline limits (see Table 15.7-4). The tissue selenium concentrations measured during baseline studies are not likely to result in toxic effects to Dolly Varden since these fish are among the more tolerant species to selenium effects (McDonald et al. 2010). To quantitatively predict tissue selenium residues in fish most accurately, lower trophic level tissue residue data would be required, and this is not available. In addition, there is no scientific information or baseline data available for selenium residues for the other fish in the LSA and RSA.

Qualitatively, an increase in concentration of selenium in the water is likely to increase the concentration of the metal in fish tissue. The potential increase in selenium tissue concentrations is likely small, since the relative increase in predicted concentration relative to baseline concentration is small and occurs only periodically (except at in North Treaty during closure). However, there is uncertainty associated with this assessment since tissue residues are not quantitatively estimated and toxic effects thresholds cannot be well defined for most of the VC fish species.

Implementation of the Aquatic Effects Monitoring Plan (Section 26.18.2) will be critical to ensuring that toxic effects of increased selenium water concentrations do not occur in fish. The monitoring plan will ensure detection of significant alterations in productive capacity or aquatic life, measurement of tissue metal concentrations in benthic invertebrates, allow for identification of potential causes, include triggers for risk assessment of potential effects, and include the provision of additional mitigation or adaptive management strategies.

The assessment of significance of the residual effects for TMF discharge is based on predicted water concentrations for selenium at the sites downstream of the TMF, and the potential for selenium to bioaccumulate to toxic tissue concentrations in fish species. The magnitude of the potential residual effects for bull trout, Dolly Varden, and rainbow trout/steelhead was assessed as medium for all phases since these fish were found during baseline studies in the lower reaches of South Teigen Creek. In addition, the whole body selenium residues in fish (Dolly Varden) collected during baseline studies were already greater than the BC tissue residue guideline limits and concentrations may be expected to increase if water concentrations increase. However, whether the increase in tissue selenium concentration is high enough to cause toxicity in the fish is uncertain, but given the sporadic nature and magnitude of the increases in selenium water concentrations relative to background (10 to 30%), it seems unlikely that toxicity thresholds will be surpassed.

Pacific salmon were not found in either North Treaty or South Teigen creeks where selenium concentrations may be elevated relative to baseline. There is a cascade on South Teigen Creek that may prevent salmon from migrating up toward the TMF, and the stream morphology of North Treaty Creek is not conducive to salmon. However, there are no physical barriers in North Treaty Creek or lower South Teigen Creek (below the cascade), so potential for residual effects cannot be ruled out as it is possible that Pacific salmon may enter these areas. Only the early juvenile stages of pre-smolt Pacific salmon would be at risk of potential effects since the adult stage occurs mostly outside of the LSA and RSA (in the marine environment) and adults do not eat during their return migrations and would not have the potential to accumulate selenium through diet (the main exposure route). Therefore, the residual effect for Pacific salmon was assessed as negligible in all phases, rather than ruled out as having no potential for residual effects.

The geographic extent of the residual effect was determined to be landscape for all fish species, since any effects are expected to occur just outside of the Project footprint downstream of the TMF. The potential for residual effects due to selenium will decrease with distance from the discharge point due to dilution, and effects are not expected in Treaty or Teigen creeks.

For all fish species, the duration of the effect was assessed as long-term for the operation phase and medium-term for the closure phase since the potential for selenium bioaccumulation may occur sporadically during the entire phase. For the post-closure phase, the potential for selenium bioaccumulation would be expected to decrease over time since no new inputs to the TMF would occur after the operation phase. Therefore, the duration of the effect was assessed as long-term, as selenium water concentrations should decrease over time back to baseline concentrations. The frequency of the residual effect was determined to be sporadic for all fish species since the increases in selenium water concentrations relative to baseline occur only intermittently during the year. Should effects occur, they would likely be reversible in the long-term as fish would likely be able to recover, adapt, or move to areas slightly farther downstream in Teigen or Treaty creeks where effects are not expected.

For discharges from the TMF of metals and other chemicals the resiliency (context) of all fish species was assessed as neutral, as there is moderate resilience to selenium bioaccumulation that occurs sporadically since fish may be able to metabolize and eliminate selenium body burdens between exposure events. Any residual effects related to the predicted elevation in selenium concentrations relative to background would likely be reversible in the long-term, since the concentrations of selenium in the water would be expected to decrease over time during the post-closure phase since no new inputs to the TMF would occur.

For all fish species, the probability that effects would occur is low during the operation and closure phases since elevated selenium water concentrations occur only sporadically relative to baseline. Similarly, the potential for selenium bioaccumulation is also low for bull trout and rainbow trout/steelhead during the post-closure phase for South Teigen, since higher concentrations relative to baseline occur in April and May only. For Dolly Varden, which is the only fish species that was found in North Treaty Creek, selenium is predicted to be greater than baseline in five months of the year, but only by about 10% compared to baseline concentrations. Therefore, the probability of residual effects on Dolly Varden from selenium was also assessed as low.

The confidence of the assessment was considered to be medium for all fish species in all phases since there is uncertainty about the likelihood and magnitude of accumulation of selenium and the resultant potential for toxic effects. Follow-up monitoring will be required to confirm the findings of the significance assessment since confidence is only moderate. Because the Aquatic Effects Monitoring Program includes components that will increase certainty by ensuring the collection of data that will specifically aid in the assessment of potential for selenium bioaccumulation (e.g., water quality sampling and tissue metal residues in benthic organisms) and trigger additional mitigation or adaptive management as needed, the final determination of significance for all fish species is **not significant – minor**.

Mine Site Water Treatment Plant Discharge

Discharge from the WTP also has the potential to introduce metals and other chemicals that may cause toxicity in downstream aquatic environments. The area immediately downstream of the WTP discharge point is non-fish-bearing, and fish are not present in Sulphurets Creek until below the cascades, approximately 9.5 km downstream (500 m upstream of the confluence with the Unuk River). Dolly Varden were present in Sulphurets Creek below the cascade and in the Unuk River during baseline studies. Rainbow trout/steelhead and Pacific salmon are found in the Unuk River. Dolly Varden collected during baseline studies from Sulphurets Creek (SC3) and the Unuk River (UR1) had selenium tissue concentrations that were greater than BC guideline limits of 1 µg/g dw (equivalent to 4 µg/g ww; Table 15.7-4). Tissue metal residues in rainbow trout/steelhead or Pacific salmon in this area are unknown.

Assessment for potential residual effects associated with Mine Site WTP discharge was done using calculated HQs followed by individual assessment of metals where the HQ was greater than 1.0. In addition, as selenium and mercury may bioaccumulate through the diet, they were also assessed using HQs relative to both guideline limits and baseline concentrations. Data from the expected case of the water quality model indicated that water quality downstream of the Mine Site WTP is expected to meet BC water quality guidelines (total metals, HQ less than 1.0) for most metals (Section 15.7.4.3.1 and Chapter 14). While dissolved aluminum, copper and total iron were initially identified through screening (i.e., HQ greater than 1.0 in some months), individual assessment of these metals suggested that they would not lead to potential residual effects.

The only metal identified following individual assessment of metals with an HQ greater than 1.0 downstream of the Mine Site WTP was selenium, which is predicted to be greater than both guideline limits and baseline concentrations in the water during all phases of the Project, starting in year 15 of the operation phase, in Sulphurets Creek (SC2 and SC3) and the Unuk River (UR1). Concentrations of selenium in the water are predicted to be below BC water quality guidelines at the UR2 site on the Unuk River, but above the baseline water concentrations measured at this site. Table 15.7-6 provides a summary of the HQs for selenium throughout the Project phases for sites downstream of the Mine Site WTP.

Since water selenium concentrations may increase above both water quality guidelines limits and background concentrations, it is also probable that fish tissue residues of selenium will increase and be detectably different compared to baseline levels. Fish tissue residues that were measured in Dolly Varden that were collected during baseline studies were already greater than the BC tissue residue guideline limits. The magnitude of the potential increase in selenium in fish tissue and the likelihood of subsequent toxic effects cannot be quantified currently (Section 15.7.4.3.1; also see next paragraph), leading to uncertainty in the prediction of future potential residual effects.

It is not currently possible to predict what tissue residues may occur in fish for several reasons. First, the sample sizes for fish tissue residue measurement during baseline studies were limited, particularly in the lower end of Sulphurets (SC3; n = 4) and the Unuk River (UR1; n = 5). Part of the reason for this was difficulty in obtaining samples since there were not many fish residing in these areas. Second, since selenium bioaccumulates through the food chain and data regarding tissue residues at lower trophic levels are not available, it can be difficult to determine the relationships, if any, among selenium concentrations in sediment, water, lower trophic levels, and fish tissue and/or egg. Selenium bioaccumulation factors may also vary between species and between trophic levels, further complicating the assessment of potential effects. In addition, establishing effects thresholds for toxicity in fish can be challenging since limited information is available on body burdens associated with toxic effects for most fish species found in the LSA and RSA and essentially no information is available for this specific area of BC. Bioaccumulation factors of selenium can be very site-dependent since bioaccumulation may depend on concentrations of selenium in the aquatic environment and the quality, quantity, and type of aquatic life (i.e., prey) in the area.

There are a number of other factors that influence the assessment of potential residual effects related to bioaccumulation of selenium downstream of the Mine Site WTP. First, the potential for selenium bioaccumulation and toxicity due to Mine Site WTP discharge will decrease with distance from the discharge location in Mitchell Creek due to dilution, which is reflected in the water quality model results (predicted selenium water concentrations at SC3 are greater than at SC2, which are greater than at UR1, which are greater than at UR2).

Second, migratory fish species, such as Pacific salmon and steelhead, spend most of their adult lives outside of the LSA and RSA, so only early life stages (e.g., alevin or parr stages) would be at risk of Project-related selenium bioaccumulation through the diet. These migratory fish species would likely have lower risk of maternal transfer of Project-related selenium from the female fish body burden to the eggs, since selenium can be metabolized and Project-related body burdens may be eliminated from fish during their time in the Pacific Ocean (Hamilton 2004). The juvenile freshwater stages of salmonids may remain in their natal streams, which are most often tributaries of the Unuk River rather than the Unuk River itself, until they are ready to migrate out to the ocean. These fish would be less likely to be affected by increased selenium water concentrations.

Third, Sulphurets Creek and the Unuk River are generally considered to be lotic (flowing) environments, although there may be some lentic (slower-moving water) environments. Lotic environments usually have lower risk of selenium bioaccumulation through the food chain than lenthic environments (Chapman, Adams et al. 2009), so bioaccumulation factors in these fast-moving waters may be lower.

Since accurate predictions cannot be made based on the information currently available, it cannot be determined quantitatively how much selenium tissue concentrations in fish or aquatic invertebrates will increase as a result of Project-related increases in selenium concentrations. Implementation of the Aquatic Effects Monitoring Plan (Section 26.18.2) will be critical to ensure detection of significant alterations in productive capacity or aquatic life and to provide triggers for a risk assessment of exposure and effects. Monitoring plan provisions include the regular measurement of tissue metal residues in benthic invertebrates in combination with monitoring of both water and sediment for metal concentrations. It also includes sampling of fish populations every three years with a measurement of tissue metal residues in both eggs, if available, and whole body. Implementation of this plan will serve to address the uncertainty associated with both the potential for bioaccumulation of selenium and the potential for toxic effects of selenium.

The assessment of residual effects to fish due to WTP discharges was based on the potential for selenium to cause toxicity in fish. Since no fish were found at the SC2 site on Sulphurets Creek, potential effects were considered only for water quality predictions at the SC3 (Dolly Varden only), UR1, and UR2 sites. Dolly Varden were found in both Lower Sulphurets Creek and the Unuk River, while rainbow trout/steelhead and Pacific salmon were found in the Unuk River.

For discharges from the WTP during operation, closure, and post-closure for all fish species, the magnitude of residual effects was assessed as high since the predicted concentrations of selenium in the water are expected to increase relative to both baseline and guideline water concentrations at the UR1 site. In addition, fish tissue residue already exceeds the BC tissue residue guideline, and it is expected that increases in water selenium concentrations will lead to increases in selenium in fish tissue, such that tissue residues will be detectably different than during baseline. It should be noted though, that the actual magnitude of increase is uncertain and that the magnitude may vary for different life stages of a species. As noted in the paragraphs above, adult salmon and steelhead spend much of their lifespan in the ocean and would be unlikely to transfer maternal body-burdens of Project-related selenium to the developing eggs. For these species, the most sensitive life stages would be the juvenile freshwater stages (e.g., alevin and parr) since they would be consuming prey that may have higher selenium content and would therefore have a higher risk of Project-related bioaccumulation of selenium prior to their outmigration to the ocean. For the purposes of the assessment, the most sensitive life stage was considered so the potential residual effect for steelhead and Pacific salmon was rated as high.

The geographic extent is considered to be regional since selenium is greater than the BC water quality guidelines and background levels at UR1, but is predicted to be below the guideline at UR2. The duration of the effect varies in the same way for all fish species. Since the concentrations of selenium in water are expected to increase during the early years of the operation phase, with observable increases relative to guideline and/or background concentrations (i.e., HQs greater than 1.0) by year 15. The concentrations of selenium after that may vary slightly between months but are predicted to remain elevated consistently during the later years of the operation phase (greater than 15 years) and all of the closure and post-closure phases (Table 15.7-6; Chapter 14). Since the duration of the effects may occur throughout most or all of a phase, the operation phase was assessed as long-term in duration, the closure phase as short-term, and the post-closure phase as far-future.

The frequency of the potential effect was assessed to be continuous for Dolly Varden and rainbow trout, since the discharge from the Mine Site WTP will occur in each month of the year and the selenium concentrations will be greater than guideline and/or background values by year 15 of the operation phase. However, for the migratory fish species (steelhead and Pacific salmon), the frequency was assessed as regular since these fish may not be present in the LSA or RSA for half or more of their lifespan because the development of outmigrating smolts to adults and maturation of adults occurs in the Pacific Ocean, outside of the areas influenced by Project-related activities.

The potential residual effect was assessed as being reversible in the long term. This is because at some point during the post-closure phase, the concentration of selenium in water will begin to decrease as there will be no new inputs made to the system. This is likely to be far into the future, since selenium can also cycle between the sediments and the food chain, particularly in lentic environments. The context was assessed as high, since the bioaccumulation of selenium has been shown to have the potential to cause population-level effects due to decrease in viability of early developmental stages of fish.

The probability that additional selenium bioaccumulation may occur is high, given that water concentrations are predicted to be above both guideline and baseline levels throughout many of the Project phases. However, the probability that toxicity due to bioaccumulation of selenium may occur in fish species is less certain, since increased tissue residues do not necessarily mean increased toxicity until a threshold level is reached. There is uncertainty about whether this toxic threshold level will be reached by fish in Lower Sulphurets Creek (below the cascades) or the Unuk River as a result of Project activities. Therefore, the probability that toxicity due to bioaccumulation of selenium may occur in fish was assessed as medium.

The confidence in the significance assessment of residual potential effects due to selenium is low to moderate. This is because there is uncertainty about tissue metal residues in fish during the baseline phase, tissue metal residues or bioaccumulation factors for selenium in the lower trophic levels, the magnitude of potential increases in fish tissue metal residues, and the body burden at which toxic effects may occur in the fish species present downstream of the Mine Site. Since the Aquatic Effects Monitoring Plan includes components that will increase certainty in determining the magnitude and extent of residual effects, the final determination of significance is **not significant – moderate**. Follow-up monitoring will be required to confirm this assessment, details of which are contained in the Aquatic Effects Monitoring Plan.

15.8.2.4.2 Petroleum Products

The toxicity of petroleum products that may be introduced into the aquatic environment is described in Section 15.7.4.1.3. Fish may be primarily affected due to construction, operation, and closure of the access roads, the transmission line, camps, and other infrastructure that is located near water where fish reside. The main pathway of petroleum product introduction into the aquatic environment during normal Project activities is during work in and around waterways. As noted in Section 15.7.4.1.3, the potential impact on aquatic environments due to large spills or accidents involving petroleum products was not considered in this chapter since they are not a normal occurrence during routine Project activities.

The determination of potential effects for toxicity due to petroleum product introduction into the aquatic environment is the same for all fish species during all phases of the Project. The magnitude of potential effects related to toxicity of petroleum products was assessed to be low. The amount of product introduced during normal Project activities is expected to be low with implementation of mitigation and management plans (see Section 15.7.4.2.4) and the selection of instream work windows to avoid sensitive timeframes for fish species (e.g., spawning season). The extent of the potential for toxic effects is considered landscape, since the effect may extend beyond the actual footprint of the Project into localized areas in the vicinity of where petroleum products may be introduced. The duration of the effect is short term since only small quantities of petroleum products would be released to the environment, so the potential for toxic effects would be short lived (less than one year). The frequency of occurrence would be sporadic, since work in and around water will occur only occasionally. The potential for toxicity to fish will be likely reversible in the short term due to dilution in the receiving environment and the partitioning of the hydrophobic components of the petroleum products to the sediment that would minimize the exposure. The context was determined to be neutral since fish are sensitive to toxic effects from petroleum product exposure but are unlikely to be exposed to concentrations high enough to cause toxicity (moderate resilience). The probability of occurrence is low, with high confidence, since various mitigation and management plans will be implemented to minimize the potential for effects due to petroleum products.

Thus, considering the above description of the potential for toxicity due to petroleum products during normal Project operation and how they may affect fish in the LSA and RSA, the potential effects are **not significant – minor**, and no additional follow-up monitoring is required.

15.8.2.4.3 Nitrogen

The potential for toxicity associated with nitrogenous compounds from blasting residues and effluent from STPs on fish are outlined in Section 15.7.4.1.4. The residual effects associated with nitrogen compounds from these sources come mainly from the discharge of effluent from either the Mine Site WTP or the TMF in the PTMA (i.e., point sources). Although some blasting residues or effluent from STPs may be present outside of the catchment areas for these two facilities (i.e., non-point sources), the overall contribution from non-point sources will be minor relative to the point sources, and may occur slowly enough that dilution in the receiving environment will further minimize any potential for toxicity. In addition, the water quality model included the input of nitrogenous compounds from blasting residues and STP effluent from the operating camps, allowing the quantitative assessment of the potential for toxic effects. For this reason, the potential for toxicity due to blasting residues and effluent from STPs was assessed based on data from the water quality model (Chapter 14).

The assessment of potential for toxic effects was based on comparison of the water quality model results to BC water quality guidelines for the protection of aquatic life. Downstream of the mine site WTP, ammonia, nitrate, and nitrite are all predicted to remain below BC water quality guidelines at all sites in all phases; therefore, it was determined that toxicity due to nitrogenous compounds downstream of the Mine Site WTP would not be a potential residual effect and was not assessed for significance of effects. For sites downstream of the TMF, the water quality model (expected case) predicted that ammonia and nitrate will be below guideline levels at all sites during all phases, but that nitrite may be greater than guideline limits. This was thought to be an artifact of the predictive water quality model, so it is unlikely that toxicity would occur.

The potential for residual effects due to toxicity of nitrogenous compounds derived from blasting and STP effluent was considered to be the same for each of the four VC fish species found downstream of the TMF in all phases of the Project. The magnitude of the potential effect was determined to be medium in the construction and operation phases since ammonia and nitrate will increase relative to background, but will remain below water quality guidelines. During the closure phase, the magnitude was assessed as low, since the concentrations of ammonia and nitrate will generally return to near-baseline levels. The potential effects will occur at the landscape level of geographic extent since any effects would occur just outside of the actual Project footprint.

The duration of potential effects would vary between the phases of the Project. In the construction phase, the duration would be medium term, and in the operation phase, it would be long term, since inputs may occur throughout the entire phase. During closure, the duration would be short term, since there would be no new inputs of nitrogenous compounds and therefore concentrations are predicted to decrease to near baseline levels. The frequency of the potential for toxicity due to nitrogenous compounds would be sporadic since the concentrations of ammonia and nitrate are predicted to remain below guideline levels. Any potential effects will also be quickly reversible since they would be sporadic in nature. The context was determined to be neutral since fish are sensitive to toxic effects from nitrogen exposure (particularly ammonia) but are unlikely to be exposed to concentrations high enough to cause toxicity (moderate resilience).

Given the above, the likelihood of effects was assessed as low probability with a high confidence level. Thus, potential residual effects on fish produced from blast explosive residues and sewage effluent was assessed as **not significant - minor**.

15.8.2.5 Overall Effect on Fish Valued Components (Bull Trout, Dolly Varden, Rainbow Trout/Steelhead, and Pacific Salmon)

The potential residual effects on fish VCs were associated with direct mortality, noise, erosion and sedimentation, and water quality degradation. These effects can possibly interact, creating additive or synergistic effects that have a different extent for the local fish population as a whole. Considering these potential effects on fish in combination with Project infrastructure in the LSA and RSA, and mitigation to minimize effects, the overall potential Project-related residual effect on local fish populations is not likely to affect the viability of these VCs and is assessed as **not significant - minor** for all residual effects except for the potential for toxicity downstream of the Mine Site WTP.

Discharge from the Mine Site WTP is predicted to lead to an increase in concentration of selenium in the water downstream relative to both guideline limits and baseline levels, including in areas where fish are found (Lower Sulphurets Creek and the Unuk River). It is possible that discharges from the WTP may lead to increased uptake of selenium in fish populations through bioaccumulation up the food chain. However, there is uncertainty in predicting the magnitude of the uptake of selenium and the toxicological implications of potentially increased tissue residues in fish (i.e., uncertainty in the toxic effects threshold concentration). The Aquatic Effects Monitoring Plan will be implemented to address these uncertainties. For this reason, discharges from the WTP have been assessed as **not significant – moderate**.

15.8.3 Residual Effects Assessment for Aquatic Habitat

Table 15.8-6 summarizes the assessment of potential residual effects for aquatic habitat. Several potential residual effects were identified that could affect aquatic habitat in the LSA and RSA. These potential residual effects include erosion and sedimentation, water quality degradation (metals from non-point sources, metals and process chemicals from the TMF or WTP discharges, petroleum products, and nitrogen and phosphorus), and aquatic habitat loss or alteration. Each of these potential residual effects is discussed below in relation to effects on aquatic habitat and productive capacity.

15.8.3.1 Erosion and Sedimentation

Section 15.7.3.1 describes erosion and sedimentation and its general effects on fish and aquatic habitats, and Section 15.7.3.2 describes mitigation measures used to control sedimentation. Sedimentation generated by the Project may cause several effects on the aquatic habitat. Potential effects include alterations to the habitat such as smothering habitat, invertebrates and invertebrate eggs, and primary producers. There could also be decreased feeding efficiency, habitat avoidance, and a loss of productive habitat capacity.

Erosion and sedimentation effects may occur during the construction, operation, and closure of the access roads, tunnels, RSFs, pits, TMF, diversions, WSF, dams, and hydroelectric facilities. There is a greater potential for the release of sediments during the construction phase, which will then decrease with operation and closure.

The residual effect of erosion and sedimentation on aquatic habitat has the potential to be significant during the construction and operation phases of the Project. However, it is expected to be minimized in terms of magnitude, geographic extent, and duration through mitigation strategies (e.g., the Erosion Control Plan and the Fish and Aquatic Habitat Effects Protection and Mitigation Plan) and BMPs. With these mitigations, the magnitude of the residual effect is low—differing from the mean baseline value, but still below the guideline level. The extent of the residual sediment effect will be landscape as the sediments will be flushed downstream. The frequency of erosion and sedimentation events will be sporadic. The duration of an event will be medium term since the effect will last from one to five years (Wood and Armitage 1997) and will be reversible over the long term as spates or flood events will be required to flush sediments deposited in the watercourses followed by recolonization of the habitat by aquatic organisms (Wallace 1990; Sedell et al. 1990). The receiving environment and aquatic organisms will have a medium resilience to short-term increases in sediments and will likely respond and adapt to the residual effect of erosion and sedimentation.

