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5.3.8 Fish

5.3.8.1 Introduction

This section assesses the potential effects of the proposed Blackwater Gold Project (the Project) on the Fish Valued Component (VC). The two indicator species of that VC are rainbow trout (*Oncorhynchus mykiss*) and kokanee (*Oncorhynchus nerka*). The assessment described in the subsections below will be conducted for each species.This Introduction describes the information sources of the assessment (**Section 5.3.8.1.1**), the applicable regulatory framework for the assessment of the VC (**Section 5.3.8.1.2**), the spatial, temporal, administrative and technical boundaries of the assessment (**Section 5.3.8.1.3**), the assessment approach (**Section 5.3.8.1.4**), the two indicator species (**Section 5.3.8.1.5**), and the measureable factors used for the assessment (**Section 5.3.8.1.6**).

The remainder of this section includes sub-sections dealing with the following: a brief summary of baseline data on the Fish VC (**Section 5.3.8.2**), potential effects and mitigation measures (**Section 5.3.8.3**), residual effects and their significance (**Section 5.3.8.4**), cumulative effects (**Section 5.3.8.5**), limitations of the assessment (**Section 5.3.8.6**), conclusions (**Section 5.3.8.7**), and follow-up monitoring (**Section 5.3.8.8**).

This section is similar in outline to **Section 5.3.9** – the assessment of Project effects on the Fish Habitat VC. There is, however, overlap because fish live in, and depend on, fish habitat. Also, fish habitat has long been used as a surrogate for fish because fish habitat can be measured more accurately than fish numbers and does not involve sampling mortality. For many environmental issues, predicting the future condition of fish habitat is more practical, reliable and accurate than predicting the future condition of fish populations.

This section describes fish species and populations and focuses on direct mortality and organismal response to environmental conditions (e.g., migration success and temperature optima). **Section 5.3.9** describes fish habitat and focuses on indirect mortality and Project effects on fish habitat (e.g., water flow). Hence, although the lists of potential effects differ for each VC, there is unavoidable overlap between the two sections.

Effects assessment was conducted on six major components of the Project: the mine site, mine access road, airstrip and airstrip access road, Freshwater Supply System (FSS), transmission line, and the Kluskus and Kluskus-Ootsa Forest Service Roads (FSR).

Fish, as defined by the federal *Fisheries Act*, are "the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals" (Government of Canada, 2013). For the Project, this includes fish species in the lakes and streams within the aquatic Local Study Area (LSA) and Regional Study Area (RSA) (both defined in **Section 4.3.1** and **Section 5.1.2.6**). In this section, most references to the LSA and RSA refer to the mine site LSA and RSA. There is also an LSA for each of the transmission line and access road corridors.

Fish are at the top of the food-web in freshwater aquatic ecosystems. Depending on species, they are planktivores (e.g., kokanee), benthivores (e.g., suckers), invertivores (e.g., rainbow trout), or piscivores (e.g., northern pikeminnow; *Ptychocheilus oregonensis*). Regardless of what they eat, the growth, reproduction, and survival of fish is dependent on water quality, the availability of habitat essential for their life history processes (e.g., migration, spawning and rearing), and the abundance of their prey, their competitors, and their predators. Because of this, fish are the ultimate freshwater receptor for potential changes to water quality and fish habitat.

The rationale for selection of fish as a VC is provided in **Section 5.3.1**. In brief, this rationale was based on the following:

- Ecological importance of fish for the maintenance of healthy aquatic ecosystems and as a food source for people and wildlife species;
- The social, cultural, and recreational value of fish to people as expressed during consultations with the public (**Section 3.4**), federal and provincial regulators (**Section 3.4**) and Aboriginal groups (**Section 3.3**);
- The likelihood that, prior to mitigation, fish would be adversely affected by the Project (**Table 4.3-2** in **Section 4.3**);
- The ability to monitor fish populations and their biological characteristics over time and space to detect potential changes resulting from Project activities; and
- The regulatory requirement to identify, avoid, mitigate, and offset any and all potential "serious harm to fish" as indicated in Section 35(1) of the *Fisheries Act* (Government of Canada, 2013), and of Section 27.1 of Environment Canada's (EC) *Metal Mining Effluent Regulations* (MMER) (EC, 2011) before the Project can proceed. (**Section 5.3.8.1.2** summarizes relevant legislation and policies for both the fish and fish habitat VCs).

The Project has the potential to affect fish directly (i.e., mortality from blasting, stranding, or impingement on intake screens) or indirectly due to changes in fish habitat quantity and quality (i.e., water quality (including water temperature), and abundance and composition of primary and secondary producer communities). An assessment of potential effects on fish is necessary to:

- Develop appropriate mitigation measures to reduce or eliminate any potential effects;
- Develop offsetting measures for potential effects that cannot be entirely mitigated;
- Identify and assess any residual effects that may remain after mitigation and offsetting; and
- Identify and assess any potential cumulative effects to fish from other past, present or reasonably foreseeable projects in the Cumulative Effects Study Area (CESA).

5.3.8.1.1 Information Sources

Section 5.1.2.6 provides a detailed summary of the information used to assess potential Project effects on fish. There were two main sources of information: baseline surveys of fish conducted from 1977 to 2013, and Traditional Knowledge (TK) gathered from consultation with First Nations. This section summarizes the sources of baseline information. **Section 5.3.8.2.12** describes TK concerning fish.

Section 5.1.2.6.2 describes the methods used to collect baseline information. The first step was a detailed review of historical information collected from 1977 to 2010 and contained in government databases, reports, and management plans, as well as in environmental baseline reports prepared for forestry and mining companies that have operated in the RSA (**Section 5.1.2.6.2.1**).

The second step was a data gap analysis accompanied by reconnaissance overflights of the LSA and RSA. A baseline study plan was developed to fill those data gaps in 2011 and 2012 (**Section 5.1.2.6.2.2**). A study plan for 2013 was based on the results of the first two years of baseline study.

Government guidelines and scientific standards and protocols were used to design the field studies (**Section 5.1.2.6.2.3**). These study plans were discussed with representatives of regulatory agencies such as the British Columbia Ministry of Environment (BC MOE), the BC Ministry of Forests, Lands and Natural Resource Operations (BC MFLNRO), and Fisheries and Oceans Canada (DFO).

The objectives of the field studies on fish were to:

- Characterize the species richness of fish communities in streams and lakes that may be affected by the Project;
- Identify the number of discreet fish populations that may be affected by the Project and delineate their geographic distribution;
- Characterize the timing, duration, and geographic extent of fish migrations that support spawning and overwintering;
- Estimate the absolute number of fish by species in Tatelkuz Lake and in three of the four headwater lakes of the LSA;
- Characterize fish use of habitat in streams and lakes potentially affected by the Project;
- Characterize fish tissue metal concentrations;
- Identify potential interactions between the Project and fish;
- Identify opportunities for mitigation and offsetting; and
- Provide baseline data that would support future Environmental Effects Monitoring (EEM) programs.

Field studies on fish from 2011 to 2013 included 13 separate components (**Table 5.3.8-1**; **Section 5.1.2.6.2.4**).

Field-collected data on fish and fish habitat were analyzed and interpreted using the scientific literature and guidance documents from the provincial and federal governments (**Section 5.1.2.6.2.5**). These were in addition to those documents listed in **Section 5.1.2.6.2.3**.

Detailed results of the 2011-2013 field studies were reported in two baseline reports: one for 2011-2012 (**Appendix 5.1.2.6A**) and one for 2013 (**Appendix 5.1.2.6B**). **Section 5.1.2.6.3** summarized and discussed those results.

Table 5.3.8-1: Summary of Fish Studies Conducted for the Project, 2011-2013

Study	2011	2012	2013
Survey of abundance, timing and biological characteristics of rainbow trout in LSA streams during the June spawning period using hoop nets	✓		
Survey of presence/absence, species diversity, relative abundance, and biological characteristics of fish communities in streams within the mine site LSA during summer months using electrofishing (with stop nets to isolate the sampling site) and minnow traps	✓	✓	✓
Survey of presence/absence, species diversity, relative abundance, and biological characteristics of fish communities in headwater lakes of the LSA during summer months using gillnets, minnow traps and angling	✓	✓	✓
Survey of kokanee spawner distribution and number in the LSA and RSA through stream bank counts	✓	✓	✓
Collection of samples of rainbow trout tissue (whole-body, muscle and liver) from stream sites and headwater lakes of the LSA for measurements of tissue metal concentrations	✓	✓	
Survey of the absolute number of fish in Tatelkuz Lake in early July using hydroacoustics			✓
Survey of the relative abundance and biological characteristics of the fish community in Tatelkuz Lake using gillnets and minnow traps			✓
Collection of samples of rainbow trout tissue and mountain whitefish (whole-body, muscle and liver) from Tatelkuz Lake for measurements of tissue metal concentrations			✓
Collection of samples of rainbow trout tissue for analysis of microsatellite DNA	✓		
Collection of samples of kokanee tissue for analysis of microsatellite DNA		✓	
Summer survey of fish at stream crossings by the proposed transmission line, mine access road, FSS pipeline, and airstrip access road using electrofishing (with stop nets) and minnow traps		✓	✓
Survey of mountain whitefish spawning migration in the late autumn using hoop netting		✓	
Survey of Lake 01538UEUT inlet tributaries using electrofishing (with stop nets) and minnow traps			✓

In addition, three analytical studies on fish and fish habitat in the LSA were conducted:

- A Fisheries Mitigation and Offsetting Plan (FMOP) (**Appendix 5.1.2.6C**) that described how much fish habitat will be lost to Project activities, how much will be saved by mitigation measures, and how much will be gained by offsetting;

- An Instream Flow Study (IFS) (**Appendix 5.1.2.6D**) that described the relationships between stream flow and the amount and quality of fish habitat in streams of the LSA;
- An Effects Assessment of Davidson Creek Flow Augmentation on Homing of Salmonid Fish (**Appendix 5.1.2.6E**), which assessed the potential effects on homing and spawning success of rainbow trout and kokanee spawners due to flow augmentation of Davidson Creek with water pumped from Tatelkuz Lake – the main mitigation measure for fish and fish habitat of the Project.

Finally, this section used modeling results from the environmental assessments for surface water flow (**Section 5.3.2**), surface water quality (**Section 5.3.3**), and sediment quality (**Section 5.3.4**) as well as habitat and instream flow modeling results from the fish habitat environmental assessment (**Section 5.3.9**) to assess potential direct and indirect effects to fish.

5.3.8.1.2 Relevant Legislation and Policies

The province of BC is responsible for the management of freshwater fish in BC. While this responsibility primarily relates to the management of fisheries for their sustained recreational use, the province has enacted legislation and various regulations that serve to protect and manage resources on which fish depend.

Under the recently amended federal *Fisheries Act* (Government of Canada, 2013), the federal government is responsible for the sustainability and protection of fish that are part of, or contribute to, “commercial, recreational, or Aboriginal fisheries.” In practice, the federal government also takes responsibility for management of anadromous fish species. (There are no anadromous fish species in the Blackwater mine site LSA or RSA.)

Table 5.3.8-2 lists and describes the federal and provincial laws and policies that protect fish and fish habitat in Canada and BC and that are applicable to the Project. It does not include legislation that is concerned solely with water quality and environmental contamination (e.g., the Canadian Environmental Protection Act).

Table 5.3.8-2: Federal and Provincial Legislation and Policies Related to Fish

Regulations and Policies	Purpose
Fisheries Act (as amended in June 2012) (Government of Canada, 2013)	Section 35(1) prohibits "…*any work, undertaking, or activity that results in serious harm to fish that are part of a commercial, recreational, or Aboriginal fishery, or to fish that support such a fishery*". Serious harm to fish is defined as "*the death of fish or any permanent alteration to, or destruction of, fish habitat*." Section 36 prohibits the deposit of deleterious substances to waters "frequented by fish". A deleterious substance is defined in the *Fisheries Act* as "*any substance that, if added to any water, will degrade or alter, or form part of a process of degradation or alteration, of the quality of that water so that it is rendered, or is likely to be rendered, deleterious to fish or fish habitat or to the use by man of fish that frequent that water.*"
Fisheries Protection Policy Statement (DFO, 2013b)	Sets out the objectives, principles, and responsibilities of various parties to attain DFO's goal "*to provide for the sustainability and ongoing productivity of commercial, recreational, and Aboriginal fisheries*." Describes the factors that must be considered before the Minister issues a Section 35(2) authorization allowing "serious harm to fish." These include: (1) the contribution of the relevant fish to the ongoing productivity of commercial, recreational, and Aboriginal fisheries; (2) fisheries management objectives; (3) whether there are measures and standards to avoid, mitigate, or offset serious harm to fish; and (4) the public interest.
Metal Mining Effluent Regulations (MMER) (Government of Canada, 2012)	Allows Proponents to deposit deleterious substances (i.e., mine tailings, waste rock, and mine effluent) into waters frequented by fish if Environment Canada, the administrator of the MMER, recommends to the Minister of Environment that Schedule 2 of the MMER should be amended to designate these waters as a Tailings Impoundment Area. Section 27.1 of the MMER requires proponents to develop and submit a fish habitat compensation plan to DFO that shows, to DFO's satisfaction, that habitat alterations and losses can be offset such that the "productive capacity of fish habitat is undiminished."
Species at Risk Act (SARA) (Government of Canada, 2002)	Prohibits the killing, harming, harassing, capturing or taking of species at risk and the possession, collection, buying, selling, or trading of listed species, and prohibits the damage or destruction of habitat critical for the protection of an extirpated, endangered or threatened species. Provides for the recovery of species at risk due to anthropogenic activity and to ensure that wildlife species of special concern do not become endangered or threatened.
British Columbia *Fish Protection Act* (Government of BC, 1997)	Provides authority to consider effects to fish and fish habitat before approving new or renewing existing water licenses and before issuing approvals for working in or near a stream. This process is designed to ensure sufficient water remains for fish when making decisions about licenses or approvals under the *Water Act*. Allows the listing of streams with recognized fish values as being sensitive to water withdrawals and protects riparian areas through provisions of the *Riparian Areas Regulation*.
British Columbia *Water Act* (Government of BC, 2004)	Regulates potential effects to fish and fish habitat through the diversion or storage of water as well as potential effects to water in and about a stream.
British Columbia *Riparian Areas Regulation* (Government of BC, 2004)	Requires Qualified Environmental Professionals to assess riparian habitat, develop mitigation measures, and avoid effects from development to fish and fish habitat.
British Columbia *Forest and Range Practices Act* (Government of BC, 2002)	Provides guidance on discretionary and mandatory riparian management areas around fish bearing streams, lakes, and wetlands. Provides guidance on size of harvestable forest areas and the rate at which wood can be removed from a watershed and provides regulations on road building.

5.3.8.1.3 Spatial, Temporal, Administrative, and Technical Boundaries

Section 4.3.1 describes the spatial and temporal boundaries for assessment of potential Project effects. This section briefly summarizes those boundaries for fish and fish habitat.

5.3.8.1.3.1 Spatial Boundaries

Spatial boundaries for the fish VC (and all other aquatics disciplines) included an LSA in which all or most potential Project effects are expected to occur) and an aquatics RSA surrounding the LSA that was used for assessment of indirect Project effects and for assessment of potential cumulative effects (**Figure 5.1.2.6-1**). (The Cumulative Effects Study Area (CESA) was identical to the aquatics RSA.)

Spatial boundaries of the LSA were based on the watersheds potentially affected by the mine site, the FSS, airstrip, transmission line, and the mine access road. It included the following:

- Davidson Creek Watershed;
- Turtle Creek Watershed;
- Creek 661 Watershed;
- Creek 705 Watershed;
- Tributaries following into Tatelkuz Lake from the south;
- Tatelkuz Lake; and
- Chedakuz Creek between the confluence with Creek 661 and Tatelkuz Lake (i.e., middle Chedakuz Creek) and between Tatelkuz Lake and the confluence with Turtle Creek (i.e., lower Chedakuz Creek).

Geographic features of the LSA are summarized in **Section 5.1.2.6.1.1**, based on detailed descriptions in Section 2.0 of **Appendix 5.1.2.6A** and in Section 2.0 of **Appendix 5.1.2.6B**.

A separate LSA for the transmission line was necessary due to the approximately 140-km long linear nature of this component. The LSA for the transmission line included a 40 m buffer width on either side of the centre line extending between the BC Hydro Glenannan sub-station near Fraser Lake and the mine site (**Figure 5.1.2.6-2**).

A separate LSA was also necessary for the 194-km long mine access road. It follows a network of forest service roads originating at the community of Engen, approximately 20 km west of Vanderhoof, and ending at the terminus of Kluskus-Ootsa FSR (**Figure 5.1.2.6-2**). The LSA for the access road also includes a 40 m buffer width on either side of the centre line.

Spatial boundaries for the RSA were based on: (1) the likely geographic extent of potential residual effects to fish from the Blackwater Project (i.e., the LSA); (2) the likely residual effects from past, present, or reasonably foreseeable future projects identified in the Project Inclusion List (**Section**

4.3.5); and (3) life history characteristics (i.e., migratory ambit) and likely population boundaries of fish species potentially affected by the Project and other projects on the Project Inclusion List.

The RSA includes the following:

- All streams and lakes included in the LSA;
- The entire Chedakuz Creek Watershed not already included in the LSA; and
- Upper Fawnie Creek Watershed including Top Lake, Laidman Lake, Williamson Lake, and Mathews Creek.

5.3.8.1.3.2 Temporal Boundaries

Temporal boundaries for the assessment of potential effects to fish are from pre-construction (i.e., baseline) through post-closure. Potential effects to fish were assessed for all four mine phases (**Section 4.3.1.2**):

1. Construction (Years -2 and -1);
2. Operations (Years +1 to +17);
3. Closure (Years +18 to +35); and
4. Post-closure (beginning in Year +36).

For most disciplines, post-closure begins when all closure activities (e.g., reclamation) are completed. However, post-closure for fish and fish habitat begins when water quality in the TSF meets discharge criteria and water is discharged to Davidson Creek. Year +36 is the first year in which water will be discharged. Full discharge will first begin in Year +37.

5.3.8.1.3.3 Administrative Boundaries

The Blackwater Project falls within the resource management boundaries of DFO's Pacific Region and BC MFLNRO's Region 7 (Omineca) (**Section 4.3.1.3).**

The mine site, airstrip, and mine access road overlap with the traditional territories of the Ulkatcho First Nation, Lhoosk'uz Dene Nation, and the Skin Tyee First Nation. In addition to these three First Nations, the Kluskus FSR and the transmission line cross the traditional territories of the Nadleh Whut'en First Nation, Nazko First Nation, Stellat'en First Nation and Saik'uz First Nation.

5.3.8.1.3.4 Technical Boundaries

Technical boundaries for the assessment of potential effects to fish include those imposed by: (1) limitations in knowledge; (2) limitations in data collection due to limitations of technical methods; and (3) assumptions required for the models used to predict fish habitat quantity and quality, stream flows and temperatures, and fish number in Tatelkuz Lake using hydroacoustics techniques (**Section 4.3.1.4**).

Limitations in knowledge include:

- Lack of case histories in which water from one part of a watershed is used to augment flows in streams in another part of the same watershed, and in which rainbow trout and kokanee reside.

Limitations in data collection included:

- Need to sub-sample habitats in the numerous headwater tributaries that exist in the Davidson Creek and Creek 661 watersheds. This was an unavoidable sampling measure caused by the long cumulative length of the stream systems in the LSA. Sub-sampling is a standard measure that is often used in surveys of large aquatic systems;
- Low densities of juvenile rainbow trout in streams of the LSA, which reduced the ability to define mesohabitat preferences of fish. This was a consequence of the low productivity of rainbow trout due to water temperatures that are below the Provincial temperature optima for this species;
- Low numbers of rainbow trout in headwater lakes 01682LNRS, 01538UEUT and 01428UEUT, which resulted in high variability of rainbow trout catch-per-unit effort (CPUE). As with juvenile rainbow trout in streams, this was a consequence of overall low aquatic productivity due, in part, to low water temperatures; and
- Inability to count small-bodied (<100 mm long), benthic fish (e.g., slimy sculpin) or shallow-water fish (e.g., brassy minnow) in Tatelkuz Lake with acoustic techniques. This is a limitation of current echosounding technology as applied to fish population enumeration.

In summary, limitations in data collection were largely due to the characteristics of the aquatic system in the LSA that was surveyed from 2011 to 2013 – a large, cool, low-productivity system.

Limitations in models included:

- Assumption that kokanee dominated the fish community in the offshore depth stratum of 5 m to 10 m in Tatelkuz Lake. The assumption was considered a reasonable one because of the available data and the known habitat preferences of kokanee in lakes;
- Assumption that fish response to flow changes is accurately assessed using stanzas that reflect biological time periods for spawning, incubation, rearing, and overwintering life history stages. This assumption was based on the known seasonal life history changes in fish behaviour and so is considered scientifically defensible;
- Assumption that changes in flows can be used as a surrogate for changes in habitat quality where flow/habitat models were not used, both in headwater sections (i.e., upper Creek 705 and upper Creek 661) and for overwintering conditions;
- Need to extrapolate hydraulic conditions at high flows for instream flow modeling because flows higher than those sampled during baseline survey must be modelled. This

was unavoidable because baseline data collection is always a snapshot in time and cannot provide data on hydrological extremes that occur rarely;

- Simplification of water temperature modeling for Davidson Creek using a mass-balance approach instead of a model based on physical processes such as evaporation. The predictive capability of a more complex model was not considered sufficient to justify developing it; and
- Assumption that water temperature in the Tailings Storage Facility (TSF) will be adequately modelled using water temperatures measured from Snake Lake. This was the best available choice because there are no other lakes of similar elevation and surface area within the LSA.

These limitations in modelling were common and typical of similar studies. The assumptions that were made were to deal with these limitations are scientifically defensible.

5.3.8.1.4 Assessment Approach

Potential effects to fish were assessed qualitatively or quantitatively depending on the potential effect assessed. Potential effects of changes in stream flows, lake WSE, water temperature, and water quality were assessed semi-quantitatively by comparing quantitative modeling results to federal or provincial guidelines, or to derived thresholds supported by the scientific literature.

Similarly, the effect of potential changes in the availability and suitability of fish habitat to fish was assessed semi-quantitatively by comparing habitat modeling results of different stream and lake habitats under various mine phases to the amount and distribution of fish habitat available under baseline conditions. A qualitative assessment of whether the potentially affected habitat was “critical”[1], “important”[2] or “marginal”[3] to the various fish populations present at the Project was made based on professional opinion supported by the published scientific literature.

Ultimately, the evaluation of the likely effectiveness of the various mitigation and offsetting measures to eliminate, reduce or compensate for potential effects and, similarly, the evaluation of the significance of potential residual effects was subjective. However, these professional assessments were supported by the quantitative modeling described above, past experience at other similar mine projects in central BC, and by the scientific literature. No assessment of effect was conducted without supporting rationale.