Table 15.8-6. Summary of Residual Effects on Aquatic Habitat

Description of Residual Effect	Project Component(s)	Timing of Effect	Magnitude	Extent	Duration	Frequency	Reversibility	Context	Likelihood of Effects: Probability	Likelihood of Effects: Confidence Level	Significance Determination	Follow-up Monitoring
Erosion and sedimentation causing smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction	Construction	Low	Landscape	Medium	Sporadic	Reversible long-term	Neutral	High	High	Not Significant (Minor)	Not Required
Erosion and sedimentation causing smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction	Operations	Low	Landscape	Medium	Sporadic	Reversible long-term	Neutral	Medium	High	Not Significant (Minor)	Not Required
Erosion and sedimentation causing smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; South Cell Tailing Management Facility; East Catchment Diversion	Closure	Negligible	Landscape	Short	Sporadic	Reversible long-term	Neutral	Medium	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Treaty Creek Access Road; Mitchell-Treaty Tunnel; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC	Construction	Low	Landscape	Short	Sporadic	Reversible long-term	High	Low	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Treaty Creek Access Road; Mitchell-Treaty Tunnel; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC	Operations	Low	Landscape	Short	Sporadic	Reversible long-term	High	Low	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Treaty Creek Access Road; Mitchell-Treaty Tunnel; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC	Closure	Low	Landscape	Short	Sporadic	Reversible long-term	High	Low	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metal exposure from non-point source (e.g. ML/ARD generation associated with construction and infrastructure development)	Treaty Creek Access Road; Mitchell-Treaty Tunnel; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC	Post-closure	Low	Landscape	Short	Sporadic	Reversible long-term	High	Low	High	Not Significant (Minor)	Not Required
Sublethal toxicity due to metals or process chemical exposure downstream of the TMF associated with scheduled discharge or seepage from the TMF	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Seepage Collection Ponds; Concentrate Storage and Loadout	Operations	Low	Landscape	Long	Sporadic	Reversible long-term	Low	Low	High	Not Significant (Minor)	Required

(continued)

Table 15.8-6. Summary of Residual Effects on Aquatic Habitat (continued)

Description of Residual Effect	Project Component(s)	Timing of Effect	Magnitude	Extent	Duration	Frequency	Reversibility	Context	Likelihood of Effects: Probability	Likelihood of Effects: Confidence Level	Significance Determination	Follow-up Monitoring
Sublethal toxicity due to metals or process chemical exposure downstream of the TMF associated with scheduled discharge or seepage from the TMF	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Seepage Collection Ponds; Concentrate Storage and Loadout	Closure	Low	Landscape	Medium	Sporadic	Reversible long-term	Low	Low	High	Not Significant (Minor)	Required
Sublethal toxicity due to metals or process chemical exposure downstream of the TMF associated with scheduled discharge or seepage from the TMF	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Seepage Collection Ponds; Concentrate Storage and Loadout	Post-closure	Low	Landscape	Long	Sporadic	Reversible long-term	Low	Low	High	Not Significant (Minor)	Required
Toxicity due to metals or process chemical exposure downstream of the Mine Site WTP associated with scheduled discharge or seepage from the Mine Site WTP	Water Storage Facility; Water Storage Dam; Water Treatment Plant; Water Treatment & Energy Recovery Area; McTagg RSF; Mitchell RSF; Mitchell Ore Preparation Complex; Mitchell Pit; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Operations	High	Regional	Long	Continuous	Reversible long-term	Neutral	Low	Medium	Not Significant (Minor)	Required
Toxicity due to metals or process chemical exposure downstream of the Mine Site WTP associated with scheduled discharge or seepage from the Mine Site WTP	Water Storage Facility; Water Storage Dam; Water Treatment Plant; Water Treatment & Energy Recovery Area; McTagg RSF; Mitchell RSF; Mitchell Ore Preparation Complex; Mitchell Pit; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Closure	High	Regional	Medium	Continuous	Reversible long-term	Neutral	Low	Medium	Not Significant (Minor)	Required
Toxicity due to metals or process chemical exposure downstream of the Mine Site WTP associated with scheduled discharge or seepage from the Mine Site WTP	Water Storage Facility; Water Storage Dam; Water Treatment Plant; Water Treatment & Energy Recovery Area; McTagg RSF; Mitchell RSF; Mitchell Ore Preparation Complex; Mitchell Pit; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Post-closure	High	Regional	Far future	Continuous	Reversible long-term	Neutral	Low	Medium	Not Significant (Minor)	Required
Toxicity due to introduction of petroleum products into aquatic environment during normal Project activities	Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road; Camp 4: Mitchell North; Camp 9: Mitchell Initial: Camp 10: Mitchell Secondary; Mitchell Operating Camp; WSD, WSF, WTP; McTagg Energy Recovery Facility	Construction	Low	Landscape	Short	Sporadic	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of petroleum products into aquatic environment during normal Project activities	Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road; Camp 4: Mitchell North; Camp 9: Mitchell Initial: Camp 10: Mitchell Secondary; Mitchell Operating Camp; WSD, WSF, WTP; McTagg Energy Recovery Facility	Operations	Low	Landscape	Short	Sporadic	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required

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Table 15.8-6. Summary of Residual Effects on Aquatic Habitat (continued)

Description of Residual Effect	Project Component(s)	Timing of Effect	Magnitude	Extent	Duration	Frequency	Reversibility	Context	Likelihood of Effects: Probability	Likelihood of Effects: Confidence Level	Significance Determination	Follow-up Monitoring
Toxicity due to introduction of petroleum products into aquatic environment during normal Project activities	Camp 11 - Treaty Marshalling Yard; Camp 12 - Highway 37 Construction; Treaty Creek Access Road; Camp 4: Mitchell North; Camp 9: Mitchell Initial: Camp 10: Mitchell Secondary; Mitchell Operating Camp; WSD, WSF, WTP; McTagg Energy Recovery Facility	Closure	Low	Landscape	Short	Sporadic	Reversible short-term	Low	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of nitrogenous compounds associated with blasting residue or sewage	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Camp 5: Treaty Plant; Treaty Operations Camps; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Treaty Creek Access Road; Mitchell-Treaty Tunnel; Construction Access Adit; Mitchell-Treaty Tunnel Saddle Area; Camp 6: Treaty Saddle;Coulter Creek Access Corridor; Explosives Manufacturing Facility; Camp 3: Eskay Staging; Camp 4: Mitchell North; Camp 7: Unuk North; Camp 8: Unuk South; Camp 9: Mitchell Initial; Camp 10: Mitchell Secondary; Mitchell Operating Camp	Construction	Negligible	Landscape	Short	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required
Toxicity due to introduction of nitrogenous compounds associated with blasting residue or sewage	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Camp 5: Treaty Plant; Treaty Operations Camps; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Treaty Creek Access Road; Mitchell-Treaty Tunnel; Construction Access Adit; Mitchell-Treaty Tunnel Saddle Area; Camp 6: Treaty Saddle;Coulter Creek Access Corridor; Explosives Manufacturing Facility; Camp 3: Eskay Staging; Camp 4: Mitchell North; Camp 7: Unuk North; Camp 8: Unuk South; Camp 9: Mitchell Initial; Camp 10: Mitchell Secondary; Mitchell Operating Camp	Operations	Negligible	Landscape	Short	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required

(continued)

Table 15.8-6. Summary of Residual Effects on Aquatic Habitat (continued)

Description of Residual Effect	Project Component(s)	Timing of Effect	Magnitude	Extent	Duration	Frequency	Reversibility	Context	Likelihood of Effects: Probability	Likelihood of Effects: Confidence Level	Significance Determination	Follow-up Monitoring
Toxicity due to introduction of nitrogenous compounds associated with blasting residue or sewage	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Camp 5: Treaty Plant; Treaty Operations Camps; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Treaty Creek Access Road; Mitchell-Treaty Tunnel; Construction Access Adit; Mitchell-Treaty Tunnel Saddle Area; Camp 6: Treaty Saddle;Coulter Creek Access Corridor; Explosives Manufacturing Facility; Camp 3: Eskay Staging; Camp 4: Mitchell North; Camp 7: Unuk North; Camp 8: Unuk South; Camp 9: Mitchell Initial; Camp 10: Mitchell Secondary; Mitchell Operating Camp	Closure	Negligible	Landscape	Short	Sporadic	Reversible short-term	Neutral	Low	High	Not Significant (Minor)	Not Required
Alteration of aquatic resources and potential for eutrophication associated with nitrogenous compounds	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Camp 5: Treaty Plant; Treaty Operations Camps; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Treaty Creek Access Road; Mitchell-Treaty Tunnel; Construction Access Adit; Mitchell-Treaty Tunnel Saddle Area; Camp 6: Treaty Saddle;Coulter Creek Access Corridor; Explosives Manufacturing Facility; Camp 3: Eskay Staging; Camp 4: Mitchell North; Camp 7: Unuk North; Camp 8: Unuk South; Camp 9: Mitchell Initial; Camp 10: Mitchell Secondary; Mitchell Operating Camp	Construction	Low	Landscape	Short	Sporadic	Reversible short-term	Low	Medium	Medium	Not Significant (Minor)	Not Required
Alteration of aquatic resources and potential for eutrophication associated with nitrogenous compounds	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Camp 5: Treaty Plant; Treaty Operations Camps; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Treaty Creek Access Road; Mitchell-Treaty Tunnel; Construction Access Adit; Mitchell-Treaty Tunnel Saddle Area; Camp 6: Treaty Saddle;Coulter Creek Access Corridor; Explosives Manufacturing Facility; Camp 3: Eskay Staging; Camp 4: Mitchell North; Camp 7: Unuk North; Camp 8: Unuk South; Camp 9: Mitchell Initial; Camp 10: Mitchell Secondary; Mitchell Operating Camp	Operations	Low	Landscape	Short	Sporadic	Reversible short-term	Low	Medium	Medium	Not Significant (Minor)	Not Required

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Table 15.8-6. Summary of Residual Effects on Aquatic Habitat (continued)

Description of Residual Effect	Project Component(s)	Timing of Effect	Magnitude	Extent	Duration	Frequency	Reversibility	Context	Likelihood of Effects: Probability	Likelihood of Effects: Confidence Level	Significance Determination	Follow-up Monitoring
Alteration of aquatic resources and potential for eutrophication associated with nitrogenous compounds	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Camp 5: Treaty Plant; Treaty Operations Camps; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Treaty Creek Access Road; Mitchell-Treaty Tunnel; Construction Access Adit; Mitchell-Treaty Tunnel Saddle Area; Camp 6: Treaty Saddle;Coulter Creek Access Corridor; Explosives Manufacturing Facility; Camp 3: Eskay Staging; Camp 4: Mitchell North; Camp 7: Unuk North; Camp 8: Unuk South; Camp 9: Mitchell Initial; Camp 10: Mitchell Secondary; Mitchell Operating Camp	Closure	Low	Landscape	Short	Sporadic	Reversible short-term	Low	Medium	Medium	Not Significant (Minor)	Not Required
Alteration of aquatic resources and potential for eutrophication associated with nitrogenous compounds	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Treaty OPC; Camp 5: Treaty Plant; Treaty Operations Camps; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Treaty Creek Access Road; Mitchell-Treaty Tunnel; Construction Access Adit; Mitchell-Treaty Tunnel Saddle Area; Camp 6: Treaty Saddle;Coulter Creek Access Corridor; Explosives Manufacturing Facility; Camp 3: Eskay Staging; Camp 4: Mitchell North; Camp 7: Unuk North; Camp 8: Unuk South; Camp 9: Mitchell Initial; Camp 10: Mitchell Secondary; Mitchell Operating Camp	Post-closure	Low	Landscape	Short	Sporadic	Reversible short-term	Low	Medium	Medium	Not Significant (Minor)	Not Required
Loss of fish habitat and decrease in the productive capacity of aquatic habitat due to linear development (access roads and transmission line), and TMF development (dams and tailings) footprints	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility	Construction	Medium	Local	Medium	One-time	Reversible short-term	Neutral	High	High	Not Significant (Minor)	Required
Loss of fish habitat and decrease in the productive capacity of aquatic habitat due to linear development (access roads and transmission line), and TMF development (dams and tailings) footprints	Coulter Creek Access Corridor; Treaty Creek Access Road; South Cell Tailing Management Facility	Operations	Medium	Local	Long	One-time	Reversible short-term	Neutral	High	High	Not Significant (Minor)	Required

(continued)

Table 15.8-6. Summary of Residual Effects on Aquatic Habitat (continued)

Description of Residual Effect	Project Component(s)	Timing of Effect	Magnitude	Extent	Duration	Frequency	Reversibility	Context	Likelihood of Effects: Probability	Likelihood of Effects: Confidence Level	Significance Determination	Follow-up Monitoring
Loss of fish habitat and decrease in the productive capacity of aquatic habitat due to water quanity reductions downstream of the TMF	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility	Construction	Low	Landscape	Medium	Continuous	Reversible short-term	Neutral	High	High	Not Significant (Minor)	Required
Loss of fish habitat and decrease in the productive capacity of aquatic habitat due to water quanity reductions downstream of the TMF	South Cell Tailing Management Facility; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility	Operations	Low	Landscape	Long	Continuous	Reversible short-term	Neutral	High	High	Not Significant (Minor)	Required
Loss of fish habitat and decrease in the productive capacity of aquatic habitat due to water quanity reductions downstream of the TMF	South Cell Tailing Management Facility; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility	Closure	Low	Landscape	Long	Continuous	Reversible short-term	Neutral	High	High	Not Significant (Minor)	Required
Loss of aquatic habitat productive capacity within McTagg, Mitchell, and non-fish bearing reaches of Sulphurets Creek due to infrastructure development (footprint) and diversion of water	McTagg Rock Storage Facililty; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit; McTagg Twinned Diversion Tunnels; diversion channels/ditches	Construction	Low	Local	Far future	One-time	Irreversible	High	High	High	Not Significant (Minor)	Not Required
Loss of aquatic habitat productive capacity within McTagg, Mitchell, and non-fish bearing reaches of Sulphurets Creek due to infrastructure development (footprint) and diversion of water	McTagg Rock Storage Facililty; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit; McTagg Twinned Diversion Tunnels; diversion channels/ditches	Operations	Low	Local	Far future	One-time	Irreversible	High	High	High	Not Significant (Minor)	Not Required
Loss of fish habitat productive capacity within the fish bearing reach of Sulphurets Creek due to infrastructure development (footprint) and water management	McTagg Rock Storage Facililty; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit; McTagg Twinned Diversion Tunnels; diversion channels/ditches	Construction	Low	Landscape	Long	Continuous	Reversible short-term	Low	Medium	High	Not Significant (Minor)	Not Required

(continued)

Table 15.8-6. Summary of Residual Effects on Aquatic Habitat (completed)

Description of Residual Effect	Project Component(s)	Timing of Effect	Magnitude	Extent	Duration	Frequency	Reversibility	Context	Likelihood of Effects: Probability	Likelihood of Effects: Confidence Level	Significance Determination	Follow-up Monitoring
Loss of fish habitat productive capacity within the fish bearing reach of Sulphurets Creek due to infrastructure development (footprint) and water management	McTagg Rock Storage Facililty; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit; McTagg Twinned Diversion Tunnels; diversion channels/ditches	Operations	Low	Landscape	Long	Continuous	Reversible short-term	Low	Medium	High	Not Significant (Minor)	Not Required
Loss of fish habitat productive capacity within the fish bearing reach of Sulphurets Creek due to infrastructure development (footprint) and water management	McTagg Rock Storage Facililty; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit; McTagg Twinned Diversion Tunnels; diversion channels/ditches	Closure	Low	Landscape	Long	Continuous	Reversible short-term	Low	Medium	High	Not Significant (Minor)	Not Required
Decrease in the productive capacity of aquatic habitat within non-fish bearing reaches of Gingrass Creek due to water quantity changes (McTagg Creek diversion and hydropower plant development)	McTagg Power Plant; McTagg Twinned Diversion Tunnels; diversion channels/ditches	Construction	Low	Landscape	Medium	Continuous	Reversible long-term	Neutral	High	High	Not Significant (Minor)	Not Required
Decrease in the productive capacity of aquatic habitat within non-fish bearing reaches of Gingrass Creek due to water quantity changes (McTagg Creek diversion and hydropower plant development)	McTagg Power Plant; McTagg Twinned Diversion Tunnels; diversion channels/ditches	Operations	Low	Landscape	Long	Continuous	Reversible long-term	Neutral	High	High	Not Significant (Minor)	Not Required
Decrease in the productive capacity of aquatic habitat within non-fish bearing reaches of Gingrass Creek due to water quantity changes (McTagg Creek diversion and hydropower plant development)	McTagg Power Plant; McTagg Twinned Diversion Tunnels; diversion channels/ditches	Closure	Low	Landscape	Medium	Continuous	Reversible short-term	Neutral	High	High	Not Significant (Minor)	Not Required
Decrease in the productive capacity of aquatic habitat within non-fish bearing reaches of Gingrass Creek due to water quantity changes (McTagg Creek diversion and hydropower plant development)	McTagg Power Plant; McTagg Twinned Diversion Tunnels; diversion channels/ditches	Post-closure	Low	Landscape	Far future	Continuous	Reversible short-term	Neutral	High	High	Not Significant (Minor)	Not Required

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There is a high probability of a residual effect of erosion and sedimentation in aquatic habitats during the construction and operation phases of the Project. There is a good understanding of the cause-effect relationship of erosion and sedimentation in aquatic habitats and therefore a high level of confidence of the residual effects assessment for sedimentation.

The residual effect of erosion and sedimentation on aquatic habitat will be negligible following mine closure. This will be due to the reduction of the disturbance of new areas, and the reclamation of previously disturbed areas. Any residual effect of erosion and sedimentation following mine closure will be sporadic, and will have a local, medium-term effect (one to five years). It will be reversible over the long term with the flushing of the system following spates, and recolonization as required by aquatic organisms. The receiving environment or population has a medium resilience to some sedimentation and will likely respond and adapt to the residual effect of erosion and sedimentation.

There is a medium probability of a residual effect of erosion and sedimentation in aquatic habitats following closure of the Project. There is a good understanding of the cause-effect relationship of erosion and sedimentation in aquatic habitats and therefore a high level of confidence of the residual effect of sedimentation.

Potential residual effects of erosion and sedimentation on aquatic habitats were assessed as **not significant-minor**, largely because the potential effects of erosion and sedimentation on aquatic habitats will be geographically isolated and will only occur sporadically.

15.8.3.2 Water Quality Degradation

15.8.3.2.1 Metals and Process Chemicals

Metals and process chemicals and their potential effects on aquatic habitat and (non-fish) aquatic life are discussed in Sections 15.7.4.1.1 and 15.7.4.1.2. Mitigation of such effects are described in Sections 15.7.4.2.1 (general), 15.7.4.2.2 (metal-specific), and 15.7.4.2.3 (process chemical–specific). Assessment of whether there is the potential for residual effects related to metals and process chemicals is discussed in Sections 15.7.4.3.1 and 15.7.4.3.2. Two principal sources of metals and one principal source of process chemicals may occur due to Project development and have a potential residual effect on fish.

First, ML/ARD may be produced due to the exposure of rock following Project-related construction and blasting activities. At these sites, exposed acid-generating rock may produce acidic runoff and metal leachates that flow into aquatic habitat. For ML/ARD produced in areas outside of the catchment for the Mine Site WSF or the TMF in the PTMA, this pathway for metal introduction into the aquatic environment is considered as a non-point source in the following paragraphs.

A second pathway for metals to enter the aquatic environment is through the discharge or seepage of effluent from the TMF or the Mine Site WSF/WTP. The TMF collects and stores the slurry (tailing solids and supernatant) from the Treaty Process Plant, and may contain both metals and process chemicals. The Mine Site WSF/WTP collects and treats water from throughout the Mine Site that has been in contact with mine pits, RSFs, and other areas where PAG rock may have been exposed during construction or Project activities. These two facilities collect potentially metal-bearing water into one place, which is then discharged to the environment at one or more discharge points (i.e., point sources).

Effluent discharged from these components may also include process chemicals such as cyanide (TMF), calcium (from lime use at the Mine Site WTP), or sulphate (from sulphuric acid use at the Mine Site WTP). Since these process chemicals are a constituent of the effluent and were included in the water quality model predictions, they are considered in this section together with metals from point sources (i.e., either TMF or Mine Site WTP discharges). Some of the ML/ARD produced during road and infrastructure construction may occur within the catchment areas for the Mine Site WTP or the TMF, and are therefore captured in the water quality model predictions for metal concentrations in receiving environments downstream of these point sources.

Metals from Non-point Sources

Once initiated, the generation of ML/ARD from exposed PAG rock may continue for decades. Alteration of aquatic habitat may occur, or non-fish aquatic life may be at risk of toxicity due to metals from non-point sources, such as ML/ARD from road and infrastructure construction, since they may be found in waterways near road construction. Effective mitigation, through the implementation of the ML/ARD Management Plan (Section 26.14), the Erosion Control Plan (Section 26.13.2), the Fish and Aquatic Habitat Effects Protection and Mitigation Plan (Section 26.18.1), and the Aquatic Effects Monitoring Plan (Section 26.18.2) will substantially minimize effects of ML/ARD associated with non-point sources to aquatic habitat, although some limited risk remains.

It is likely that the potential for effects will be limited to a localized area that is just outside of the Project footprint (i.e., the aquatic environment adjacent to a Project road footprint; landscape geographic extent) and will only occur for short durations before the problem is identified and mitigated. Since the duration of ML/ARD introduction into the aquatic environment is likely short, and the ML/ARD introduction to the aquatic environment will likely be slow (runoff) and further mitigated by dilution in the flowing water of potentially affected waterways, the magnitude of potential effects was assessed as low. The ML/ARD Management Plan addresses for how PAG rock will be handled, and indicates that mitigation measures would be applied as appropriate, so the frequency of potential effects was assessed as sporadic. Should toxicity due to ML/ARD occur, the effects will dissipate through long-term, natural processes (reversible in the long term). Resiliency was assessed as high because aquatic organisms are sensitive to toxicity and the sediment may retain some of the metals that are introduced (high context). However, if the appropriate management and monitoring plans are adhered to, the overall probability of ML/ARD toxicity to aquatic habitat was assessed as low, with high confidence. Thus, potential effects associated with ML/ARD from non-point sources was assessed as **not significant – minor** for aquatic habitat.

Tailing Management Facility Discharge

Discharge from the TMF has the potential to introduce metals and other chemicals that can cause toxicity to fish in downstream environments, which could affect aquatic habitat. Assessment for potential residual effects associated with Mine Site WTP discharge was done using calculated HQs followed by individual assessment of metals where the HQ was greater than 1.0. Data from the expected case of the water quality model indicate that water quality downstream of the TMF is expected to be lower than BC water quality guidelines for most metals (Chapter 14). However, as discussed in Section 15.7.4.3.1, selenium and mercury are unique among metals since their primary route of uptake is through the diet and they have the potential to bioaccumulate and were therefore also assessed relative to baseline concentrations. While these metals are predicted to remain below water quality guideline concentrations and mercury is predicted to remain below baseline levels, there are some periods when water concentrations of selenium may be greater than concentrations measured during baseline studies (HQ greater than 1.0; see Table 15.7-5).

Selenium is expected to increase slightly compared to baseline concentrations in North Treaty Creek (NTR2) and South Teigen Creek (STE3) which are closest to the TMF (Table 15.7.-5) during some months in various phases of the Project. Selenium water concentrations in Treaty (TRC2) and Teigen (TEC2) creeks are predicted to remain at or below baseline levels (Table 15.7-5). These slight increases in North Treaty or South Teigen creeks may pose a risk to non-fish aquatic life, since increased uptake may be possible if the additional selenium enters the food chain either due to increased tissue residues or increased biomass.

These slight increases in North Treaty or South Teigen creeks may pose a risk to aquatic habitat, since increased accumulation of selenium in the sediment or uptake of selenium by aquatic biota may occur (Section 15.7.4.3.1). Qualitatively, an increase in concentration of selenium in the water is likely to increase the concentration of the metal in both sediment and non-fish aquatic life (primary producers and benthic invertebrates). The potential increase in selenium sediment or tissue concentrations is likely small, since the relative increase in predicted concentration relative to baseline concentration is small and occurs only periodically.

The main concern with selenium in organisms of the lower trophic levels (primary producers, primary consumers, and secondary consumers) is that they are very efficient at taking up and storing selenium from the aquatic environment and biomagnifying it between trophic levels (Chapman, Adams et al. 2009; Janz, DeForest et al. 2009). When aquatic insects or benthic invertebrates containing selenium in their tissues become prey for fish, they can pass their body burdens along to the fish. In this way, organisms at higher trophic levels can accumulate concentrations of selenium that can cause toxicity, even if water concentrations are below guideline limits (Sections 15.7.4.3.1 and 15.8.2.5.1). However, most (non-fish) aquatic life such as bacteria, periphyton, and benthic invertebrates are more tolerant of selenium exposures and can bioaccumulate it without adverse effects (Janz, DeForest et al. 2009), although there are some species that are sensitive to selenium toxicity (DeBruyn and Chapman 2007). Therefore, even though accumulation of selenium in aquatic habitat (sediment) and aquatic life (primary producers and benthic invertebrates) can be a concern for higher trophic levels, it may not be a cause for concern in organisms of the lower trophic levels, particularly at the low selenium concentrations predicted downstream of the TMF.

The assessment of significance of the residual effects for TMF discharge is based on predicted water concentrations for selenium at the sites downstream of the TMF and the potential for selenium to accumulate in aquatic habitat (e.g., sediment) and (non-fish) aquatic organisms and cause toxicity.

The concentrations of selenium in sediment and (non-fish) aquatic life tissues are likely to increase if water concentrations of selenium increase. However, increased tissue residues are unlikely to cause toxicity in lower trophic level organisms; therefore, the magnitude of the potential residual effects was assessed as low in all Project phases. The geographic extent of the residual effect was determined to be landscape for aquatic habitat, since any effects are expected to occur downstream of the TMF, which will be outside of the Project footprint. The potential for residual effects due to selenium will decrease with distance from the discharge point due to dilution, and effects are not predicted in Treaty or Teigen creeks.

For aquatic habitat, the duration of the potential effect was assessed as long term for the operation phase and medium term for the closure phase since the potential for selenium bioaccumulation in either sediment or lower trophic level organisms may occur sporadically during the entire phase. For the post-closure phase, the potential for selenium bioaccumulation would be expected to decrease over time since no new inputs to the TMF would occur after the operation phase. Therefore, the duration of the effect was assessed as long term, since selenium water concentrations would be expected to decrease over time to baseline concentrations.