[1] Critical habitat is defined as habitat “with high productive capacity that is essential to sustain fish populations” (DFO, 1998a). Critical habitat is generally discreet spawning and/or nursery grounds that cannot be replaced by offsetting measures.
[2] Important habitat is defined as habitat “not critical to the long-term survival of the affected fish population because of the availability of similar habitat within the watershed” (DFO, 1998a).
[3] Marginal habitat is defined as habitat “with low productive capacity to support the life history stage of the affected fish population” (DFO, 1998a).

5.3.8.1.5 Fish Indicator Species

Two indicator fish species were used to assess potential effects to fish: rainbow trout and kokanee. The methods used to select these indicators and the reasons for their selection are provided in **Section 4.3** and **Section 5.3.1**, respectively.

In brief, these species were selected as indicators because they are the two most numerous fish species in the LSA and RSA, they are both food fish that are targets of recreational and Aboriginal fisheries, and they both use stream and lake habitat (although at different times of the year). Equally important, they have sufficiently different diets, habitat preferences, and seasonal life history timing that any potential effect of Project activities on fish and fish habitat in streams and lakes of the LSA and RSA will inevitably affect one or both species.

Kokanee are the most numerous fish in Tatelkuz Lake (the only kokanee residence lake in the LSA), and they are temporarily the most numerous stream fish in the LSA when they emerge from Tatelkuz Lake to spawn in streams in mid- to late summer. **Section 5.1.2.6.3.2.4** summarizes the ecology of kokanee in the aquatics LSA. Key elements of that summary are repeated in **Section 5.3.8.2.4**.

Rainbow trout is the second most numerous fish species in Tatelkuz Lake, and the predominant fish species in three of the four headwater lakes of the LSA. (Lake chub, *Couesius plumbeus*, is the only fish species present in Snake Lake.) Except during the kokanee spawning migration, rainbow trout are the predominant fish species in streams of the LSA and RSA. Rainbow trout are the only fish species present in streams that will be directly affected by development of the mine site. Adult rainbow trout emerge from their residence lakes in early June to spawn in streams and then return to lakes before the end of June, but juvenile rainbow trout remain in streams for up to 3 years before migrating to residence lakes to adopt an adult life style. **Section 5.1.2.6.3.2.5** summarizes the ecology of rainbow trout in the aquatics LSA. Key elements of that summary are repeated in **Section 5.3.8.2.5**.

Of the remaining ten species of fish found in the aquatics LSA, five (mountain whitefish, longnose sucker, largescale sucker, white sucker and burbot) are components of recreational and/or Aboriginal fisheries. Brief summaries of the ecology of those five harvested species are shown in **Sections 5.3.8.2.6** to **Section 5.3.8.2.10**. Summaries of the life histories of the five non-harvest species (northern pikeminnow, lake chub, slimy sculpin, brassy minnow and longnose dace) are shown in **Sections 5.1.2.6.3.2.11** to **5.1.2.6.3.2.15**.

5.3.8.1.6 Measureable Factors

The two indicator species are animals with complex life histories. A number of measureable factors are available to characterize the two indicator species (**Table 5.3.8-3**).

Table 5.3.8-3: Selected Indicators and Measurable Factors for Fish VC

Indicator	Measurable Factor	Rationale
Rainbow trout	Spawning run size, timing, and duration	Indicator of annual escapement and population size Indicator of environmental drivers of spawning timing Indicator of the number and location of breeding populations
	Juvenile density and CPUE in streams in summer as indexed by one-pass electrofishing with stop nets	Indicators of annual spawning success and of juvenile survival Indicators of spatial distribution and habitat preferences
	Juvenile and adult CPUE in lakes as indexed by gillnetting	Indicators of population size
	Absolute numbers, density (number/ha), and biomass (kg/ha) in Tatelkuz Lake as estimated by hydroacoustic methods	Measure of population size
	Absolute numbers and biomass in headwater lakes as estimated by extrapolating density from Tatelkuz Lake	Estimator of population size
	Mean length, weight, age, and condition factor, length- and age-frequency distributions; and growth in length	Indicators of body size, growth, survival and physical condition
	Length and age at 50% maturity	Indicator of size and age at maturation
	Gonadosomatic index	Indicator of sexual maturation status
	Hepatosomatic index	Indicator of fish health status
	Stomach contents	Diet
	Tissue metal concentrations	Measure of tissue metals residues Indicator of background metal concentrations in food and water Indicator of potential effects on animal health and human health
	DNA microsatellite analysis	Indicator of number, location, and relatedness of breeding populations
Kokanee	Spawning run size, timing, and duration	Indicator of annual escapement and of population size Indicator of environmental drivers of spawning timing Indicator of the number and location of breeding populations
	Number of spawners and redds	Indicator of spawning success
	Depth and habitat types associated with redds	Indicators of habitat choice by spawning kokanee
	Juvenile and adult CPUE in lakes (as indexed by gillnetting)	Indicator of annual recruitment and population size
	Absolute numbers, density (number/ha), and biomass (kg/ha) in Tatelkuz Lake as estimated by hydroacoustic methods	Measure of population size and weight
	Mean length, weight, age, and condition factor, length- and age-	Indicators of body size, growth, survival and physical condition

Indicator	Measurable Factor	Rationale
	frequency distributions; and growth in length	
	Length and age at 50% maturity	Indicator of size and age of maturation
	Gonadosomatic index	Indicator of sexual maturation status
	Hepatosomatic index	Indicator of fish health status
	Stomach contents	Diet
	DNA microsatellite analysis	Indicator of number, location, and relatedness of breeding populations

Mountain whitefish was the second fish species sampled for tissue metal concentrations in Tatelkuz Lake. This species was chosen, in part, because it is known from TEK to support, or to have supported, Aboriginal fisheries.

Three additional factors were employed for both rainbow trout and kokanee, but are not listed in **Table 5.3.8-3** because they are ecosystem-level characteristics rather than species-specific: (1) the existence of commercial, recreational and Aboriginal fisheries; (2) fish species richness (or the total number of fish species) in each stream and lake; and (3) conservation status of each member of the fish communities.

5.3.8.2 Valued Component Baseline

Section 5.1.2.6 provides a detailed summary of baseline conditions for the fish VC in the Project LSA and RSA, including data sources, study areas, methods, results and interpretation. This section will not repeat that summary, but only list the major conclusions.

5.3.8.2.1 Commercial, Recreational and Aboriginal Fisheries

There are no commercial fisheries within the LSA or the RSA (**Section 5.1.2.6.3.2.1**). There are recreational fisheries for rainbow trout, as shown, for example, by the presence of a fishing resort at the northern end of Tatelkuz Lake. Representatives of First Nations groups have noted that boating supports fishing activity in these areas (Interviews with Lhoosk'uz Dene Elders, 2013). However, the magnitude and intensity of those recreational fisheries are not known because there have been no creel surveys in the RSA. In a May 2013 Open House; a community member noted the south-east side of Tatelkuz Lake is used for recreational purposes such as camping and fishing.There are Aboriginal fisheries in the LSA, as described in **Section 5.3.8.2.12**.

5.3.8.2.2 Fish Species Richness

A total of 12 fish species are present in streams and lakes of the mine site LSA (**Table 5.3.8-4**). This list also includes all of the fish species captured at stream crossings of the access road, the water pipeline of the FSS, and the airstrip access road. It also includes all fish species identified as present in the mine site LSA in historical reports and in interviews with Lhoosk'uz Dene elders.

Table 5.3.8-4 also includes the fish species that were captured at stream crossings of the transmission line LSA and the access road LSA, but it does not include the other fish species that are known from historical reports to be present in those streams.

Fish species richness in the mine site LSA and RSA ranges from 1 to 5 species in streams and from 1 to 10 species in lakes (**Table 5.3.8-5**). As expected, fish species richness increases with increased size of waterbody in both streams and lakes (Griffiths, 1997), reflecting a general increase in habitat diversity with increasing size of waterbodies. Among streams, Chedakuz Creek has the greatest species richness followed by Creek 705. Turtle Creek has the lowest species richness. Among lakes, Tatelkuz Lake has the greatest species richness, followed by Kuyakuz and Laidman lakes. Snake Lake and Lake 01682LNRS each support only one fish species.

Rainbow trout, an opportunistic and resilient species that can adapt to a wide range of habitat conditions, is the most common species, being present in every waterbody except Snake Lake. Longnose sucker is the second most commonly occurring species, followed by mountain whitefish and kokanee. The presence of kokanee in the largest lakes of the RSA indicates a resilient species because those lakes are expected to support large populations of kokanee (as demonstrated for the Tatelkuz Lake population of kokanee by the hydroacoustic survey reported in **Section 5.1.2.6.3.2.4**) that can persist while being harvested by recreational and Aboriginal fisheries. The remaining nine species are each present in one to three waterbodies.

Table 5.3.8-4: Fish Species Captured in the Mine Site LSA

Common Name	Scientific Name	BC Fish Species Code
Kokanee	*Oncorhynchus nerka*	KO
Rainbow trout	*Oncorhynchus mykiss*	RB
Mountain whitefish	*Prosopium williamsoni*	MW
Northern pikeminnow	*Ptycheilus oregonensis*	NSC
Longnose sucker	*Catostomus catostomus*	LSU
Largescale sucker	*Catostomus macrocheilus*	CSU
Burbot	*Lota lota*	BB
Brassy minnow	*Hybognathus hankinsoni*	BMC
Lake chub	*Couesius plumbeus*	LKC
Slimy sculpin	*Cottus cognatus*	CCG
Longnose dace	*Rhinichthyes cataractae*	LNC
White sucker	*Catostomus commersonii*	WSU

Table 5.3.8-5: Fish Species Present in the Mine Site LSA and RSA

Stream/Lake	RB	LSU	MW	KO	CSU	NSC	BB	CCG	LKC	BMC	WSU	LNC	CAS	Total
Local Study Area														
Davidson Creek	X	-	X	X	-	-	-	-	-	-	-	-	-	3
Turtle Creek	X	-	-	-	-	-	-	-	-	-	-	-	-	1
Creek 661	X	-	-	X	-	-	-	-	-	-	-	-	-	2
Creek 705	X	X	X	-	-	-	X	-	-	-	-	-	-	4
Chedakuz Creek	X	X	-	X	-	-	-	X	-	-	-	X	-	5
Lake 01682LNRS	X	-	-	-	-	-	-	-	-	-	-	-	-	1
Lake 01538UEUT	X	X	-	-	-	-	-	-	-	-	-	-	-	2
Lake 01428UEUT	X	X	-	-	-	-	-	-	-	-	-	-	-	2
Snake Lake	-	-	-	-	-	-	-	-	X	-	-	-	-	1
Tatelkuz Lake	X	X	X	X	X	X	X	X	-	X	X	-	-	10
Subtotal	9	5	3	4	1	1	2	2	1	1	1	1	0	
Regional Study Area														
Fawnie Creek	X	-	-	X	-	-	-	-	-	-	-	-	-	2
Kuyakuz Lake**(1)**	X	X	X	X	X	-	-	-	X	-	-	-	-	6
Laidman Lake**(2)**	X	X	X	-	X	X	-	-	-	-	-	-	X	6
Top Lake**(3)**	X	X	X	-	-	-	-	-	-	-	-	-	-	3
Subtotal	4	3	3	2	2	1	0	0	1	0	0	0	1	
Total	**13**	**8**	**6**	**6**	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	

Note: (1) Burns (1977); (2) Coombes (1985b); (3) Coombes (1985a).

5.3.8.2.3 Conservation Status

There are no *Species at Risk Act* (*SARA*)-listed fish species present in the mine site LSA or RSA.

Brassy minnow is the only one of the 12 fish species present in the LSA that has a conservation classification. The BC Conservation Data Centre (BC CDC) classifies brassy minnow as sensitive or vulnerable (i.e., a blue-listed species with a rank of S2S3) because its distribution in BC is disjunct, with isolated populations in the lower Fraser Valley and in the Nechako Lowlands near Vanderhoof and Prince George (McPhail, 2007; BC CDC, 2013; Nowosad and Taylor, 2013). Species of plants and animals with disjunct distributions typically have higher risk of local extirpation than species with continuous distributions. Blue-listed taxa are at risk, but are not extirpated, endangered or threatened.

Brassy minnow is not assigned a rank by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (COSEWIC, 2013).

The global ranking for brassy minnow is G5TNR where G5 = demonstrably widespread, abundant and secure (BC CDC, 2013). This is because brassy minnow is widespread and has a contiguous distribution throughout the central United States and south-eastern Canada.

Brassy minnow is present in other water bodies in the RSA. A total of 10 brassy minnow were found in Reaches 4 and 5 of Mathews Creek during a fish inventory that was conducted as part of the search for potential offsetting fish habitat (Annex I in **Appendix 5.1.2.6C**). Those two reaches were classified as low-gradient, sinuous meadow habitat. They both contained pools, runs, in-stream vegetation and were broken up by numerous beaver dams. Banks of both reaches were trampled by cattle.

Small numbers of brassy minnow were captured by electrofishing and minnow traps at stream crossings of the transmission line in 2012 (**Appendix 5.1.2.6A**), and in minnow traps in shallow water areas of Tatelkuz Lake in 2013 (**Appendix 5.1.2.6B**).

Brassy minnow may be present in other water bodies of the RSA that have not yet been surveyed or which have been surveyed but not with focus on the low-gradient, shallow, weedy habitat that brassy minnow prefer. In the Chedakuz Creek Watershed, brassy minnow may be present at some places in the littoral zone of Kuyakuz Lake. In the Fawnie Creek Watershed, they may be present in the littoral zones of Laidman and Top lakes and in some reaches of Fawnie Creek.

A population of white sturgeon (*Acipenser transmontanus*) is present in the Nechako River. That river is outside the aquatic RSA of this Project, but it will be crossed by the transmission line. The Nechako white sturgeon population was red-listed by the province in 2010 (BC CDC, 2013). Its conservation status is S1 or “critically imperilled” due to long-term reproductive failure that began in the 1960s after the river was dammed for purposes of hydroelectric power production. In 2003, COSEWIC classified the Nechako sturgeon as “endangered” (COSEWIC, 2003; Ptolemy and Vennesland, 2003).

In March 2014, Environment Canada, Parks Canada and DFO, released the final *Recovery Strategy for White Sturgeon in Canada* to the SARA Public Registry (http://www.registrelep-sararegistry.gc.ca). This planning document identifies what needs to be done to arrest or reverse the decline of white sturgeon. It sets goals and objectives and identifies the main areas of activities to be undertaken. DFO is now preparing an Action Plan for the Nechako population of white sturgeon. It will contain specific recovery measures to support conservation of the species.

The only other blue-listed aquatic species is the Rocky Mountain Capshell (*Acroloxus coloradensis*), a type of freshwater limpet, that was observed in a single sample of littoral zone BMI collected from Lake 01682LNRS with a kick-net in August 2012 (**Appendix 5.1.2.6A**). The Rocky Mountain Capshell is recognized as a species of Special Concern by the BC CDC (BC CDC, 2014). It has a Provincial S3 conservation status (i.e., blue-listed) and a Global status of G3 (BC CDC, 2014). COSEWIC classifies it as “Not at Risk”. It was assigned to the Provincial blue-list because it is the only species of the Family Acroloxidae found in North America, and in BC it is found only in the east-central region (Klinkenberg, 2012). Its habitat is high-altitude oligotrophic and mesotrophic lakes and ponds. It is found in rocky, exposed portions of lakes and ponds in shallow water on the underside of rocks and vegetation on wave-swept shores. Populations are not endangered, but their habitat type is limited.

5.3.8.2.4 Kokanee

Section 5.1.2.6.3.2.4 summarized baseline information on the population ecology of kokanee in the LSA. The following section lists the key conclusions.

5.3.8.2.4.1 General Life History

Kokanee spend most of their lives in lakes where they feed on zooplankton and small fish in the shallow pelagic zone. In late summer and fall, when water temperatures drop below 12°c, adult kokanee migrate from their residence lakes to tributary streams to spawn (**Table 5.3.8-6**). On the spawning grounds, females establish territories and dig redds into which they deposit their eggs. After fertilization of eggs by a male, the female covers the nest with gravel. Adults die within several weeks of spawning and their carcasses drift downstream or are buried under sediment or are scavenged by birds and bears. Embryos incubate in gravel over winter. Fry emerge in the spring after ice break-up and quickly migrate to their residence lake. They remain there, feeding and growing, until they reach the size and age of sexual maturation.

Table 5.3.8-6: Life History Periodicity Chart for Kokanee and Rainbow Trout, LSA and RSA, 2011-2013

Species	Life Stage – Activity	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Kokanee	Adult migration/spawning													■	■	■	■	■	■						
	Embryo incubation	■	■	■	■	■	■	■							■	■	■	■	■	■	■	■	■	■	■
	Juvenile migration							■	■	■	■														
	Juvenile rearing											■	■	■	■	■	■	■	■	■	■	■	■		
	Juvenile overwintering	■	■	■	■	■	■	■																■	■
	Adult rearing							■	■	■	■	■	■	■	■										
	Adult overwintering	■	■	■	■	■	■													■	■	■	■	■	■
Rainbow trout	Adult migration/spawning										■	■	■												
	Embryo incubation											■	■	■	■	■									
	Juvenile migration (lake dwelling)												■	■	■	■	■	■							
	Juvenile rearing													■	■	■	■	■	■	■	■	■	■		
	Juvenile overwintering	■	■	■	■	■	■	■	■													■	■	■	■
	Adult rearing									■	■	■	■	■	■	■	■	■							
	Adult overwintering	■	■	■	■	■	■	■	■										■	■	■	■	■	■	■

Note: Red bars represents embryo stages, blue bars represents adult stages, and green bars represents juvenile stages

5.3.8.2.4.2 Number and Location of Populations

Tatelkuz and Kuyakuz lakes are the two kokanee residence lakes in the LSA and RSA, respectively. Kokanee are not present in the four headwater lakes of the LSA.

Microsatellite DNA analysis of kokanee tissue samples collected in 2012 from spawners in the LSA and RSA showed three broad groupings:

- Chedakuz Creek upstream of Kuyakuz Lake;
- Creek 661, middle Chedakuz Creek between Tatelkuz Lake and the confluence of Creek 661 and Davidson Creek; and
- Lower Chedakuz Creek, Creek 522107 (a tributary to lower Chedakuz Creek), and Fawnie Creek.

This analysis, which is described in detail in Annex 5.10-12 of **Appendix 5.1.2.6A**, indicates the presence of three populations of kokanee in the RSA: one of which lives Kuyakuz Lake and spawns in its tributaries, and two of which live in Tatelkuz Lake and spawn in its tributaries. Most of the samples were demonstrably genetically distinct from one another, particularly upper Chedakuz Creek, and are probably largely demographically independent from one another, although some movement likely does occur occasionally between localities. The clustering of samples from lower Chedakuz Creek and Fawnie Creek supports movement of kokanee spawners between the two watersheds through the Nechako Reservoir.

Section 5.1.2.6.3.2.4 and **Figures 5.1.2.6-48** and **5.1.2.6-49** show the spatial distribution of kokanee in streams and lakes of the LSA.

5.3.8.2.4.3 Total Number in Tatelkuz Lake

The hydroacoustic study of Tatelkuz Lake in early July 2013, calibrated by the gillnet survey of the fish community of mid-July 2013, estimated a total of 606,274 kokanee in Tatelkuz Lake (**Table 5.3.8-7**). That was 78.2% of all of fish counted in the lake. Tatelkuz Lake is essentially a kokanee lake. The 95% confidence limits of that total number of kokanee range from 503,207 to 709,340 or ±17% of the total number.

The relatively high abundance of kokanee in the lake is due to their preference for relatively shallow (5 m to 15 m deep) offshore habitat, which is the single largest type of habitat by volume in Tatelkuz Lake.

When multiplied by the mean weight of kokanee (90 g) measured during the Tatelkuz Lake fish community survey, the total number of kokanee is equivalent to a total biomass of 54,565 kg (95% CL = 45,289 to 63,841) and a biomass density of 60.8 kg/ha (95% CL = 50.5 to 71.1).

Table 5.3.8-7: Number and Density of Fish in Tatelkuz Lake, July 2013, from Hydroacoustic Survey

	Number				Density (number/ha)		
Species	**Estimate**	**Lower 95% CL**	**Upper 95% CL**	**Percent of Total**	**Estimate**	**Lower 95% CL**	**Upper 95% CL**
Kokanee	606,274	503,207	709,340	78.2	676	561	791
Rainbow trout	117,068	97,167	136,970	15.1	131	108	153
Mountain whitefish	26,360	21,879	30,841	3.4	29	24	34
Longnose sucker	13,955	11,583	16,328	1.8	16	13	18
Northern pikeminnow	11,629	9,652	13,606	1.5	13	11	15
Total	**775,286**	**643,487**	**907,085**	**100.0**	**864**	**717**	**1,011**

Source: Annex 5.14-1 of Appendix 5.1.2.6B.

Note: CL = confidence limit; ha = hectare. Density calculated from lake surface area of 897 ha at time of hydroacoustic survey. Total number of fish estimated in the lake does not include benthic fish species (slimy sculpin, brassy minnow, burbot, largescale sucker, and white sucker) that were undetectable with acoustics and that were not caught in large numbers in gillnets.

Numerical estimates for kokanee are credible for two reasons. First, the precision of the estimate of total number of fish was high (±17% of the total compared to a typical range of ±15% to 40%) due to a fairly uniform night-time spatial distribution of fish.

Second, the whole-lake fish density estimates of 864 total fish/ha (all species combined) and 676 kokanee/ha are comparable with densities reported for other water bodies of western Canada and the US. In Stave Reservoir of southwestern BC, the total fish density for nearshore and offshore zones combined was 137 to 527 fish/ha and kokanee density was 135 to 513 fish/ha from 2005 to 2009 (Stables and Perrin, 2010). In both zones of Coquitlam Reservoir of southwestern BC, total fish and kokanee densities were 538 and 214 fish/ha, respectively (Bussanich et al. 2005). Pelagic surveys of kokanee in western reservoirs (where no nearshore sampling was conducted and other species were not listed) have reported densities of 576 kokanee/ha in Dworshak Reservoir (Idaho) in 2005 (Stark, 2006), 307 to 670 kokanee/ha in Lake Pend Oreille (Idaho) for 2006-2008 (Maiolie et al., 2008; Schoby et al., 2009; Wahl et al., 2010), and 156 to 901 kokanee/ha in Kootenay Reservoir of south-eastern BC from 1985 to 2006 including years of fertilization (Schindler et al., 2009).

Annex 5.14-1 of **Appendix 5.1.2.6B** provides more detail about the methods and results of the hydroacoustic survey.

5.3.8.2.4.4 Spawning Timing

Kokanee from Tatelkuz Lake spawn in three major creeks (Chedakuz Creek, Creek 661 and Davidson Creek) and in a number of smaller creeks in the LSA (**Figure 5.1.2.6-48**).

Kokanee spawners from Tatelkuz Lake were observed in spawning creeks of the LSA from mid-July to late September – a 10 week-long period (**Table 5.3.8-8**).

Table 5.3.8-8: Kokanee Spawn Timing, LSA, 2011-2013

Stream	July		August				September			
	17-23	24-31	1-8	9-16	17-23	24-31	1-7	8-15	16-22	23-31
Davidson Creek	■	■	**■**	**■**	■	■				
Creek 661			■	**■**	**■**	■	■			
Lower Chedakuz Creek							■	**■**	**■**	■
Middle Chedakuz Creek			■	**■**	**■**	■	■			

Note: Bold borders indicate probable peak spawning period.

Kokanee first enter Davidson Creek in mid-July, which is at least 2 weeks earlier than any of the other four streams. They have the longest spawning period – 6 weeks. Peak spawning is between 8 and 12 August. Kokanee enter Creek 661 and middle Chedakuz Creek in early August and leave in early September. Peak spawning in both streams is in the second and third week of August. Kokanee enter lower Chedakuz Creek in early September – 6 weeks later than Davidson Creek – and peak spawning is in mid-September.

These differences in spawning timing among stream are largely due to differences in water temperature on the spawning grounds. The earliest spawning occurs in the coldest stream – lower Davidson Creek – and the latest spawning occurs in the warmest stream – lower Chedakuz Creek.

5.3.8.2.4.5 Spatial Distribution of Spawners in Streams

Linear densities (number/m) rather than areal densities (number/m^2) were used to quantify the spatial distribution of kokanee in streams because areal densities of kokanee spawners and redds could not be calculated for surveys conducted on some streams (e.g., middle Chedakuz Creek) because of the absence of data on wetted width, and because it was assumed that linear densities were highly positively correlated with areal densities. A linear regression of areal spawner density on linear spawner density for the combined kokanee stream survey data of the three survey years (2011, 2012 and 2013) confirmed this assumption. The two variables are highly significantly ($P<0.001$) and positively correlated, and linear density explained 72% of the variance in areal density.

The highest linear densities (1.05 to 1.97 fish/m) of kokanee spawners in the LSA were observed in Reaches 17 and 20 of middle Chedakuz Creek. (Reaches 17 to 19 lie between Tatelkuz Lake and the confluence of Creek 661, and Reach 20 extends upstream of that confluence.) Few kokanee spawners were observed in the upper half of middle Chedakuz Creek, indicating that kokanee spawners from Kuyakuz Lake prefer to migrate upstream into tributaries of Kuyakuz Lake, particularly upper Chedakuz Creek, rather than downstream into middle Chedakuz Creek.

Mean linear density in Creek 661 was highest in Reach 1, just upstream of the confluence with middle Chedakuz Creek, and decreased with increasing upstream distance. A similar pattern of decreasing density with upstream distance was observed in lower Chedakuz Creek and Davidson Creek. Density in Lower Chedakuz Creek was highest in Reach 15 immediately downstream of

Tatelkuz Lake and decreased in Reaches 14 and 13. Density in Davidson Creek increased to a maximum in Reach 2 and then decreased in Reaches 3 and 4.

In summary, kokanee of the LSA prefer to travel upstream to spawn, most likely because it allows their fry to migrate downstream to a residence lake with the direction of stream flow rather than against it. In the case of lower Chedakuz Creek, most kokanee spawn close to the outlet of Tatelkuz Lake, presumably to reduce the distance their fry must migrate upstream to reach the lake. Similarly, in the case of Davidson Creek, fry must migrate upstream only a short (~900m), low-velocity section of lower Chedakuz Creek to reach Tatelkuz Lake.

5.3.8.2.4.6 Number of Spawners

When kokanee spawners migrate out of Tatelkuz Lake to spawn in streams, they are temporarily the single most abundant fish species in streams of the LSA. The most accurate estimate of the number of kokanee that spawn in the LSA each year was calculated by combining all spawner density data from 2011, 2012 and 2013 and then extrapolating those density estimates across the length of all reaches known to support kokanee spawning. A total of 24,988 kokanee spawners was calculated, of which middle Chedakuz Creek between Tatelkuz Lake and the confluence of Creek 661 contributed 9,805 (or 39.2% or the total), followed by Creek 661 (5,893 or 23.6%), lower Chedakuz Creek (5,343 or 21.4%), and Davidson Creek (3,947 or 15.8%).

That estimate of total spawner number is 4.1% of the total number of kokanee counted in Tatelkuz Lake in July 2013.

5.3.8.2.4.7 Age and Growth

Kokanee in Tatelkuz Lake live to a maximum age of 5 years. Mean age at 50% maturity is 2 years and mean age at 95% maturity is 4 years. Growth is rapid – mean length in their first summer of growth is 30 mm, but they reach a mean length of 180 mm by 2 years and 240 mm by 4 years.

5.3.8.2.4.8 Diet

There was a clear separation of diet between kokanee and rainbow trout. Kokanee consume pelagic prey, mainly amphipods, but rainbow trout consume a mixture of benthic and pelagic prey.

5.3.8.2.5 Rainbow Trout

Section 5.1.2.6.3.2.5 summarizes baseline information of the population ecology of rainbow trout in the LSA. The following section summarizes the key conclusions.

5.3.8.2.5.1 General Life History

Rainbow trout are spring spawners (**Table 5.3.8-6**). Once stream water temperature rises above 4°C, adults migrate from overwintering lakes or rivers to tributary streams. After spawning they return to their lakes or rivers of residence. Embryos incubate in gravel for several weeks and fry emerge to rear in stream habitat. Juveniles spend their first summer in streams – and sometimes stay as long as 1 or 2 years if there is available habitat – and then migrate to their overwintering river or lake. There, they rear and forage until becoming sexually mature adults, typically within 3 to 5 years.

5.3.8.2.5.2 Number and Location of Populations

All rainbow trout populations in the LSA are assumed to be lake-resident because with few exceptions the rainbow trout captured in streams in the summers of 2011, 2012 and 2013 were juveniles between the ages of 0 and 3 years. Adult rainbow trout were found only in lakes or in streams during the spring spawning period. Lakes are the only waterbodies that provide the large volume of under-ice habitat that is required to support adult rainbow trout during the winter.

Section 5.1.2.6.3.2.5 and **Figures 5.1.2.6-61** to **5.1.2.6-63** show the spatial distribution of rainbow trout in streams and lakes of the LSA.

Microsatellite DNA analysis of 170 samples of rainbow trout tissue sampled from streams and headwater lakes in 2011 and 2012 showed four broad groupings corresponding to four watersheds: Davidson Creek, Creek 705, Turtle Creek, and Creek 661 (**Figure 5.1.2.6-64**). Most of the samples were demonstrably genetically distinct from one another and are probably largely demographically independent from one another, although some movement likely does occur occasionally between localities (see Annex 5.10-1 of **Appendix 5.1.2.6A** for more details of the analysis).

Based on these results, one population is assumed to spawn in each of the four watersheds of the LSA, except for those watersheds with headwater lakes, in which case one additional population is assumed to exist for each headwater lake. Hence, there are seven populations of rainbow trout in the LSA: two in Davidson Creek, one each in Turtle Creek and Creek 661, and three in Creek 705 (**Figure 5.1.2.6-65**).

5.3.8.2.5.3 Total Number in Tatelkuz Lake and Headwater Lakes

The hydroacoustic survey estimated 117,068 rainbow trout in Tatelkuz Lake in July 2013 (**Table 5.3.8-7**), or 15.1% of the total number of fish in the lake. The 95% CL of that total number of rainbow trout were 97,167 to 136,970 or +/-17% of the total number. That total number was equivalent to a density of 131/ha (95% CL = 108 to 153 fish/ha). Multiplying the total number by the mean weight of rainbow trout (89 g) gave a total biomass of 10,419 kg (95% CL = 8,648 to 12,190) and a biomass density of 11.6 kg/ha (95% CL = 9.6 to 13.6).

Extrapolating the rainbow trout density measured for Tatelkuz Lake to the three headwater lakes gave reasonable estimates of total number: 120 for Lake 01682LNRS, 2,218 for Lake 01428UEUT, and 4,682 for Lake 01538UEUT (**Table 5.3.8-37**). This extrapolation was justified by a statistical comparison of mean gillnet CPUE of rainbow trout among Tatelkuz Lake and the three headwater lakes (**Table 5.3.8-38**).

5.3.8.2.5.4 Number of Spawners

A total of 2,023 fish were captured in hoop nets installed in Davidson Creek, Turtle Creek, Creek 661 and Creek 705 in June 2011, of which 1,997 (or 98.7%) were rainbow trout. Total hoop net CPUE of rainbow trout in June 2011 was highest in Creek 705, followed by Turtle Creek, Creek 661, and Davidson Creek (**Figure 5.1.2.6-66**).

If one assumes that the number of spawners counted in a stream is proportional to the total number of rainbow trout in its residence lake that belong to that population, then total hoop net CPUE can be used to estimate the proportion of the rainbow trout in Tatelkuz Lake that belong to Davidson Creek, Creek 661, and Turtle Creek populations (**Table 5.1.2.6-39**). These calculations indicate that the number of rainbow trout in Tatelkuz Lake that emerged from gravel in Davidson Creek is approximately 19% of the total number of rainbow trout in the lake. This is acknowledged to be an order-of-magnitude estimate. Its main value is that it indicates that approximately four-fifths of the rainbow trout in Tatelkuz Lake are derived from creeks other than Davidson Creek.

5.3.8.2.5.5 Spawning Timing

Rainbow trout spawners were first counted at hoop nets on 7 June 2011 and were last counted on 28 June 2011 – a total period of 21 days (**Table 5.1.2.6-40**). Dates of 50% upstream counts ranged from June 11 to 25 with a mid-date of June 18, and dates of 50% downstream counts ranged from June 15 to 23 with a mid-date of June 19. On average, the spawning run lasted 18 days: 6 days to migrate to the spawning grounds, 5 days to spawn, and 7 days to return to the residence lakes (**Table 5.1.2.6-40**).

5.3.8.2.5.6 Juvenile Abundance and Spatial Distribution

Inventories of rainbow trout juveniles in streams of the LSA were conducted in the summers of 2011, 2012 and 2013. In general, the density of juveniles was low. Electrofishing CPUE ranged from 0.0 to 7.2 fish/100 s, and electrofishing density ranged from 0.0 to 28.3 fish/100 m^2. The frequency distributions of CPUE and density were skewed to low values – over 70% of the 78 values of electrofishing CPUE were below 1.0 fish/100 s, and over 75% of fish densities were below 5.0 fish/100 m^2.

This range of densities encompasses the BC provincial “biostandards” developed for stream populations of rainbow trout surveyed before and after watershed habitat restoration (Keeley et al., 1996; Koning and Keeley, 1997). (The primary restoration activity was adding habitat complexes such as LWD to streams.) The mean “before” density reported by Koning and Keeley (1997) was 3.6 fish/100 m^2 and the mean “after” density was 9.7 fish/100 m^2. Hence, the “before restoration” biostandard is most applicable to rainbow trout in streams of the LSA. That is, streams in the LSA support low-productivity populations of rainbow trout.

Pooling electrofishing CPUE of rainbow trout by population over both the 2011 and 2012 surveys showed that the Creek 705 Headwaters South population had the highest mean CPUE, followed by the Creek 705 Headwaters North population, the Davidson Creek Headwaters population, and the Creek 661 population. The Tatelkuz Lake Tributaries Watershed (lower Chedakuz Creek) had the lowest CPUE.

The low density of rainbow trout meant there were few obvious relationships between rainbow trout electrofishing CPUE and mesohabitat types (i.e., percent riffles, percent pools, and percent glides) for each stream sampling site.

5.3.8.2.5.7 Spatial Distribution in Tatelkuz Lake

The gillnet survey of the fish community of Tatelkuz Lake in July 2013 showed that that during the day, rainbow trout were especially abundant in the nearshore zone and near the lake surface (0-5 m depth) in both inshore and offshore habitat (**Figures 5.1.2.6-57** and **5.1.2.6-58**). At night, their nearshore abundance decreased and the offshore fish moved deeper in the water column.

5.3.8.2.5.8 Age and Growth

Rainbow trout live to a maximum age of 9 years (**Table 5.1.2.6-42**). Mean age is 2 years in streams and 3 to 4 years in lakes. Growth curves were generally similar among populations (**Figure 5.1.2.6-70**). Length ranged between 50 and 90 mm in the mid-summer of the first year and reached 250 mm by age 3 to 4 years. Few fish exceeded 400 mm in length.

5.3.8.2.5.9 Sexual Maturation

Length at 50% maturity of rainbow trout ranged from 100 to 300 mm among populations in the LSA, with a pooled estimate over all populations of 150 mm (**Figure 5.1.2.6-71**). No fish were mature at lengths below 100 mm. For all populations pooled, 95% of fish were mature at a length of 300 mm.

5.3.8.2.5.10 Diet

Stomach contents of rainbow trout captured from streams and lakes of the LSA showed that rainbow trout are opportunistic feeders, consuming the most common prey available from both benthic and pelagic habitat. These include aquatic and terrestrial insects, molluscs, crustaceans, fish eggs, and other small fish. Rainbow trout in streams feed primarily on benthic invertebrates, drifting aquatic insects and terrestrial insects that fall on the water surface. Once in lakes, they will also feed on zooplankton and other fish, if those prey are available.

5.3.8.2.5.11 Tissue Metal Concentrations

Rainbow trout and mountain whitefish were chosen as the two fish species for measurement of tissue metals concentrations. Rainbow trout were chosen because they were the predominant fish species in streams and headwater lakes and the second most common species in Tatelkuz Lake. Mountain whitefish were chosen because they were abundant in gillnet catches from Tatelkuz Lake, they are large-bodied fish that provided large tissue samples, they are the target of recreational and Aboriginal fisheries (at least historically), and they have different habitat preferences and prey than rainbow trout, indicating potentially different tissue metals profiles.

5.3.8.2.5.11.1 Metal Concentrations

A total of 133 rainbow trout were collected for tissue metals sampling in 2011, 2012 and 2013. Sampling sites included Davidson Creek (7 sites), Turtle Creek (4 sites), Creek 661 (5 sites), Chedakuz Creek (1 site), one site each in headwater lakes 01538UEUT, 01428UEUT, and 01682LNRS, and 19 sites in Tatelkuz Lake. Samples included juveniles and adults ranging over the entire ranges of ages and lengths. A total of 29 mountain whitefish were collected for tissue metals sampling from Tatelkuz Lake in 2013.

Metal concentrations were required from different parts of fish. Muscle and liver metal concentrations were required to evaluate human health because both parts of the fish are eaten by humans. Whole-body metal concentrations were also required for ecological risk assessment because piscivorous wildlife consumes the whole body not just muscle or liver. A total of 297 tissue samples were analyzed: 218 for rainbow trout (96 whole fish, 93 muscle and 69 liver) and 39 for mountain whitefish (19 whole fish, 10 muscle and 10 liver).

Each of these tissue samples was analyzed for percent moisture, concentrations of 41 total metals, and percent lipid content. Sub-sets of whole fish, liver, and muscle samples were also analyzed for methyl-mercury (MeHg) concentration.

Because there were two species, three tissue types, and a large number of analytical variables, Principal Component Analysis (PCA), a type of multivariate statistical analysis, was used to identify major trends in the fish tissue metals data set and remove redundancies in the data set. Section 5.13 of **Appendix 5.1.2.6B** describes the detailed PCA. It was also summarized in **Section 5.1.2.6**. Only a brief summary is shown here.

The first component (PC1) was interpreted as representing the concentration of heavy metals (e.g., copper, molybdenum and zinc). (Note that the term “heavy metals” is conventionally used to describe a loosely defined subset of elements that exhibit metallic properties. The term does not indicate toxicity because all heavy metals, with the exception of mercury, are micro-nutrients that are essential for life and hence are found naturally in all fish tissue.)

The second component (PC2) was interpreted as the concentration of structural metals (e.g., metals such as calcium used in bones). Plots of PC2 scores on PC1 scores for mountain whitefish and rainbow trout separated the three types of tissues without any overlap. Whole fish samples had high concentrations of heavy metals and structural metals, liver samples had high concentrations of heavy metals but low concentrations of structural metals, and muscle samples had low concentrations of heavy metals and intermediate concentrations of structural metals.

“High” concentration in this context means relative to “low” concentrations in other tissues. The issue of biological toxicity is discussed in the following three sections on mercury, methyl-mercury and selenium – the only three metals for which there are guidelines on tissue residue concentrations.

5.3.8.2.5.11.2 Mercury

Total mercury (Hg) was given a focused statistical analysis because it is one of the few metals that have no known biological function, and is highly toxic to plants and animals especially the methylated organic form (see section below). Mean total mercury concentrations for both mountain whitefish and rainbow trout were highest in liver tissue and lowest in whole fish. Only one of the 218 rainbow trout tissue samples collected in 2011 and 2012 exceeded Health Canada's total mercury guideline for human consumption of 0.5 mg/kg wet weight (wwt) – a liver sample taken from a trout captured from Lake 01682LNRS. None of the rainbow trout and mountain whitefish tissue samples collected from Tatelkuz Lake in July 2013 exceeded Health Canada's total mercury guideline.

It is important to recognize that the Health Canada mercury guideline is not a threshold concentration above which toxic effects are expected. Instead, it is a guideline established to protect people, particularly pregnant women, who consistently eat large amounts of fish over long time periods. The concentrations of mercury found in mountain whitefish and rainbow trout of the LSA are similar to those reported for pristine watersheds. For example, they fall within the lower range of mercury concentrations reported for mountain whitefish and rainbow trout in the Canadian Fish Mercury Database (Depew et al., 2013). Mean mercury concentrations for rainbow trout of the Blackwater LSA are similar to those reported by BC MOE for rainbow trout sampled from 24 uncontaminated lakes in BC (Rieberger, 1992).

5.3.8.2.5.11.3 Methyl-mercury

Methyl-mercury is the most toxic form of mercury. A total of 22 rainbow trout tissues and 10 mountain whitefish tissues were analyzed for methyl-mercury concentrations. On average, rainbow trout methyl-mercury concentration was 51% of total mercury concentration, and mountain whitefish methyl-mercury concentration was 32% of total mercury concentration.

A site-specific methyl-mercury guideline of 0.062 mg/L was calculated by determining the species of fish-eating birds that resides or visits the Project area that has the highest potential consumption rate of fish. (This is the recommended protocol of the Canadian Council of Ministers of the Environment or CCME.) For the rainbow trout samples of 2011 and 2012, only two tissue samples from a single rainbow trout from Lake 01682LNRS exceeded that guideline. For the fish samples collected from Tatelkuz Lake in July 2013, only one mountain whitefish liver sample exceeded the Blackwater site-specific methyl-mercury guideline.

5.3.8.2.5.11.4 Selenium

Selenium (Se) was also the subject of focused analysis because it is an essential micronutrient for all animals, but it is toxic to wildlife in high concentrations. For both rainbow trout and mountain whitefish sampled from Tatelkuz Lake in July 2013, mean total selenium concentration was highest for liver tissue and lowest for muscle tissue, with whole fish having an intermediate concentration.

A different situation was found in the rainbow trout samples collected in 2011 and 2012 – the highest selenium concentrations were found in muscle and whole body samples of juvenile rainbow trout. Pooling all rainbow trout tissues for all three years showed highly significant (P<0.001) negative correlations of selenium concentration and body length for both muscle and whole body tissues but not for liver.

The most reasonable explanation for these differences is that it reflects the difference between selenium uptake from diet and selenium depuration into eggs and milt. Both processes are linked to changes in body size and habitat. Juvenile rainbow trout accumulate selenium in their livers and muscle as they feed and grow in streams. Sexually mature adults living in lakes also accumulate selenium in their tissues, but are able to transfer some of it from muscle tissue into eggs and milt – which are then expelled once a year during spawning. Hence, their total selenium concentrations in muscle and whole fish samples are lower than those of juvenile fish.

None of the rainbow trout and mountain whitefish tissue samples exceeded the lowest of the three selenium guidelines issued by the BC MOE and the BC Ministry of Health (i.e., 1.8 mg/kg wwt for 7 servings/week).

BC MOE established an interim total selenium whole fish guideline for protection of aquatic life of 1 mg/kg wwt for whole fish samples. The guideline was exceeded by all 59 of the liver samples collected from lakes and streams in 2011 and 2012, but by none of the muscle samples. Eight whole rainbow trout collected from streams in 2011 and 2012 exceeded the guideline. That guideline was also exceeded by all of the rainbow trout liver samples collected from Tatelkuz Lake, but none of the muscle or whole fish samples.

5.3.8.2.6 Mountain Whitefish

Mountain whitefish was the third most common species captured in Tatelkuz Lake in 2013, comprising 12.8% of the total number of fish observed and captured from that lake. It was the sixth most common species captured in stream surveys in 2011 and 2012, comprising 0.1% of the total number of fish observed and captured.

Mountain whitefish is one of many species of whitefishes (Subfamily Coregoninae) in the northern hemisphere. It is a lake-resident fish that spawns in large tributary streams in late fall and early winter (Roberge et al., 2002) (**Table 5.1.2.6-27**). No nest is prepared. Instead, eggs are broadcast over gravel. Adults return to lakes immediately after spawning. Embryos develop in the gravel over winter and fry emerge in spring and immediately migrate to residence lakes. Their diet consists mainly of BMI.

In BC, mountain whitefish is a sport fish and historically a food fish. It is reported as a species captured in Aboriginal fisheries in the aquatics LSA.

The mountain whitefish spawning survey of fall 2012 (described in **Appendix 5.1.2.6A**) was restricted to selected tributary streams. There was no survey of mountain whitefish spawning activity in Tatelkuz Lake because, although beach spawning in lakes is known for some BC populations of mountain whitefish (e.g., in Okanagan Lake), there is no historical record or TK information that indicates beach spawning by mountain whitefish in Tatelkuz Lake. There are gravel and cobble substrates in the littoral zone of Tatelkuz Lake, but the steep sides of the lake and its narrow littoral zone do not provide abundant spawning habitat.

The fall 2012 survey showed that mountain whitefish spawners were present in low numbers in lower Davidson Creek and in Creek 705. This indicates the existence of at least two populations in the aquatics LSA: one population that resides in Tatelkuz Lake and spawns in Chedakuz Creek and its tributaries and a second population that resides in one or more lakes in the Fawnie Creek Watershed and spawns in Fawnie Creek and its tributaries.