The frequency of the residual effect was determined to be sporadic for aquatic habitat since the increases in selenium water concentrations relative to baseline occur only intermittently during the year in the areas nearest the TMF discharge points. Should effects occur (bioaccumulation and/or toxicity), they would likely be reversible in the long term as the concentrations of selenium in the water would be expected to decrease over time during the post-closure phase. Aquatic habitat and lower trophic level organisms would likely release selenium from the sediment and tissue residues once inputs of selenium in the water are terminated. Although some cycling of selenium may occur between sediment and aquatic life during this time, the lotic nature of the aquatic environment downstream of the TMF may encourage the movement of selenium out of the area and a return to baseline conditions. For discharges from the TMF, the resiliency (context) of aquatic habitat was assessed as low as there is high resilience to selenium bioaccumulation (i.e., lower trophic level organisms are often quite tolerant of higher tissue residues).

For aquatic habitat and (non-fish) aquatic life, the probability that selenium toxicity would occur is low during all phases since elevated selenium water concentrations occur only sporadically relative to baseline and because these organisms are more tolerant of selenium than fish. The confidence of the assessment was considered to be high for aquatic habitat in all phases since the magnitude of the potential increases is low and aquatic habitat is less sensitive to potential toxic effects of selenium. Therefore, the final determination of significance for aquatic habitat is **not significant - minor**.

Implementation of the Aquatic Effects Monitoring Plan (Section 26.18.2) will be critical to ensuring that trends in the selenium concentrations in tissue are monitored regularly in the lower trophic levels to provide a level of protection to fish. The monitoring plan will ensure detection of significant alterations in productive capacity or aquatic life, ensure measurement of tissue metal concentrations in benthic invertebrates, allow for identification of potential causes, include development of triggers for risk assessment of potential effects, and provide adaptive management strategies.

Mine Site Water Treatment Plant Discharge

Discharge from the WTP also has the potential to introduce metals and other chemicals that may cause toxicity in (non-fish) aquatic life in the downstream aquatic habitat. During baseline studies, it was found that the quantity and quality of aquatic life (periphyton and benthic invertebrates) was low in Sulphurets Creek (SC2 and SC3) and only slightly better in the Unuk River (UR1 and UR2; Section 15.1.5.2, and Appendices 15-B and 15-D).

Assessment for potential residual effects associated with Mine Site WTP discharge was done using calculated HQs followed by individual assessment of metals where the HQ was greater than 1.0. In addition, as selenium and mercury may bioaccumulate through the diet, they were also assessed using HQs relative to both guideline limits and baseline concentrations. Data from the expected case of the water quality model indicated that water quality downstream of the Mine Site WTP is expected to meet BC water quality guidelines (total metals, HQ less than 1.0) for most metals (Section 15.7.4.3.1; Chapter 14). While dissolved aluminum, copper, and total iron were initially identified through screening (i.e., HQ greater than 1.0 in some months), individual assessment of these metals suggested that they would not lead to potential residual effects.

The only metal that was identified following individual assessment metals with an HQ that was greater than 1.0 downstream of the Mine Site WTP was selenium, which is predicted to be greater than both guideline limits and background concentrations in the water during all phases of the Project, starting in year 15 of the operation phase, in Sulphurets Creek (SC2 and SC3) and the Unuk River (UR1). Concentrations of selenium in the water are predicted to be below BC water quality guidelines at the UR2 site on the Unuk River, but above baseline water concentrations measured at this site. Table 15.7-6 provides a summary of the HQs for selenium throughout the Project phases for sites downstream of the Mine Site WTP.

As noted above for discharges from the TMF, the main concern with selenium in organisms of the lower trophic levels (primary producers, primary consumers, and secondary consumers) is that they are very efficient at taking up and storing selenium from the aquatic environment and biomagnifying it between trophic levels, with the potential for toxic effects in higher trophic level organisms (Chapman, Adams et al. 2009; Janz, DeForest et al. 2009). Most (non-fish) aquatic life such as bacteria, periphyton, and benthic invertebrates are more tolerant of selenium exposures and can bioaccumulate it without adverse effects (Janz, DeForest et al. 2009), although there are some species that are sensitive to selenium toxicity (DeBruyn and Chapman 2007). Therefore, even though toxicity due to accumulation of selenium in aquatic habitat (sediment) and aquatic life (primary producers and benthic invertebrates) can be a concern for higher trophic levels, it may not be a cause for concern in organisms of the lower trophic levels.

The assessment of significance of the residual effects for Mine Site WTP discharge is based on predicted water concentrations for selenium at the sites downstream of the WTP and the potential for selenium to accumulate in the aquatic habitat (e.g., sediment) and (non-fish) aquatic organisms and cause toxicity.

The concentrations of selenium in sediment and (non-fish) aquatic life tissues are likely to increase if water concentrations of selenium increase, and increases in selenium sediment or tissue residue concentrations are likely to be detectably different from baseline conditions. While increased tissue residues are less likely to cause toxicity in lower trophic level organisms (Janz, DeForest et al. 2009), the predicted concentrations are higher downstream of the WTP (i.e., greater than water quality guidelines), so there is the potential for toxicity to aquatic invertebrates. Therefore, magnitude of the potential residual effect was assessed as high in all Project phases. The geographic extent of the residual effect was determined to be regional for aquatic habitat, since selenium concentrations are predicted to be greater than BC water quality guidelines at UR1, but below guidelines at UR2. The potential for residual effects (accumulation of selenium in sediment and aquatic life; toxicity to aquatic life) due to selenium will decrease with distance from the discharge point due to dilution.

For aquatic habitat, the duration of the potential effect was assessed as long term for the operation phase, medium term for the closure phase, and far future for the post-closure phase since the potential for selenium bioaccumulation in either sediment or lower trophic level organisms and toxicity to aquatic invertebrates may occur throughout the entire phase. The frequency of the residual effect was determined to be continuous for aquatic habitat since the increases in selenium water concentrations relative to both water quality guidelines and baseline occur continuously during the year, starting in approximately year 15 of the operation phase.

Should effects occur (bioaccumulation and/or toxicity), they would likely be reversible in the long term as the concentrations of selenium in the water would be expected to decrease over time during the post-closure phase (far-future). For discharges from the WTP, the resiliency (context) of aquatic habitat was assessed as moderate as there is high resilience to selenium bioaccumulation (i.e., lower trophic level organisms are often quite tolerant of higher tissue residues), but since the concentrations are predicted to be greater than water quality guidelines for the protection of aquatic life throughout all phases (Table 15.7-6; Chapter 14), more sensitive aquatic invertebrates may experience toxicity.

For aquatic habitat and (non-fish) aquatic life, the probability that selenium toxicity would occur is low during all phases since, although elevated selenium water concentrations occur continuously, aquatic habitat, primary producers, and benthic invertebrates are more tolerant of selenium than fish. The confidence of the assessment was considered to be medium for aquatic habitat in all phases since there is uncertainty about the magnitude of the potential increases in tissue residue due to bioaccumulation and the potential for toxic effects in (non-fish) aquatic life. Therefore, the final determination of significance for aquatic habitat is **not significant - minor**.

Implementation of the Aquatic Effects Monitoring Plan (Chapter 26.18.12) will ensure that trends in selenium concentrations in tissue are monitored regularly in the lower trophic to determine if toxicity is occurring in these organisms and to provide a level of protection to fish. The monitoring plan will ensure detection of significant alterations in productive capacity or aquatic life, provide measurement of tissue metal concentrations in benthic invertebrates, allow for identification of potential causes, include the development of triggers for risk assessment of potential effects, and include the provision of adaptive management strategies.

15.8.3.2.2 Petroleum Products

The potential effects of petroleum product introduction into aquatic habitat are described in Section 15.7.4.1.3, and mitigation measures are described in Section 15.7.4.2.4. Aquatic habitat may be primarily affected due to construction, operation, and closure of the access roads, the transmission line, camps, and other infrastructure that is located near waterways. The main pathway of petroleum product introduction into aquatic habitat during normal Project activities will be during work in and around waterways. As noted in Section 15.7.4.1.3, the potential influence on aquatic environments due to large spills or accidents involving petroleum products was not considered in this chapter since they are not a normal occurrence during routine Project activities.

The residual effects for petroleum products were assessed on the basis of potential for contamination of sediments and/or water leading to toxicity in (non-fish) aquatic organisms. The magnitude of potential effects was assessed to be low. This is because the amount of product introduced during normal Project activities is expected to be low with implementation of mitigation and management plans (Section 15.7.4.2.4). The extent of the potential for residual effects is considered landscape, since the effect may extend beyond the actual footprint of the Project into localized areas in the immediate vicinity of where small amounts of petroleum products may be introduced. The duration of the effect is short term since only small quantities of petroleum products would be released to the environment, so the potential for toxic effects to aquatic life would be short lived (less than one year). The frequency of occurrence would be sporadic, since work in and around water will occur occasionally. The potential for toxicity to aquatic life will be likely reversible in the short term due to dilution in the receiving environment and the partitioning of the hydrophobic components of the petroleum products to the sediment that would decrease the bioavailability of the products. The context was determined to be neutral since aquatic life are sensitive to toxic effects from petroleum product exposure but are unlikely to be exposed to concentrations high enough for long enough to cause toxicity (moderate resilience). The probability of occurrence is low, with high confidence, since various mitigation and management plans will be implemented to minimize the potential for effects due to petroleum products.

Potential residual effects of petroleum product introduction to aquatic habitat during normal Project activities were assessed as **not significant – minor** in the LSA and RSA, largely because the potential effects of petroleum product spills are geographically isolated and occur sporadically. No additional or follow-up monitoring is required.

15.8.3.2.3 Nitrogen or Phosphorus

The potential effects of nitrogenous compounds (from blasting residue or STP effluent) or phosphorus (STP effluent) are described in Section 15.7.4.1.4, and mitigation measures are described in Section 15.7.4.2.5. Blasting residues could be generated during the construction and operation phases of the Project. Project-specific modes of blasting residues during construction include the construction of all Project access roads, TMF, tunnelling and portal development, development of overburden and non-ore RSFs and pits, construction of the WSD, and diversion ditches and tunnels. Blasting residues will be generated during the operation phase for Project activities associated with continuous blasting and rock removal, such as pit areas. Potential sources of sewage effluent include all camps during the construction, operation, and closure phases.

There are two main potential effects associated with nitrogenous compounds or phosphorus. First, nitrogenous compounds can cause toxicity in aquatic organisms. Second, both nitrogenous compounds and phosphorus can alter aquatic productive capacity due to changes in nutrient loading that can affect the overall trophic status of aquatic systems.

Most of the potential input of nitrogen and phosphorus from blasting and effluent from STPs will be with the catchments for the TMF and Mine Site WTP, so were included in the water quality model as sources (Chapter 14). Therefore the water quality model predictions (Chapter 14; Appendix 14-H), were used to directly assess potential effects associated with nitrogen and phosphorus.

Toxicity due to Nitrogenous Compounds

The potential for toxicity associated with nitrogenous compounds to (non-fish) aquatic life is based on whether predicted concentrations of ammonia or nitrate will meet water quality guidelines for the protection of aquatic life. Downstream of both the TMF and the Mine Site WTP, ammonia and nitrate are predicted to remain below water quality guidelines at all of the monitoring sites during all phases of the Project.

The magnitude of the potential for toxicity to (non-fish) aquatic life due to nitrogenous compounds was determined to be negligible since the potential for effects will decrease with distance from the discharge point. The potential effect was assessed to have landscape geographic extent since the effects may occur immediately downstream of a discharge point, which would be just outside of the Project footprint. The duration and frequency of the effect (toxicity) was considered to be short term and sporadic, since exposures would be localized to the area immediately downstream of the discharge point and since aquatic life may be able to adapt to new conditions. The reversibility and context was assessed as reversible, short term, and neutral, since the aquatic habitat may have moderate resilience to nitrogenous compounds, depending on which organisms are present at the potentially affected area.

Potential residual effects of blast residues and sewage effluent on aquatic habitats were assessed as **not significant - minor** in the LSA, largely because the potential for toxicity of aquatic life due to nitrogenous compounds occurs only in localized areas.

Nutrient Loading – Nitrogen and Phosphorus

Compared to baseline loading, the nitrogen and phosphorus loading rates during different phases of the Project were predicted to change for areas downstream of the TMF and Mine Site WTP discharges (Table 15.7-8). This has the potential to affect the primary production, and hence, the trophic status of the receiving environment (Table 15.7-7) and primary production. Therefore, there is some potential for residual effects on productive capacity due to nutrient loading.

The magnitude of the potential residual effect is low during construction, closure, and post-closure, since inputs of nitrogenous compounds and phosphorus will be low during these phases and therefore changes to productive capacity are likely to be smaller. During the operation phase, the magnitude of the effect was assessed as low. Although the nutrient loadings are predicted to be higher, biomass accumulation will be likely still controlled by the length of time between flood events, which will be unchanged because of no major predicted changes to flow regimes of streams most affected by nutrient loading, and by top-grazing effects by instream invertebrates. The extent of the effect was assessed to be landscape, since changes in nutrient loads will be different from baseline conditions downstream of discharge points. The duration of the potential effect was determined to be short and sporadic during all phases, since the potential effects due to changes in nutrient loads are only important during summer months (i.e., seasonal and therefore intermittent). The effect was determined to be reversible in the short term with low context, since the primary producer and benthic invertebrate communities are regularly changing in response to various conditions (such as light, temperature, nutrients, etc.) and are therefore quite resilient to changes in nutrient loads. The probability that there will be alteration in primary producer and benthic invertebrate communities is medium with medium confidence, since changes in the community structure or biomass could occur but the magnitude of the effect is difficult to predict since it is multi-factorial (i.e., depends on other environmental conditions as well).

Therefore, the potential for residual effects due to changes in nutrient loading on aquatic habitat (specifically productive capacity) were assessed as **not significant - minor** in the LSA and RSA.

15.8.4 Habitat Loss and Alteration

15.8.4.1 Fish Habitat

15.8.4.1.1 Overview

Fish habitat loss refers to removing or physically altering aspects of the environment directly or indirectly used by fish. More specifically, fish habitat loss can refer to the removal of riparian and instream habitat, the loss of fish habitat productive capacity, restricting fish passage, and the alteration of water quantity. Similar effects may occur in non-fish-bearing waterways, and these effects are discussed as aquatic habitat loss and alteration. Project-specific fish and aquatic habitat loss is described in detail in Section 15.7.5.1, while mitigation is outlined in Section 15.7.5.2.

Project-specific fish and aquatic habitat loss and alteration will be caused through the construction, operation, and closure of Project infrastructure (Table 15.7-15). There will be Project-related fish habitat loss associated with the following:

- the TMF and seepage collection pond;
- TMF infrastructure;
- water quantity loss downstream of the TMF;
- access road stream crossings (TCAR and CCAR); and
- transmission line stream crossings.

15.8.4.1.2 Project Infrastructure Habitat Compensation

Compensation

Project access roads are expected to remove 1,108 m^2 of fish habitat due to the installation of bridge piers, culverts, and rip-rap. The TMF and seepage pond dams are expected to remove 39,415 m^2 of fish habitat. The transmission line will not produce a loss or alteration of instream habitat; however, 9,000 m^2 of riparian habitat will be altered due to the clearing of vegetation for the alignment. Water quantity changes downstream of the TMF in South Teigen and North Treaty creeks will result in a loss of 4,211 m^2 of fish habitat. For all areas where fish habitat loss is unavoidable and unmitigable, compensation will be carried out to achieve the policy of no net loss of productive capacity of aquatic habitat as outlined by DFO (1986). The HADD Fish Habitat Compensation Plan (Appendix 15-R) will effectively compensate for fish habitat loss by creating additional fish habitat within and outside of the LSA and RSA according to DFO's no net loss policy (DFO 1986).

The objectives of the compensation plan are to follow DFO's regulatory requirements for Fisheries Authorizations, including:

- to describe the physical and biological characteristics of the habitat that will be lost;
- to propose technically feasible compensations projects, as per regulatory requirements, that will provide compensatory habitat at a minimum 2:1 ratio;
- to describe the methods that were used to prepare a habitat budget;
- to describe the methods that will be used to mitigate the effects of habitat construction; and
- to describe the post-monitoring evaluation program.

Field assessments implemented in 2008 and 2009 provided the information necessary to describe the physical habitat (bankfull width, bankfull depth, gradient, stream length, etc.) and biological attributes (riparian cover, instream cover, fish community) of each stream and reach where a loss of fish habitat will occur within the TMF. This information was used to assign fish habitat suitability indices to each stream and wetland.

The total area of habitat that will be lost was calculated from the proposed design of Project infrastructure and the results of water quantity modelling. By multiplying each area by the appropriate HSI, habitat units (HUs) were calculated that incorporate both quantity and quality of habitat.

Pre-field planning and field assessments implemented in 2009, 2010, and 2011 provided the information necessary to identify technically feasible compensation projects. Two compensation projects in the Teigen and Glacier creek watersheds were identified as compensation sites to offset fish habitat loss. Existing site conditions, project objectives and techniques, and designs are discussed for each project within the report. The number of HUs that will be created are presented for each project.

The Habitat Evaluation Procedure was used to prepare a habitat budget. Peer-reviewed HSIs were used for HU calculation. A peer-reviewed habitat suitability model does not exist for Dolly

Varden; hence, HSI values were obtained from a search of the scientific literature on Dolly Varden habitat preferences.

A total area of 53,734 m^2 (5.37 ha) of fish habitat will be lost from construction of the TMF, seepage collection ponds, access road crossings, and transmission line crossings, and due to water quantity reductions in North Treaty and South Teigen creeks downstream of the dams. This represents a total of 91,115 HUs. Two fish habitat compensation sites were identified to compensate for the Project-related habitat loss: Teigen Creek Site 1 and Glacier Creek Site 1.

Teigen Creek Site 1 is located on the north side of the Teigen Creek Valley, approximately 0.8 km upstream of the South Teigen Creek confluence. The nearest road to the site is Highway 37, approximately 7 km to the northeast. The proposed compensation sites will provide a large amount of permanent, good-quality habitat for rearing and overwintering along with spawning habitat for coho salmon. Teigen Creek Site 1 will support all life stages of two target species: Dolly Varden and coho salmon. This site will address legislated fisheries management objectives for DFO and provincial fisheries agencies and will provide multi-species benefits.

The objectives for Teigen Creek Site 1 are:

- to construct a surface-water intake from Teigen Creek to supply reliable flow into a protected off-channel and through a series of ponds;
- to create 14.55 ha of good quality overwintering and rearing habitat in ponds;
- to construct 1,889 m of channels to create 0.38 ha of habitat with complex features (pools, riffles, wood, boulders);
- to enhance the functional aspects of wetland ecosystems (e.g., nutrient recycling, water quality improvement, and fish and wildlife habitat);
- to provide spawning habitat for coho salmon and Dolly Varden using wood cover, gravel substrate, and deep pools within the constructed channels; and
- to maintain fish access and prevent beaver dam construction with beaver-proof fencing and wood structures at pond outlets.

The 0.41 ha of existing poor quality, shallow fish habitat in Teigen Creek Site 1 will be replaced with 14.93 ha of good quality habitat. This is greater than a 25-fold increase in habitat at the site. A total of 262,882 HUs and 145,114 m^2 will be gained from this site.

Glacier Creek is a moderate-size, third-order tributary to the Bell-Irving River that crosses Highway 37 about 20 km south of Bell 2 Lodge. Glacier Creek Site 1 is adjacent to Reach 1 of Glacier Creek between the Highway 37 culvert and the confluence with the Bell-Irving River.

The proposed compensation site will provide a large amount of permanent, good-quality habitat for rearing and overwintering, along with spawning habitat for coho salmon. Glacier Creek Site 1 will support all life stages of two target species: Dolly Varden and coho salmon. This site will address fisheries management objectives for DFO and provincial fisheries agencies, and provide multi-species benefits.

The objectives for Glacier Creek Site 1 are:

- to construct groundwater-fed off-channel habitat, with surface water intake from Glacier Creek, to supply reliable flow into the protected off-channel and through a series of ponds;
- to create 1.90 ha of good quality overwintering and rearing habitat in ponds;
- to construct 808 m of channels to create 0.16 ha of habitat with complex features (pools, riffles, wood, boulders);
- to create functional aspects of wetland ecosystems (e.g., nutrient recycling, water quality improvement, and fish and wildlife habitat);
- to provide spawning habitat for coho salmon and Dolly Varden using wood cover, gravel substrate, and deep pools within the constructed channels; and
- to maintain fish access and prevent beaver dam construction with beaver-proof fencing and wood structures at pond outlets.

No fish habitat currently exists at Glacier Creek Site 1; therefore, 2.06 ha of good quality habitat would be constructed. A secondary outcome of this off-channel fish habitat project will be the creation of wetland functions. These include providing additional fish and wildlife habitat, water quality improvement, water storage, and nutrient cycling. A total of 38,035 HUs and 20,580 m^2 will be gained from this site.

A total area of 165,694 m^2 (16.57 ha) of fish habitat will be created as a result of the proposed Teigen and Glacier creeks technically feasible compensation projects. This represents a total of 300,917 HUs. The ratio of compensatory habitat area to lost habitat area is 3.1:1. The ratio of compensatory HUs to lost HUs is 3.3:1, which is greater than the minimum 2:1 ratio typically requested by DFO. Therefore, the requirements to compensate for Project-related fish habitat loss will be achieved.

Potential Effects and Mitigation of Compensation Sites

At Teigen Creek Site 1, potential effects due to fish habitat compensation works may include loss of existing fish habitat and fish populations, loss of western toad habitat, and the loss or alteration of provincially rare blue-listed ecosystems. Fish habitat quality at the site was considered poor in mid-summer in most of the shallow beaver ponds. Shallow ponds were frozen to the bottom during mid-winter, or nearly frozen with 0.3 m of water depth under ice. No fish were caught in these ponds, and dissolved oxygen concentrations were low (2.5 mg/L). Overwintering habitat quality was strongly influenced by the presence of winter base flow, groundwater seepage, and ice thickness. Most of the existing beaver ponds at the site provided poor quality overwintering habitat. In summary, the existing habitat at the site was of poor quality with obstructed fish access such that the overall productivity was low. Fish access through the beaver pond complex was obstructed by beaver dams and fish could not access habitat upstream of dams. Contributing to the fish access problem was the lack of perennial flow, lack of water depth, mainly organic substrate and discontinuous channels between ponds. Typically, coho salmon juveniles rear in off-channel areas similar to the Teigen Creek site, but their absence was likely due to a combination of these limitations. Therefore, the potential effects of compensation are predicted to be low on existing fish and fish habitat, and the proposed works would increase the productive capacity at the site.

Western toad is listed as a rare species, is designated as a “species of special concern” by the Committee on the Status of Endangered Wildlife in Canada, and is present on Schedule 1 of the federal *Species at Risk Act* (2002). The species is also present on the red list published by the International Union for Conservation of Nature (2013). Western toads were not observed at the site during breeding surveys. No breeding sites were confirmed, however, suitable breeding habitat was present at the site. To mitigate for western toad habitat loss at compensation sites with potential/confirmed toad habitat, the following measures will be implemented in the design and construction phases of the Project site:

- create ponds with shallow areas that maintain solar radiation of the ponds, allowing for suitable toad larval rearing habitat;
- create ponds with deep areas that increase the hydroperiod of the ponds to maintain pond habitat throughout the breeding and larval development stages;
- plant emergent aquatic vegetation within pond;
- create mudflats along the pond margins to provide breeding habitat; and
- construct compensation projects that will adhere to western toad breeding and rearing timing windows (i.e., mid-May to early September) within toad habitat.

The following provincially rare blue-listed ecosystems are present at the site: Fm03, Ws06, and Fl02. To mitigate for rare ecosystem habitat alteration and/or loss at compensation sites with rare ecosystems, the following measures will be implemented in the design and construction phases of the Project site:

- develop prescriptions to avoid or minimize degradation to rare ecosystems at a spatial and temporal scale prior to construction (including providing a clear definition of degradation, and methodology on how to measure it);
- design off-channel complexes to simulate natural conditions through seasonal flooding;
- ensure clearing activities are coordinated with other timing restrictions for wildlife and fish; and
- manage construction spoil to not affect identified rare ecosystems.

At Glacier Creek Site 1, potential effects due to fish habitat compensation works may include loss or alteration of provincially rare blue-listed ecosystems. The mitigation measures listed above are the same for Glacier Creek Site 1.Additional mitigation measures for construction are identified in the HADD Fish Habitat Compensation Plan (Appendix 15-R).

15.8.4.1.3 Tailing Habitat Compensation

Compensation

The TMF and seepage ponds will require a Section 36(1) *Fisheries Act* (1985) authorization to permit the deposit of deleterious substances within fish-bearing watercourses. Section 36(1) of the MMER (SOR/2002-222) governs compensation for the loss of fish habitat within the TMF. The TMF and seepage ponds will result in a loss of fish habitat in South Teigen and North Treaty watersheds. The TMF is expected to result in the loss and alteration of 89,620 m^2 of fish habitat. The MMER Fish Habitat Compensation Plan (Appendix 15-Q) will effectively compensate for fish habitat loss by creating additional fish habitat within and outside of the LSA and RSA according to DFO's no net loss policy.