The large number of mountain whitefish residing in Tatelkuz Lake indicates that they require large amounts of spawning habitat. The low numbers of spawners captured in streams in fall 2012 indicates that either most spawners do not use small tributary streams to Chedakuz Creek. Therefore, it is likely that most mountain whitefish residing in Tatelkuz Lake spawn in Chedakuz Creek because it is the main inlet and outlet of the lake and is the largest stream in the immediate vicinity of the lake. Middle Chedakuz Creek is the most likely spawning location because newly-emerged fry would be washed downstream into Tatelkuz Lake. The use of Chedakuz Creek by mountain whitefish for spawning and embryo incubation has not yet been confirmed due to the difficulty in installing hoop nets in such a large stream, particularly at higher fall discharges.

5.3.8.2.7 Longnose Sucker

Longnose sucker was the sixth most common species captured in Tatelkuz Lake in July 2013, comprising 4.2% of the total number of fish captured or observed. It was the fourth most common species captured in stream surveys in 2011 and 2012, comprising 0.2% of total number of fish observed or captured.

It belongs to the sucker family (Family Catostomidae). It resides in both lakes and rivers and feeds exclusively on BMIs. Immediately after ice-out in spring, adult longnose suckers migrate to spawning sites in tributary streams (Roberge et al., 2002) (**Table 5.1.2.6-27**). Eggs are sticky and are deposited on the surface of gravel (Scott and Crossman, 1973). Adults quickly return to their residence area, whether lake or stream. Fry hatch several weeks later and migrate to their residence lake.

Longnose sucker is reported as a species captured in Aboriginal fisheries in the aquatics LSA.

Tatelkuz and Kuyakuz lakes are probably the primary residence lakes for longnose sucker in the LSA and RSA. Burns (1977) reported them present in Kuyakuz Lake, and Walsh and Hale (1977) reported them present in Tatelkuz Lake. In 2012, they were captured in the two headwater lakes of Creek 705 (Lake 01538UEUT and Lake 01428UEUT), but not in Lake 01682LNRS, the headwater lake of Davidson Creek.

The population structure of longnose sucker in the LSA and RSA is not well understood because of low catches. A working hypothesis is the presence of at least four separate populations – one each for Tatelkuz Lake, Kuyakuz Lake, Lake 01538UEUT, and Lake 01428UEUT.

5.3.8.2.8 Largescale Sucker

Largescale sucker was the eighth most common species captured in Tatelkuz Lake in 2013, comprising 0.9% of the total number of fish captured or observed. It was not captured in stream surveys conducted in 2011 and 2012.

Largescale sucker is reported as a species captured in Aboriginal fisheries in the aquatics LSA.

Largescale sucker belongs to the sucker family (Family Catostomidae). It resides in both lakes and slow-moving rivers. Adults feed primarily on BMI and periphyton, while juveniles feed on plankton. They spawn in the spring, after water temperatures reach a minimum of 8°C (**Table 5.1.2.6-27**). Spawning takes place over coarse gravel or cobble substrates. Spawning sites are typically located in shallow water areas of lakes or adjacent to riffles in rivers. No nest is created, although the substrate is cleaned and a shallow depression is created during egg release. Eggs are broadcast over the cleaned gravel and adhere to the gravel surface. Fry emerge between 7 and 20 days after fertilization, depending on temperature.

Tatelkuz and Kuyakuz lakes are the primary residence lakes for largescale sucker in the LSA and RSA (Burns, 1977). The population structure of largescale sucker in the LSA and RSA is not well understood because of low catches in 1977 and 2013.

5.3.8.2.9 White Sucker

White sucker was the ninth most common species captured in Tatelkuz Lake in 2013, comprising 0.2% of the total number of fish captured or observed. A single white sucker was captured in 2012 by minnow traps at a stream that will be crossed by the transmission line. That single fish comprises 0.004% of the total number of fish counted and captured in streams in 2011 and 2012.

White sucker belongs to the sucker family (Family Catostomidae). Like the longnose sucker, it resides in lakes and streams and migrates to tributaries in spring to spawn (Scott and Crossman, 1975). It feeds on BMI.

White sucker is reported as a species captured in Aboriginal fisheries in the aquatics LSA.

Its population structure in the LSA and RSA is not well understood because of low catches. One population exists in Tatelkuz Lake, and at least one other population exists in a watershed along the transmission line corridor.

5.3.8.2.10 Burbot

Burbot was the tenth most common species captured in Tatelkuz Lake in 2013, comprising 0.1% of the total number of fish captured. It was the seventh most common species captured in streams in 2011 and 2012, comprising 0.01% of the total number of fish observed and captured.

Burbot are the only freshwater member of the cod family (Family Gadidae). They are also one of only two species in the LSA and RSA that spawn in winter (January to March). The other winter-spawning species is mountain whitefish, which spawn in early winter. Burbot spawn mainly on lake shoals or in the outlets of lakes (Scott and Crossman, 1973). Embryos take 1 to 2 months to develop, depending on temperature (McPhail, 2007). Juveniles feed on algae and BMI. Adult burbot are predators of fish eggs and juveniles, as well as of BMI.

Burbot are targets of both recreational and Aboriginal fisheries in the aquatics LSA.

Burbot population structure in Tatelkuz Lake is not well understood because of low catches. One population exists in Tatelkuz Lake and at least one population exists in the Fawnie Creek Watershed, based on the capture of four burbot in June 2011 as they passed through hoop nets in lower Creek 705 and the capture of several burbot in lower Creek 705 in July 2013. Their capture during the rainbow trout spawning season in 2011 suggests they were intent on eating rainbow trout eggs.

5.3.8.2.11 Past, Present and Future Projects and Activities

The fish VC potentially interacts with other projects or activities in the RSA as a result of spatial or temporal overlap. **Table 4.3-11** in **Section 4.3** shows the Summary Project Inclusion List developed for cumulative effects assessment. Of the 13 items on that list, ten have potential relevance to the fish VC, as follows:

- Pacific Gas Looping Project;
- Mining – existing;
- Mining – exploration;
- Forestry – logging;
- Hunting, trapping and guide outfitting;
- Fishing and hunting lodges;
- Recreation;
- Agriculture;
- Transportation; and
- Crown land tenures.

Section 5.3.8.5 describes in detail the cumulative impacts of those ten projects and activities on the fish VC.

5.3.8.2.12 Traditional Knowledge

Traditional Knowledge (TK) of fish and fish habitat was gathered during consultations with the various Aboriginal groups whose traditional territories may be affected by the Project. To date, these consultations have included meetings and interviews with members of the following groups:

- Lhoosk'uz Dene Nation;
- Nadleh Whut'en First Nation;

- Saik'uz First Nation;
- Stellat'en First Nation;
- Ulkatcho First Nation;
- Nazko First Nation; and
- Skin Tyee First Nation.

Section 7.2.7 summarizes the available information on traditional land use by these groups.

Indian Reserve (IR) #28 is located at the northern end of Tatelkuz Lake. The reserve is occupied by one family with four members of the Lhoosk'uz Dene Nation. Fishing remains an important food source for this family who estimates that approximately three to four meals per week consist of fresh or dried fish. In an interview with residents of IR #28 on 4 July 2013, it was reported that they harvest rainbow trout, suckers, and kokanee in Tatelkuz Lake, lower Davidson Creek, and lower and middle Chedakuz Creek (Interviews with Lhoosk'uz Dene Elders, 2013). (Upper Chedakuz Creek is the major inlet to Kuyakuz Lake, middle Chedakuz Creek runs from the outlet of Kuyakuz Lake to the inlet of Tatelkuz Lake, and lower Chedakuz Creek runs from the outlet of Tatelkuz Lake to the Nechako Reservoir.)

They usually fish in the spring when rainbow trout and suckers migrate from their residence lakes into spawning streams.

Rainbow trout and suckers are also fished in the "Twin Lakes" (Lake 113 and Mills Lake) located within the northeast corner of the RSA.

There have been historical Aboriginal fisheries in the RSA, as evidenced by the numerous archaeological sites distributed along the shorelines of Tatelkuz and Kuyakuz lakes (New Gold, 2012). Kuyakuz Lake remains an important fishing spot for Lhoosk'uz Dene Nation and Ulkatcho First Nation.

The Ulkatcho Traditional Land Use Study (TLUS) (summarized in **Section 7.2.7** of this Application) identified Kuyakuz Lake, Moose Lake, and Johnny Lake as areas of intensive use within the RSA. Species fished within the RSA and LSA include suckers, burbot, and trout.

Sockeye salmon is a species of importance to the Saik'uz First Nation, Nadleh Whut'en and Stellat'en First Nation. The Nechako and Stellako rivers, which will be crossed by the Project's proposed transmission line, are popular rivers to catch salmon. Depending on the availability of sockeye (either due to seasonal or spawning cycles), other fish supplements their intake. This includes char, whitefish, kokanee, mountain whitefish, burbot and rainbow trout. These fish species are caught in streams, rivers and lakes, some of which may be crossed by the transmission line.

5.3.8.3 Potential Effects of the Proposed Project and Proposed Mitigation

This subsection identifies and analyzes potential adverse effects on the fish VC resulting from the proposed Project's construction, operations, closure and post-closure phases.

It first describes the features of the six major components of the Project (mine site; mine access road; airstrip and airstrip access road; Freshwater Supply System or FSS; transmission line; and the Kluskus FSR and Kluskus-Ootsa FSR) that may potentially affect the fish VC (**Section 5.3.8.3.1**).

Then, for each of those six components, potential effects are described, mitigation measures are outlined and residual effects after mitigation are listed (**Sections 5.3.8.3.2** to **5.3.8.3.7**). Hence mitigation measures are identified in each of the six component-specific sections. **Section 5.3.8.3.8** lists residual effects for all six Project components. These residual effects are then characterized and assessed in **Section 5.3.8.4**.

Identification of potential effects on fish was not based on the type of interaction of mine activities and the VCs (i.e., a key interaction that has a direct effect that may be significant; a moderate interaction that has an indirect effect that is not significant; or a negligible interaction). There was no *a priori* judgement of potential effects by their mitigatability. Instead, all potential effects were listed, regardless of whether they can be mitigated or not. Then, the application of mitigation measures led to identification of residual effects that were then assessed for significance.

Methods of analysis are described in each of the component-specific sections and include the following:

- Potential effects on fish due to potential changes in water quality in study area streams and lakes are assessed using available guidelines for the protection of freshwater aquatic biota;
- Potential effects on fish due to potential changes in water temperature in study area streams are assessed by comparing the predicted thermal regimes to baseline thermal regimes and to optimal and tolerance limits for rainbow trout and kokanee; and
- Potential habitat effects, including potential flow effects, are assessed using the fish habitat VC (**Section 5.3.9**), which considers the results of the Instream Flow Study.

5.3.8.3.1 Project Works and Activities

Effects assessment was conducted on six major components of the Project: the mine site, mine access road, airstrip and airstrip access road, FSS, transmission line, and the Kluskus and Kluskus-Ootsa FSRs. **Section 2.2** provides a detailed description of Project works and activities. This section briefly describes each of these components.

5.3.8.3.1.1 Mine Site

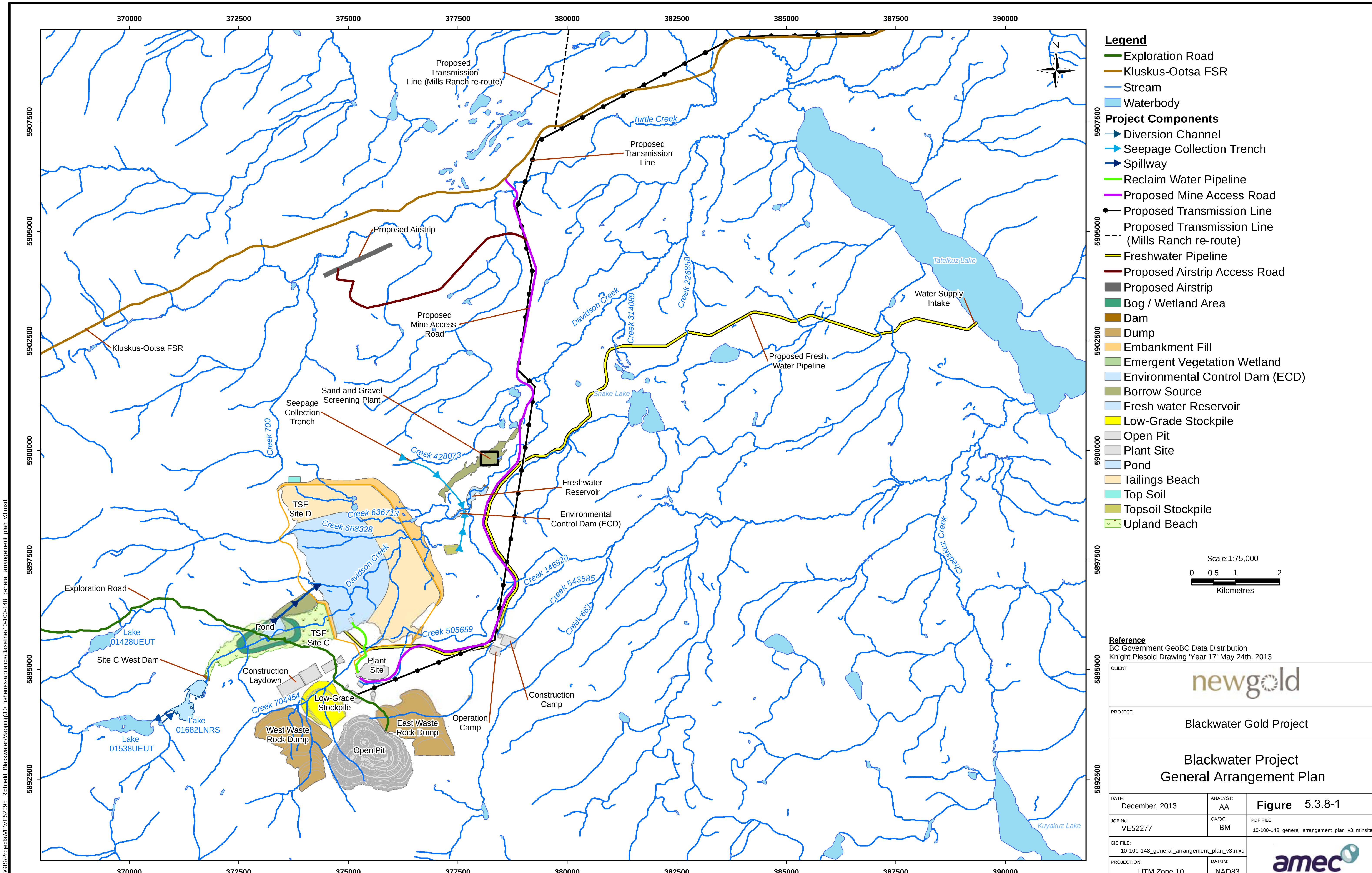
The mine site consists of an open pit, East and West Waste Rock Dumps, low-grade ore stockpile, a central plant site, construction and operations lay-down areas, construction and operations camps, and a TSF (**Table 5.3.8-9** and **Figure 5.3.8-1**). The mine site has a footprint area of 4,400 ha. Almost all components of the mine site will be located in the Davidson Creek Watershed. Part of the East Waste Rock Dump will fall within the Creek 661 Watershed.

Portions of other project infrastructure components, including the mine access road, FSS, and the transmission line will also be located within the mine site footprint.

Table 5.3.8-9: Mine Site Components and Footprint

Project Component or Facility	Description
Open Pit	Footprint of approximately 238 ha. Approximately 2 km long from east to west and 1.5 km long from north to south. Anticipated depth of 550 m below existing surface topography.
East and West Waste Rock Dumps	East Waste Rock Dump: Footprint of approximately 158 ha to store 50 Mt of Type 5 Non-Acid Generating (NAG) rock and overburden. West Waste Rock Dump: Footprint of approximately 172 ha to store 87 Mt of NAG 4, NAG 5 and overburden.
Low Grade Ore Stockpile	Footprint of approximately 76 ha to store 50 Mt of low-grade ore.
Construction Laydown Area	Occupies approximately 31 ha.
TSF	Footprint of approximately 1,117 ha comprising Site C, which occupies 192 ha and Site D, which occupies 925 ha. The TSF is designed to store a total of 784 Mt of both tailings and Potentially Acid Generating (PAG) waste rock.
Plant Site and Crusher	Industrial buildings occupy approximately 35 ha.
Operations Camp	Occupies approximately 5 ha with buildings to accommodate up to 400 personnel.
Topsoil Stockpile	Footprint of approximately 10 ha distributed in two locations within the mine site.
Borrow Areas	73 ha comprised of 30 ha for the Site C main dam and 43 ha for the Site D main dam. The borrow areas also include a sand and screening plant.

Note: Mt = million tonnes.



Legend
Exploration Road
Kluskus-Ootsa FSR
Stream
Waterbody
Project Components
Diversion Channel
Seepage Collection Trench
Spillway
Reclaim Water Pipeline
Proposed Mine Access Road
Proposed Transmission Line
Proposed Transmission Line (Mills Ranch re-route)
Freshwater Pipeline
Proposed Airstrip Access Road
Proposed Airstrip
Bog / Wetland Area
Dam
Dump
Embankment Fill
Emergent Vegetation Wetland
Environmental Control Dam (ECD)
Borrow Source
Fresh water Reservoir
Low-Grade Stockpile
Open Pit
Plant Site
Pond
Tailings Beach
Top Soil
Topsoil Stockpile
Upland Beach
Scale:1:75,000
0 0.5 1 2
Kilometres
Proposed Transmission Line (Mills Ranch re-route)
Proposed Transmission Line
Turtle Creek
Proposed Airstrip
Proposed Mine Access Road
Kluskus-Ootsa FSR
Davidson Creek
Creek 314089
Creek 226858
Tatelkuz Lake
Water Supply Intake
Proposed Fresh Water Pipeline
Snake Lake
Sand and Gravel Screening Plant
Seepage Collection Trench
Creek 700
Creek 428073
Freshwater Reservoir
Environmental Control Dam (ECD)
TSF Site D
Creek 636713
Creek 668328
Davidson Creek
Creek 146920
Creek 543585
Creek 661
Chedakuz Creek
Exploration Road
Pond
TSF Site C
Creek 505659
Lake 01428UEUT
Site C West Dam
Construction Laydown
Plant Site
Construction Camp
Operation Camp
Creek 704454
Low-Grade Stockpile
Lake 01682LNRS
Lake 01538UEUT
West Waste Rock Dump
East Waste Rock Dump
Open Pit
Kuyakuz Lake
370000
372500
375000
377500
380000
382500
385000
387500
390000
5907500
5905000
5902500
5900000
5897500
5895000
5892500
Reference
BC Government GeoBC Data Distribution
Knight Piesold Drawing 'Year 17' May 24th, 2013
CLIENT:
newgold
PROJECT:
Blackwater Gold Project
Blackwater Project
General Arrangement Plan
DATE: December, 2013
ANALYST: AA
Figure 5.3.8-1
JOB No: VE52277
QA/QC: BM
PDF FILE: 10-100-148_general_arrangement_plan_v3_minsite.pdf
GIS FILE: 10-100-148_general_arrangement_plan_v3.mxd
PROJECTION: UTM Zone 10
DATUM: NAD83
amec

5.3.8.3.1.1.1 Construction Phase

Construction will take place in Years -2 and -1. At the mine site, it will begin with the clearing of top-soil and over-burden from the open pit, waste rock dumps, TSF dam and mine effluent storage areas, the construction lay-down area, and the ore-processing area where the plant site, mill, core-logging buildings, fuel site, warehouses, truck shop, maintenance buildings, the explosives facility, and construction camp will be built (**Table 5.3.8-10**). Two separate ore stockpiles will be established immediately west of the plant site: a temporary one for high-grade ore and a second for low-grade ore. Once the land is cleared, buildings will be constructed, surface drainage ditching around ore-stockpiles and waste rock dumps will be installed, and the camp waste management system, including the site landfill, incinerator, and domestic sewage system, will be built. NAG rock removed from the pit will be used to construct site roads.

Table 5.3.8-10: Project Activities during the Construction Phase

Project Component	Activities
Site Infrastructure and Site Roads	Clearing, grading and topsoil salvage, construction and lay-down areas, surface drainage controls, construction of site infrastructure (fuel site, warehousing and materials storage, construction lay-down area, truck stop, camp and maintenance buildings, explosives facility), camp waste management system (site landfill and domestic sewage system).
Ore Processing Area	Clearing and construction of ore processing area (plant site, mill and processing area, core logging area) foundations and building construction, crusher and conveyor and low-grade ore stockpile.
Waste Rock Areas	Construction of mine waste rock dumps.
TSF	Clearing, grading and topsoil salvage, construction of TSF (tailings and return water lines), construct dams and collect water, Site C west dam, Site C main dam, Site D main dam and embankment.
Wetland and Water Management System, Freshwater Reservoir	Construction of water management system (site surface drainage management, erosion and sediment control, water recovery and recycle system from TSF).
Borrow Areas	Development of borrow sites (Site C main dam, esker borrow source and sand and gravel screening plant).

The plant site buildings and most of the site facilities will lie within the Davidson Creek Watershed and upstream of the TSF catchment area, thereby minimizing any direct impact on other watersheds in the area. Surface drainage from the mine site will flow to the TSF.

The Site C West TSF dam, the Site C TSF dam, and the Site D TSF dam will be constructed using NAG material removed from the pit. Each of these dams will be built in lifts until the engineered heights and widths required for initial operations are achieved. At the same time, pipelines for the mine effluent and for the water recovery and recycling systems will be installed in the TSF. Once built, the dams will begin to collect run-off from the upper Davidson Creek and Creek 661 watersheds. Initially, NAG and PAG waste will be placed in the Site C TSF.

During initial development of TSF Site C, a saddle dam will be constructed in the upper reaches of Davidson Creek, approximately 900 m downstream of Lake 01682LNRS. This dam will permanently isolate all fish habitat in Reach 12 of Davidson Creek and Lake 01682LNRS, beginning in early construction.

Borrow areas required for construction materials will be developed at the beginning of the construction phase. These include the esker borrow source, and the Site C dam area. The sand and gravel screening plant will be built in the esker borrow source area.

5.3.8.3.1.1.2 Operations Phase

Operations will take place from Years +1 to +17. Activities during Operations will focus on ore extraction and processing (**Table 5.3.8-11**). Ore will be blasted from the open pit with ammonium-nitrate fuel/oil explosives placed in drill holes. Ore will be loaded into 290 tonne haul trucks by electric/diesel shovels and delivered to a primary crusher. Crushed ore will then be fed into a whole-ore cyanide leach gold-silver recovery mill. Tailings from the mill will be treated by a SO_2/air treatment plant to destroy cyanide used in the extraction process before disposal in the TSF. The gold and silver will be recovered into a gold-silver ore product and shipped by air or road.

Table 5.3.8-11: Project Activities during the Operations Phase

Project Component	Activities
Site Infrastructure and Roads	Worker accommodations Operations, hazardous materials management (waste, explosives, spills), camp and offices waste management.
Open Mine Pit	Drill, blast, excavate, transport ore.
Ore Processing Area	Process area operations.
Waste Rock Areas	Mine waste rock dump placement.
TSF	TSF ongoing development and operation.
Wetland and Water Management System, Freshwater Reservoir	Water management system operation and maintenance.

Ore will be stockpiled during operations. High-grade ore stockpiling will end in Year +1 once the mill starts up. Low-grade ore will continue to be stockpiled throughout operations. After the high-grade stockpile is reclaimed, plant feed will be maintained by ore delivered directly from the pit. Ore from the low-grade ore will be fed to the plant after Year +10.

Initially, PAG waste rock will be placed in the Site C TSF, but it will be recovered within 1 year and all PAG waste-rock will be placed in the Site D TSF beginning in Year +2. This will continue throughout operations. NAG waste-rock will be used to continue building the Site D TSF dam as required.

Waste rock and over-burden will continue to be extracted from the pit and stored in the East and West waste-rock dumps and overburden storage areas during operations. An overburden stockpile will be established at the south end of the Site D TSF dam to provide an overburden supply for the final years of dam construction. Overburden will also be stored near the Site C TSF for use during site reclamation. By Year +9, the pit will be mined to the final wall configuration and all overburden will have been mined out and stored. Progressive reclamation of the over-burden storage areas and waste-rock dumps will begin in Year +1 and continue throughout operations.

Water stored in the Site C TSF pond will serve as the primary source of process water during the initial 2 years of mill operations. After that, water stored in the Site D pond will be the primary source of process water. This will continue until the end of mining operations in Year +17. Any additional freshwater required by the plant that cannot be supplied by the TSF ponds will be provided by the FSS. The water will be pumped from Tatelkuz Lake to the freshwater reservoir and then pumped to the mill.

An environmental control dam (ECD) will be constructed in Year +1 to capture seepage and surface runoff from the Site D TSF dam. Seepage collected in the pond behind this dam will be pumped back to the TSF.

5.3.8.3.1.1.3 Closure Phase

Closure will take place from Years +18 to +35. After Operations are complete, the Project will be decommissioned and reclaimed (**Table 5.3.8-12**).

Table 5.3.8-12: Project Activities during the Closure/Decommissioning Phase

Project Component	Activities
Site Infrastructure and Roads	Decommission, dismantle and remove equipment (conveyors, crusher, warehousing, fuel storage, truck stop), reclaim areas of soil contamination, implement reclamation plan (grade and level site, implement erosion and sediment control features and spread overburden and topsoil).
Mine Pit	Construct rock safety berm, spillways, and channel to TSF, overburden in bench flats, fertilize pit water while filling if required.
Ore Processing Area	Decommission, dismantle and remove equipment.
Waste Rock Areas	Re-grade, construct drainage control swales, cover, and re-vegetate.
TSF	Site C: Remove pumps/pipelines, cover, wetland and upland beach re-vegetation, outlet connection, reseed downstream slope, and decommission seepage sump. Site D: Pump supernatant and Tatelkuz Lake water to pit, construct spillways, cover, deflector berm, outlet connection.
Wetland and Water Management System, Freshwater Reservoir	Monitor water quality.

Proposed end land uses after mine closure include wildlife and recreation. The closure strategy includes accelerated flooding of the open pit through pumping of water from the TSF and Tatelkuz Lake. It also includes covering the NAG waste rock dumps and diverting the run-off from these facilities to the open pit or to the TSF. After the pit is filled, water diversions around the TSF will be breached to return watercourses to their natural drainages. (The exceptions to this generalization are the dam that will isolate Lake 01682LNRS from the Davidson Creek Watershed and the diversion from Lake 01682LNRS to Lake 01538UEUT, neither of which will be altered.)

At this time, the pit lake will discharge to the TSF. Only when water quality in the TSF meets site-specific water quality objectives for the protection of freshwater aquatic biota will overflow from the TSF be allowed to flow downstream to Davidson Creek. To assist in achieving these objectives, a NAG tailings final cover will be placed on tailings, constructed wetlands will be established in the saturated areas of the TSF impoundment and the exposed beaches will be covered with overburden. (**Appendix 2.6C** describes a conceptual design for the treatment wetlands.)

Once all ore is processed, the east half of the East dump will be mined out to provide overburden for reclamation of the Site D TSF and the waste dumps. Reclamation will also be carried out in all other previously unreclaimed areas.

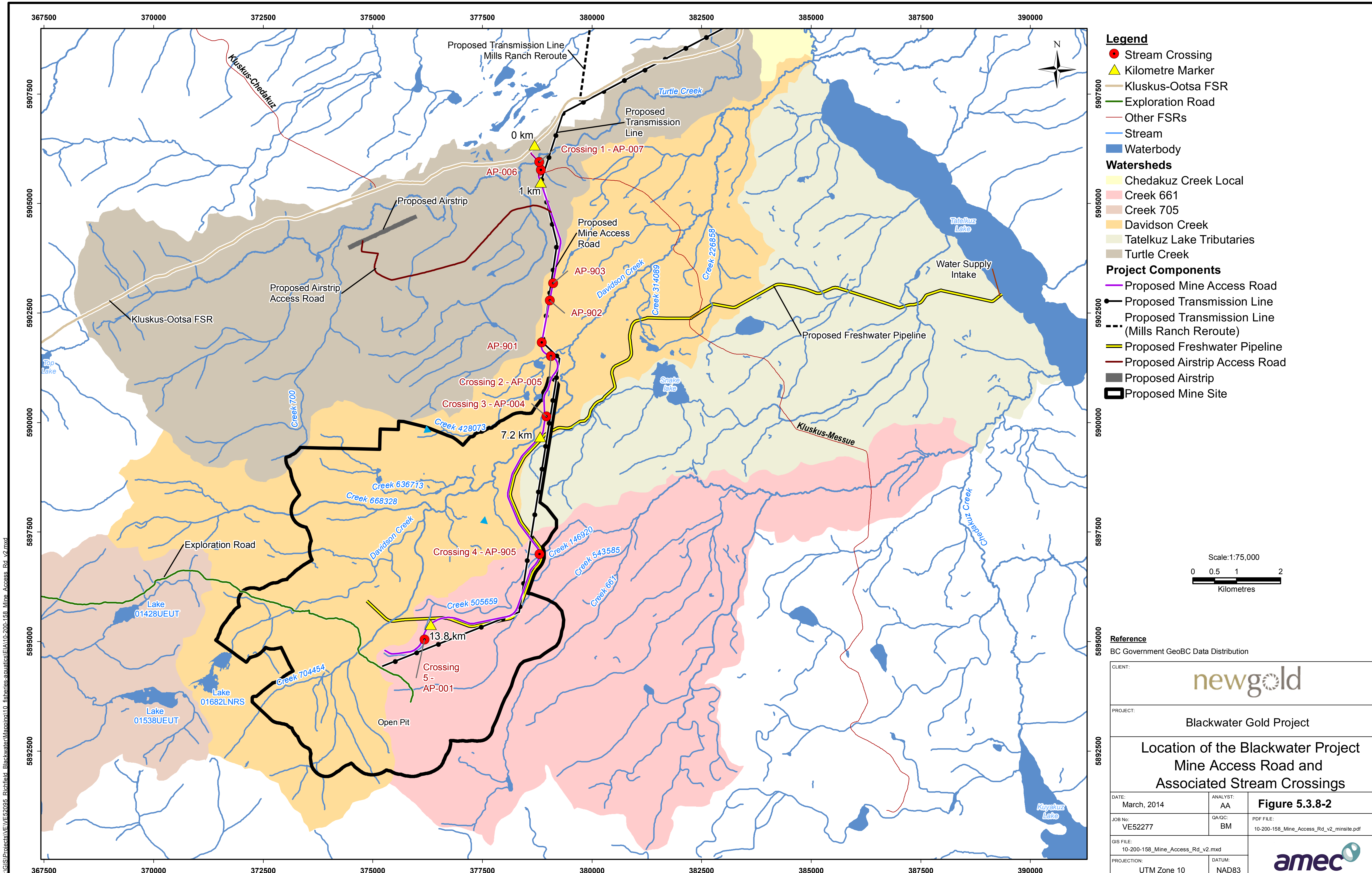
5.3.8.3.1.2 Mine Access Road

Access to the mine site will be provided via a new mine access road. It will be approximately 16 km long and will connect the mine site to the existing Kluskus-Ootsa FSR (**Figure 5.3.8-2**). Current access to the Project site via the existing mine exploration road will be closed and decommissioned.

5.3.8.3.1.2.1 Construction Phase

Construction of the mine access road will require tree clearing and grading of the Right-of-Way (ROW). Width of the ROW will vary from 30 to 55 m depending on site-specific cut and fill and backslope requirements. The cleared roadway ROW may occur adjacent to the proposed transmission line and/or freshwater pipeline, and therefore the roadway may be built within a cleared corridor that is wider than the ROW.

Five permanent watercourses and four non-classified drainages (NCD) – a mapped stream that does not satisfy the criteria for the definition of a stream (defined as a having a continuous channel bed >100 m long or being fish-bearing) (BC MOF, 1995, 1998) – will be crossed by the route. The road crossings at all five permanent watercourses are either confirmed or assumed to be fish-bearing (**Table 5.3.8-13**). The four non-classified drainages do not support fish and, therefore, are not discussed further.



Location of the Blackwater Project Mine Access Road and Associated Stream Crossings

Figure 5.3.8-2

Table 5.3.8-13: Stream Crossing Sites of the Mine Access Road

Crossing Number	Site ID[1]	Stream Name	Stream Classification[2]	Fish Captured[3]
5	AP-001	Creek 505659	S3	NFC
3	AP-004	Davidson Creek	S2	RB
2	AP-005	Unnamed	S4	RB
-	AP-006	Unnamed	NCD	NFC
1	AP-007	Turtle Creek	S3	RB
-	AP-901	Unnamed	NCD	NFC
-	AP-902	Unnamed	NCD	NFC
-	AP-903	Unnamed	NCD	NFC
4	AP-905	Creek 505659	S4	RB

Note: Dashes indicate no crossing number.
(1) Annex 5.8-1 of **Appendix 5.1.2.6B**.
(2) Class S1 streams are >20 m wide; S2 streams are >5 - 20 m wide; S3 streams are 1.5 - 5 m wide; and S4 streams are <1.5 m wide. Streams without fish are classified S5 or S6. Class S5 streams are >3 m wide, and S6 streams are <3 m wide. NCD = non-classified drainage, and NVC = no visible channel (BC MOF, 1995, 1998).
(3) RB = Rainbow Trout; NFC = no fish caught.

Crossing 1, located at site AP-007, is on Turtle Creek. At Crossing 1, Turtle Creek is classified as S3, i.e., a fish-bearing stream with channel width between 1.5 m and 5 m (BC MOF, 1995, 1998). Rainbow trout are present in Turtle Creek, and good quality rainbow trout habitat is present in the vicinity of Crossing 1 (**Appendix 5.1.2.6A** and **Appendix 5.1.2.6B**).

Crossing 2, located at site AP-005, is on an unnamed tributary to Davidson Creek. This watercourse is classified as S4 (i.e., a fish-bearing stream with channel width less than 1.5 m). Rainbow trout have been captured at this crossing site and good quality rainbow trout habitat is present.

Crossings 3 and 4, located at sites AP-004 and AP-905, are on Davidson Creek and Creek 505659, respectively. Davidson Creek at the crossing site is classified as S2 (i.e., fish-bearing stream with channel width between 5 m and 20 m). Creek 505659 at the crossing site is classified as S3. Rainbow trout are present at both crossings.

Crossing 5, located at site AP-001, is on the headwaters of Creek 505659. The creek at this location is fish-bearing with a channel width of less than 1.5 m (i.e., S4). Rainbow trout have not been captured at this location, but it is assumed they could be present at this site, particularly in spring when flows are high and access by rainbow trout would be possible.

All five of the permanent streams will be crossed by clear-span bridges ranging in length from 12.0 m to 18.3 m. “Clear-span” means the bridges will have no permanent facilities within the active channel and no channel realignment will be required during bridge installation. Riprap will be placed around the bridge abutments to protect them from potential erosion and scour. Culverts will be installed at non-classified drainages to convey flow across the mine access road during high-flow seasons (i.e., spring freshet).

5.3.8.3.1.2.2 Operations Phase

Maintenance of the road during the mine Operations phase will include regular inspections and repairs of roadside ditches, culverts, and bridges. Road grading will be carried out regularly to maintain the driving surface of the road.

5.3.8.3.1.2.3 Closure Phase

During the mine closure phase, the road will be maintained to allow access to site by work crews.

5.3.8.3.1.2.4 Post-Closure Phase

During post-closure, the roads will be left stable and access will be managed, if required for ongoing monitoring and reclamation activities. If not, then the road will be decommissioned and reclaimed. That will involve ripping up the road surface, re-contouring to pre-disturbance topography, and re-vegetating with native plant species common to the area. All clear-span bridges and culverts will be removed, followed by channel restoration and watercourse crossing ROW reclamation. The goal will be to return to road to as near to pre-mining conditions as possible.

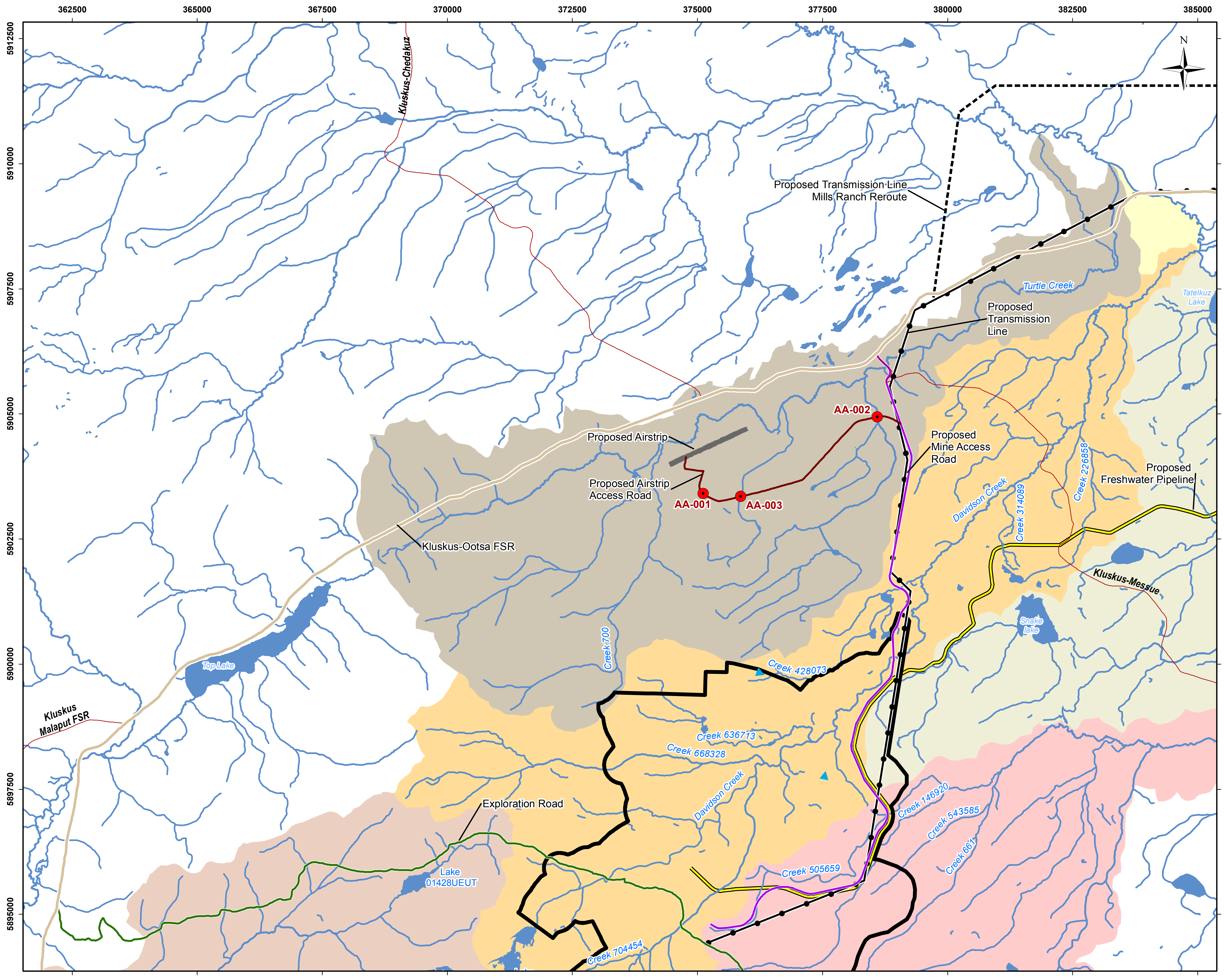
5.3.8.3.1.3 Airstrip and Airstrip Access Road

An airstrip will be built to transport personnel to and from the Blackwater mine site (**Figure 5.3.8-3**). The airstrip will be built to accommodate turbo-prop aircraft, including Dash 8-type aircraft.

The airstrip will be located in the Turtle Creek Watershed on the site of a previously logged forest cut-block. The airstrip will be located approximately 18.5 km by road from the Blackwater mine camp. The airstrip will be built on a site with no existing fish-bearing watercourses.

5.3.8.3.1.3.1 Construction Phase

Components of the airstrip development will include the airstrip access road, the airstrip and taxiway, and aerodrome facilities. The runway will be 1,706 m long and 30 m wide with an additional 7.5 m wide graded area at each side of the runway and a 60 m long graded area at both ends of the runway. The taxiway will have a width of 18 m with 6 m wide graded areas at each edge. Overall, the airstrip site will be approximately 1.83 km long and 90 m wide, with a total area of approximately 15.5 ha. Ditches and collection ponds will be built around the airstrip to control and attenuate surface water run-off from the runway, taxiway, and aerodrome facilities. All collected run-off will be collected and transported off-site for treatment before release to the receiving environment.



Legend

- Stream Crossing
- Kluskus-Ootsa FSR
- Exploration Road
- Other FSRs
- Stream
- Waterbody

Watersheds

- Chedakuz Creek Local
- Creek 661
- Creek 705
- Davidson Creek
- Tatelkuz Lake Tributaries
- Turtle Creek

Project Components

- Proposed Mine Access Road
- Proposed Transmission Line
- Proposed Transmission Line (Mills Ranch Reroute)
- Proposed Freshwater Pipeline
- Proposed Airstrip Access Road
- Proposed Airstrip
- Proposed Mine Site

Scale:1:75,000

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Location of Blackwater Project Airstrip Access Road and Associated Stream Crossings

DATE:	ANALYST:	
March, 2014	KA	**Figure 5.3.8-3**
JOB No: VE52277	QA/QC: BM	PDF FILE: 10-200-160_Airstrip_v2_minsite.pdf
GIS FILE: 10-200-160_Airstrip_v2.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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An existing forestry road will be upgraded to serve as the airstrip access road. The airstrip access road will extend approximately 5.6 km from km 1.8 of the proposed mine access road to the airstrip site.

The airstrip access road will cross three unnamed tributaries to Turtle Creek (**Table 5.3.8-14**). Only one of those streams is fish-bearing. The other two streams are non-classified drainages that do not support fish or have any discernible fish habitat. The single fish-bearing stream at site AA-002 is known to support rainbow trout. Currently, the existing culvert at that stream crossing acts as a barrier to upstream fish passage because it is not sufficiently embedded and is undersized.

Table 5.3.8-14: Airstrip Access Road Crossing Sites

Site ID[(1)]	Stream Name	Stream Classification[(2)]	Fish Captured[(3)]
AA-001	Unnamed	NCD	NFC
AA-002	Unnamed	S4	SPP
AA-003	Unnamed	NCD	NFC

Note: [(1)] Annex 5.8-1 of **Appendix 5.1.2.6B**.
[(2)] Class S1 streams are >20 m wide; S2 streams are >5 - 20 m wide; S3 streams are 1.5 - 5 m wide; and S4 streams are <1.5 m wide. Streams without fish are classified S5 or S6. Class S5 streams are > 3 m wide, and S6 streams are <3 m wide. NCD = non-classified drainage and NVC = no visible channel.
[(3)] NFC = no fish caught and SPP = unidentified fish species.

A new clear-span bridge will be installed at crossing site AA-002 over the only permanent fish-bearing stream located along the airstrip road alignment. Existing crossing structures will be used if possible along the existing forestry road at sites AA-001 and AA-003 located on non-fish-bearing tributaries to Turtle Creek. Upgrades are likely not required because these streams are classified as NCD. If replacement of these existing crossing structures is required, then sufficiently sized and embedded culverts will be installed. Re-ditching and vegetation clearing along the access road will be required to allow vehicle access to the airstrip.

5.3.8.3.1.3.2 Operations Phase

Maintenance of the airstrip access road during the mine Operations phase will include regular inspections and repairs of roadside ditches, culverts, and bridges. Road grading will be carried out regularly to maintain the driving surface of the road.

5.3.8.3.1.3.3 Closure Phase

The airstrip will be reclaimed during the mine closure phase. Airstrip facilities will be removed and the site will be re-contoured to pre-disturbance topography and re-vegetated with native plant species.

5.3.8.3.1.4 Freshwater Supply System (FSS)

This section describes the FSS and the flow regimes under which it will operate. To enhance understanding, this section also provides a preview of the methodology and results of the assessment process that led to development of the flow regimes.

The Project is designed as a zero discharge facility during the operations and closure phases (**Section 2.2**). This means that flows in Davidson Creek immediately downstream of the TSF will be reduced to zero, which would result in impacts to aquatic communities. In order to mitigate flow reductions, the FSS will be used to augment Davidson Creek flows downstream of the TSF. The FSS will also supply mine plant water needs, and may occasionally supply water to supplement requirements for mineral processing or to saturate PAG within the TSF.

Section 2.2.4.3 (Freshwater Supply System) describes the FSS in detail. Freshwater for the Project will be pumped from Tatelkuz Lake, located approximately 20 km northeast of the mine site (**Figure 5.3.8-5**). Tatelkuz Lake was identified as the most practical water source because it is the largest lake in the LSA and so extraction of water will have the least effects on fish and fish habitat. It is fed by a watershed with an area of approximately 395 km^2 so it provides the lowest risk source with regard to security of water supply. There is a cleared area at the southeast end of the lake that is available for use as a pumping site, and the water pipeline can be run along existing forestry roads from the cleared area to the mine site.

The FSS was designed to provide:

- Constant water supply from Tatelkuz Lake for plant water needs, and to augment flows in lower Davidson Creek; and
- Occasional water supply from Tatelkuz Lake to supplement requirements for mineral processing or to saturate PAG within the TSF, if required.