A total area of 89,620 m^2 (8.96 ha) of fish habitat will be lost from South Teigen and North Treaty watersheds due to the deposit of deleterious substances into the proposed TMF and seepage collection ponds. This represents a total of 153,982 HUs. Two fish habitat compensation sites were identified to compensate for the Project related habitat loss: Treaty Creek Site 1 and Taft Creek Site 1.

Treaty Creek Site 1 is located at the junction of North Treaty and Treaty creeks. It is approximately 8 km southeast of the TMF and approximately 20 km upstream of the confluence of Treaty Creek and the Bell-Irving River. The nearest road to the site is Highway 37, approximately 22 km east, but once the TMF is built, the TCAR will be immediately adjacent to Treaty Creek Site 1.

Treaty Creek Site 1 in the Treaty Creek watershed provides a unique opportunity to divert water from North Treaty Creek into a protected side channel and off-channel complex consisting of deep ponds and channels. The proposed Project will provide a large amount of permanent, good quality habitat for rearing, overwintering, and spawning. It will support all life stages of the two target species: Dolly Varden and coho salmon. The BC MOE has developed provincial fisheries management objectives for species (e.g., Dolly Varden) other than migratory Pacific salmon. DFO is responsible for the management of migratory Pacific salmon (e.g., coho salmon). Therefore, this site will address fisheries management objectives for DFO and provincial fisheries agencies and provide multi-species benefit.

The objectives for Treaty Creek Site 1 are:

- to construct a surface water intake from North Treaty Creek to supply reliable flow into a protected side channel and through a series of ponds;
- to create 15.38 ha of good quality overwintering and rearing habitat in ponds;
- to construct 2,118 m of channels to create 0.42 ha of habitat with complex features (pools, riffles, wood, and boulders);
- to enhance the functional aspects of wetland ecosystems (e.g., nutrient recycling, water quality improvement, and fish and wildlife habitat);

- to provide spawning habitat for coho salmon and Dolly Varden using wood cover, gravel substrate, and deep pools within the constructed channels; and
- to maintain fish access and prevent beaver dam construction with beaver-proof fencing and wood structures at pond outlets.

The 0.45 ha of existing poor quality, shallow fish habitat in Site 1 will be replaced with a total of 15.8 ha of good quality habitat. This is greater than a 30-fold increase in habitat at the site that will be included in the HU budgeting. A secondary outcome of this off-channel fish habitat project is the enhancement of key wetland functions. These include providing additional fish and wildlife habitat, water quality improvement water storage, and nutrient cycling. A total of 279,403 HUs and 153,567 m^2 will be gained from this site.

Taft Creek is a large, fourth-order tributary to the Bell-Irving River, comparable in size to Teigen and Treaty creeks. It drains west from a range of steep mountains and contains important fish and fish habitat resources. Taft Creek Site 1 is located on the east side of Taft Creek between the Highway 37 bridge and confluence with the Bell-Irving River, approximately 1 km downstream. It is 35 km south of Bell 2 Lodge.

The proposed compensation site will provide a large amount of good quality habitat for rearing and overwintering along with a small amount of spawning habitat. It will support the two target species: Dolly Varden and coho salmon. Rainbow trout fry and chinook salmon fry may use the constructed site to a minor amount given their preference for moderate velocity summer rearing habitat.

The objectives for Taft Creek Site 1 are:

- to create 4.47 ha of good quality off-channel overwintering and rearing habitat in ponds;
- to construct 968 m of stream channels to create 0.19 ha of rearing habitat with complex habitat features (pools, riffles, wood, and boulders); and
- to maintain fish access and prevent beaver dam construction with beaver-proof fencing and wood structures at pond outlets.

A total of 83,986 HUs and 46,609 m^2 will be gained from this site.

A total area of 200,176 m^2 (20.0 ha) of fish habitat will be created as a result of the two proposed technically feasible compensation projects. This area represents a total of 363,389 HUs. The ratio of compensatory habitat area in this plan to lost habitat area is 2.2:1. The ratio of compensatory HUs to lost HUs is 2.4:1. This is greater than the minimum 2:1 ratio typically requested by DFO. Therefore, the requirements to compensate for Project-related fish habitat loss will be effectively achieved.

Potential Effects and Mitigation of Compensation Sites

In Treaty Creek Site 1, potential effects due to fish habitat compensation works may include loss of existing fish habitat and fish populations, loss of western toad habitat, and loss or alteration of provincially rare blue-listed ecosystems. The mitigation measures listed for Teigen Creek Site 1 are the same for this site.

In Taft Creek Site 1, potential effects may include loss or alteration of provincially rare blue-listed ecosystems. The mitigation measures listed for Teigen Creek Site 1 are the same for this site.

Additional mitigation measures for construction are identified in the MMER Fish Habitat Compensation Plan (Appendix 15-Q).

15.8.4.1.4 Residual Evaluation

Fish habitat loss and alteration was assessed as a one-time event to occur during the construction phase of the Project. This effect, after consideration of fish habitat compensation and management practices, was assessed as medium magnitude. Effects associated with fish habitat loss and alteration are considered landscape in their geographical extent, and their duration will be short term because the time between habitat destruction and creation (i.e., the fish habitat compensation plan) is short. Reversibility of effects was assessed as reversible short-term because habitat compensation measures should replace lost habitat after a couple of years. Because instream and riparian habitat vary in their level of adaptability to alteration, context (or resiliency) was assessed as neutral. Effects to fish habitat will occur due to the construction of Project infrastructure; therefore, the likelihood of effects was assessed as high probability and high confidence. Although potential residual effects associated with fish habitat will occur, effects will be minimized and mitigated through the implementation of several guidelines, BMPs, and plans (e.g., DFO operational statements, timing windows for instream work, and fish habitat compensation plans). Thus, potential residual effects associated with fish habitat loss and alteration caused by access road, transmission line, and TMF construction and resulting downstream water quantity loss were assessed as **not significant-minor**.

15.8.4.2 Non-fish-bearing Aquatic Habitat

In addition to the fish habitat alteration or loss, some aquatic habitat (non-fish-bearing waterways) will also be affected by Project-related activities associated with:

- the McTagg and Mitchell RSFs;
- the mine pits;
- WSF/WTP infrastructure, including the dam and seepage collection pond; and
- water quantity changes due to diversions of non-contact water.

Loss of non-fish-bearing aquatic habitat will also occur in the Mine Site as a result of Project infrastructure construction and operation (mine pits, RSFs, WSF) and diversion of non-contact water from existing creeks (McTagg and Mitchell). This will result in the loss of approximately 97 km of stream length (approximately 30% of total length) in the Mine Site by the end of operation phase. However, there will also be approximately 17 km of new potential aquatic habitat created, as open diversion channels and ditches will be constructed around the Mine Site for non-contact water, so the overall habitat loss will be lower (approximately 25% of the total area). Habitat loss will primarily occur in the construction phase, with some continued loss during the operation phase as RSFs and mine pits are expanded during the operation phase. The lost aquatic habitat will be of low quality, with metal concentrations in the sediments that often exceed the provincial guidelines for the protection of aquatic life, and low in nutrient availability since these are glacier-fed streams downstream of mineral deposits (Section 15.1.5.2). Because the habitat being lost is of low quality and some new habitat will be created in open diversion channels/ditches, the magnitude of the effect was assessed as low. The extent of the effect is local, since the loss occurs within the Project footprint. The loss will occur as a one-time event, and the duration will be far-future since the effect is irreversible. The context (resilience) was assessed as high since the aquatic community within the lost streams cannot adapt or recover in streams that are lost; however, new aquatic communities may establish in the constructed diversion channels/ditches. There is high confidence and high probability that the loss of habitat will occur as a result of Project activities. The significance of the loss of habitat was assessed as **not significant - minor** since the aquatic habitat is of low quality, and baseline studies indicate that the aquatic resources in this area are of low quantity and quality.

Alteration in the productive capacity of aquatic habitat due to water quantity changes may occur in areas downstream of the Mine Site as a result of water diversion (McTagg Creek to Gingras Creek), hydroelectric development (McTagg Power Plant), and staged discharges from the WTP (effects to Mitchell Creek downstream of the discharge point). This may alter the suitability of aquatic habitat for colonization by (non-fish) aquatic organisms as a result of increased flows (scouring) or decreased flows (drying, decreased wetted width). Mitchell Creek, downstream of the WSF, will be subject to periods of time in which there will be limited water due to staged discharges from the WTP and low flow from diversion structures, which may cause the loss of aquatic communities. These effects will occur throughout all phases of the Project. As noted above, the aquatic habitat that will be altered is of relatively low quality, with metal concentrations in the sediments that often exceed the provincial guidelines for the protection of aquatic life and low nutrient availability since these are glacier-fed streams downstream of mineral deposits (Section 15.1.5.2). Since the habitat alteration will occur in an area of low quality habitat and aquatic communities, the magnitude of effects was assessed as low. The extent is landscape since the effects will occur downstream of Project infrastructure. The effects may occur throughout the entirety of each phase of the Project, so duration was assessed as medium for the construction and closure phases, long for the operation phase, and far-future for the closure phase. The effects will occur continuously. The resilience (context) was assessed as medium since aquatic communities will be able to adapt to the new hydrological regimes, and effects will be reversible in the long term as new community dynamics are established. There is a high probability and high confidence that effects will occur since they are a consequence of changes in hydrological regimes associated with Project development.

15.8.4.3 Overall Effect on Aquatic Habitat

The residual effects for aquatic habitat are erosion and sedimentation, water quality degradation, and habitat loss and alteration. These effects can possibly interact, creating additive or synergistic affects that have a different extent for aquatic habitat. Considering these potential effects on aquatic habitat in combination with Project infrastructure in the LSA and RSA and mitigation and compensation to minimize effects, the overall potential Project-related residual effects do not have the potential to affect the viability of aquatic habitat overall, and are assessed as **not significant - minor**.

15.9 Potential Cumulative Effects for Fish and Aquatic Habitat

Project-related residual effects are anticipated for all identified effects (i.e., direct mortality, noise, erosion and sedimentation, water quality degradation, and fish habitat loss and alteration) for all identified fish VCs (i.e., bull trout, Dolly Varden, rainbow trout/steelhead, and Pacific salmon) and aquatic habitat VC. If all activity-specific guidelines, mitigation and management plans, BMPs, DFO operational statements, operating windows, and laws are strictly adhered to, residual effects and cumulative effects may still occur.

Cumulative effects on fish and aquatic habitat can occur when potential KSM Project effects combine with effects caused by other projects. When effects from the Project and other activities combine, the effect of the initial effect can increase due to cumulative or synergistic/antagonistic responses. Cumulative effects from past, present, or potential future activities, along with the KSM Project, were assessed to determine the overall effect to aquatic habitat in the LSA and RSA and downstream watersheds.

15.9.1 Scoping of Cumulative Effects

15.9.1.1 Spatial Linkages with other Projects and Human Actions

Table 15.9-1 summarizes the linkages between the KSM Project and other human actions in regard to fish and aquatic habitat.

Watersheds with the potential to be affected by KSM Project activities include the Unuk River, Sulphurets Creek, Teigen Creek, Treaty Creek, and Bell-Irving River watersheds. Past, present, and/or potential future activities may combine to affect fish and aquatic habitat in the LSA and RSA or in downstream watersheds. The past projects and human activities that may affect fish and aquatic habitat and spatially overlap potential effects from the KSM Project are (Figure 15.9-1):

- Eskay Creek Mine (effluent flows into the Unuk River);
- Granduc Mine (concentrator effluent follows the Bowser River Valley to Bowser Lake);
- fishing; and
- past forestry activities in the Bell-Irving watershed.

Past projects Johnny Mountain Mine and Snip Mine, although relatively close in proximity to the KSM Project, are not included in the cumulative effects assessment (CEA) for fish and aquatic habitat, as their effluent was discharged outside the boundaries of the watersheds potentially influenced by the KSM Project (Figure 5.11-1).

Table 15.9-1. Summary of Potential Linkages between KSM Project and other Human Actions in regards to Fish and Aquatic Habitat

Action/Project		Past	Present	Future
Past Projects	Eskay Creek Mine	X - Road/ watercourse crossings; tailing drain into the Unuk River	NL	NL
	Granduc Mine	X - Road/ watercourse crossings; tailing drain into Bowser River	NL	NL
	Johnny Mountain Mine	NL	NL	NL
	Kitsault Mine (Closed)	NL	NL	NL
	Snip Mine	NL	NL	NL
	Sulphurets Project	X - tailing drain into Sulphurets Creek	NL	NL
	Swamp Point Aggregate Mine	NL	NL	NL
Present Projects	Forrest Kerr Hydroelectric	NL	NL	X - Road/ watercourse crossings for shared section of Eskay Creek Mine Road
	Long Lake Hydroelectric	NL	NL	NL
	NTL (Northwest Transmission Line)	NL	NL	X - construction overlaps; watercourse crossings in the Bell-Irving watershed
	Red Chris Mine	NL	NL	NL
	Wolverine Mine	NL	NL	NL
Reasonably Foreseeable Future Projects	Arctos Anthracite Coal Mine	NL	NL	NL
	Bear River Gravel	NL	NL	NL
	Bronson Slope Mine	NL	NL	NL
	Brucejack Mine	NL	NL	X - tailing drain into Unuk River; Project in Sulphurets watershed; watercourse crossings in Bowser River, Todedada Creek, and Wildfire Creek watersheds
	Galore Creek Mine	NL	NL	NL
	Granduc Copper Mine	NL	NL	X - tailing drain into Bowser River
	Kitsault Mine	NL	NL	NL
	Kutcho Mine	NL	NL	NL
	McLymont Creek Hydroelectric	NL	NL	NL
	Schaft Creek Mine	NL	NL	NL
	Snowfield Project	NL	NL	X - tailing drain into Bowser River from Scott Creek; watercourse crossings in Bowser River, Todedada Creek, and Wildfire Creek watershed
	Storie Moly Mine	NL	NL	NL
	Turnagain Mine	NL	NL	NL
	Treaty Creek Hydroelectric	NL	NL	X - upper watershed of Treaty Creek
Land Use Activities	Agricultural Resources	NL	NL	NL
	Fishing	X	X	X
	Guide Outfitting	NL	NL	NL
	Resident and Aboriginal Harvest	NL	NL	NL
	Mineral and Energy Resource Exploration	X	X	X
	Recreation and Tourism	NL	NL	NL
	Timber Harvesting	X	NL	X
	Traffic and Roads	NL	NL	NL

NL = No Linkage (no spatial and temporal overlap, or potential effects do not act in combination)

X = Potential spatial and temporal linkage with project or action

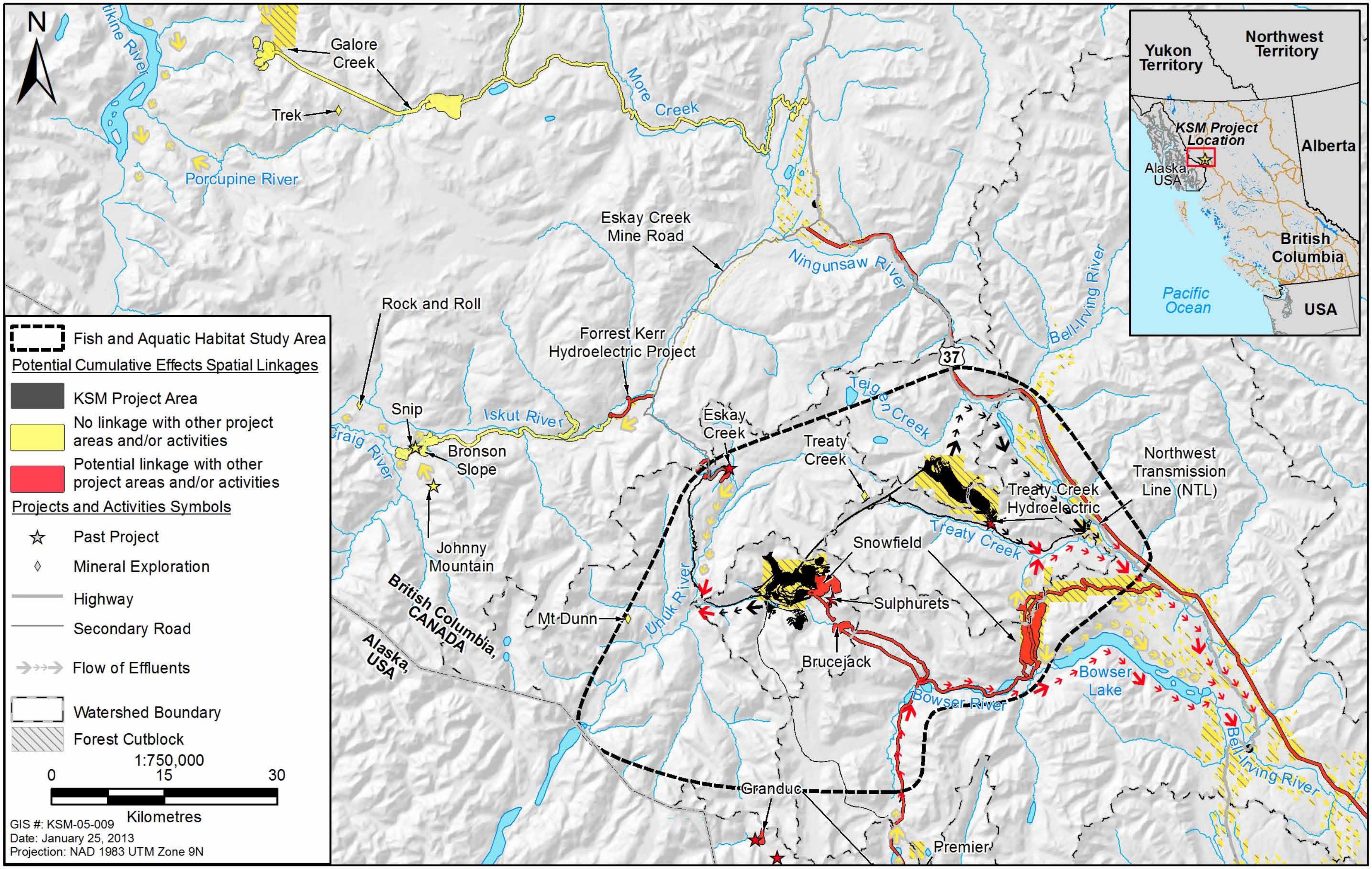

Figure 15.9-1

SEABRIDGE GOLD
KSM PROJECT

KSM Project Cumulative Effects Issue Scoping: Potential Spatial Linkages for Fish and Aquatic Habitat

Figure 15.9-1

Rescan
Engineers & Scientists

Present and future projects and human activities with potential effects to fish and aquatic habitat that overlap spatially with potential effects from the KSM Project include:

- Northwest Transmission Line (access corridor overlaps);
- Forest Kerr Hydroelectric (access corridor overlaps);
- Brucejack Mine (access corridor overlaps and effluent);
- Snowfield Project (access corridor overlaps and effluent);
- Granduc Copper Mine (access corridor overlaps);
- Treaty Creek Hydroelectric (access corridor overlaps);
- fishing;
- possible future mineral and energy resource exploration; and
- possible future forestry activities.

15.9.1.2 Temporal Linkages with other Projects and Human Actions

Effects to fish and aquatic habitat from past projects and human activities may temporally overlap with potential effects from the KSM Project, if effluent from the activities persists in the aquatic environment or if habitat has not had sufficient time to recover from past effects. Past projects and human activities that may overlap temporally with the KSM Project are:

- Eskay Creek Mine;
- Granduc Mine;
- Sulphurets Project;
- fishing;
- mineral exploration; and
- forestry activities.

Present and future projects and human activities with potential effects to fish and aquatic habitat that could overlap temporally with potential effects from the KSM Project are listed in Section 15.9.1.1.

15.9.2 Cumulative Effects Assessment for Fish Valued Components (Bull Trout, Dolly Varden, Rainbow Trout/Steelhead, and Pacific Salmon)

Table 15.9-2 presents a summary of projects and activities with the potential to interact cumulatively with expected Project-specific residual effects for fish VCs. Fish VCs were grouped together within this section because the proposed cumulative effects and mitigation strategies are similar in scope and nature.

Table 15.9-2. Summary of Projects and Activities with Potential to Interact Cumulatively with Expected Project-specific Residual Effects on Fish VCs and Aquatic Habitat VC

Description of KSM Residual Effect	Potential for Cumulative Effect: Relevant Projects and Activities				
	Eskay Creek Mine	Granduc Mine	Sulphurets Project	Forrest Kerr Hydroelectric	NTL (Northwest Transmission Line)
Direct Mortality	Possible Interaction	Possible Interaction	No Interaction	No Interaction	Possible Interaction
Noise	Possible Interaction	Possible Interaction	No Interaction	No Interaction	Possible Interaction
Erosion and sedimentation	Possible Interaction	Possible Interaction	Possible Interaction	Possible Interaction	Possible Interaction
Water Quality Degradation	Possible Interaction	Possible Interaction	Possible Interaction	Possible Interaction	Possible Interaction
Habitat Loss and Alteration	Possible Interaction	No Interaction	No Interaction	No Interaction	Possible Interaction

Description of KSM Residual Effect	Potential for Cumulative Effect: Relevant Projects and Activities				
	Brucejack Mine	Snowfield Project	Granduc Copper Mine	Treaty Creek Hydroelectric	Fishing
Direct Mortality	Possible Interaction	Possible Interaction	Possible Interaction	Possible Interaction	Possible Interaction
Noise	Possible Interaction	Possible Interaction	Possible Interaction	Possible Interaction	No Interaction
Erosion and sedimentation	Possible Interaction	Possible Interaction	Possible Interaction	Possible Interaction	No Interaction
Water Quality Degradation	Possible Interaction	Possible Interaction	Possible Interaction	Possible Interaction	No Interaction
Habitat Loss and Alteration	Possible Interaction	Possible Interaction	Possible Interaction	Possible Interaction	No Interaction

Description of KSM Residual Effect	Potential for Cumulative Effect: Relevant Projects and Activities	
	Mineral and Energy Resource Exploration	Timber Harvesting
Direct Mortality	Possible Interaction	Possible Interaction
Noise	Possible Interaction	Possible Interaction
Erosion and sedimentation	Possible Interaction	Possible Interaction
Water Quality Degradation	Possible Interaction	Possible Interaction
Habitat Loss and Alteration	Possible Interaction	Possible Interaction

15.9.2.1 Project-specific Residual Effects on Fish Valued Components that are Not Likely to Result in Cumulative Effects

All residual effects, except direct mortality, were determined not to have an interaction with fishing because the act of fishing only involves catching fish.

15.9.2.2 Cumulative Effect of Direct Mortality

15.9.2.2.1 Project-specific Cumulative Effects of Direct Mortality

Fishing and the use of heavy equipment in and around water may affect fish in a cumulative manner, if the activities were to drastically increase or spatially extend across a broad area. Increased fishing pressure on bull trout, rainbow trout/steelhead, and Pacific salmon may occur due to improved access to waterbodies near the LSA and RSA. Increased fishing pressure may occur because of all identified relevant projects and activities. The use of heavy equipment caused by the construction and maintenance of access roads or Project-related infrastructure may contribute cumulatively to direct mortality effects.

The majority of past, present, and future projects may cumulatively increase fish mortality; however, the potential for increased mortality is low because there are no fish present within most project infrastructure. Fish are not present within the footprint areas of Eskay Creek Mine, Granduc Mine, Sulphurets Project, Brucejack Mine, Snowfield Project, and Granduc Copper Mine. However, there are fish present within watercourses at past/present/future access roads.

15.9.2.2.2 Project-specific Cumulative Effects Mitigations for Direct Mortality

The effects of direct mortality are generally spatially and temporally isolated. Thus, effects are unlikely to become cumulative if the mitigation and management plans pertaining to fishing and the use of equipment in and around water are applied.

Project-specific cumulative effect mitigations are the same as previously mentioned in Section 15.7.1.2, and include:

- gating access roads to prohibit the entry by non-authorized vehicles;
- implementing a company policy that prohibits employees and contractors from engaging in fishing while present at the Mine Site or while travelling to and from the mine on company business;
- isolating Project work sites to prevent fish movement into the work site;
- salvaging and/or removing fish from the enclosed work site;
- adhering to work windows; and
- environmental monitoring.

15.9.2.2.3 Other Project/Activity Mitigations to Address Direct Mortality

It is anticipated that other projects will adopt that same mitigation strategies as the KSM Project. Mitigation measures proposed for the KSM Project are standards stated in federal and provincial guidelines (e.g., DFO Land Development Guidelines for the Protection of Aquatic Habitat

[DFO 1993], BC MOE Standards and Best Practices for Instream Works [BC MOE 2004], Pacific Region Operational Statements [DFO 2010]), to which all projects are subject.