The mine water requirements included the following:

- Davidson Creek in-stream flow needs for fish;
- Davidson Creek flushing flows to clean sediment from substrate;
- Process plant and site fresh water needs (e.g., gland water, reagent mixing, etc.);
- Reclaim water to support mineral processing in extreme dry conditions (minimum surplus capacity); and
- Additional water for flooding waste rock and tailings in the TSF, if required.

A design flow rate of 2,400 m^3/h was selected to minimize the required storage capacity for normal operation of the system. Standard pipe sizes of 610 mm steel or 750 mm HDPE will accommodate this flow rate.

Storage of this water in the freshwater reservoir will be needed as a contingency in the event of system repair or maintenance. Minimum surplus capacity has been sized to ensure the system will have additional pumping capacity and availability to provide an additional 3 Mm^3 of water per year as a contingency against a series of extremely dry years.

The design flow rate of the system is largely driven by the instream flow needs (IFN) for fish in lower Davidson Creek. IFN will be supplied to Davidson Creek beginning in the preproduction period, when Davidson Creek is cut off at TSF Site D, through the operational life of the Project and closure phase until post-closure, when the open pit and TSF will be discharging water of suitable quality for release to Davidson Creek.

Withdrawal of water from Tatelkuz Lake has the potential to lower the water surface elevation of the lake and to reduce flows in the 800 m section of Chedakuz Creek between the lake outlet and the mouth of Davidson Creek. Therefore, it is critical that the volumes of water pumped from Tatelkuz Lake to the mine site and into Davidson Creek are managed carefully to avoid any adverse effects on Tatelkuz Lake or on lower Chedakuz Creek.

Flows required to mitigate potential effects on Davidson Creek were defined by an instream flow needs (IFN) analysis, which is described in detail in the Instream Flow Study (IFS) (**Appendix 5.1.2.6D**). IFN are flows adequate to protect instream values for fish. They were defined as sufficient to preserve 90% of mean baseline habitat availability for each of four biologically relevant time periods: winter (juvenile rainbow trout overwintering), spring (rainbow trout migration and spawning), summer (kokanee spawning and juvenile rainbow trout rearing), and fall (kokanee egg incubation and juvenile rainbow trout rearing). IFN were used to define a mitigation flow regime for Davidson Creek.

Figure 5.3.8-4 shows the proposed flow regime in Davidson Creek for an average and drier than average year (light blue line), a wetter than average year (purple line), and baseline flows (light green line). Flows during December, January, February and March will be similar for average years, dry years, wet years and baseline. Flows will rise during April to a maximum in May and June and then fall in July and August to low levels in September, October and November. During those 8 months, flows for average and dry years will be lower than baseline flows. In wet years, flushing flows will be released in early May in order to clean sediment out of the substrates of Davidson Creek. Those flushing flows will briefly exceed baseline flows in May. Otherwise, flows in wet years will be the same magnitude and follow the same schedule as flows in average and dry years.

The contingency for drier than average years will be to remove spring flushing flows. This is considered acceptable because flushing flows will be released during wet years and the frequency of wet years is similar to the frequency of dry years.

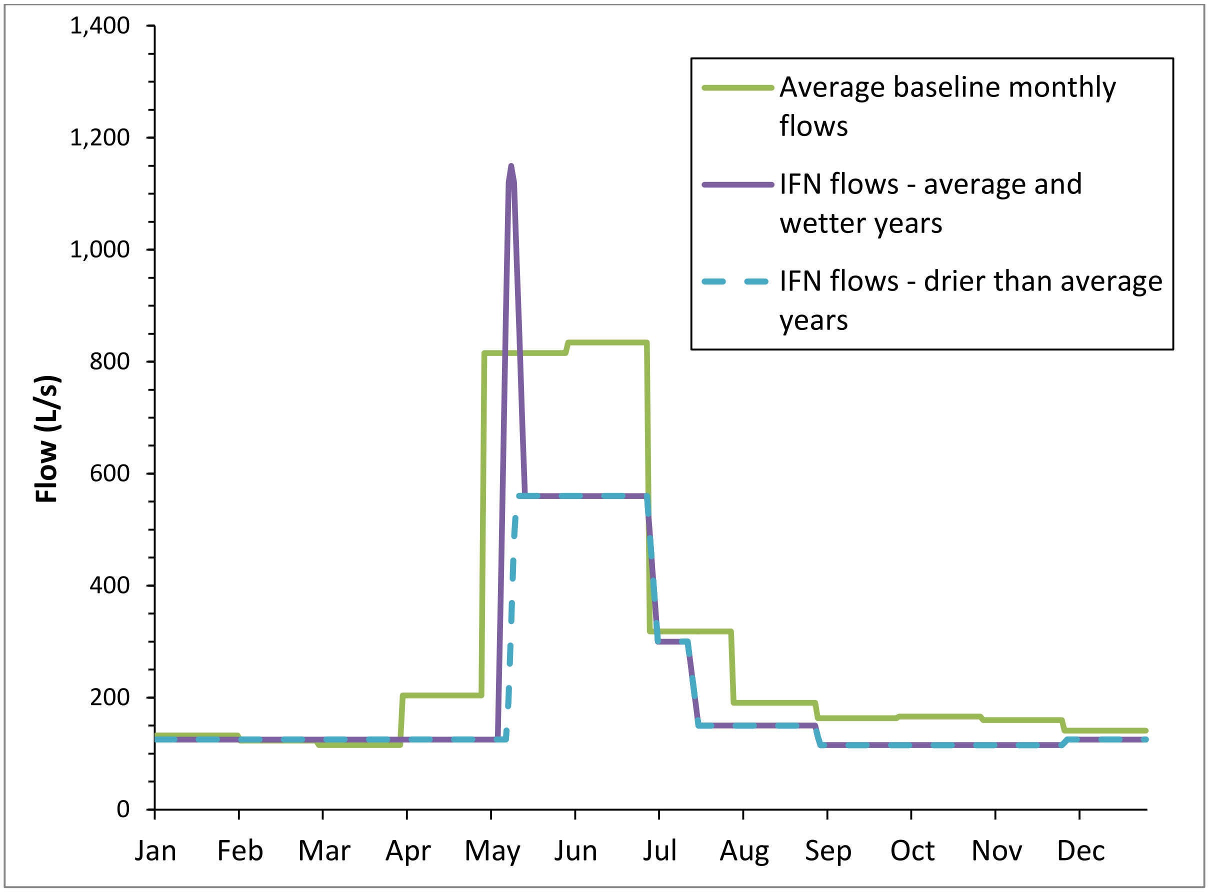


Figure 5.3.8-4: Mean Daily Baseline and Mitigation Flow Regimes for Middle Davidson Creek at FSS Outfall

The total withdrawals required to supply these IFN are 6.56 M m^3/y (**Table 5.3.8-15** and **Table 5.3.8-16**).

Continuous mine site water needs will be 33 L/s (or 1.05 Mm^3/year) throughout the operations and closure phases of the Project. These were defined by process requirements (**Section 2.2.3.5.3**). During operations, the 33 L/s will be supplied to the mill to provide fresh water that cannot be obtained through recycling or use of TSF supernatant. During closure, the 33 L/s will be supplied to the open pit to speed pit filling, and thereby reduce the potential for acid generation.

Supplemental water from Tatelkuz Lake may be required to address shortfalls in the site water balance under extreme dry conditions to ensure sub-aqueous disposal of PAG tailings. Supplemental requirements may range from 0.98 Mm^3/y and 2.92 Mm^3/y during Years 2 through 11 of mine life (**Table 2.2.3-31**) for extreme dry conditions defined by 5th percentile monthly flow dry values. This is an unlikely scenario because there is a 95% chance that flows will be greater. Hence, this scenario was not modelled.

Table 5.3.8-15: Target Flow Regime for Davidson Creek at FSS Outfall for Average or Above Average Water Years

Date	Type of Flow	Flow (L/s)	Implementation
10 - 12 May	Channel Flushing Flow	1,123	400% mean annual discharge (MAD = 281 L/s)
16 May - 30 Jun	Rainbow Trout - Spawning	560	Rainbow Trout spawning IFN
4 Jul - 15 Jul	Rainbow Trout – Incubation and Rearing	300	Maintains redds constructed at depths of 10 cm or greater at rainbow trout spawning flows (560 L/s)
19 Jul - 31 Aug	Rainbow Trout – Rearing Kokanee - Spawning	150	Kokanee spawning IFN
2 Sep - 30 Nov	Rainbow Trout – Rearing Kokanee - Incubation	115	Rainbow trout rearing IFN; Maintains redds constructed at depths of 4 cm or greater at kokanee spawning flows (150 L/s)
2 Dec - 6 May	Rainbow Trout - Overwintering	125	Minimum of monthly mean annual flows for winter period

Note: Transitional conditions between each of the defined flows have been determined to avoid flow adjustment impacts (**Appendix 5.1.2.6D**).

Table 5.3.8-16: Target Flow Regime for Davidson Creek at FSS Outfall for Period 2 December to 30 June during Below Average Water Years

Date	Type of Flow	Flow (L/s)	Implementation
10 May - 30 Jun	Rainbow Trout - Spawning	560	Rainbow Trout spawning IFN
4 Jul - 15 Jul	Rainbow Trout – Incubation and Rearing	300	Maintains redds constructed at depths of 10 cm or greater at rainbow trout spawning flows (560 L/s)
19 Jul - 31 Aug	Rainbow Trout – Rearing Kokanee - Spawning	150	Kokanee spawning IFN
2 Sep - 30 Nov	Rainbow Trout – Rearing Kokanee - Incubation	115	Rainbow trout rearing IFN; Maintains redds constructed at depths of 4 cm or greater at kokanee spawning flows (150 L/s)
2 Dec - 6 May	Rainbow Trout - Overwintering	125	Minimum of monthly mean annual flows for winter period

Note: Decrease in flushing flows from 400% MAD (1,123 L/s) to 200% MAD (560 L/s).

The potential for adverse effects of this flow regime was assessed by modelling the effects of withdrawals on Tatelkuz Lake water surface elevations, on flows in lower Chedakuz Creek, and on fish habitat availability in both the lake and creek. Modelled withdrawals included provision of 33 L/s for mill or pit filling and of Davidson Creek IFN throughout operations and closure. To ensure conservatism, the modelling did not assume the loss of flushing flows during dry years. Supplemental water needs for the TSF under extreme dry conditions (i.e. 5% probability) were not modelled. The effects of water withdrawals were assumed to be similar during operations and closure phases, but smaller during construction and post-closure.

Potential effects within the 1 m depth contour of Tatelkuz Lake were assessed by modeling changes to fish habitat for baseline conditions and for all Project phases, for both monthly average and monthly 1:50 year dry scenarios. The maximum real change in lake water levels will occur in

June and will amount to a reduction of 0.07 m under average conditions, and a reduction of 0.11 m under 1:50 dry year conditions. These changes are small relative to baseline mean annual (0.80 m) and maximum annual (2.0 m) fluctuations in lake levels. The aggregate change in modelled habitat availability during the operations and closure phases will be less than 1% under average conditions, and less than 3% under 1:50 year dry conditions. The largest changes will occur for littoral habitats dominated by boulders, which occur at higher elevations along the lake shoreline and represent less than 4% of total habitat. Reductions will be greater than 18% for average conditions and 0% under 1:50 dry conditions (i.e., no change occurs because these habitats are not available at baseline for the 1:50 dry). In summary, no significant impacts to littoral or riparian fish habitat in Tatelkuz Lake are expected as a result of reductions in Tatelkuz Lake water surface elevations of up to 0.11 m.

Potential effects in lower Chedakuz Creek between the outlet of Tatelkuz Lake and the confluence with Davidson Creek, as well as for the reach immediately downstream of that confluence, were modelled using a time-series approach that compared baseline habitat availability with habitat availability for each Project phase. A 15-year simulated monthly flow time series was used. The maximum aggregate change to habitat availability for the modelled Chedakuz Creek sections will be a 4% reduction in kokanee spawning habitat during the operations phase. This is not considered to be an ecologically significant change in habitat availability, or a potentially adverse effect on fish.

5.3.8.3.1.4.1 Construction Phase

Water pumps will be installed in a concrete structure that will be constructed on the shoreline of Tatelkuz Lake. Construction of the structure will require an adjacent laydown area for support activities.

The pump house will contain four vertical turbine pumps (three operating, one spare). Water will be drawn continuously from the lake through two intake pipes. The intake pipes will each be approximately 50 m long. The pipes will be 610 mm in diameter and their inlets will be installed at depths between 8 and 12 m deep, well below the lowest natural lake level.

Water will be conveyed via a pipeline from the lake to the freshwater reservoir at the mine site. The pipeline has two sections: a 13.6 km-long section from Tatelkuz Lake to the freshwater reservoir and a 6.8 km-long section from the freshwater reservoir to the plant site.

The pipeline to the mine site will be a combination of 610 mm diameter standard steel pipe, to be used for the initial high-pressure sections closest to each booster pump station, and 710 mm diameter HDPE DR17 pipe for the rest. The pipeline will be buried with a nominal cover of 600 mm of random fill, either by excavation or soil-mounding above-grade, for basic protection from fire and tampering.

Four booster stations will be built along the pipeline to pump the water to the mine site. Booster station 1 will be approximately 6 km from the lake and will be the halfway point in terms of total dynamic head for this pipeline section. Booster stations 2 and 3 are combined in the same structure that will have a tee to split flows between the two booster stations or to the gravity discharge pipeline that will flow 100 m to the freshwater reservoir. Booster station 2 will pump water 4.2 km to booster station 4. Booster station 4 will lift the water to the fresh water tank at the plant site area. Booster station 3 will provide water to the TSF, 750 m away when surplus capacity is available in the system.

An access road will parallel the pipeline and provide access to the housing structure and booster stations. The road will consist of 11.7 km of existing logging road and 1.6 km of new construction. The remainder of the pipeline parallels the mine access road.

The freshwater pipeline will cross nine streams from Tatelkuz Lake to the freshwater reservoir on the mine site (**Figure 5.3.8-5**). Most of these crossings are pre-existing because the pipeline will follow an existing road. In some cases, the streams will be crossed with existing bridges. In others, an existing culvert will be upgraded to a clear-span bridge.

The crossings are labelled PL-1 to PL-9. PL-1 is located closest to Tatelkuz Lake on a stream that drains directly into Tatelkuz Lake. The stream is classified as an S3 fish-bearing stream (**Appendix 5.1.2.6B**).

Crossing PL-2 is on a tributary that drains into the same tributary that crossing PL-1 is on. It is also classified as an S3. Rainbow trout were not captured at this site because the tributary was dry when assessed in the summer of 2013.

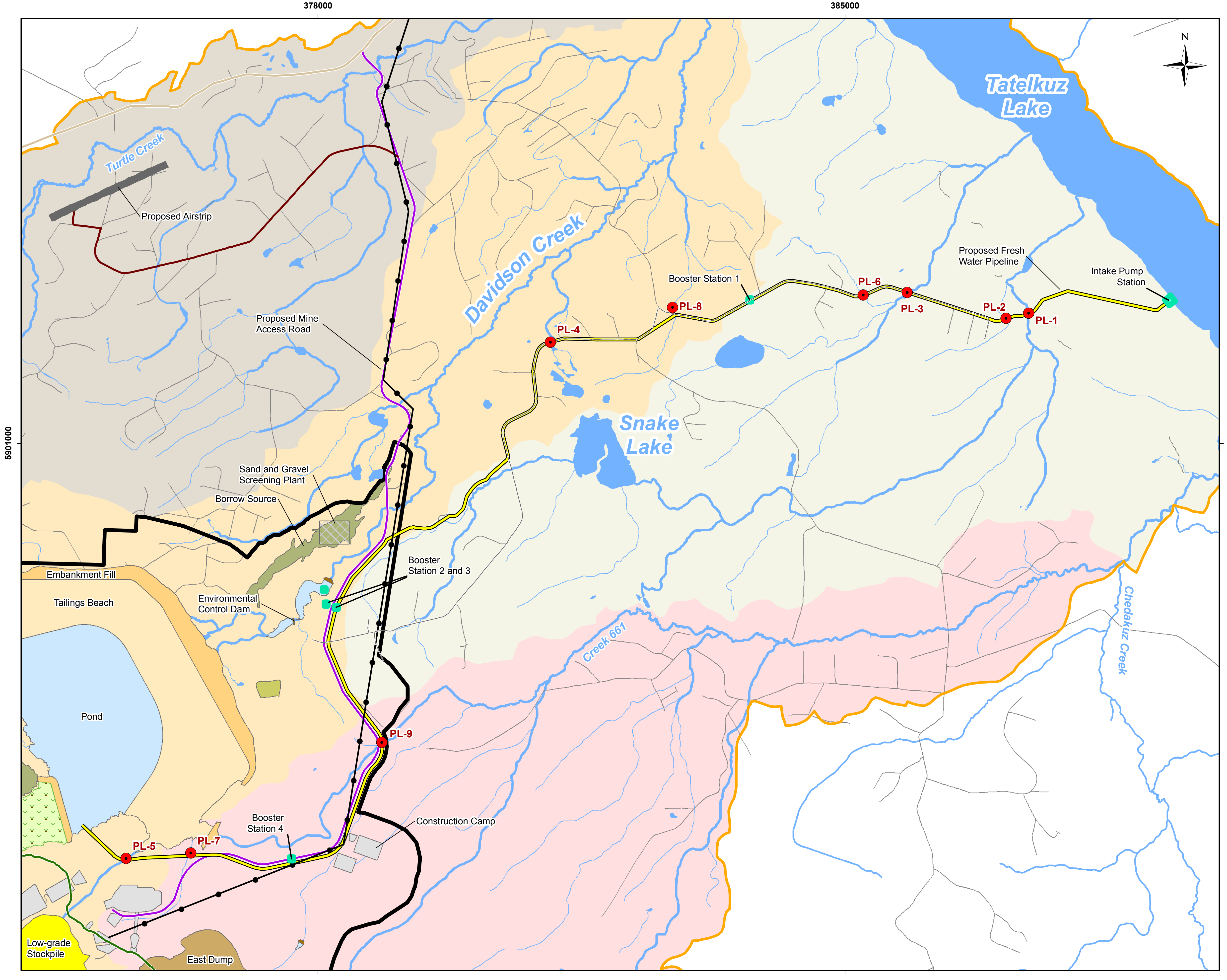
Crossing PL-3 also sits on a tributary that drains into Tatelkuz Lake. The creek at this location is classified as S2. Rainbow trout were not captured at this site, but it is assumed they could be present because they were confirmed to be present in this stream at downstream sites near the lake.

Crossing PL-6 is a small tributary that drains into the same tributary that crossing PL-3 is on. The creek at PL-6 is S4. No data on fish species presence in this watercourse was available because the tributary was dry during the 2013 survey.

Crossing PL-8 is located on a tributary to Davidson Creek and is upstream from pipeline booster station 1. The creek at this location is classified as S3. Rainbow trout have not been captured at this location but it is assumed they could be present downstream. A perched culvert at this crossing may prevent fish passage upstream.

Crossing PL-4 is located on a tributary to Davidson Creek. There is a culvert installed at this location, but there is no visible channel upstream or downstream from the culvert. It will not be discussed further because it is considered non-fish bearing.

Crossing PL-9 is located on a tributary to Creek 661. This stream is classified as S3 and rainbow trout are known to be present at this crossing site. The crossing at PL-9 is also located along the mine access route.



Legend

- Pipeline Stream Crossings
- Fresh Water Pumpstations
- Kluskus-Ootsa FSR
- Existing Road
- Stream
- Waterbody

Watersheds

- Chedakuz Creek Local
- Creek 661
- Creek 705
- Davidson Creek
- Tatelkuz Lake Tributaries
- Turtle Creek

Project Components

- Exploration Road
- Proposed Mine Access Road
- Proposed Transmission Line
- Proposed Fresh Water Pipeline
- Proposed Airstrip Access Road
- Proposed Airstrip
- Proposed Mine Site

Proposed Site Facilities

- Dam
- Dump
- Embankment Fill
- Emergent Vegetation Wetland
- Environmental Control Dam (ECD)
- Esker Borrow Source
- Low-Grade Stockpile
- Open Pit
- Plant Site
- Pond
- Tailings Beach
- Topsoil Stockpile
- Upland Beach
- Sand and Gravel Screening Plant

Fish and Aquatic Resources

- Local Study Area

Scale:1:50,000

0 0.5 1 1.5

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Freshwater Supply Pipeline

DATE: January, 2014	ANALYST: KA	**Figure 5.3.8-5**
JOB No: VE52095	QA/QC: MM	PDF FILE: 10-200-165_PipelineLSA.pdf
GIS FILE: 10-200-165_PipelineLSA.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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Crossings PL-7 and PL-5 are both located within the mine site. PL- 7 is located in a tributary to Creek 661 and is classified as an S4. No data on fish species presence in this watercourse was available because the tributary was dry during the 2013 survey. Crossing PL-5 is located on a tributary to Davidson Creek. The stream is an S3. The presence of rainbow trout was confirmed at this crossing.

During construction, those crossings outside of the mine site will have existing structures such as culverts removed and bridges constructed. The pipeline will be attached to those bridges. The exception is crossing PL-6 which will be trenched. Because fish habitat at those crossings within the mine site (PL-5 and PL-7) will be unavoidably affected by Project development they are included in the habitat budget of the FMOP (**Appendix 5.1.2.6C**).

The freshwater reservoir will provide storage capacity for Davidson Creek instream flow needs and for mine needs (**Figure 5.3.8-6**).

To create the reservoir, a dam will be constructed along Davidson Creek with a height of approximately 14 m. The dam will impound approximately 400,000 m^3 of fresh water storage capacity.

Water will be discharged from the reservoir to Davidson Creek through two pipelines near the downstream toe of the dam: a 150 mm diameter pipe for the Instream Flow Needs (IFN) flows and a concrete-enclosed 610 mm diameter steel pipe for flushing flows (i.e., for channel maintenance). The discharge outlet will discharge to a rip-rap-lined outfall channel for energy dissipation and to assist with aeration to raise DO concentrations in the discharged water.

The water release conditions will be controlled by a temperature and flow control system (TFCS) consisting of temperature and flow measurement devices and associated control logic feedback loops on the discharge pipeline. A reservoir bypass line will connect directly to the water supply pipeline to allow for direct discharge of the required IFN during reservoir maintenance. It can also be used to provide cooler water as required for fisheries in Davidson Creek.

5.3.8.3.1.4.2 Operations Phase

Maintenance of the FSS during mine operations will include regular inspections and repairs of the intake structures and pumps, the pipeline and its booster stations, and the ditches, culverts, and bridges of the access road. Road grading will be carried out regularly to maintain the driving surface of the road.

5.3.8.3.1.4.3 Closure Phase

Water will be pumped from Tatelkuz Lake to the mine site during construction, operations, and closure. Pumping will continue during closure to assist in filling the mine pit. Pumping will cease once the pit is full and spilling water into the TSF and the TSF begins to fully discharge into Davidson Creek in Year +37. The post-closure period for fish and fish habitat will begin at that time. The FSS will be reclaimed during the post-closure phase. All intake facilities, pipeline, and booster pumps will be removed and the route will be re-contoured to pre-disturbance topography and re-vegetated with native plant species.

5.3.8.3.1.5 Transmission Line

The proposed 230 kV transmission line will extend approximately 140 km between the BC Hydro Glenannan sub-station near Fraser Lake and a new sub-station adjacent to the mine process facilities (**Figure 5.3.8-7**). Two potential reroutes are included in the design of the transmission line. One reroute involves an alternate crossing at the Stellako River at the northern end of the transmission line ROW (i.e., the Stellako Reroute). The other reroute would avoid the Mills Ranch at the south end of the transmission line ROW (i.e., Mills Ranch Reroute).

5.3.8.3.1.5.1 Construction Phase

The transmission line will be supported by wooden H-frame or steel structures towers placed approximately every 250 m along the route. A ROW with a width of 40 m will be cleared with consideration for danger trees. The proposed transmission line will following existing road infrastructure wherever possible.

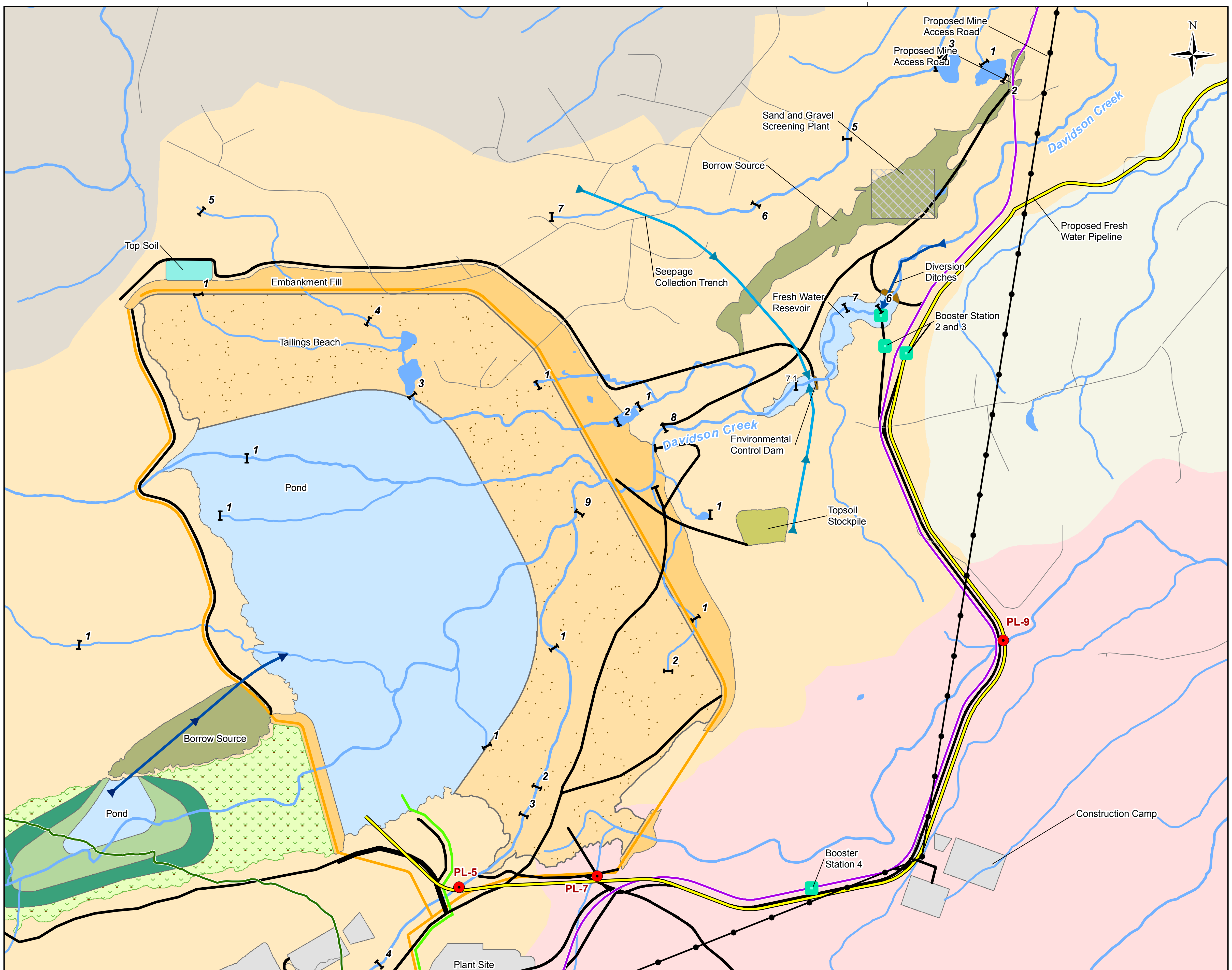
Access to the proposed transmission line will be possible from existing roads for the majority of the route. Those roads will be upgraded where necessary. This would include existing crossings of the Stellako and Nechako rivers. However, construction of new temporary and permanent access roads will be required where the transmission line route deviates from existing roads. Stream crossings for all new temporary access roads will follow DFO guidelines for avoiding fish habitat, which in most cases will be clear-span bridges. Clear-span bridges will have no permanent facilities within the active channel and channel realignment will not be required.

5.3.8.3.1.5.2 Operations Phase

Once construction of the transmission line is complete, temporary access roads may be deactivated if no longer required. Some maintenance of the ROW, however, will be required during the operations phase. Deactivation will include removal of any bridges and reclamation of road surfaces by ripping-up the road surface, re-contouring to pre-disturbance topography, and re-vegetating with native species common to the area.

5.3.8.3.1.5.3 Closure Phase

The transmission line and ROW will be reclaimed to pre-mining conditions during the post-closure phase. The majority of power line poles will be removed, although poles near creeks or wetlands may be retained to provide nesting habitat for raptors.



Legend

- Pipeline Stream Crossings
- Fresh Water Pumpstations
- Existing Road
- Stream
- Waterbody

Watersheds

- Chedakuz Creek Local
- Creek 661
- Creek 705
- Davidson Creek
- Tatelkuz Lake Tributaries
- Turtle Creek

Project Components

- Exploration Road
- Proposed Mine Access Road
- Proposed Transmission Line
- Proposed Fresh Water Pipeline

Proposed Site Facilities

- Tailings Pipeline
- Water Reclaim Pipeline
- Construction Haul Road
- Seepage Collection
- Spillway
- Diversion Ditches
- Dam
- Dump
- Embankment Fill
- Emergent Vegetation Wetland
- Environmental Control Dam (ECD)
- Esker Borrow Source
- Low-Grade Stockpile
- Open Pit
- Plant Site
- Pond
- Tailings Beach
- Topsoil Stockpile
- Upland Beach
- Sand and Gravel Screening Plant

Scale:1:24,000

0 400 800 1200

Meters

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Dam and Freshwater Reservoir

DATE: January, 2014	ANALYST: KA	**Figure 5.3.8-6**
JOB No: VE52095	QA/QC: MM	PDF FILE: 10-200-166_Dam_Reservoir.pdf
GIS FILE: 10-200-166_Dam_Reservoir.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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5.3.8.3.1.6 Kluskus FSR and Kluskus-Ootsa FSR

The Proponent will use the existing Kluskus and the Kluskus-Ootsa FSRs for year-round access between Highway 16 and the mine site access road. To do this, the surface of a portion of the Kluskus-Ootsa FSR will be upgraded to allow for use during spring break-up, which typically occurs between the middle of March to the end of May (**Figure 5.3.8-8**). Also, a 2 km-long section will be realigned for safety reasons. The proposed road upgrade and realignment will involve:

- Re-gravelling the road from 101+650 km to 123+973 km;
- Realigning the road from 104+900 km to 106+738 km; and
- Improving existing ditch lines or constructing new ditch lines where required.

Re-gravelling will involve grading the existing road surface. Gravel surfacing will then be placed and compacted on top of the existing road surface to a thickness of 200 mm. Large rocks and debris will be removed from any of the existing ditches (where they are present) to improve drainage.

Road realignment will involve timber clearing along a 30 m wide ROW. Road grading and gravel surfacing will then be carried out along the realigned section using heavy machinery. Roadside ditches will be excavated along the realigned sections and along the FSR where no ditch line currently exists.

The Kluskus and Kluskus-Ootsa FSRs include 100 watercourse crossings, of which 31 were rated as fish bearing (S1-S4), 4 were rated as non-fish bearing (S6), and 65 were rated as non-classified drainages (Annex 5.8-1 of **Appendix 5.1.2.6B**).

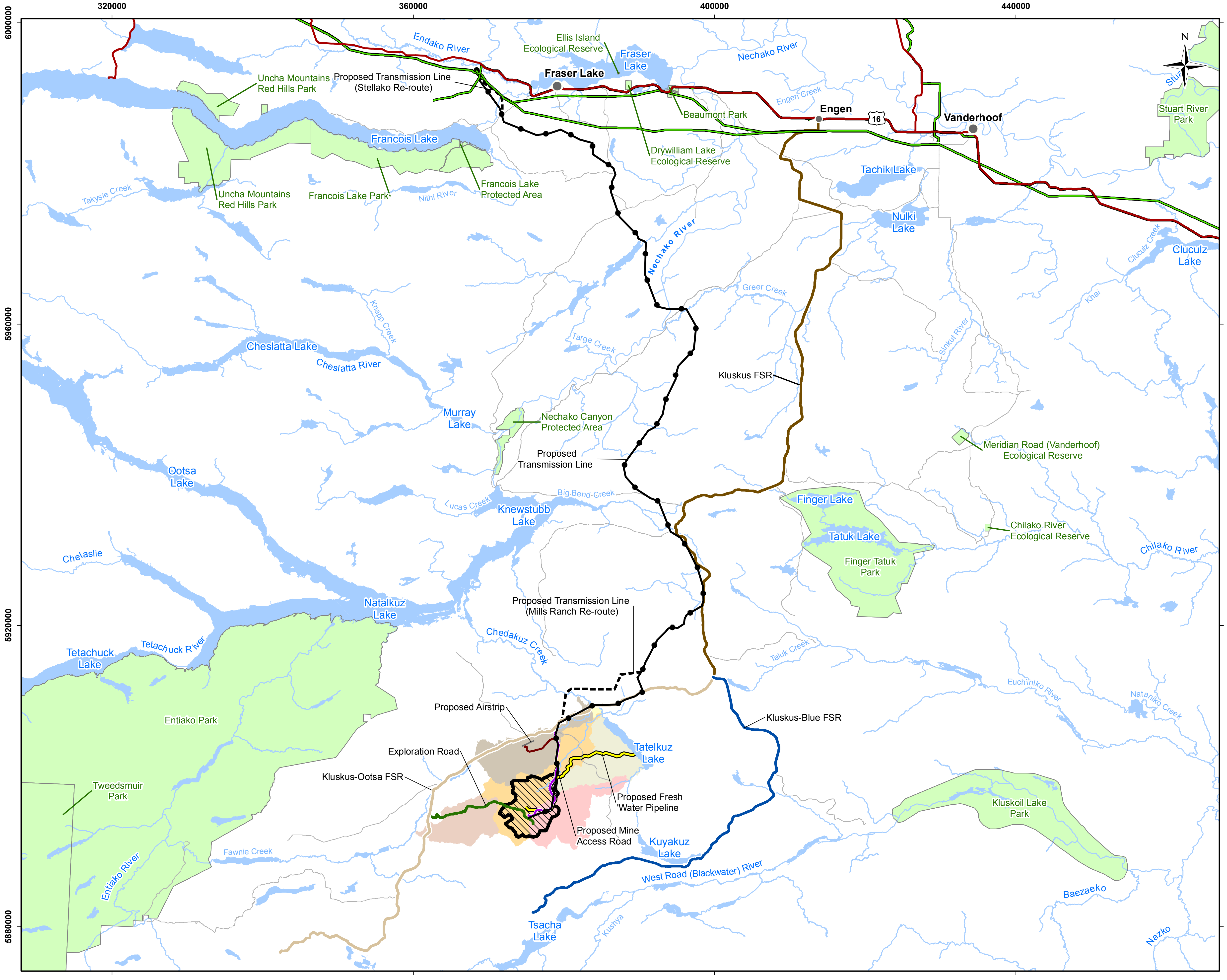
5.3.8.3.1.6.1 Construction Phase

The proposed Kluskus-Ootsa FSR will cross two streams along the realigned section of the road (**Table 5.3.8-17**). Crossing AE-013 was rated as S4, and crossing AE-012 was rated as an NCD (Annex 5.8-1 of **Appendix 5.1.2.6B**). The existing culvert at the fish-bearing stream crossing AE-013 is perched and acts as a barrier to fish passage.

Table 5.3.8-17: Kluskus-Ootsa FSR Realignment Stream Crossing Sites

Site ID(1)	Stream Name	Stream Classification(2)	Fish Captured(3)
AE-012	Unnamed	NCD	NFC
AE-013	Unnamed	S4	NFC

Note: (1) Annex 5.8-1 of **Appendix 5.1.2.6B.**
(2) Class S1 streams are >20 m wide; S2 streams are >5 - 20 m wide; S3 streams are 1.5 - 5 m wide; and S4 streams are <1.5 m wide. Streams without fish are classified S5 or S6. Class S5 streams are >3 m wide, and S6 streams are <3 m wide. NCD = non-classified drainage, NVC = no visible channel
(3) NFC = no fish caught.



Legend

- Populated Place
- Highway
- Existing Transmission Line
- Kluskus FSR
- Kluskus-Blue FSR
- Kluskus-Ootsa FSR
- Exploration Road
- Other FSR's
- Stream (4th Order)
- Waterbody
- Parks & Protected Areas

Project Components

- Proposed Mine Access Road
- Proposed Fresh Water Pipeline
- Proposed Transmission Line
- Proposed Transmission Line (Stellako Reroute)
- Proposed Transmission Line (Mills Ranch Reroute)
- Proposed Airstrip Access Road
- Proposed Airstrip
- Proposed Mine Site

Watersheds

- Chedakuz Creek Local
- Creek 661
- Creek 705
- Davidson Creek
- Tatelkuz Lake Tributaries
- Turtle Creek

Scale: 1:500,000

0 5 10 20

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Location of Blackwater Project Proposed Transmission Line ROW

DATE: January, 2014	ANALYST: KA	**Figure 5.3.8-7**	
JOB No: VE52277	QA/QC: MY	PDF FILE: 10-200-159_TransmissionLine_v2.pdf	
GIS FILE: 10-200-159_TransmissionLine_v2.mxd			
PROJECTION: UTM Zone 10	DATUM: NAD83	amec	

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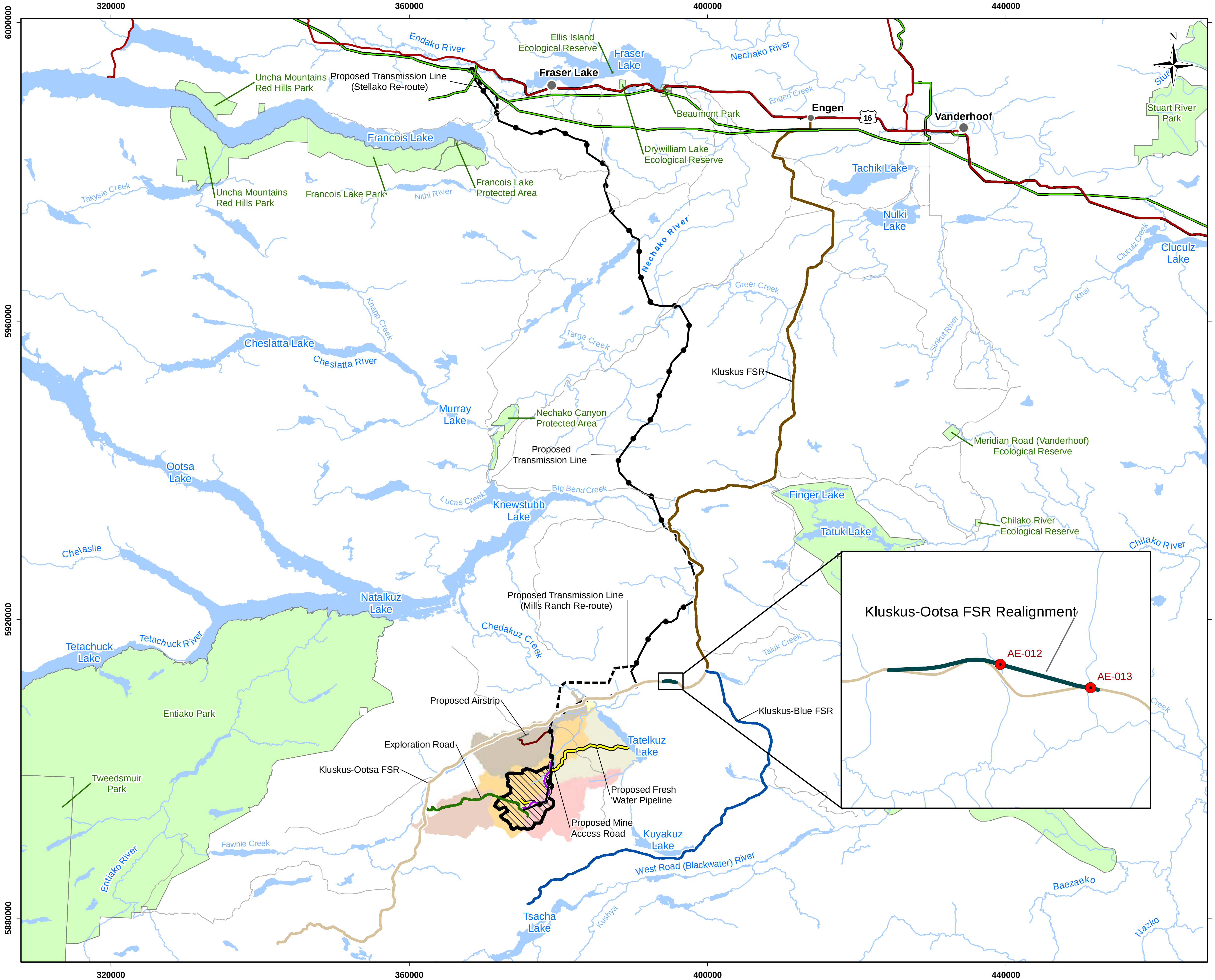

Legend

- Stream Crossing
- Populated Place
- Highway
- Existing Transmission Line
- Kluskus FSR
- Kluskus-Blue FSR
- Kluskus-Ootsa FSR
- Kluskus-Ootsa FSR Realignment
- Exploration Road
- Other FSR's
- Stream (4th Order)
- Waterbody
- Parks & Protected Areas

Project Components

- Proposed Mine Access Road
- Proposed Fresh Water Pipeline
- Proposed Transmission Line
- Proposed Transmission Line (Stellako Reroute)
- Proposed Transmission Line (Mills Ranch Reroute)
- Proposed Airstrip Access Road
- Proposed Airstrip
- Proposed Mine Site

Watersheds

- Chedakuz Creek Local
- Creek 661
- Creek 705
- Davidson Creek
- Tatelkuz Lake Tributaries
- Turtle Creek

Scale: 1:500,000

0 5 10 20

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Location of the Blackwater Project Kluskus FSR and Kluskus-Ootsa FSR

DATE: January, 2014 | ANALYST: AA | **Figure** 5.3.8-8

JOB No: VE52277 | QA/QC: MY | PDF FILE: 10-200-160_TransmissionLine_wInset_v2.pdf

GIS FILE: 10-200-160_TransmissionLine_wInset_v2.mxd

PROJECTION: UTM Zone 10 | DATUM: NAD83

amec

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Construction of two new stream crossings will be required along the realigned section of the Kluskus-Ootsa FSR. A new clear-span bridge will be installed at site AE-013 on the one permanent stream that crosses the realigned road section. (Alternatively, an open-bottom culvert will be used). An adequately sized and embedded corrugated steel pipe crossing structure will be installed at site AE-012 to maintain flow conveyance across the FSR.

Existing cross drainage culverts along the FSRs will be replaced if damaged. New cross-drain culverts will be installed where required. Replacement of stream crossing structures at thirteen sites will be required where barriers to fish passage exist.

5.3.8.3.1.6.2 Operations Phase

Maintenance of the Kluskus-Ootsa FSRs during mine operations will include regular inspections and repairs of ditches, culverts, and bridges of the access road. Road grading will be carried out regularly to maintain the driving surface of the road. Responsibility for these tasks will be shared by all road users, including the forestry companies whose vehicles currently make the greatest use of the roads.

5.3.8.3.1.6.3 Closure Phase

During the mine closure phase, the Kluskus and Kluskus-Ootsa FSRs will remain open and will be maintained.

5.3.8.3.2 Mine Site

Six potential classes of effects on fish will be caused by development of the mine site, as follows:

- Loss of fish habitat in upper Davidson Creek Watershed as a result of development of the mine site;
- Changes in flows in Davidson Creek, Creek 661, and Creek 705;
- Changes in water quality in Davidson Creek, Creek 661, and Creek 705;
- Potential disruption of homing by rainbow trout and kokanee spawners to Davidson Creek as a result of flow augmentation of Davidson Creek with water pumped from Tatelkuz Lake;
- Potential for changes to parasite community, genetic composition and homing and spawning behaviour of rainbow trout residing in lakes 01682LNRS and 01538UEUT as a result of the diversion of Lake 01682LNRS into 01538UEUT; and
- Changes in water temperature of Davidson Creek.

This section examined each of those six classes of potential effects and proposed mitigation measures. Residual effects that cannot be mitigated were carried forward to residual effects assessment in **Section 5.3.8.4**.

5.3.8.3.2.1 Potential Effects on Fish from Mine Site Development

5.3.8.3.2.1.1 Potential Effects

Streams in the Davidson Creek and Creek 661 watersheds will be directly affected by the proposed mine site. Affected streams will include the Davidson Creek mainstem, Creek 688328, Creek 704454, Creek 505659, Creek 146920, and various tributary streams (**Table 5.3.8-18** and **Figure 5.3.8-9**).