15.9.2.2.4 Determination of Potential for Residual Cumulative Effect and Significance

The magnitude of residual cumulative effects associated with direct mortality will be low because events will be localized and geographically isolated. In addition, direct mortality events will be of short duration and will occur sporadically. Since the timing and duration of direct mortality is short, this effect can be reversed relatively quickly (i.e., reversible short-term), and the VC will be able to respond and adapt (i.e., context is low). If the appropriate management plans are adhered to, the probability of occurrence is low (with high confidence).

Thus, considering the above description of direct mortality mechanisms, residual cumulative direct mortality was assessed as **not significant-minor** for fish VCs in the cumulative effects study area (Tables 15.9-3 to 15.9-6).

15.9.2.3 Cumulative Effect of Noise

15.9.2.3.1 Project-specific Cumulative Effects of Noise

Noise effects stemming from the Project are expected to predominately occur within the construction phase. It will also be reasonable to assume that noise-related effects from other projects and activities will occur during the construction phase.

The majority of past, present, and future projects may cumulatively increase noise on fish. The potential for increased noise is low because there are no fish present within most project infrastructure. Fish are not present within the footprints of Eskay Creek Mine, Granduc Mine, Sulphurets Project, Brucejack Mine, Snowfield Project, and Granduc Copper Mine. However, there are fish present within watercourses at past, present, and future access roads. Past or future projects have been or will be constructed during separate temporal periods; therefore, the potential for cumulative effects from noise effects is unlikely.

15.9.2.3.2 Project-specific Cumulative Effects Mitigations for Noise

Similar to direct mortality effects, noise-related effects to fish are generally spatially and temporally isolated.

Project-specific cumulative effect mitigations are the same as previously mentioned in Section 15.7.2.2, and include:

- site blasting will be at least 10 m away from fish-bearing streams;
- blasts will also be kept below 100 kPa as recommended by Wright and Hopky (1998); and
- environmental monitoring.

15.9.2.3.3 Other Project/Activity Mitigations to Address Noise

It is anticipated that other projects will adopt that same mitigation strategies as the KSM Project. Mitigation measures proposed for the KSM Project are standards stated in federal and provincial guidelines (e.g., Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters [Wright and Hopkey 1998]), to which all projects are subject.

15.9.2.3.4 Determination of Potential for Residual Cumulative Effect and Significance

The magnitude of residual cumulative effects associated with noise will be negligible because events will be localized and geographically isolated. In addition, noise events will be of short duration and will occur sporadically during Project construction. Since the timing and duration of most noise events will be short, this effect can be reversed relatively quickly (i.e., reversible short-term), and the VC will be able to respond and adapt to this stressor (i.e., context is low). If the appropriate management plans (e.g., Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters [Wright and Hopkey 1998]; the Fish and Aquatic Habitat Protection and Mitigation Plan; and set-back distances) are adhered to, the probability of occurrence is low (with high confidence).

Thus, considering the above description of noise, residual cumulative effects to fish VCs in the cumulative effects study area were assessed as **not significant-minor** (Tables 15.9-3 to 15.9-6).

15.9.2.4 Cumulative Effect of Erosion and Sedimentation

15.9.2.4.1 Project-specific Cumulative Effects of Erosion and Sedimentation

The geographic scope of erosion and sedimentation can range from localized to far-reaching events depending on the amount and type (e.g., particle size) of sediment that is introduced into the aquatic environment. In addition, sedimentation effects can occur throughout the Project's construction, operation, and closure phases. These spatial and temporal properties of erosion and sedimentation are likely similar for other projects and activities that may act cumulatively with potential Project-related erosion and sedimentation effects.

The majority of past, present, and future projects may cumulatively affect fish from increased sedimentation. The potential for increased sedimentation is low because there are no fish present within most project infrastructure, and fish are located a considerable distance downstream from most project infrastructure. Fish are not present within the footprints of Eskay Creek Mine, Granduc Mine, Sulphurets Project, Brucejack Mine, Snowfield Project, and Granduc Copper Mine. The nearest watercourse downstream of these projects are as follows: Eskay Creek Mine – Unuk River; Granduc Mine – Bowser River; Sulphurets Project – Unuk River; Brucejack Mine – Unuk River; Snowfield Project – Unuk River; and Granduc Copper Mine – Bowser River. However, there are fish present within watercourses at past, present, and future access roads, in which erosion events could occur.

Table 15.9-3. Summary of Residual Cumulative Effects on Bull Trout

															Likelihood of Effects							
Description of Residual Effect	Other Project(s)/ Activity(ies)	Timing of Effect	Magnitude	Magnitude Adjusted for CE	Extent	Extent Adjusted for CE	Duration	Duration Adjusted for CE	Frequency	Frequency Adjusted for CE	Reversibility	Reversibility Adjusted for CE	Context	Context Adjusted for CE	Probability	Probability Adjusted for CE	Confidence Level	Conf. Level Adjusted for CE	Significance Determination	Significance Determination Adjusted for CE	Follow-up Monitoring	Follow-up Monitoring Adjusted for CE
Blunt tissue trauma causing mortality to all fish life stages	Treaty Creek Access Road	Construction	Low	Low	Local	Local	Short	Short	Sporadic	Sporadic	Reversible short-term	Reversible short-term	Low	Low	Low	Low	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Blunt tissue trauma causing mortality to all fish life stages	Treaty Creek Access Road	Operations	Low	Low	Local	Local	Short	Short	Sporadic	Sporadic	Reversible short-term	Reversible short-term	Low	Low	Low	Low	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Blunt tissue trauma causing mortality to all fish life stages	Treaty Creek Access Road	Closure	Low	Low	Local	Local	Short	Short	Sporadic	Sporadic	Reversible short-term	Reversible short-term	Low	Low	Low	Low	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Noise causing sub-lethal effects, decreased feeding efficiency and habitat avoidance	Treaty Creek Access Road	Construction	Negligible	Negligible	Local	Local	Short	Short	Sporadic	Sporadic	Reversible short-term	Reversible short-term	Low	Low	Low	Low	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Treaty Creek Access Road; North Cell Tailing Management Facility; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction	Construction	Low	Low	Landscape	Landscape	Medium	Medium	Sporadic	Sporadic	Reversible long-term	Reversible long-term	Neutral	Neutral	Medium	Medium	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Treaty Creek Access Road; North Cell Tailing Management Facility; South Cell Tailing Management Facility; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction	Operations	Low	Low	Landscape	Landscape	Medium	Medium	Sporadic	Sporadic	Reversible long-term	Reversible long-term	Neutral	Neutral	Medium	Medium	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Treaty Creek Access Road; North Cell Tailing Management Facility; South Cell Tailing Management Facility	Closure	Negligible	Negligible	Landscape	Landscape	Short	Short	Sporadic	Sporadic	Reversible long-term	Reversible long-term	Neutral	Neutral	Medium	Medium	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Water quality degradation due to metals, process chemicals, petroleum products, or nitrogenous compounds resulting in toxicity to fish	Treaty OPC; Concentrate Storage and Loadout; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle	Operations	Medium	N/A	Landscape	N/A	Long	N/A	Sporadic	N/A	Reversible long-term	N/A	Neutral	N/A	Low	N/A	Medium	N/A	Not Significant (Minor)	N/A	Required	Not Required
Water quality degradation due to metals, process chemicals, petroleum products, or nitrogenous compounds resulting in toxicity to fish	Treaty OPC; Concentrate Storage and Loadout; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle	Closure	Medium	N/A	Landscape	N/A	Medium	N/A	Sporadic	N/A	Reversible long-term	N/A	Neutral	N/A	Low	N/A	Medium	N/A	Not Significant (Minor)	N/A	Required	Not Required
Water quality degradation due to metals, process chemicals, petroleum products, or nitrogenous compounds resulting in toxicity to fish	Treaty OPC; Concentrate Storage and Loadout; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle	Post-closure	Medium	N/A	Landscape	N/A	Long	N/A	Sporadic	N/A	Reversible long-term	N/A	Neutral	N/A	Low	N/A	Medium	N/A	Not Significant (Minor)	N/A	Required	Not Required
Overall Effect	All	Post-closure	Medium	Medium	Landscape	Landscape	Long	Long	Sporadic	Sporadic	Reversible long-term	Reversible long-term	Neutral	Neutral	Low	Low	Medium	Medium	Not Significant (Minor)	Not Significant (Minor)	Required	Not Required

Note: CE = Cumulative Effect.

Table 15.9-4. Summary of Residual Cumulative Effects on Dolly Varden

Description of Residual Effect	Other Project(s)/ Activity(ies)	Timing of Effect	Magnitude	Magnitude Adjusted for CE	Extent	Extent Adjusted for CE	Duration	Duration Adjusted for CE	Frequency	Frequency Adjusted for CE	Reversibility	Reversibility Adjusted for CE	Context	Context Adjusted for CE	Likelihood of Effects				Significance Determination	Significance Determination Adjusted for CE	Follow-up Monitoring	Follow-up Monitoring Adjusted for CE
															Probability	Probability Adjusted for CE	Confidence Level	Conf. Level Adjusted for CE				
Blunt tissue trauma causing mortality to all fish life stages	Coulter Creek Access Corridor; Treaty Creek Access Road; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Construction	Low	Low	Local	Local	Short	Short	Sporadic	Sporadic	Reversible short-term	Reversible short-term	Low	Low	Low	Low	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Blunt tissue trauma causing mortality to all fish life stages	Coulter Creek Access Corridor; Treaty Creek Access Road; South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Operations	Low	Low	Local	Local	Short	Short	Sporadic	Sporadic	Reversible short-term	Reversible short-term	Low	Low	Low	Low	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Blunt tissue trauma causing mortality to all fish life stages	Coulter Creek Access Corridor; Treaty Creek Access Road; South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Closure	Low	Low	Local	Local	Short	Short	Sporadic	Sporadic	Reversible short-term	Reversible short-term	Low	Low	Low	Low	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Noise causing sub-lethal effects, decreased feeding efficiency and habitat	Coulter Creek Access Corridor; Treaty Creek Access Road; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Construction	Negligible	Negligible	Local	Local	Short	Short	Sporadic	Sporadic	Reversible short-term	Reversible short-term	Low	Low	Low	Low	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Noise causing sub-lethal effects, decreased feeding efficiency and habitat avoidance	South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Operations	Negligible	Negligible	Local	Local	Short	Short	One-time	One-time	Reversible short-term	Reversible short-term	Low	Low	Low	Low	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction	Construction	Low	Low	Landscape	Landscape	Medium	Medium	Sporadic	Sporadic	Reversible long-term	Reversible long-term	Neutral	Neutral	Medium	Medium	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction	Operations	Low	Low	Landscape	Landscape	Medium	Medium	Sporadic	Sporadic	Reversible long-term	Reversible long-term	Neutral	Neutral	Medium	Medium	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; South Cell Tailing Management Facility; East Catchment Diversion	Closure	Negligible	Negligible	Landscape	Landscape	Short	Short	Sporadic	Sporadic	Reversible long-term	Reversible long-term	Neutral	Neutral	Medium	Medium	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Water quality degradation due to metals, process chemicals, petroleum products, or nitrogenous compounds resulting in toxicity to fish	Treaty OPC; Concentrate Storage and Loadout; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle;Coulter Creek Access Corridor; Treaty Creek Access Road; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle; Camp 7: Unuk North; Camp 8: Unuk South; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Coulter Creek Access Corridor; McTagg Diversion Tunnel; McTagg Rock Storage Facililty; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Operations	High	N/A	Regional	N/A	Long	N/A	Continuous	N/A	Reversible long-term	N/A	High	N/A	Medium	N/A	Medium	N/A	Not Significant (Moderate)	N/A	Required	Not Required

(continued)

Table 15.9-4. Summary of Residual Cumulative Effects on Dolly Varden (completed)

															Likelihood of Effects							
Description of Residual Effect	**Other Project(s)/ Activity(ies)**	**Timing of Effect**	**Magnitude**	**Magnitude Adjusted for CE**	**Extent**	**Extent Adjusted for CE**	**Duration**	**Duration Adjusted for CE**	**Frequency**	**Frequency Adjusted for CE**	**Reversibility**	**Reversibility Adjusted for CE**	**Context**	**Context Adjusted for CE**	**Probability**	**Probability Adjusted for CE**	**Confidence Level**	**Conf. Level Adjusted for CE**	**Significance Determination**	**Significance Determination Adjusted for CE**	**Follow-up Monitoring**	**Follow-up Monitoring Adjusted for CE**
Water quality degradation due to metals, process chemicals, petroleum products, or nitrogenous compounds resulting in toxicity to fish	Treaty OPC; Concentrate Storage and Loadout; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle;Coulter Creek Access Corridor; Treaty Creek Access Road; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle; Camp 7: Unuk North; Camp 8: Unuk South; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Coulter Creek Access Corridor; McTagg Diversion Tunnel; McTagg Rock Storage Facililty; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Closure	High	N/A	Regional	N/A	Medium	N/A	Continuous	N/A	Reversible long-term	N/A	High	N/A	Medium	N/A	Medium	N/A	Not Significant (Moderate)	N/A	Required	Not Required
Water quality degradation due to metals, process chemicals, petroleum products, or nitrogenous compounds resulting in toxicity to fish	Treaty OPC; Concentrate Storage and Loadout; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle;Coulter Creek Access Corridor; Treaty Creek Access Road; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle; Camp 7: Unuk North; Camp 8: Unuk South; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Coulter Creek Access Corridor; McTagg Diversion Tunnel; McTagg Rock Storage Facililty; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Post-closure	High	N/A	Regional	N/A	Far future	N/A	Continuous	N/A	Reversible long-term	N/A	High	N/A	Medium	N/A	Medium	N/A	Not Significant (Moderate)	N/A	Required	Not Required
Overall Effect	All	Post-closure	High	High	Regional	Regional	Far future	Far future	Continuous	Continuous	Reversible long-term	Reversible long-term	High	High	Medium	Medium	Medium	Medium	Not Significant (Moderate)	Not Significant (Moderate)	Required	Not Required

Note: CE = Cumulative Effect.

Table 15.9-5. Summary of Residual Cumulative Effects on Rainbow Trout/Steelhead

															Likelihood of Effects							
Description of Residual Effect	Other Project(s)/ Activity(ies)	Timing of Effect	Magnitude	Magnitude Adjusted for CE	Extent	Extent Adjusted for CE	Duration	Duration Adjusted for CE	Frequency	Frequency Adjusted for CE	Reversibility	Reversibility Adjusted for CE	Context	Context Adjusted for CE	Probability	Probability Adjusted for CE	Confidence Level	Conf. Level Adjusted for CE	Significance Determination	Significance Determination Adjusted for CE	Follow-up Monitoring	Follow-up Monitoring Adjusted for CE
Blunt tissue trauma causing mortality to all fish life stages	Coulter Creek Access Corridor; Treaty Creek Access Road; Centre Cell Tailing Management Facility; North Cell Tailing	Construction	Low	Low	Local	Local	Short	Short	Sporadic	Sporadic	Reversible short-term	Reversible short-term	Low	Low	Low	Low	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Blunt tissue trauma causing mortality to all fish life stages	Coulter Creek Access Corridor; Treaty Creek Access Road; South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; North Cell Tailing	Operations	Low	Low	Local	Local	Short	Short	Sporadic	Sporadic	Reversible short-term	Reversible short-term	Low	Low	Low	Low	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Blunt tissue trauma causing mortality to all fish life stages	Coulter Creek Access Corridor; Treaty Creek Access Road; South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; North Cell Tailing	Closure	Low	Low	Local	Local	Short	Short	Sporadic	Sporadic	Reversible short-term	Reversible short-term	Low	Low	Low	Low	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Noise causing sub-lethal effects, decreased feeding efficiency and habitat avoidance	Coulter Creek Access Corridor; Treaty Creek Access Road; Centre Cell Tailing Management Facility; North Cell Tailing	Construction	Negligible	Negligible	Local	Local	Short	Short	Sporadic	Sporadic	Reversible short-term	Reversible short-term	Low	Low	Low	Low	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Noise causing sub-lethal effects, decreased feeding efficiency and habitat avoidance	South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Operations	Negligible	Negligible	Local	Local	Short	Short	One-time	One-time	Reversible short-term	Reversible short-term	Low	Low	Low	Low	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37	Construction	Low	Low	Landscape	Landscape	Medium	Medium	Sporadic	Sporadic	Reversible long-term	Reversible long-term	Neutral	Neutral	Medium	Medium	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37	Operations	Low	Low	Landscape	Landscape	Medium	Medium	Sporadic	Sporadic	Reversible long-term	Reversible long-term	Neutral	Neutral	Medium	Medium	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; South Cell Tailing Management Facility; East Catchment Diversion	Closure	Negligible	Negligible	Landscape	Landscape	Short	Short	Sporadic	Sporadic	Reversible long-term	Reversible long-term	Neutral	Neutral	Medium	Medium	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Water quality degradation due to metals, process chemicals, petroleum products, or nitrogenous compounds resulting in toxicity to fish	Treaty OPC; Concentrate Storage and Loadout; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle;Coulter Creek Access Corridor; Treaty Creek Access Road; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle; Camp 7: Unuk North; Camp 8: Unuk South; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Coulter Creek Access Corridor; McTagg Diversion Tunnel; McTagg Rock Storage Facililty; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Operations	High	N/A	Regional	N/A	Long	N/A	Continuous	N/A	Reversible long-term	N/A	High	N/A	Medium	N/A	Medium	N/A	Not Significant (Moderate)	N/A	Required	Not Required

(continued)

Table 15.9-5. Summary of Residual Cumulative Effects on Rainbow Trout/Steelhead (completed)

															Likelihood of Effects							
Description of Residual Effect	Other Project(s)/ Activity(ies)	Timing of Effect	Magnitude	Magnitude Adjusted for CE	Extent	Extent Adjusted for CE	Duration	Duration Adjusted for CE	Frequency	Frequency Adjusted for CE	Reversibility	Reversibility Adjusted for CE	Context	Context Adjusted for CE	Probability	Probability Adjusted for CE	Confidence Level	Conf. Level Adjusted for CE	Significance Determination	Significance Determination Adjusted for CE	Follow-up Monitoring	Follow-up Monitoring Adjusted for CE
Water quality degradation due to metals, process chemicals, petroleum products, or nitrogenous compounds resulting in toxicity to fish	Treaty OPC; Concentrate Storage and Loadout; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle;Coulter Creek Access Corridor; Treaty Creek Access Road; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle; Camp 7: Unuk North; Camp 8: Unuk South; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Coulter Creek Access Corridor; McTagg Diversion Tunnel; McTagg Rock Storage Facililty; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Closure	High	N/A	Regional	N/A	Medium	N/A	Continuous	N/A	Reversible long-term	N/A	High	N/A	Medium	N/A	Medium	N/A	Not Significant (Moderate)	N/A	Required	Not Required
Water quality degradation due to metals, process chemicals, petroleum products, or nitrogenous compounds resulting in toxicity to fish	Treaty OPC; Concentrate Storage and Loadout; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle;Coulter Creek Access Corridor; Treaty Creek Access Road; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle; Camp 7: Unuk North; Camp 8: Unuk South; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Coulter Creek Access Corridor; McTagg Diversion Tunnel; McTagg Rock Storage Facililty; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Post-closure	High	N/A	Regional	N/A	Far future	N/A	Continuous	N/A	Reversible long-term	N/A	High	N/A	Medium	N/A	Medium	N/A	Not Significant (Moderate)	N/A	Required	Not Required
Overall Effect	All	Post-closure	High	High	Regional	Regional	Far future	Far future	Continuous	Continuous	Reversible long-term	Reversible long-term	High	High	Medium	Medium	Medium	Medium	Not Significant (Moderate)	Not Significant (Moderate)	Required	Not Required

Note: CE = Cumulative Effect.

Table 15.9-6. Summary of Residual Cumulative Effects on Pacific Salmon

															Likelihood of Effects							
Description of Residual Effect	Other Project(s)/ Activity(ies)	Timing of Effect	Magnitude	Magnitude Adjusted for CE	Extent	Extent Adjusted for CE	Duration	Duration Adjusted for CE	Frequency	Frequency Adjusted for CE	Reversibility	Reversibility Adjusted for CE	Context	Context Adjusted for CE	Probability	Probability Adjusted for CE	Confidence Level	Conf. Level Adjusted for CE	Significance Determination	Significance Determination Adjusted for CE	Follow-up Monitoring	Follow-up Monitoring Adjusted for CE
Blunt tissue trauma causing mortality to all fish life stages	Coulter Creek Access Corridor; Treaty Creek Access Road; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Construction	Low	Low	Local	Local	Short	Short	Sporadic	Sporadic	Reversible short-term	Reversible short-term	Low	Low	Low	Low	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Blunt tissue trauma causing mortality to all fish life stages	Coulter Creek Access Corridor; Treaty Creek Access Road; South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Operations	Low	Low	Local	Local	Short	Short	Sporadic	Sporadic	Reversible short-term	Reversible short-term	Low	Low	Low	Low	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Blunt tissue trauma causing mortality to all fish life stages	Coulter Creek Access Corridor; Treaty Creek Access Road; South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Closure	Low	Low	Local	Local	Short	Short	Sporadic	Sporadic	Reversible short-term	Reversible short-term	Low	Low	Low	Low	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Noise causing sub-lethal effects, decreased feeding efficiency and habitat avoidance	Coulter Creek Access Corridor; Treaty Creek Access Road; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Construction	Negligible	Negligible	Local	Local	Short	Short	Sporadic	Sporadic	Reversible short-term	Reversible short-term	Low	Low	Low	Low	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Noise causing sub-lethal effects, decreased feeding efficiency and habitat avoidance	South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; North Cell Tailing Management Facility	Operations	Negligible	Negligible	Local	Local	Short	Short	One-time	One-time	Reversible short-term	Reversible short-term	Low	Low	Low	Low	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction	Construction	Low	Low	Landscape	Landscape	Medium	Medium	Sporadic	Sporadic	Reversible long-term	Reversible long-term	Neutral	Neutral	Medium	Medium	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction	Operations	Low	Low	Landscape	Landscape	Medium	Medium	Sporadic	Sporadic	Reversible long-term	Reversible long-term	Neutral	Neutral	Medium	Medium	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, habitat avoidance, smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; South Cell Tailing Management Facility; East Catchment Diversion	Closure	Negligible	Negligible	Landscape	Landscape	Short	Short	Sporadic	Sporadic	Reversible long-term	Reversible long-term	Neutral	Neutral	Medium	Medium	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Water quality degradation due to metals, process chemicals, petroleum products, or nitrogenous compounds resulting in toxicity to fish	Treaty OPC; Concentrate Storage and Loadout; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle;Coulter Creek Access Corridor; Treaty Creek Access Road; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle; Camp 7: Unuk North; Camp 8: Unuk South; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Coulter Creek Access Corridor; McTagg Diversion Tunnel; McTagg Rock Storage Facility; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Operations	High	N/A	Regional	N/A	Long	N/A	Regular	N/A	Reversible long-term	N/A	High	N/A	Medium	N/A	Medium	N/A	Not Significant (Moderate)	N/A	Required	Not Required

(continued)

Table 15.9-6. Summary of Residual Cumulative Effects on Pacific Salmon (completed)

Description of Residual Effect	Other Project(s)/ Activity(ies)	Timing of Effect	Magnitude	Magnitude Adjusted for CE	Extent	Extent Adjusted for CE	Duration	Duration Adjusted for CE	Frequency	Frequency Adjusted for CE	Reversibility	Reversibility Adjusted for CE	Context	Context Adjusted for CE	Likelihood of Effects				Significance Determination	Significance Determination Adjusted for CE	Follow-up Monitoring	Follow-up Monitoring Adjusted for CE
															Probability	Probability Adjusted for CE	Confidence Level	Conf. Level Adjusted for CE				
Water quality degradation due to metals, process chemicals, petroleum products, or nitrogenous compounds resulting in toxicity to fish	Treaty OPC; Concentrate Storage and Loadout; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle;Coulter Creek Access Corridor; Treaty Creek Access Road; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle; Camp 7: Unuk North; Camp 8: Unuk South; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Coulter Creek Access Corridor; McTagg Diversion Tunnel; McTagg Rock Storage Facility; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Closure	High	N/A	Regional	N/A	Medium	N/A	Regular	N/A	Reversible long-term	N/A	High	N/A	Medium	N/A	Medium	N/A	Not Significant (Moderate)	N/A	Required	Not Required
Water quality degradation due to metals, process chemicals, petroleum products, or nitrogenous compounds resulting in toxicity to fish	Treaty OPC; Concentrate Storage and Loadout; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle;Coulter Creek Access Corridor; Treaty Creek Access Road; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle; Camp 7: Unuk North; Camp 8: Unuk South; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Coulter Creek Access Corridor; McTagg Diversion Tunnel; McTagg Rock Storage Facility; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Post-closure	High	N/A	Regional	N/A	Far future	N/A	Regular	N/A	Reversible long-term	N/A	High	N/A	Medium	N/A	Medium	N/A	Not Significant (Moderate)	N/A	Required	Not Required
Overall Effect	All	Post-closure	High	High	Regional	Regional	Far future	Far future	Regular	Regular	Reversible long-term	Reversible long-term	High	High	Medium	Medium	Medium	Medium	Not Significant (Moderate)	Not Significant (Moderate)	Required	Not Required

Note: CE = Cumulative Effect.

15.9.2.4.2 Project-specific Cumulative Effects Mitigations for Erosion and Sedimentation

Project-specific cumulative effect mitigations are the same as previously mentioned in Section 15.7.3.2, and include:

- using water diversion structures to divert dirty water from the work zone to a sediment control area;
- installing silt fencing, geotextile cloth, straw bales, berms, or other sediment control structures;
- allowing constructed ponds to settle before connecting to the stream;
- ensuring constructed banks are graded at a stable slope;
- stabilizing excavated materials and areas denuded of vegetation using temporary erosion control blankets, biodegradable mats, planted vegetation, or other erosion control techniques; and
- environmental monitoring.

15.9.2.4.3 Other Project/Activity Mitigations to Address Erosion and Sedimentation

It is anticipated that other projects will adopt that same mitigation strategies as the KSM Project. Mitigation measures proposed for the KSM Project are standards stated in federal and provincial guidelines (e.g., DFO Land Development Guidelines for the Protection of Aquatic Habitat [DFO 1993], BC MOE Standards and Best Practices for Instream Works [BC MOE 2004], Fish-Stream Crossing Guidebook [BC MOF 2002], sewage effluent permit requirements, and Pacific Region Operational Statements [DFO 2010]), to which all projects are subject.

15.9.2.4.4 Determination of Potential for Residual Cumulative Effect and Significance

The magnitude of residual cumulative effects associated with erosion and sedimentation will be low because events will be localized and geographically isolated. Erosion events, should they occur, will be of medium-term duration (effect lasts from one to five years) and will occur sporadically during Project phases. The effects of erosion and sedimentation cannot be easily reversed, thus reversal will occur over many years (reversible long-term). Furthermore, fish may not be able to fully respond or adapt to the effects of erosion and sedimentation, thus context (or resiliency) was assessed as neutral. If, however, the appropriate management plans (e.g., the Erosion Control Plan; the Fish and Aquatic Habitat Protection and Mitigation Plan; and the BMPs for erosion and sedimentation) are adhered to, the probability of erosion causing effects is likely, but should not occur.

Thus, considering the above description, the residual cumulative effects of erosion and sedimentation on fish was assessed as **not significant-minor** (Tables 15.9-3 to 15.9-6).

15.9.2.5 Cumulative Effect of Water Quality Degradation

15.9.2.5.1 Project-specific Cumulative Effects of Water Quality Degradation

The majority of past, present, and future projects identified as having potential linkages for cumulative effects may contribute to toxicity in fish associated with water quality degradation (metals, process chemicals, petroleum products, and nitrogenous compounds). Fish are not present within the footprints of Eskay Creek Mine, Granduc Mine, Sulphurets Project, Brucejack Mine, Snowfield Project, and Granduc Copper Mine. The nearest fish-bearing watercourses downstream of other projects are as follows: Eskay Creek Mine – Coulter Creek and Unuk River; Granduc Mine – Bowser River; Sulphurets Project – Sulphurets Creek and Unuk River; Brucejack Mine – Sulphurets Creek and Unuk River; Snowfield Project – Sulphurets Creek and Unuk River; and Granduc Copper Mine – Bowser River.

Metals may be introduced to the environment from two main sources. ML/ARD, with mobilization of metals in acidic leachate, can be generated from weathering of PAG rock that is exposed during construction of infrastructure or ongoing activities associated with mining. Point source discharges of effluent from mining infrastructure (such as tailing ponds) may also be a source of metals and process chemicals (such as cyanide, flocculants, etc.). Petroleum products may be introduced to aquatic environments due to work that occurs in and around waterways. Nitrogenous compounds, derived from either blasting residues/airborne particles or STP effluent, can also enter the aquatic environment and have the potential to cause toxicity in fish. Collectively, these chemical compounds can alter water quality and can individually or in mixtures lead to toxicity in fish. Toxicity in fish may be seen as impairments in reproduction, immune competence, olfaction, osmoregulatory balance, and behavioural changes.

There are fish present within watercourses near past, present, and future access roads, where the introduction of metals, petroleum products, and blasting residues (if blasting is required to construct the road) into the aquatic environment may occur from multiple projects. However, fish are generally located a considerable distance downstream from most of the main infrastructure associated with past, present, or future project infrastructure (e.g. existing or potential mine pits, tailing ponds, processing facilities). Metals and other chemicals can still be a concern since they can be carried long distances, dissolved in or carried by water. The potential for toxic effects will depend on the dilution capacity available with distance from the source, since concentrations (and thus the probability of toxicity) will decrease with distance.

Inputs of metals from historical projects including the Eskay Creek Mine, Granduc Mine, and Sulphurets Project would have been measured during baseline studies since they contribute to background, existing concentrations and would have been incorporated into the water chemistry of the receiving environment. These baseline data were already captured in the predictive water quality modelling that was completed (Appendix 14-H). Provided that no new changes occur in the conditions at these historical mines, metal inputs should remain stable or decrease over time. No additional cumulative effects related to these Projects would be expected with development of the KSM Project beyond what was already included in the predicted concentrations of metals based on baseline studies.

There are a number of future projects that may have spatial or temporal overlaps with the KSM Project. The Snowfield Project is located immediately adjacent to the KSM Project, such that the Snowfield property may be influenced by KSM Project access plans for the area (Snowden 2012). The Snowfield deposit area drains downstream to Mitchell Creek (Wardop 2010), which is upstream of the proposed WSF for the KSM Project. A Preliminary Economic Assessment (PEA) was completed in 2010 that explored the value of combining the Brucejack and Snowfield projects (Wardop 2010). The Snowfield Project proponent has no current plans to advance development; therefore, the Snowfield Project was considered to not have the potential for cumulative effects to water qualityCEA.

The reopened Granduc Copper Mine is located 40 km northwest of Stewart in northwestern BC, and previously produced between 1971 and 1984 (Section 5.3.3.2). Castle Resources Inc. acquired the Granduc property from Bell Copper in July 2010, and began exploration drilling with the aim of redeveloping the mine (Marketwire 2010; Scales 2012). In 2011, Castle Resources Inc. had the 17-km tunnel rehabilitated, and plans to rehabilitate specific levels of the old underground mine to establish underground drill stations for exploration. Castle Resources Inc. is currently working on a PEA that will evaluate mining methods, tailing impoundment, and a suitable milling process (Dickson 2012), indicating that a temporal overlap with the KSM Project is possible. It is expected that the mine will use sub-level caving techniques (Dickson 2012; Scales 2012). The drainage from the Granduc Copper Mine is to the Bowser River, Bowser Lake, and ultimately to the Bell-Irving River. However, since residual water quality effects from activities in the PTMA of the KSM Project are not predicted to occur in Treaty or Teigen creeks (and therefore no effects are predicted in the Bell-Irving River), there is no spatial overlap in water quality effects from the projects, and the Granduc Copper Mine was excluded from the fish and aquatic habitat CEA.

Similarly, the Treaty Creek Hydroelectric project (on upper Treaty Creek) and the Northwest Transmission Line project (in the Bell-Irving watershed) may have temporal overlap with the KSM Project. However, these projects are located in areas where they would not be expected to have a spatial overlap with the KSM Project since no water quality degradation effects are predicted in Treaty Creek or the Bell-Irving River for the KSM Project.

The proposed Brucejack Project is located immediately east of the KSM Project, and entered the BC Environmental Assessment process in 2012. The Brucejack Project is an underground gold and silver mining operation targeting two deposits. The mine life is projected to be a minimum of 16 years, with anticipated commencement of operations in 2016 (Tetra Tech Wardrop 2011), indicating that a temporal overlap with the KSM Project is possible. Approximately 5 Mt of waste rock will be produced throughout the mine life, with 2 Mt of waste rock stored sub-aqueously in the southwest corner of Brucejack Lake. An estimated 8 Mt of flotation tailing material will additionally be deposited in Brucejack Lake. Brucejack Lake drains west into the Sulphurets-Unuk watershed (Rescan 2013). Water quality effects from the Brucejack Project have the potential to interact with residual effects from the KSM Project; therefore the Brucejack Project was included in the fish and aquatic habitat CEA.

A residual effect on water quality in the Sulphurets-Unuk watershed due to increased selenium concentrations was predicted for the KSM Project. This residual effect is predicted to be not significant (moderate) with mitigation (Chapter 14) to water quality, and not significant (moderate) to fish (Section 15.8.2.5.1). For fish, the magnitude of the residual effect in Sulphurets Creek and in the Unuk River is high. Increased selenium loading from the Brucejack Project has the potential to increase concentrations of selenium in Sulphurets Creek and the Unuk River, which could result in a cumulative effect of a greater magnitude in the Unuk River at the BC-Alaska border. Estimations of water quality effects from the Brucejack Project Description (Rescan 2013) submitted to the BC EAO were used to quantify the additional selenium loading.

15.9.2.5.2 Project-specific Cumulative Effects Mitigations for Water Quality Degradation

Extensive mitigation to avoid degradation of surface water quality was included in the design for the proposed KSM Project. Mitigation includes measures to avoid, reduce, and monitor adverse effects to surface water quality, and specific mitigation measures were developed for the various pathways in which Project components can potentially interact with surface water quality. Water quality effects for the KSM Project will be primarily mitigated through water management, including diversion of non-contact water and collection and treatment of contact water. Effluent discharges from the WSF and the TMF will be staged to the natural hydrograph to minimize water quality effects. Section 14.7.2 (Surface Water Quality chapter) provides detail on KSM Project water quality mitigation.

Project-specific cumulative effect mitigations for the protection of water quality are the same as previously mentioned in Section 15.7.4.2, and include:

- selection of road alignments that minimize areas with high potential for ML/ARD;
- orientation of the TMF so that discharges during the Project operation phase occur predominantly to Treaty Creek, rather than to South Teigen/Teigen creeks, whichcontain more sensitive fish habitat than Treaty Creek;
- collection of seepage from TMF and WSF and return of seepage to the TMF or WSF/WTP;
- careful control of discharges from the TMF and WTP to stage discharges with hydrological conditions, ensuring adequate dilution capacity of receiving environments (i.e. implementation of the Water Management Plan);
- adhering to appropriate construction operating window for instream work;
- fuel stored in bermed and lined containment facilities to prevent seepage into the soil;
- spill kits;
- equipment maintenance;
- stream setback distances for construction;
- implementation of mitigation strategies for blasting residue as outlined in various acts, regulations, and Pacific Region Operational Statements (DFO 2010);
- proper sewage treatment and disposal, as required by the Municipal Wastewater Regulation (BC Reg. 87/2012) or the Sewerage System Regulation (BC Reg. 326/2004);
- implementation of the ML/ARD Management Plan;
- implementation of the Erosion Control Plan;
- implementation of the Fish and Aquatic Habitat Protection and Mitigation Plan; and
- environmental monitoring under the Aquatic Effects Monitoring Plan.

Water quality monitoring and adaptive management are expected to minimize water quality effects throughout the construction, operation, closure, and post-closure phases.

15.9.2.5.3 Other Project/Activity Mitigations to Address Water Quality Degradation

The Brucejack Project is proposing a combination of sub-aqueous disposal and backfill to underground workings for waste rock and tailing material. A high-density sludge lime water treatment system is proposed as a contingency to address potential water quality effects in the Sulphurets-Unuk watershed (Rescan 2013).

It is anticipated that other projects will adopt that same mitigation strategies as the KSM Project. Mitigation measures proposed for the KSM Project are standards stated in federal and provincial guidelines and include:

- DFO Land Development Guidelines for the Protection of Aquatic Habitat (1993);
- BC MOE Standards and Best Practices for Instream Works (2004);
- Fish-Stream Crossing Guidebook (BC MOF 2002);
- Pacific Region Operational Statements (DFO 2010);
- Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters (Wright and Hopkey 1998); and,
- Spill Containment and Emergency Response Plan.

It is also expected that other current or future projects that may discharge effluent to shared waterways will meet discharge criteria, such that resultant downstream concentrations will not increase above the Project-specific predictions as a result of cumulative water quality effects.

15.9.2.5.4 Determination of Potential for Residual Cumulative Effect and Significance

The Brucejack Project Description identified the potential for local, low magnitude effects on water quality (Rescan 2013). The cumulative effect on water quality from the Brucejack Project will not influence the descriptors used in the assessment of Project-specific residual effects, because concentrations of selenium in the Sulphurets-Unuk watershed are not expected to increase above the Project-specific predictions as a result of cumulative water quality effects. Therefore, there will be no residual cumulative effects, so the rating applied was **not applicable (N/A)**.

When completing Tables 15.9-3 to 15.9-6, water quality degradation as an effect was summarized as one line. In the residual effects assessment section, the potential residual effects of water quality degradation were broken down into multiple, more specific causes of water quality changes in order to facilitate assessment (metals from non-point sources, discharge from TMF, discharge from Mine Site WTP, petroleum products, and nitrogenous compounds). Since no residual cumulative effects were predicted for water quality degradation, the summary line for this residual effect was the TMF discharge significance assessment for bull trout, and the Mine Site WTP discharge significance assessment for the other three fish species (Section 15.8.2.5.1).

15.9.2.6 Overall Cumulative Effect on Fish Valued Components

The cumulative effect on fish VCs was assessed as **not significant - minor** for direct mortality, noise, and sedimentation and erosion. The potential for residual cumulative effects related to water quality degradation was determined to be **not applicable (N/A**; Tables 15.9-3 to 15.9-6).

The overall cumulative effect was based on the Project residual effects for water quality degradation since this was the most significant potential effect for all VC fish species. Although cumulative effects for water quality degradation were rated as N/A in this assessment, for the purposes of an overall rating (final line of Tables 15.9-3 and 15.9-6), ratings equivalent to the Project residual effects were assigned for overall cumulative effects for each of the residual effect descriptors. Therefore, the overall cumulative effect was assessed as **not significant – minor** for bull trout and **not significant – moderate** for Dolly Varden, rainbow trout/steelhead, and Pacific salmon.

15.9.3 Cumulative Effects Assessment for Aquatic Habitat Valued Component

Table 15.9-2 presents a summary of projects and activities with the potential to interact cumulatively with expected Project-specific residual effects for the aquatic habitat VC, which includes both sediment quality and non-fish aquatic life.

15.9.3.1 Project-specific Residual Effects on Aquatic Habitat Valued Component that are not likely to Result in Cumulative Effects

The potential for interaction of residual effects from the KSM Project with other past, current, or future projects is the same as with the fish VCs, as described in Section 15.9.2.1. All residual effects, except direct mortality, were determined to not have an interaction with fishing because the act of fishing only involves catching fish.

15.9.3.2 Cumulative Effects of Erosion and Sedimentation

15.9.3.2.1 Project-specific Cumulative Effect of Erosion and Sedimentation

Erosion and sedimentation can lead to alteration of aquatic habitat by blocking light and can cause smothering of aquatic life. The geographic scope of erosion and sedimentation can range from localized to far-reaching events depending on the amount and type (e.g., particle size) of sediment that is introduced into the aquatic environment. Erosion and sedimentation can occur throughout the Project's construction, operation, and closure phases. These spatial and temporal properties of erosion and sedimentation are likely similar for other projects and activities that may act cumulatively with potential Project-related erosion and sedimentation effects. Cumulative effects associated with erosion and sedimentation may occur outside of the KSM Project infrastructure, downstream in waterways shared with other past, present, or future projects. The nearest watercourses downstream of other projects are as follows: Eskay Creek Mine – Coulter Creek and Unuk River; Granduc Mine – Bowser River; Sulphurets Project – Sulphurets Creek and Unuk River; Brucejack Mine – Sulphurets Creek and Unuk River; Snowfield Project – Sulphurets Creek and Unuk River; and Granduc Copper Mine – Bowser River.

The majority of past, present, and future projects may cumulatively affect aquatic habitat from increased erosion and sedimentation (Table 15.9-2). The potential for increased sedimentation is low because an Erosion Control Plan will be implemented, thus limiting any issues to relatively isolated and localized areas. In addition, the development of the mine infrastructure associated with the KSM Project (excluding roads and transmission lines) will occur at or near the headwaters of most potentially affected streams; thus, no further development is possible upstream. Since erosion and sedimentation are often associated with fairly localized effects, the potential for cumulative effects due to erosion and sedimentation from other projects (which may be located significant distances upstream from waterways shared with the KSM Project) is reduced.

15.9.3.2.2 Project-specific Cumulative Effect Mitigation for Erosion and Sedimentation

Project-specific cumulative effect mitigation for aquatic habitat is as described in Section 15.9.2.4.

15.9.3.2.3 Other Project/Activity Mitigation to Address Erosion and Sedimentation

It is anticipated that other projects will adopt similar mitigation strategies as the KSM Project, and these are as described for fish in Section 15.9.2.4.

15.9.3.2.4 Determination of Potential for Residual Cumulative Effect and Significance

The magnitude of residual cumulative effects associated with erosion and sedimentation on aquatic habitat will be low because events will be localized and geographically isolated. Erosion events, should they occur, will be of medium-term duration (effect lasts from one to five years) and will occur sporadically during Project phases. The effects of erosion and sedimentation cannot be easily reversed, thus reversal will occur over many years (reversible long-term). Furthermore, aquatic habitat and non-fish aquatic life may not be able to fully respond or adapt to the effects of erosion and sedimentation, thus context (or resiliency) was assessed as neutral. If, however, the appropriate management plans (e.g., the Erosion Control Plan; the Fish and Aquatic Habitat Protection and Mitigation Plan; and the BMPs for erosion and sedimentation) are adhered to, the probability of erosion and sedimentation causing effects is possible, but should not occur.

Thus, considering the above description, the residual cumulative effects of erosion and sedimentation on aquatic habitat and non-fish aquatic life were assessed as **not significant - minor** (Table 15.9-7).

15.9.3.3 Cumulative Effect of Water Quality Degradation

15.9.3.3.1 Project-specific Cumulative Effect of Water Quality Degradation

The majority of past, present, and future projects identified as having potential linkages for residual cumulative effects may contribute to toxicity in fish associated with water quality degradation (metals, process chemicals, petroleum products, and nitrogenous compounds). Aquatic habitat is found in many locations, both near and far from potential infrastructure associated with developments.

Metals may be introduced to the environment from two main sources. ML/ARD, with mobilization of metals in acidic leachate, can be generated from weathering of PAG rock that is exposed during construction of infrastructure or ongoing activities associated with mining. Point source discharges of effluent from mining infrastructure (such as tailing ponds) may also be a source of metals and process chemicals (such as cyanide, flocculants, etc.). Petroleum products may be introduced to aquatic environments due to work that occurs in and around waterways. Nitrogenous compounds, derived from either blasting residues/airborne particles or STP effluent, can also enter the aquatic environment and have the potential to cause toxicity in fish. Collectively, these chemical compounds can alter water quality and can individually or in mixtures lead to toxicity in fish. Toxicity in fish may be seen as impairments in reproduction, immune competence, olfaction, osmoregulatory balance, and behavioural changes.

There is (non-fish) aquatic life and aquatic habitat within watercourses near past, present, or future access roads, where introduction of metals, petroleum products, and blasting residues into the aquatic environment may occur from multiple projects. However, aquatic habitat that is located a considerable distance downstream from most of the main infrastructure associated with past, present, or future project infrastructure (e.g. existing or potential mine pits, tailing ponds, processing facilities) can also be at risk of exposure to chemicals in the water. Metals and other chemicals can be carried long distances, dissolved in or carried by water. The potential for toxic effects will depend on the dilution capacity available with distance from the source since concentrations (and thus the probability of toxicity) will decrease with distance.

Inputs of metals from historical projects including the Eskay Creek Mine, Granduc Mine, and Sulphurets Project would have been measured during baseline studies since they contribute to background, existing concentrations and would have been incorporated into the water chemistry of the receiving environment. These baseline data were already captured in the predictive water quality modelling that was completed (Appendix 14-H). Provided that no new changes occur in the conditions at these historical mines, metal inputs should remain stable or decrease over time. No additional cumulative effects related to these Projects would be expected with development of the KSM Project beyond what was already included in the predicted concentrations of metals based on baseline studies; therefore these three developments were excluded from the fish and aquatic habitat CEA.

There are a number of future projects that may have spatial or temporal overlaps with the KSM Project. The Snowfield Project is located immediately adjacent to the KSM Project, such that the Snowfield property may be influenced by KSM Project access plans for the area (Snowden 2012). The Snowfield deposit area drains downstream to Mitchell Creek (Wardop 2010), which is upstream of the proposed WSF for the KSM Project. A PEA was completed in 2010 that explored the value of combining the Brucejack and Snowfield projects (Wardop 2010). The Snowfield Project proponent has no current plans to advance development; therefore, since there is no potential temporal overlap, the Snowfield Project was considered to not have the potential for cumulative effects to water quality.

The reopened Granduc Copper Mine is located 40 km northwest of Stewart in northwestern BC and previously produced between 1971 and 1984 (Section 5.3.3.2). Castle Resources Inc. acquired the Granduc property from Bell Copper in July 2010, and began exploration drilling with the aim of redeveloping the mine (Marketwire 2010; Scales 2012). In 2011, Castle Resources Inc. had the 17-km tunnel rehabilitated, and plans to rehabilitate specific levels of the old underground mine to establish underground drill stations for exploration. Castle Resources Inc. is currently working on a PEA that will evaluate mining methods, tailing impoundment, and a suitable milling process (Dickson 2012). It is expected that the mine will use sub-level caving techniques (Dickson 2012; Scales 2012). The drainage from the Granduc Copper Mine is to the Bowser River, Bowser Lake, and ultimately to the Bell-Irving River. Since residual water quality effects from activities in the PTMA of the KSM Project are not predicted to occur in Treaty or Teigen creeks (and therefore no effects are predicted in the Bell-Irving River), there is no spatial overlap in water quality effects from the projects, and the Granduc Copper Mine was considered to not have the potential for cumulative effects to water quality.

Table 15.9-7. Summary of Residual Cumulative Effects on Aquatic Habitat

Description of Residual Effect	Other Project(s)/ Activity(ies)	Timing of Effect	Magnitude	Magnitude Adjusted for CE	Extent	Extent Adjusted for CE	Duration	Duration Adjusted for CE	Frequency	Frequency Adjusted for CE	Reversibility	Reversibility Adjusted for CE	Context	Context Adjusted for CE	Likelihood of Effects				Significance Determination	Significance Determination Adjusted for CE	Follow-up Monitoring	Follow-up Monitoring Adjusted for CE
															Probability	Probability Adjusted for CE	Confidence Level	Conf. Level Adjusted for CE				
Erosion and sedimentation causing smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction	Construction	Low	Low	Landscape	Landscape	Medium	Medium	Sporadic	Sporadic	Reversible long-term	Reversible long-term	Neutral	Neutral	High	High	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Erosion and sedimentation causing smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; South Cell Tailing Management Facility; Centre Cell Tailing Management Facility; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction	Operations	Low	Low	Landscape	Landscape	Medium	Medium	Sporadic	Sporadic	Reversible long-term	Reversible long-term	Neutral	Neutral	Medium	Medium	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Erosion and sedimentation causing smothering of aquatic invertebrates, loss of productive habitat capacity	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; South Cell Tailing Management Facility; East Catchment Diversion	Closure	Negligible	Negligible	Landscape	Landscape	Short	Short	Sporadic	Sporadic	Reversible long-term	Reversible long-term	Neutral	Neutral	Medium	Medium	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Water quality degradation due to metals, process chemicals, petroleum products, or nitrogenous compounds resulting in toxicity to (non-fish) aquatic life	Treaty OPC; Concentrate Storage and Loadout; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle;Coulter Creek Access Corridor; Treaty Creek Access Road; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle; Camp 7: Unuk North; Camp 8: Unuk South; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Coulter Creek Access Corridor; McTagg Diversion Tunnel; McTagg Rock Storage Facililty; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Operations	High	N/A	Regional	N/A	Long	N/A	Continuous	N/A	Reversible long-term	N/A	Neutral	N/A	Low	N/A	Medium	N/A	Not Significant (Minor)	N/A	Required	Not Required
Water quality degradation due to metals, process chemicals, petroleum products, or nitrogenous compounds resulting in toxicity to (non-fish) aquatic life	Treaty OPC; Concentrate Storage and Loadout; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle;Coulter Creek Access Corridor; Treaty Creek Access Road; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle; Camp 7: Unuk North; Camp 8: Unuk South; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Coulter Creek Access Corridor; McTagg Diversion Tunnel; McTagg Rock Storage Facililty; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Closure	High	N/A	Regional	N/A	Medium	N/A	Continuous	N/A	Reversible long-term	N/A	Neutral	N/A	Low	N/A	Medium	N/A	Not Significant (Minor)	N/A	Required	Not Required

(continued)

Table 15.9-7. Summary of Residual Cumulative Effects on Aquatic Habitat (continued)

Description of Residual Effect	Other Project(s)/ Activity(ies)	Timing of Effect	Magnitude	Magnitude Adjusted for CE	Extent	Extent Adjusted for CE	Duration	Duration Adjusted for CE	Frequency	Frequency Adjusted for CE	Reversibility	Reversibility Adjusted for CE	Context	Context Adjusted for CE	Likelihood of Effects				Significance Determination	Significance Determination Adjusted for CE	Follow-up Monitoring	Follow-up Monitoring Adjusted for CE
															Probability	Probability Adjusted for CE	Confidence Level	Conf. Level Adjusted for CE				
Water quality degradation due to metals, process chemicals, petroleum products, or nitrogenous compounds resulting in toxicity to fish	Treaty OPC; Concentrate Storage and Loadout; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility; South Cell Tailing Management Facility; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle;Coulter Creek Access Corridor; Treaty Creek Access Road; Camp 11: Treaty Marshalling Yard; Camp 12: Highway 37 Construction; Camp 6: Treaty Saddle; Camp 7: Unuk North; Camp 8: Unuk South; Mitchell-Treaty Tunnel; Treaty Creek Access Road; East Catchment Diversion; Coulter Creek Access Corridor; McTagg Diversion Tunnel; McTagg Rock Storage Facililty; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit	Post-closure	High	N/A	Regional	N/A	Far future	N/A	Continuous	N/A	Reversible long-term	N/A	Neutral	N/A	Low	N/A	Medium	N/A	Not Significant (Minor)	N/A	Required	Not Required
Loss of fish habitat and decrease in the productive capacity of aquatic habitat due to linear development (access roads and transmission line), and TMF development (dams and tailings) footprints	Coulter Creek Access Corridor; Treaty Creek Access Road; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility	Construction	Medium	Medium	Local	Local	Medium	Medium	One-time	One-time	Reversible short-term	Reversible short-term	Neutral	Neutral	High	High	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Loss of fish habitat and decrease in the productive capacity of aquatic habitat due to linear development (access roads and transmission line), and TMF development (dams and tailings) footprints	Coulter Creek Access Corridor; Treaty Creek Access Road; South Cell Tailing Management Facility	Operations	Medium	Medium	Local	Local	Long	Long	One-time	One-time	Reversible short-term	Reversible short-term	Neutral	Neutral	High	High	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Loss of fish habitat and decrease in the productive capacity of aquatic habitat due to water quanity reductions downstream of the TMF	North Cell Tailing Management Facility; Centre Cell Tailing Management Facility	Construction	Low	Low	Landscape	Landscape	Medium	Medium	Continuous	Continuous	Reversible short-term	Reversible short-term	Neutral	Neutral	High	High	High	High	Not Significant (Minor)	Not Significant (Minor)	Required	Required
Loss of fish habitat and decrease in the productive capacity of aquatic habitat due to water quanity reductions downstream of the TMF	South Cell Tailing Management Facility; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility	Operations	Low	Low	Landscape	Landscape	Long	Long	Continuous	Continuous	Reversible short-term	Reversible short-term	Neutral	Neutral	High	High	High	High	Not Significant (Minor)	Not Significant (Minor)	Required	Not Required
Loss of fish habitat and decrease in the productive capacity of aquatic habitat due to water quanity reductions downstream of the TMF	South Cell Tailing Management Facility; North Cell Tailing Management Facility; Centre Cell Tailing Management Facility	Closure	Low	Low	Landscape	Landscape	Medium	Medium	Continuous	Continuous	Reversible short-term	Reversible short-term	Neutral	Neutral	High	High	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Loss of aquatic habitat productive capacity within McTagg, Mitchell, and non-fish bearing reaches of Sulphurets Creek due to infrastructure development (footprint) and diversion of water	McTagg Rock Storage Facility; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit; McTagg Twinned Diversion Tunnels; diversion channels/ditches	Construction	Low	Low	Local	Local	Far future	Far future	One-time	One-time	Irreversible	Irreversible	Low	Low	High	High	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required

(continued)

Table 15.9-7. Summary of Residual Cumulative Effects on Aquatic Habitat (completed)

															Likelihood of Effects							
Description of Residual Effect	Other Project(s)/ Activity(ies)	Timing of Effect	Magnitude	Magnitude Adjusted for CE	Extent	Extent Adjusted for CE	Duration	Duration Adjusted for CE	Frequency	Frequency Adjusted for CE	Reversibility	Reversibility Adjusted for CE	Context	Context Adjusted for CE	Probability	Probability Adjusted for CE	Confidence Level	Conf. Level Adjusted for CE	Significance Determination	Significance Determination Adjusted for CE	Follow-up Monitoring	Follow-up Monitoring Adjusted for CE
Loss of aquatic habitat productive capacity within McTagg, Mitchell, and non-fish bearing reaches of Sulphurets Creek due to infrastructure development (footprint) and diversion of water	McTagg Rock Storage Facility; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit; McTagg Twinned Diversion Tunnels; diversion channels/ditches	Operations	Low	Low	Local	Local	Far future	Far future	One-time	One-time	Irreversible	Irreversible	Low	Low	High	High	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Loss of fish habitat productive capacity within the fish bearing reach of Sulphurets Creek due to infrastructure development (footprint) and water management	McTagg Rock Storage Facility; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit; McTagg Twinned Diversion Tunnels; diversion channels/ditches	Construction	Low	Low	Landscape	Landscape	Medium	Medium	Continuous	Continuous	Reversible short-term	Reversible short-term	Low	Low	Medium	Medium	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Loss of fish habitat productive capacity within the fish bearing reach of Sulphurets Creek due to infrastructure development (footprint) and water management	McTagg Rock Storage Facility; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit; McTagg Twinned Diversion Tunnels; diversion channels/ditches	Operations	Low	Low	Landscape	Landscape	Long	Long	Continuous	Continuous	Reversible short-term	Reversible short-term	Low	Low	Medium	Medium	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Loss of fish habitat productive capacity within the fish bearing reach of Sulphurets Creek due to infrastructure development (footprint) and water management	McTagg Rock Storage Facility; Mitchell Rock Storage Facility; Mitchell Ore Preparation Complex; Mitchell Pit; Water Storage Facility; Water Treatment & Energy Recovery Area; Sludge Management Facilities; Sulphurets Laydown Area; Sulphurets-Mitchell Conveyor Tunnel; Sulphurets Pit; Kerr Pit; McTagg Twinned Diversion Tunnels; diversion channels/ditches	Closure	Low	Low	Landscape	Landscape	Long	Long	Continuous	Continuous	Reversible short-term	Reversible short-term	Low	Low	Medium	Medium	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Decrease in the productive capacity of aquatic habitat within non-fish bearing reaches of Gingras Creek due to water quantity changes (McTagg Creek diversion and hydropower plant development)	McTagg Power Plant, McTagg Twinned Diversion Tunnels; diversion channels/ditches	Construction	Low	Low	Landscape	Landscape	Long	Long	Continuous	Continuous	Reversible long-term	Reversible long-term	Neutral	Neutral	High	High	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Decrease in the productive capacity of aquatic habitat within non-fish bearing reaches of Gingras Creek due to water quantity changes (McTagg Creek diversion and hydropower plant development)	McTagg Power Plant, McTagg Twinned Diversion Tunnels; diversion channels/ditches	Operations	Low	Low	Landscape	Landscape	Long	Long	Continuous	Continuous	Reversible long-term	Reversible long-term	Neutral	Neutral	High	High	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Decrease in the productive capacity of aquatic habitat within non-fish bearing reaches of Gingras Creek due to water quantity changes (McTagg Creek diversion and hydropower plant development)	McTagg Power Plant, McTagg Twinned Diversion Tunnels; diversion channels/ditches	Closure	Low	Low	Landscape	Landscape	Medium	Medium	Continuous	Continuous	Reversible long-term	Reversible long-term	Neutral	Neutral	High	High	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Decrease in the productive capacity of aquatic habitat within non-fish bearing reaches of Gingras Creek due to water quantity changes (McTagg Creek diversion and hydropower plant development)	McTagg Power Plant, McTagg Twinned Diversion Tunnels; diversion channels/ditches	Post-closure	Low	Low	Landscape	Landscape	Far future	Far future	Continuous	Continuous	Reversible long-term	Reversible long-term	Neutral	Neutral	High	High	High	High	Not Significant (Minor)	Not Significant (Minor)	Not Required	Not Required
Overall Effect	All	Post-closure	High	High	Regional	Regional	Far future	Far future	Continuous	Continuous	Reversible long-term	Reversible long-term	Neutral	Neutral	Low	Low	Medium	Medium	Not Significant (Minor)	Not Significant (Minor)	Required	Not Required

Note: CE = Cumulative Effect.

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Similarly, the Treaty Creek Hydroelectric project (on upper Treaty Creek) and the Northwest Transmission Line project (in the Bell-Irving watershed) may have temporal overlap with the KSM Project. However, these projects are located in areas where they would not be expected to have a spatial overlap with the KSM Project since no water quality degradation effects are predicted in Treaty Creek or the Bell-Irving River for the KSM Project.

The proposed Brucejack Project is located immediately east of the KSM Project and entered the BC Environmental Assessment process in 2012. The Brucejack Project is an underground gold and silver mining operation targeting two deposits. The mine life is projected to be a minimum of 16 years, with anticipated commencement of operations in 2016 (Tetra Tech Wardrop 2011), indicating that a temporal overlap with the KSM Project is possible. Approximately 5 Mt of waste rock will be produced throughout the mine life, with 2 Mt of waste rock stored sub-aqueously in the southwest corner of Brucejack Lake. An estimated 8 Mt of flotation tailing material will additionally be deposited in Brucejack Lake. Brucejack Lake drains west into the Sulphurets-Unuk watershed (Rescan 2013). Water quality effects from the Brucejack Project have the potential to interact with residual effects from the KSM Project; therefore the Brucejack Project was included in the fish and aquatic habitat CEA.

A residual effect on water quality in the Sulphurets-Unuk watershed due to increased selenium concentrations was predicted for the KSM Project in relation to fish (**not significant - moderate**, Section 15.8.2.5.1) and water quality (**not significant - moderate**, Chapter 14). However, for aquatic habitat, the potential residual effect was assessed as **not significant - minor** (Section 15.8.3.2.1). Increased selenium loading from the Brucejack Project has the potential to increase concentrations of selenium in Sulphurets Creek and the Unuk River, which could result in a cumulative effect of a greater magnitude in the Unuk River at the BC-Alaska border. Estimations of water quality effects from the Brucejack Project Description (Rescan 2013) submitted to the BC EAO were used to quantify the additional selenium loading.

15.9.3.3.2 Project-specific Cumulative Effect Mitigations for Water Quality Degradation

Project-specific cumulative effect mitigation for aquatic habitat is as described for fish in Section 15.9.2.7.

15.9.3.3.3 Other Project/Activity Mitigations to Address Water Quality Degradation

It is anticipated that other projects will adopt similar mitigation strategies as the KSM Project, and these are as described for fish in Section 15.9.2.7.

15.9.3.3.4 Determination of Potential for Residual Cumulative Effect and Significance

The Brucejack Project Description identified the potential for local, low magnitude effects on water quality (Rescan 2013), which suggests that the effects on water quality will not be distinguishable from background concentrations by the time the water reaches Sulphurets Creek. The cumulative effect on water quality from the Brucejack Project will not influence the descriptors used in the assessment of Project-specific residual effects, as concentrations of selenium in the Sulphurets-Unuk watershed are not expected to increase above the KSM Project-specific predictions as a result of cumulative water quality effects. Therefore, there will be no residual cumulative effects, so the rating applied was **not applicable (N/A)**.

When completing Table 15.9-7, water quality degradation as an effect was summarized as one line. In the residual effects assessment section, the potential residual effects of water quality degradation were broken down into multiple, more specific causes of water quality changes in order to facilitate a more detailed assessment (metals from non-point sources, discharge from TMF, discharge from Mine Site WTP, petroleum products, and nitrogenous compounds). Since no residual cumulative effects were predicted for water quality degradation, to simplify the table, on the summary line the Mine Site WTP discharge assessment for aquatic habitat was used (Section 15.8.3.2.1).

15.9.3.4 Cumulative Effect of Habitat Loss and Alteration

15.9.3.4.1 Project-specific Cumulative Effects of Habitat Loss and Alteration

Cumulative effects associated with fish habitat loss and alterations are expected to occur in the cumulative effects study area. There are no fish present within most project infrastructure, such as Eskay Creek, Granduc, Sulphurets, Brucejack, Snowfield, and Granduc Copper mines. The associated access roads of these mines as well as the Northwest Transmission Line access roads have resulted, or will result, in fish habitat loss at watercourse crossings. The Northwest Transmission Line Project has caused the loss of fish habitat through the removal of riparian habitat due to the installation of the transmission line alignment.

Lost and altered fish habitat will be compensated for as per project-specific Fish Habitat Compensation Plans. These compensation plans must be approved by the DFO and must achieve no net loss of fish habitat; therefore, cumulative effects associated with past, present, and future projects are minimal.

15.9.3.4.2 Project-specific Cumulative Effects Mitigations for Habitat Loss and Alteration

Mitigation measures to prevent the loss and alteration of fish habitat will be implemented to minimize cumulative effects associated with habitat loss. Guidelines, BMPs, and DFO operational statements must be followed for each project and their activities to minimize the cumulative effect of habitat loss in the cumulative effects study area. Detailed and functional fish habitat compensation plans must also be developed and approved by the DFO. Thus, additional mitigation to address potential cumulative effects are not required.

15.9.3.4.3 Other Project/Activity Mitigations to Address Habitat Loss and Alteration

It is anticipated that other projects will adopt that same mitigation strategies and compensation plans as the KSM Project. Compensation measures proposed for the KSM Project are standards stated in federal DFO guidelines to which all projects are subject.

15.9.3.4.4 Determination of Potential for Residual Cumulative Effect and Significance

Fish habitat loss and alteration was assessed as a one-time event to occur during the construction phase of the Project. This effect, after consideration of fish habitat compensation and management practices, was assessed as medium magnitude. Effects associated with fish habitat loss and alteration are considered landscape in their geographical extent, and their duration will be short-term, because the time between habitat destruction and creation (i.e., fish habitat compensation plan) is short. Reversibility of effects was assessed as reversible short-term, because riparian habitat can naturally regenerate and instream habitat compensation measures should replace lost habitat after many years. Because instream and riparian habitat vary in their level of adaptability to alteration, context (or resiliency) was assessed as neutral. Effects to fish habitat will occur due to the construction of Project infrastructure; therefore, the likelihood of effects was assessed as high probability and high confidence. Although potential residual effects associated with fish habitat will occur, effects will be minimized and mitigated through the implementation of several guidelines, BMPs, and plans (e.g., DFO operational statements; timing windows for instream work; and fish habitat compensation plans). Thus, potential cumulative effects associated with fish habitat loss and alteration caused by access road, transmission line, TMF construction, and resulting downstream water quantity loss were assessed as **not significant - minor** (Table 15.9-7).

Residual effects due to the loss of non-fish-bearing aquatic habitat within and downstream of the Mine Site due to KSM Project infrastructure construction and water diversions were discussed in Sections 15.7.5.1.6 and 15.8.3.5 and were assessed as **not significant - minor**. Other foreseeable projects (e.g., Brucejack Mine and Snowfield Project) may also contribute to a one-time loss of non-fish-bearing aquatic habitat in the Sulphurets Creek watershed. While this has the potential to decrease sediment inputs and benthic drift to downstream aquatic environments, it is likely that the effect would be minor, since the developments would occur significant distances upstream from waterways that would be affected by cumulative effects (e.g. Sulphurets Creek and the Unuk River). Also, potentially affected areas for foreseeable mining development would likely be located in the glaciated headwaters of various creeks, which are typically low in nutrients and would likely have low productive capacity; thus a low magnitude for residual cumulative effects was assessed. Any residual effects would occur at a landscape level, since they would occur outside of the Project infrastructure. Any residual cumulative effect would likely be reversible in the long term. However, there is uncertainty in this assessment since plans regarding future mine development in the cumulative effects study area are not currently available, which affects both the probability of effects occurring and the confidence level in the assessment. Overall, the residual cumulative effect for loss of non-fish-bearing aquatic habitat was assessed to be **not significant - minor**.

15.9.3.5 Overall Cumulative Effect on Aquatic Habitat Valued Component

Key measures to reduce the potential for residual effects on aquatic habitat as a result of KSM Project activities include a combination of management plans, mitigation plans, and monitoring programs, which are described in Sections 15.7.5.8.7 and 15.9.3.4.3. It is expected that future projects will also include similar mitigation and management strategies, such that the potential for residual cumulative effects is not significant. The potential for residual cumulative effects on aquatic habitat as a result of interaction between the KSM Project and other past, present, or future projects was assessed to be **not significant - minor** for potential effects related to erosion and sedimentation and loss of habitat. The potential for residual cumulative effects related to water quality changes was rated as **not applicable (N/A)**.

However, the overall cumulative effect was based on the Project residual effects for water quality degradation since this was the most significant potential effect for the aquatic habitat VC. Although cumulative effects for water quality degradation were rated as N/A in the cumulative effects assessment, for the purposes of an overall rating (final line of Table 15.9-7), ratings equivalent to the Project residual effects were assigned for overall cumulative effects for each of the residual effect descriptors. Therefore, the overall cumulative effect was assessed as **not significant - minor** for aquatic habitat.

15.10 Summary of Assessment of Potential Environmental Effects on Fish and Aquatic Habitat

Table 15.10-1 presents a summary of the assessment of potential environmental effects for fish and aquatic habitat.

15.11 Fish and Aquatic Habitat Conclusions

Residual effects for fish VCs are direct mortality, noise, erosion and sedimentation, and water quality degradation leading to toxicity in fish. There is potential that Project-related increases in selenium concentrations downstream of the Mine Site WTP may lead to toxicity in fish residing downstream in Lower Sulphurets Creek (below the cascades) or in the Unuk River. This potential residual effect was rated **not significant - moderate**. Otherwise, all other potential Project-related residual effects on fish VCs (i.e., Dolly Varden, bull trout, rainbow trout/steelhead, and Pacific salmon) were assessed as **not significant - minor,** and are not likely to affect fish population viability.

Project-specific fish habitat loss will be caused through the construction, operation, and closure of Project infrastructure. There will be Project-related fish habitat loss associated with the following:

- the TMF and seepage pond;
- TMF infrastructure (dams, the TMF waste pile, and the Treaty Creek pipeline outlet);
- water quantity loss downstream of the TMF in South Teigen and North Treaty creeks;
- access road stream crossings (TCAR and CCAR); and
- transmission line stream crossings.

There are no Project-related fish habitat losses in Teigen Creek associated with the KSM Project.

Project-specific fish habitat loss will be compensated through the development and implementation of fish habitat compensation plan(s). Two separate compensation plans were developed to: 1) regulate the deposit of tailing and other waste matter produced during mining activities into natural fish-bearing waters (Section 36, *Fisheries Act* [1985]); and 2) to regulate the loss of fish habitat due to Project infrastructure (Section 35, *Fisheries Act* [1985]). The compensation plans were developed according to DFO's policy of a 2:1 habitat gain-to-loss ratio to ensure certainty of success and to maintain the overall net productive capacity.

Overall, potential Project-related residual effects on the aquatic habitat VC were assessed as **not significant - minor**. Residual effects for aquatic habitat VC are direct mortality, noise, erosion and sedimentation, water quality degradation, and (non-fish-bearing) habitat loss.

Table 15.10-1. Summary of Assessment of Potential Environmental Effects: Fish and Aquatic Habitat

Valued Component	Phase of Project	Potential Effect	Key Mitigation Measures	Significance Analysis of Project Residual Effects	Significance Analysis of Cumulative Residual Effects
Bull Trout	Construction	Direct mortality caused by impact with machinery	Use BMPs to minimize fish mortality with construction machinery; adhere to DFO's operational statements; adhere to appropriate construction operating window for instream work; site isolation; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)
	Operation	Direct mortality caused by impact with machinery; increased fishing pressure	Use BMPs to minimize fish mortality with construction machinery; adhere to DFO's operational statements; adhere to Fish and Aquatic Habitat Protection and Mitigation Plan; implement no-fishing policy for employees	Not Significant (minor)	Not Significant (minor)
	Closure	Direct mortality caused by impact with machinery; increased fishing pressure	Use BMPs to minimize fish mortality with construction machinery; adhere to DFO's operational statements; adhere to Fish and Aquatic Habitat Protection and Mitigation Plan; implement no-fishing policy for employees	Not Significant (minor)	Not Significant (minor)
	Construction	Noise from blasting and construction activities causing sublethal effects, decreased feeding efficiency, and habitat avoidance	Use BMPs to minimize noise effects; adhere to DFO's operational statements; setback distances; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)
	Construction	Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, and habitat avoidance	Use BMPs to minimize sediment entry to waterbodies; adhere to DFO's operational statements; adhere to appropriate construction operating window for instream work and the Sediment and Erosion Control Plan; site isolation; water quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)

(continued)

Table 15.10-1. Summary of Assessment of Potential Environmental Effects: Fish and Aquatic Habitat (continued)

Valued Component	Phase of Project	Potential Effect	Key Mitigation Measures	Significance Analysis of Project Residual Effects	Significance Analysis of Cumulative Residual Effects
	Operation	Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, and habitat avoidance	Use BMPs to minimize sediment entry to waterbodies; adhere to Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)
	Closure	Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, and habitat avoidance	Use BMPs to minimize sediment entry to waterbodies; adhere to Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)
	Construction	Sublethal toxicity due to metal exposure from non-point sources (e.g., ML/ARD leachates)	Select road and transmission line alignment to minimize high potential areas for ML/ARD; implement ML/ARD Prediction and Prevention Management Plan; adhere to Sediment and Erosion Control Plan; water and sediment quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	N/A
	Operation	Sublethal toxicity due to metal exposure from non-point sources (e.g., ML/ARD leachates)	Implement ML/ARD Prediction and Prevention Management Plan; adhere to Sediment and Erosion Control Plan; water and sediment quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	N/A
	Closure	Sublethal toxicity due to metal exposure from non-point sources (e.g., ML/ARD leachates)	Implement ML/ARD Prediction and Prevention Management Plan; adhere to Sediment and Erosion Control Plan; water and sediment quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	N/A

(continued)

Table 15.10-1. Summary of Assessment of Potential Environmental Effects: Fish and Aquatic Habitat (continued)

Valued Component	Phase of Project	Potential Effect	Key Mitigation Measures	Significance Analysis of Project Residual Effects	Significance Analysis of Cumulative Residual Effects
	Construction	Sublethal toxicity due to metals or process chemical exposures downstream of the TMF	TMF discharges paced with hydrology of receiving enviroment; no discharges during low flow periods of the receiving environment; water from seepage collection ponds returned to TMF; proper storage standards for chemicals; water treatment during post-closure if necessary to ensure water quality targets are met; implement ML/ARD Management Plan, Spill Containment and Emergency Response Plan, Effluent Monitoring Plan, and Aquatic Effects Monitoring Plan	Not Significant (minor)	N/A
	Operation	Sublethal toxicity due to metals or process chemical exposures downstream of the TMF	TMF discharges paced with hydrology of receiving enviroment; no discharges during low flow periods of the receiving environment; water from seepage collection ponds returned to TMF; proper storage standards for chemicals; water treatment during post-closure if necessary to ensure water quality targets are met; implement ML/ARD Management Plan, Spill Containment and Emergency Response Plan, Effluent Monitoring Plan, and Aquatic Effects Monitoring Plan	Not Significant (minor)	N/A
	Closure	Sublethal toxicity due to metals or process chemical exposures downstream of the TMF	TMF discharges paced with hydrology of receiving enviroment; no discharges during low flow periods of the receiving environment; water from seepage collection ponds returned to TMF; proper storage standards for chemicals; water treatment during post-closure if necessary to ensure water quality targets are met; implement ML/ARD Management Plan, Spill Containment and Emergency Response Plan, Effluent Monitoring Plan, and Aquatic Effects Monitoring Plan	Not Significant (minor)	N/A

(continued)

Table 15.10-1. Summary of Assessment of Potential Environmental Effects: Fish and Aquatic Habitat (continued)

Valued Component	Phase of Project	Potential Effect	Key Mitigation Measures	Significance Analysis of Project Residual Effects	Significance Analysis of Cumulative Residual Effects
	Post-Closure	Sublethal toxicity due to metals or process chemical exposures downstream of the TMF	TMF discharges paced with hydrology of receiving enviroment; no discharges during low flow periods of the receiving environment; water from seepage collection ponds returned to TMF; proper storage standards for chemicals; water treatment during post-closure if necessary to ensure water quality targets are met; implement ML/ARD Management Plan, Spill Containment and Emergency Response Plan, Effluent Monitoring Plan, and Aquatic Effects Monitoring Plan	Not Significant (minor)	N/A
	Construction	Sublethal toxicity due to petroleum products entering waterbodies	Use BMPs to minimize spill entry to waterbodies; adhere to DFO's operational statements; adhere to the Spill Containment and Emergency Response Plan; spill kits, equipment maintenance, stream setback distances, water quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	N/A
	Operation	Sublethal toxicity due to petroleum products entering waterbodies during instream construction, operation, and maintenance of roads and transmission line	Use BMPs to minimize spill entry to waterbodies; adhere to DFO's operational statements; adhere to appropriate construction operating window for instream work; adhere to the Spill Containment and Emergency Response Plan; spill kits, equipment maintenance, stream setback distances, water quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	N/A

(continued)

Table 15.10-1. Summary of Assessment of Potential Environmental Effects: Fish and Aquatic Habitat (continued)

Valued Component	Phase of Project	Potential Effect	Key Mitigation Measures	Significance Analysis of Project Residual Effects	Significance Analysis of Cumulative Residual Effects
	Closure	Sublethal toxicity due to petroleum products entering waterbodies during road and transmission line closure	Use BMPs to minimize spill entry to waterbodies; adhere to DFO's operational statements; adhere to appropriate construction operating window for instream work; adhere to the Spill Containment and Emergency Response Plan; spill kits, equipment maintenance, stream setback distances, water quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	N/A
	Construction	Sublethal toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage effluent	Use BMPs to minimize residue entry to waterbodies; adhere to DFO's operational statements; adhere to Fish and Aquatic Habitat Effects Protection and Mitigation Plan and Sediment and Erosion Control Plan; site isolation; water quality maintenance; use BMPs and industry water treatment standards to treat waste effluent and minimize residue entry to waterbodies	Not Significant (minor)	N/A
	Operation	Sublethal toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage effluent	Use BMPs to minimize residue entry to waterbodies; adhere to Fish and Aquatic Habitat Effects Protection and Mitigation Plan and Erosion and Sediment Management Plan; use BMPs and industry water treatment standards to treat waste effluent and minimize residue entry to waterbodies	Not Significant (minor)	N/A
	Closure	Sublethal toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage effluent	Use BMPs to minimize residue entry to waterbodies; adhere to Fish and Aquatic Habitat Effects Protection and Mitigation Plan and Erosion and Sediment Management Plan; use BMPs and industry water treatment standards to treat waste effluent and minimize residue entry to waterbodies	Not Significant (minor)	N/A

(continued)

Table 15.10-1. Summary of Assessment of Potential Environmental Effects: Fish and Aquatic Habitat (continued)

Valued Component	Phase of Project	Potential Effect	Key Mitigation Measures	Significance Analysis of Project Residual Effects	Significance Analysis of Cumulative Residual Effects
	Construction	Loss of instream and riparian habitat and productive capacity at stream crossings and infrastructure	Use BMPs to minimize habitat loss; use DFO's operational statement for transmission lines; implement Fish Habitat Compensation Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)
	Operation	Loss of instream and riparian habitat and productive capacity at stream crossings and infrastructure	Use BMPs to minimize habitat loss; use DFO's operational statement for transmission lines; implement Fish Habitat Compensation Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)
	Closure	Loss of instream and riparian habitat and productive capacity at stream crossings and infrastructure	Use BMPs to minimize habitat loss; use DFO's operational statement for transmission lines; implement Fish Habitat Compensation Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)
Dolly Varden/ rainbow trout/ steelhead / Pacific salmon	Construction	Direct mortality caused by impact with machinery	Use BMPs to minimize fish mortality with construction machinery; adhere to DFO's operational statements; adhere to appropriate construction operating window for instream work; site isolation; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)
	Operation	Direct mortality caused by impact with machinery; increased fishing pressure	Use BMPs to minimize fish mortality with construction machinery; adhere to DFO's operational statements; adhere to Fish and Aquatic Habitat Protection and Mitigation Plan; adhere to Access Road Control Plan; implement no-fishing policy for employees	Not Significant (minor)	Not Significant (minor)

(continued)

Table 15.10-1. Summary of Assessment of Potential Environmental Effects: Fish and Aquatic Habitat (continued)

Valued Component	Phase of Project	Potential Effect	Key Mitigation Measures	Significance Analysis of Project Residual Effects	Significance Analysis of Cumulative Residual Effects
	Closure	Direct mortality caused by impact with machinery; increased fishing pressure	Use BMPs to minimize fish mortality with construction machinery; adhere to DFO's operational statements; adhere to Fish and Aquatic Habitat Protection and Mitigation Plan; implement no-fishing policy for employees	Not Significant (minor)	Not Significant (minor)
	Construction	Noise from blasting and construction activities causing sublethal effects, decreased feeding efficiency, and habitat avoidance	Use BMPs to minimize noise effects; adhere to DFO's operational statements; setback distances; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)
	Closure	Noise from blasting and construction activities causing sublethal effects, decreased feeding efficiency, and habitat avoidance	Use BMPs to minimize noise effects; adhere to DFO's operational statements; setback distances; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)
	Construction	Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, and habitat avoidance	Use BMPs to minimize sediment entry to waterbodies; adhere to DFO's operational statements; adhere to appropriate construction operating window for instream work and the Sediment and Erosion Control Plan; site isolation; water quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)

(continued)

Table 15.10-1. Summary of Assessment of Potential Environmental Effects: Fish and Aquatic Habitat (continued)

Valued Component	Phase of Project	Potential Effect	Key Mitigation Measures	Significance Analysis of Project Residual Effects	Significance Analysis of Cumulative Residual Effects
	Operation	Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, and habitat avoidance	Use BMPs to minimize sediment entry to waterbodies; adhere to Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)
	Closure	Erosion and sedimentation causing smothering of eggs, decreased feeding efficiency, and habitat avoidance	Use BMPs to minimize sediment entry to waterbodies; adhere to Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)
	Construction	Sublethal toxicity due to metal exposure from non-point sources (e.g., ML/ARD leachates)	Select road and transmission line alignment to minimize high potential areas for ML/ARD; implement ML/ARD Prediction and Prevention Management Plan; adhere to Sediment and Erosion Control Plan; water and sediment quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	N/A
	Operation	Sublethal toxicity due to metal exposure from non-point sources (e.g., ML/ARD leachates)	Implement ML/ARD Prediction and Prevention Management Plan; adhere to Sediment and Erosion Control Plan; water and sediment quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	N/A
	Closure	Sublethal toxicity due to metal exposure from non-point sources (e.g., ML/ARD leachates)	Implement ML/ARD Prediction and Prevention Management Plan; adhere to Sediment and Erosion Control Plan; water and sediment quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	N/A

(continued)

Table 15.10-1. Summary of Assessment of Potential Environmental Effects: Fish and Aquatic Habitat (continued)

Valued Component	Phase of Project	Potential Effect	Key Mitigation Measures	Significance Analysis of Project Residual Effects	Significance Analysis of Cumulative Residual Effects
	Construction	Sublethal toxicity due to metals or process chemical exposures downstream of the TMF	TMF discharges paced with hydrology of receiving enviroment; no discharges during low flow periods of the receiving environment; water from seepage collection ponds returned to TMF; proper storage standards for chemicals; water treatment during post-closure if necessary to ensure water quality targets are met; implement ML/ARD Management Plan, Spill Containment and Emergency Response Plan, Effluent Monitoring Plan, and Aquatic Effects Monitoring Plan	Not Significant (minor)	N/A
	Operation	Sublethal toxicity due to metals or process chemical exposures downstream of the TMF	TMF discharges paced with hydrology of receiving enviroment; no discharges during low flow periods of the receiving environment; water from seepage collection ponds returned to TMF; proper storage standards for chemicals; water treatment during post-closure if necessary to ensure water quality targets are met; implement ML/ARD Management Plan, Spill Containment and Emergency Response Plan, Effluent Monitoring Plan, and Aquatic Effects Monitoring Plan	Not Significant (minor)	N/A
	Closure	Sublethal toxicity due to metals or process chemical exposures downstream of the TMF	TMF discharges paced with hydrology of receiving enviroment; no discharges during low flow periods of the receiving environment; water from seepage collection ponds returned to TMF; proper storage standards for chemicals; water treatment during post-closure if necessary to ensure water quality targets are met; implement ML/ARD Management Plan, Spill Containment and Emergency Response Plan, Effluent Monitoring Plan, and Aquatic Effects Monitoring Plan	Not Significant (minor)	N/A

(continued)

Table 15.10-1. Summary of Assessment of Potential Environmental Effects: Fish and Aquatic Habitat (continued)

Valued Component	Phase of Project	Potential Effect	Key Mitigation Measures	Significance Analysis of Project Residual Effects	Significance Analysis of Cumulative Residual Effects
	Post-Closure	Sublethal toxicity due to metals or process chemical exposures downstream of the TMF	TMF discharges paced with hydrology of receiving enviroment; no discharges during low flow periods of the receiving environment; water from seepage collection ponds returned to TMF; proper storage standards for chemicals; water treatment during post-closure if necessary to ensure water quality targets are met; implement ML/ARD Management Plan, Spill Containment and Emergency Response Plan, Effluent Monitoring Plan, and Aquatic Effects Monitoring Plan	Not Significant (minor)	N/A
	Construction	Sublethal toxicity due to metals or process chemical exposures downstream of the Mine Site WTP	Collection of all contact water from within the Mine Site catchment area and diversion of contact water to the WTP; treat contaminated water prior to discharge; Discharges from WSF/WTP phased to match hydrological regime; collection of seepage water in the seepage collection pond below the WSD; return of seepage water to the WSF/WTP; Implement and adhere to the ML/ARD Management Plan, Water Treatment, Effluent Monitoring Plan, and the Aquatic Effects Monitoring Plan	Not Significant (minor)	N/A
	Operation	Sublethal toxicity due to metals or process chemical exposures downstream of the Mine Site WTP	Collection of all contact water from within the Mine Site catchment area and diversion of contact water to the WTP; treat contaminated water prior to discharge; Discharges from WSF/WTP phased to match hydrological regime; collection of seepage water in the seepage collection pond below the WSD; return of seepage water to the WSF/WTP; Implement and adhere to the ML/ARD Management Plan, Water Treatment, Effluent Monitoring Plan, and the Aquatic Effects Monitoring Plan	Not Significant (moderate)	N/A

(continued)

Table 15.10-1. Summary of Assessment of Potential Environmental Effects: Fish and Aquatic Habitat (continued)

Valued Component	Phase of Project	Potential Effect	Key Mitigation Measures	Significance Analysis of Project Residual Effects	Significance Analysis of Cumulative Residual Effects
	Closure	Sublethal toxicity due to metals or process chemical exposures downstream of the Mine Site WTP	Collection of all contact water from within the Mine Site catchment area and diversion of contact water to the WTP; treat contaminated water prior to discharge; Discharges from WSF/WTP phased to match hydrological regime; collection of seepage water in the seepage collection pond below the WSD; return of seepage water to the WSF/WTP; Implement and adhere to the ML/ARD Management Plan, Water Treatment, Effluent Monitoring Plan, and the Aquatic Effects Monitoring Plan	Not Significant (moderate)	N/A
	Post-Closure	Sublethal toxicity due to metals or process chemical exposures downstream of the Mine Site WTP	Collection of all contact water from within the Mine Site catchment area and diversion of contact water to the WTP; treat contaminated water prior to discharge; Discharges from WSF/WTP phased to match hydrological regime; collection of seepage water in the seepage collection pond below the WSD; return of seepage water to the WSF/WTP; Implement and adhere to the ML/ARD Management Plan, Water Treatment, Effluent Monitoring Plan, and the Aquatic Effects Monitoring Plan	Not Significant (moderate)	N/A
	Construction	Sublethal toxicity due to petroleum products entering waterbodies	Use BMPs to minimize spill entry to waterbodies; adhere to DFO's operational statements; adhere to the Spill Containment and Emergency Response Plan; spill kits, equipment maintenance, stream setback distances, Water quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	N/A

(continued)

Table 15.10-1. Summary of Assessment of Potential Environmental Effects: Fish and Aquatic Habitat (continued)

Valued Component	Phase of Project	Potential Effect	Key Mitigation Measures	Significance Analysis of Project Residual Effects	Significance Analysis of Cumulative Residual Effects
	Operation	Sublethal toxicity due to petroleum products entering waterbodies during instream construction, operation, and maintenance of roads and transmission line	Use BMPs to minimize spill entry to waterbodies; adhere to DFO's operational statements; adhere to appropriate construction operating window for instream work; adhere to the Spill Containment and Emergency Response Plan; spill kits, equipment maintenance, stream setback distances, water quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	N/A
	Closure	Sublethal toxicity due to petroleum products entering waterbodies during road and transmission line closure	Use BMPs to minimize spill entry to waterbodies; adhere to DFO's operational statements; adhere to appropriate construction operating window for instream work; adhere to the Spill Containment and Emergency Response Plan; spill kits, equipment maintenance, stream setback distances, water quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	N/A
	Construction	Sublethal toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage effluent	Use BMPs to minimize blast residue entry to waterbodies; adhere to DFO's operational statements; adhere to Fish and Aquatic Habitat Effects Protection and Mitigation Plan and Sediment and Erosion Control Plan; site isolation; water quality maintenance; use BMPs and industry water treatment standards to treat waste effluent and minimize residue entry to waterbodies	Not Significant (minor)	N/A
	Operation	Sublethal toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage effluent	Use BMPs to minimize residue entry to waterbodies; adhere to Fish and Aquatic Habitat Effects Protection and Mitigation Plan and Erosion and Sediment Management Plan; use BMPs and industry water treatment standards to treat waste effluent and minimize residue entry to waterbodies	Not Significant (minor)	N/A

(continued)

Table 15.10-1. Summary of Assessment of Potential Environmental Effects: Fish and Aquatic Habitat (continued)

Valued Component	Phase of Project	Potential Effect	Key Mitigation Measures	Significance Analysis of Project Residual Effects	Significance Analysis of Cumulative Residual Effects
	Closure	Sublethal toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage effluent	Use BMPs to minimize residue entry to waterbodies; adhere to Fish and Aquatic Habitat Effects Protection and Mitigation Plan and Erosion and Sediment Management Plan; use BMPs and industry water treatment standards to treat waste effluent and minimize residue entry to waterbodies	Not Significant (minor)	N/A
	Construction	Loss of instream and riparian habitat and productive capacity at stream crossings and infrastructure	Use BMPs to minimize habitat loss; use DFO's operational statement for transmission lines; implement Fish Habitat Compensation Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)
	Operation	Loss of instream and riparian habitat and productive capacity at stream crossings and infrastructure	Use BMPs to minimize habitat loss; use DFO's operational statement for transmission lines; implement Fish Habitat Compensation Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)
	Closure	Loss of instream and riparian habitat and productive capacity at stream crossings and infrastructure	Use BMPs to minimize habitat loss; use DFO's operational statement for transmission lines; implement Fish Habitat Compensation Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)
Aquatic Habitat	Construction	Erosion and sedimentation causing smothering of aquatic invertebrates and loss of productive habitat capacity	Use BMPs to minimize sediment entry to waterbodies; adhere to DFO's operational statements; adhere to appropriate construction operating window for instream work and the Sediment and Erosion Control Plan; site isolation; water quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	

(continued)

Table 15.10-1. Summary of Assessment of Potential Environmental Effects: Fish and Aquatic Habitat (continued)

Valued Component	Phase of Project	Potential Effect	Key Mitigation Measures	Significance Analysis of Project Residual Effects	Significance Analysis of Cumulative Residual Effects
	Operation	Erosion and sedimentation causing smothering of aquatic invertebrates and loss of productive habitat capacity	Use BMPs to minimize sediment entry to waterbodies; adhere to Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)
	Closure	Erosion and sedimentation causing smothering of aquatic invertebrates and loss of productive habitat capacity	Use BMPs to minimize sediment entry to waterbodies; adhere to Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)
	Construction	Sublethal toxicity due to metal exposure from non-point sources (e.g., ML/ARD leachates)	Select road and transmission line alignment to minimize high potential areas for ML/ARD; implement ML/ARD Prediction and Prevention Management Plan; adhere to Sediment and Erosion Control Plan; water and sediment quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	N/A
	Operation	Sublethal toxicity due to metal exposure from non-point sources (e.g., ML/ARD leachates)	Implement ML/ARD Prediction and Prevention Management Plan; adhere to Sediment and Erosion Control Plan; water and sediment quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	N/A
	Closure	Sublethal toxicity due to metal exposure from non-point sources (e.g., ML/ARD leachates)	Implement ML/ARD Prediction and Prevention Management Plan; adhere to Sediment and Erosion Control Plan; water and sediment quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	N/A

(continued)

Table 15.10-1. Summary of Assessment of Potential Environmental Effects: Fish and Aquatic Habitat (continued)

Valued Component	Phase of Project	Potential Effect	Key Mitigation Measures	Significance Analysis of Project Residual Effects	Significance Analysis of Cumulative Residual Effects
	Construction	Sublethal toxicity due to metals or process chemical exposures downstream of the TMF	TMF discharges paced with hydrology of receiving enviroment; no discharges during low flow periods of the receiving environment; water from seepage collection ponds returned to TMF; proper storage standards for chemicals; water treatment during post-closure if necessary to ensure water quality targets are met; implement ML/ARD Management Plan, Spill Containment and Emergency Response Plan, Effluent Monitoring Plan, and Aquatic Effects Monitoring Plan	Not Significant (minor)	N/A
	Operation	Sublethal toxicity due to metals or process chemical exposures downstream of the TMF	TMF discharges paced with hydrology of receiving enviroment; no discharges during low flow periods of the receiving environment; water from seepage collection ponds returned to TMF; proper storage standards for chemicals; water treatment during post-closure if necessary to ensure water quality targets are met; implement ML/ARD Management Plan, Spill Containment and Emergency Response Plan, Effluent Monitoring Plan, and Aquatic Effects Monitoring Plan	Not Significant (minor)	N/A
	Closure	Sublethal toxicity due to metals or process chemical exposures downstream of the TMF	TMF discharges paced with hydrology of receiving enviroment; no discharges during low flow periods of the receiving environment; water from seepage collection ponds returned to TMF; proper storage standards for chemicals; water treatment during post-closure if necessary to ensure water quality targets are met; implement ML/ARD Management Plan, Spill Containment and Emergency Response Plan, Effluent Monitoring Plan, and Aquatic Effects Monitoring Plan	Not Significant (minor)	N/A

(continued)

Table 15.10-1. Summary of Assessment of Potential Environmental Effects: Fish and Aquatic Habitat (continued)

Valued Component	Phase of Project	Potential Effect	Key Mitigation Measures	Significance Analysis of Project Residual Effects	Significance Analysis of Cumulative Residual Effects
	Post-Closure	Sublethal toxicity due to metals or process chemical exposures downstream of the TMF	TMF discharges paced with hydrology of receiving enviroment; no discharges during low flow periods of the receiving environment; water from seepage collection ponds returned to TMF; proper storage standards for chemicals; water treatment during post-closure if necessary to ensure water quality targets are met; implement ML/ARD Management Plan, Spill Containment and Emergency Response Plan, Effluent Monitoring Plan, and Aquatic Effects Monitoring Plan	Not Significant (minor)	N/A
	Construction	Sublethal toxicity due to metals or process chemical exposures downstream of the Mine Site WTP	Collection of all contact water from within the Mine Site catchment area and diversion of contact water to the WTP; treat contaminated water prior to discharge; Discharges from WSF/WTP phased to match hydrological regime; collection of seepage water in the seepage collection pond below the WSD; return of seepage water to the WSF/WTP; Implement and adhere to the ML/ARD Management Plan, Water Treatment, Effluent Monitoring Plan, and the Aquatic Effects Monitoring Plan	Not Significant (minor)	N/A
	Operation	Sublethal toxicity due to metals or process chemical exposures downstream of the Mine Site WTP	Collection of all contact water from within the Mine Site catchment area and diversion of contact water to the WTP; treat contaminated water prior to discharge; Discharges from WSF/WTP phased to match hydrological regime; collection of seepage water in the seepage collection pond below the WSD; return of seepage water to the WSF/WTP; Implement and adhere to the ML/ARD Management Plan, Water Treatment, Effluent Monitoring Plan, and the Aquatic Effects Monitoring Plan	Not Significant (minor)	N/A

(continued)

Table 15.10-1. Summary of Assessment of Potential Environmental Effects: Fish and Aquatic Habitat (continued)

Valued Component	Phase of Project	Potential Effect	Key Mitigation Measures	Significance Analysis of Project Residual Effects	Significance Analysis of Cumulative Residual Effects
	Closure	Sublethal toxicity due to metals or process chemical exposures downstream of the Mine Site WTP	Collection of all contact water from within the Mine Site catchment area and diversion of contact water to the WTP; treat contaminated water prior to discharge; Discharges from WSF/WTP phased to match hydrological regime; collection of seepage water in the seepage collection pond below the WSD; return of seepage water to the WSF/WTP; Implement and adhere to the ML/ARD Management Plan, Water Treatment, Effluent Monitoring Plan, and the Aquatic Effects Monitoring Plan	Not Significant (minor)	N/A
	Post-Closure	Sublethal toxicity due to metals or process chemical exposures downstream of the Mine Site WTP	Collection of all contact water from within the Mine Site catchment area and diversion of contact water to the WTP; treat contaminated water prior to discharge; Discharges from WSF/WTP phased to match hydrological regime; collection of seepage water in the seepage collection pond below the WSD; return of seepage water to the WSF/WTP; Implement and adhere to the ML/ARD Management Plan, Water Treatment, Effluent Monitoring Plan, and the Aquatic Effects Monitoring Plan	Not Significant (moderate)	N/A
	Construction	Sublethal toxicity due to petroleum products entering waterbodies	Use BMPs to minimize spill entry to waterbodies; adhere to DFO's operational statements; adhere to the Spill Containment and Emergency Response Plan; spill kits, Equipment maintenance, stream setback distances, water quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	N/A

(continued)

Table 15.10-1. Summary of Assessment of Potential Environmental Effects: Fish and Aquatic Habitat (continued)

Valued Component	Phase of Project	Potential Effect	Key Mitigation Measures	Significance Analysis of Project Residual Effects	Significance Analysis of Cumulative Residual Effects
	Operation	Sublethal toxicity due to petroleum products entering waterbodies during instream construction, operation, and maintenance of roads and transmission line	Use BMPs to minimize spill entry to waterbodies; adhere to DFO's operational statements; adhere to appropriate construction operating window for instream work; adhere to the Spill Containment and Emergency Response Plan; spill kits, equipment maintenance, stream setback distances, water quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	N/A
	Closure	Sublethal toxicity due to petroleum products entering waterbodies during road and transmission line closure	Use BMPs to minimize spill entry to waterbodies; adhere to DFO's operational statements; adhere to appropriate construction operating window for instream work; adhere to the Spill Containment and Emergency Response Plan; spill kits, equipment maintenance, stream setback distances, water quality maintenance; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	N/A
	Construction	Eutrophication or sublethal toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage effluent	Use BMPs to minimize blast residue entry to waterbodies; adhere to DFO's operational statements; adhere to Fish and Aquatic Habitat Effects Protection and Mitigation Plan and Sediment and Erosion Control Plan; site isolation; water quality maintenance; use BMPs and industry water treatment standards to treat waste effluent and minimize residue entry to waterbodies	Not Significant (minor)	N/A

(continued)

Table 15.10-1. Summary of Assessment of Potential Environmental Effects: Fish and Aquatic Habitat (completed)

Valued Component	Phase of Project	Potential Effect	Key Mitigation Measures	Significance Analysis of Project Residual Effects	Significance Analysis of Cumulative Residual Effects
	Operation	Eutrophication or sublethal toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage effluent	Use BMPs to minimize residue entry to waterbodies; adhere to Fish and Aquatic Habitat Effects Protection and Mitigation Plan and Erosion and Sediment Management Plan; use BMPs and industry water treatment standards to treat waste effluent and minimize residue entry to waterbodies	Not Significant (minor)	N/A
	Closure	Eutrophication or sublethal toxicity due to introduction of nitrogenous nutrients associated with blasting residue or sewage effluent	Use BMPs to minimize residue entry to waterbodies; adhere to Fish and Aquatic Habitat Effects Protection and Mitigation Plan and Erosion and Sediment Management Plan; use BMPs and industry water treatment standards to treat waste effluent and minimize residue entry to waterbodies	Not Significant (minor)	N/A
	Construction	Loss of instream and riparian habitat and productive capacity at stream crossings and infrastructure	Use BMPs to minimize habitat loss; use DFO's operational statement for transmission lines; implement Fish Habitat Compensation Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	N/A
	Operation	Loss of instream and riparian habitat and productive capacity at stream crossings and infrastructure	Use BMPs to minimize habitat loss; use DFO's operational statement for transmission lines; implement Fish Habitat Compensation Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)
	Closure	Loss of instream and riparian habitat and productive capacity at stream crossings and infrastructure	Use BMPs to minimize habitat loss; use DFO's operational statement for transmission lines; implement Fish Habitat Compensation Plan; Fish and Aquatic Habitat Protection and Mitigation Plan	Not Significant (minor)	Not Significant (minor)

The key assumptions of the fish and aquatic habitat effects assessment are:

- Assessment and determination of any potential residual and cumulative effects assumed that all guidelines, mitigation and management plans, BMPs, regulations, and operating standards designed to protect fish and aquatic resources are strictly adhered to.
- Assessment and determination of discharge potential effects on downstream fish and aquatic habitat relied upon the accuracy of water quality modelling data results.
- Assessment and determination of downstream fish habitat loss effects, related to TMF water management, relied upon the accuracy of water quantity modelling data results.

The key limitation of the fish and aquatic habitat effects CEA is:

- Assessment and determination of any potential cumulative effects was based upon limited quantitative data available from interacting projects within the cumulative effects study area.

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