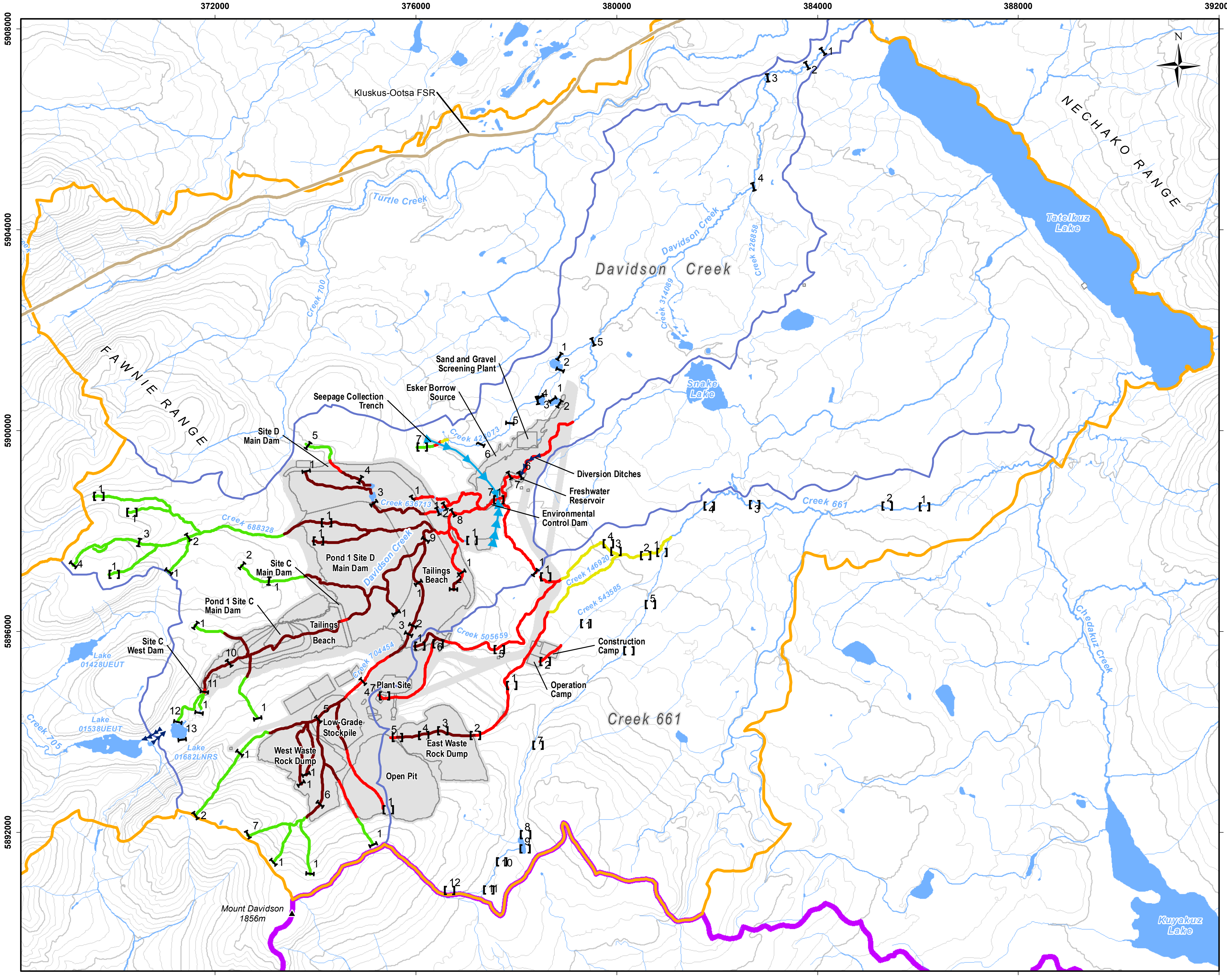
Table 5.3.8-18: Streams Affected by the Mine Site

Watershed	Watershed ID	Stream Name	Reaches	Stream Classification(1)	Fish Presence(2)
Davidson Creek	100-567134-610692-522527	Davidson Creek	6, 7, 7.1, 8, 9, 10, 11, 12	Reaches 6-7.1: S2 Reaches 8-10, 12: S3 Reach 11: S4	RB
	100-567134-610692-522527-428073	Unnamed	1	S6	None
	100-567134-610692-522527-616152	Unnamed	1	S4	None
	100-567134-610692-522527-636713	Unnamed	1, 2, 3, 4, 5	Reaches-2: S3 Reaches 3-5: S4	Unconfirmed RB
	100-567134-610692-522527-636713-214958	Unnamed	1	No data	None
	100-567134-610692-522527-636713-214958-727555	Unnamed	1	No data	None
	100-567134-610692-522527-636713-637972	Unnamed	1	S4	Unconfirmed RB
	100-567134-610692-522527-670952	Unnamed	1	No data	None
	100-567134-610692-522527-674890	Unnamed	1, 2	S4	Reach 1: Unconfirmed RB Reach 2: None
	100-567134-610692-522527-688328	Creek 688328	1, 2	S3	RB
	100-567134-610692-522527-688328-175057	Unnamed	1	NVC	None
	100-567134-610692-522527-704454	Creek 704454	1, 2, 3, 4, 5, 6	S3	Reaches 1-5: RB Reach 6: Unconfirmed RB
	100-567134-610692-522527-704454-503067	Unnamed	1	S4	Unconfirmed RB
	100-567134-610692-522527-704454-569241	Unnamed	1	S4	Unconfirmed RB
	100-567134-610692-522527-704454-569241-068254	Unnamed	1	S4	Unconfirmed RB

Watershed	Watershed ID	Stream Name	Reaches	Stream Classification[1]	Fish Presence[2]
	100-567134-610692-522527-704454-569241-076095	Unnamed	1	S3	Unconfirmed RB
	100-567134-610692-522527-704454-686326	Unnamed	1	S4	Unconfirmed RB
	100-567134-610692-522527-758727	Unnamed	1	NVC	None
	100-567134-610692-522527-776798	Unnamed	1	S4	Unconfirmed RB
	100-567134-610692-522527-896157	Unnamed	1	S4	Unconfirmed RB
	100-567134-610692-522527-899664	Unnamed	1	S4	Unconfirmed RB
Creek 661	100-567134-610692-671007-505659	Creek 505659	5, 6, 7	Reach 5: S3 Reach 6-7:S4	Reach 5: RB Reach 6-7: Unconfirmed RB
	100-567134-610692-671007-505659-146920	Creek 146920	2, 3, 4, 5	Reach2: S3 Reach 3: S4 Reaches 4-5: NCD	Reaches 2-3: Unconfirmed RB Reaches 4-5: None
	100-567134-610692-671007-505659-348488	Unnamed	1	No data	None
	100-567134-610692-671007-505659-764541	Unnamed	1	No data	None
	100-567134-610692-671007-543585	Unnamed	1, 2	NVC	None

Note: [1] Fish streams are classified S1–S4. Class S1 streams are >20 m wide; S2 streams are >5 - 20 m wide; S3 streams are 1.5 - 5 m wide; and S4 streams are <1.5 m wide. Streams without fish are classified S5 or S6. Class S5 streams are >3 m wide, and S6 streams are <3 m wide. NCD = non-classified drainage, NVC = no visible channel, No data = stream classification data not available
[2] RB = Rainbow Trout; NFC = no fish caught.

Potential effects on fish of construction, operations, and closure of the mine site were identified based on the DFO *Pathways of Effects for Fish Passage Issues* (DFO, 2010a), *Placement of Material or Structures in Water* (DFO, 2010b), *Change in Timing, Duration, and Frequency of Flow* (DFO, 2010c), *Use of Explosives* (DFO, 2010d), *Vegetation Clearing* (DFO, 2010e), *Grading* (DFO, 2010f), *Excavation* (DFO, 2010g), *Use of Industrial Equipment* (DFO, 2010h) and *Cleaning or Maintenance of Bridges and other Structures* (DFO, 2010i).



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Legend

- [ ] Reach Break
- Kluskus-Ootsa FSR
- Contour (25m)
- Stream
- Lake
- Watershed Boundary
- Proposed Mine Footprint
- Proposed Site Facilities
- Flow Direction
- Seepage Collection Trench

Permanently Altered or Destroyed Fish Habitat

- Upstream Habitat Isolation
- Mine Site Facilities Footprint
- Inside Tailings Impondment
- Downstream Flow Reductions

Hydrology, Surface Water and Sediment Quality, Fish and Fish Habitat

- Regional Study Area
- Local Study Area

Scale:1:75,000

0 0.5 1 2 3

Kilometres

Reference

BC Government GeoBC Data Distribution
Knight Piesold 'Year 17' Drawing May 24, 2013
AMEC 2011-2012 Baseline Report Fish & Aquatic Resource

CLIENT: newgold

PROJECT: Blackwater Gold Project

Distribution of Permanently Altered or Destroyed Fish Habitat in the Davidson Creek and Creek 661 Watersheds

DATE: May, 2014	ANALYST: WR	Figure 5.3.8-9
JOB No: VE52420	QA/QC: BM	PDF FILE: 10-100-111_DistPotFishHabLoss_v7.pdf
GIS FILE: 10-100-111_DistPotFishHabLoss_v7.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Potential effects to fish during construction, operations, and closure of the mine site include the following issues:

- Loss of fish habitat (and hence loss of fish production);
- Fish passage:
  - Prevention of upstream and downstream fish passage in headwater streams of upper Davidson and Creek 661;
  - Alteration of migration patterns; and
  - Entrainment, impingement, or mortality of resident species.
- Flow alteration, including timing, duration, and volume;
- Water temperature and water quality:
  - Changes in thermal cues and creation of temperature barriers; and
  - Inputs of nutrient-containing blast residues to streams.
- Dewatering – displacement or stranding of fish;
- Vegetation clearing:
  - Decreased bank stability and increased erosion potential;
  - Decreased shading and increased water temperatures; and
  - Decreased external nutrient/energy inputs and changes in food supplies.
- Construction activity:
  - Direct fish mortalities or injuries resulting from instream construction activities, including clearing and grading; and
  - Decreased fish health, growth, and/or survival caused by spills or leaks of deleterious substances, including fuel, oil, and grease.
- Erosion and sediment:
  - Increased TSS concentrations due to clearing of vegetation, grading, and exposure of soils within the mine site, and mobilization of sediments in the stream channels due to fording or site preparation by heavy machinery and due to input of sediments to creeks. Elevated TSS concentrations can affect fish directly by impairing respiration, altering behaviour (e.g., migration patterns), changing feeding efficiency and predator detection, and indirectly by altering primary production and benthic invertebrate production upon which fish depend for food (Singleton 1985; Lloyd, et al. 1987; Newcombe, 1994); and
  - Mortality of developing fish embryos due to reduce oxygen availability caused by deposition of sediments.

Fish Effects under the Mine Site Footprint

At full development, the proposed TSF will be situated in the upper reaches of Davidson Creek (Reaches 9 to 11) and its headwater tributaries, including all of Creek 636713, and the lower reaches of Creek 688328 and Creek 704454. These creeks will be permanently lost under the TSF during the early construction and operational stages.

Mine site facilities, waste rock dumps, and other stockpiles (i.e., low-grade stockpile, overburden, etc.) will be located in headwater tributaries of Davidson Creek and Creek 661. Construction of these project components will result in the permanent loss of the following streams:

- Upper reaches of Creek 704454 above the TSF, a headwater tributary to Davidson Creek;
- Upper reaches of Creek 505659, Creek 146920, and Creek 543585; and
- Headwater tributaries of Creek 661.

Runoff from the East Waste Rock Dump will be intercepted by settling ponds. Discharges from the settling ponds will flow to the TSF during operations. A diversion channel will be built at closure for those flows. This will affect Creek 505659 and Creek 146920. These headwater drainages will be cut off by settling ponds or the closure diversion channel would be permanently lost and they would no longer be accessible by fish. The constructed overflow spillway from TSF Site D to Davidson Creek will be built at closure, following the natural topography along Creek 505659, which will result in the permanent loss of fish habitat in Creek 505659 under the spillway footprint.

Construction of seepage collection facilities, the ECD, and the freshwater reservoir component of the FSS during operations will result in loss of fish habitat in Reaches 6, 7, and 7.1 of Davidson Creek.

During the closure phase, these facilities will be decommissioned and replaced with a treatment wetland to improve the water quality of seepage from TSF Site D. The treatment wetland will have a larger physical footprint than the operational water management components, and combined, will result in the loss of fish habitat in Reaches 6 through 8 of Davidson Creek.

The open pit will be located on two unnamed tributaries to Creek 704454. Fish habitat will be permanently lost under the open pit.

In summary, there is high probability that this effect will occur when the Project is developed. The effect will be of high magnitude because it will affect fish and fish habitat in upper Davidson Creek and headwater streams of Creek 661. The extent of the effect is local because fish will be moved to adjacent downstream reaches of Davidson Creek and fish habitat will be lost from the mine site. The effect is of long-term duration because fish habitat will be lost for the duration of the Project and some fish habitat will be permanently lost (**Table 5.3.8-19**).

Table 5.3.8-19: Potential Effects on Fish of Development of the Mine Site

Potential Environmental Effect	Project Phase	Likelihood of Occurrence Without Mitigation/Offsetting
Loss of fish habitat (and hence of fish production)	Construction	Likely
Mortality of individual fish or fish eggs under the mine footprint	Construction	Likely
Fish mortality during fish salvage	Construction	Likely
Mortality of individual fish or fish eggs due to stranding	Construction	Likely
Direct mortality or injury to fish or fish eggs due to blasting	Operations	Likely
Interruption of fish passage upstream of the mine site footprint and alteration of fish migration patterns	Construction/Operations/Closure/ Post-Closure	Likely
Decreased health, growth and survival of fish due to spills or leakage of fuels or deleterious substances into watercourses.	Construction/Operations/Closure	Likely

Fish Effects Upstream of the Mine Footprint

Development of the mine site will also affect fish and fish habitat upstream of the mine site footprint in Davidson Creek. Fish and fish habitat will be isolated within upstream portions of Davidson Creek, its tributaries and Lake 01682LNRS. Without mitigation measures, over 24,669 m^2 of upstream fish habitat will be isolated. The upper reaches of Davidson Creek potentially affected by the mine site provide spawning areas that support a rainbow trout population in the Lake 01682LNRS. The upstream spawning habitat remaining after development will not be sufficient to maintain that self-sustaining headwater population of rainbow trout.

During initial development of TSF Site C, a saddle dam will be constructed in the upper reaches of Davidson Creek, approximately 900 m downstream of Lake 01682LNRS. This dam will permanently isolate fish in Reach 12 of Davidson Creek and in Lake 01682LNRS, beginning in early construction.

Construction of TSF Site D will also isolate fish in the upper reaches of Creek 688328 and Creek 704454. Fish habitat upstream of TSF Site D outside of the mine footprint will not be physically altered, but the productive capacity of these tributaries will be altered because:

- Any rainbow trout isolated upstream of the mine site will be unable to survive due to the lack of suitable overwintering habitat (pool depths are typically less than 0.3 m and freeze to the bottom in winter);
- Rainbow trout will not be able to move up into this habitat after the mine is built; and
- Water, nutrients, and benthic macroinvertebrate drift would no longer flow from these reaches to habitat lower in Davidson Creek.

In summary, loss of the headwater lake rainbow trout population upstream of the mine site footprint is highly probable when the Project is developed. The effect is of high magnitude because it means a loss of a fish population, but it is local in extent because it is restricted to the LSA. Duration of the effect is long-term (**Table 5.3.8-19**).

5.3.8.3.2.1.2 Mitigation Measures

Mine Footprint

Loss of fish production that will follow from loss of fish habitat on the mine site will be offset by creation, enhancement and rehabilitation of fish habitat, as described in the FMOP (**Appendix 5.1.2.6C**).

Staged construction of the TSF will be employed to minimize any risk of fish stranding or mortality within the mine site. TSF Site C, located in the headwaters of Davidson Creek will be constructed first to support mining and tailings disposal for early operational stages. Construction of the larger, downstream TSF Site D will commence during early operations, to manage mill process water requirements and tailings disposal for the remaining mine life. Staged construction will reduce the potential for fish stranding by minimizing the habitat area isolated at one time.

Fish salvages will be completed at all streams and water bodies under the mine footprint before the start of construction at each specific area. **Section 12.2.1.18.4.21** outlines a preliminary fish salvage plan. A more detailed plan will be prepared prior to salvage. Fish will be salvaged from isolated work areas and returned to Davidson Creek or Creek 661, depending on the location of salvage, downstream of any work areas. The person undertaking the fish salvage operation will obtain and hold all necessary permits required by the Federal *Fisheries Act* and BC statutes to collect and transport fish. Salvage operations will require the isolation of the work site and the collection and removal of all fish from areas where fish may be entrapped or destroyed by construction activities. Fish will be collected mainly with electrofishing equipment, but other gears such as minnow traps and seines may be used depending on conditions.

Construction timing for any instream structures or barriers to fish passage will be scheduled to occur during the reduced risk window for rainbow trout between 15 July and 15 April of the following year (BC MOE, 2004). This will reduce the risk of direct mortality of fish and eggs and of interrupting fish spawning migrations. Instream work will only be conducted outside the reduced risk window for streams in which fish have already been salvaged.

The potential for fish mortality due to blasting on the mine site will be fully mitigated by conducting fish salvages to remove all fish from areas where blasting will occur, and following *Guidelines for the Use of Explosives in or near Canadian Fisheries Waters* (DFO, 1998b), and *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013a).

Upstream of the Mine Site

To minimize potential effects to fish in upstream Davidson Creek, Lake 01682LNRS will be diverted through a newly constructed stream channel to Lake 01538UEUT, one of two headwater lakes in the Creek 705 Watershed. **Appendix 5.1.2.6C** provides a detailed description of that diversion. The objective will be to maintain a self-sustaining population of rainbow trout in Lake 01682LNRS by providing access to spawning habitat in the Creek 705 Watershed.

This mitigation involves constructing a lake dam adjacent to the TSF Site C saddle dam and a diversion channel, so that water in the lake flows downstream to Lake 01538UEUT. (Figures 5-1 to 5-5 in **Appendix 5.1.2.6C** show the design features of this proposed mitigation.) Under this concept, two additional benefits will accrue: potential seepage from TSF Site C to Lake 01682LNRS will be eliminated by creation of a hydraulic barrier, and additional lake area will be created. A hydraulic barrier will be maintained in the new lake by creating a lake elevation greater than the elevation of tailings in TSF Site C, such that seepage is directed from the lake towards the TSF.

The new diversion channel connecting Lake 01682LNRS to Lake 01538UEUT will be constructed in a lowland area along the northern edge of the natural saddle between the two lakes. The new diversion channel will be approximately 300 m long. Based on elevation differences between the two lakes and outlet discharge from Lake 01682LNRS, the new channel will have a low gradient (0.3% to 0.7%) and a mean wetted width varying from 2 m to 3 m.

Construction of the new diversion channel and enlargement of Lake 01682LNRS will be aligned with construction plans and schedules for TSF Site C. Scheduling will ensure that the connection to the Creek 705 Watershed occurs prior to isolating Lake 01682LNRS from Davidson Creek to avoid any disruption to rainbow trout spawning. Scheduling will also consider the reduced risk construction timing window for rainbow trout between 15 July and 15 April (BC MOE, 2004).

The new diversion channel will preferably be constructed during the late summer or fall months when flows are lowest and no fish are spawning.**Table 5.3.8-20** summarizes the mitigation measures that will be implemented to minimize or eliminate effects of the proposed mine site on fish.

Table 5.3.8-20: Mitigation Measures to Avoid or Reduce Potential Effects on Fish of Mine Site Development

Likely Environmental Effect	Project Phase	Mitigation/Enhancement Measure	Mitigation/ Offsetting Success Rating
Loss of fish habitat (and hence of fish production)	Construction	Creation, enhancement and rehabilitation of fish habitat, as described in the FMOP (**Appendix 5.1.2.6C**).	High

Likely Environmental Effect	Project Phase	Mitigation/Enhancement Measure	Mitigation/ Offsetting Success Rating
Mortality of individual fish or fish eggs under the mine footprint	Construction	Where instream construction is required, work areas will be isolated and fish salvage and relocation will be completed prior to starting work as described in the Fish Salvage Plan (**Section 12.2.1.18.4.21**). Instream construction will be conducted during the Reduced Risk Timing Window for rainbow trout (15 July to 15 April of the following year) to avoid interruptions to spawning migrations and egg mortalities. Instream construction will only be allowed outside the Reduced Risk Timing Window if fish have already been removed by salvaging.	High
Fish mortality due to fish salvage	Construction	Fish salvages will be conducted using appropriate gear for the habitat salvaged operated by appropriately experienced teams, as described in the Fish Salvage Plan (**Section 12.2.1.18.4.21**).	High
Mortality of individual fish or fish eggs due to stranding	Construction	Fish salvages will be completed for all stream areas that will be impacted by the mine footprint, as described in the Fish Salvage Plan (**Section 12.2.1.18.4.21**). Staged construction of the Lake 01682LNRS diversion and dam construction will be required to ensure that no fish are stranded during construction.	High
Direct mortality or injury to fish or fish eggs due to blasting	Operations	Prior to blasting, fish salvages and isolation of mine site streams will be carried out to ensure that no fish are present, as described in the Fish Salvage Plan (**Section 12.2.1.18.4.21**).	High
Interruption of fish passage upstream of the mine site footprint and alteration of fish migration patterns	Construction/ Operations/ Closure	Lake 01682LNRS and Reach 12 of Davidson Creek will be diverted into Lake 01538UEUT of the Creek 705 Watershed to ensure downstream connectivity for these water bodies.	High
Reduced growth and survival of fish due to spills or leakage of fuels or deleterious substances into watercourses	Construction/ Operations/ Closure	An emergency spill response kit will be kept on-site during construction. Fuels will be stored and refuelling will be conducted outside of riparian areas at all times. Machinery that arrives on site will be in a clean condition and will be maintained free of fluid leaks. A seepage management system consisting of seepage collection ponds, a seepage collection trench, and an ECD will be installed to prevent surface water discharges or sediment contributions to downstream receiving environments.	High

The mitigation/offsetting success ratings shown in **Table 5.3.8-20** are equivalent to the confidence ratings defined in **Section 4.3.5** and summarized in **Table 5.3.8-56**. Briefly, low success rating means mitigation has not been proven to be successful, moderate success rating means mitigation has been proven to be successful elsewhere, and high success rating means mitigation has been proven effective.

In the case of fish on the mine site, mitigation/offsetting success rating is classified as high because all fish habitat lost to mine development will be offset by habitat created, rehabilitated or enhanced elsewhere. The total habitat area permanently altered or destroyed is estimated to be 75,867 m^2. Fish habitat under the mine footprint will be permanently altered or destroyed and will require DFO to authorize these unavoidable losses of fish habitat under section 35(2)(b) of the *Fisheries Act* (Government of Canada, 2013). **Appendix 5.1.2.6C** describes the Fisheries Mitigation and Offset Plan (FMOP).

5.3.8.3.2.2 Potential Effects on Fish from Changes in Flow

5.3.8.3.2.2.1 Potential Effects

Section 5.3.9.3.2.2 describes in detail the potential effects of development of the mine site on stream flows in the LSA. Only a brief summary is provided in this section.

Changes in stream flows in Davidson Creek, lower Chedakuz Creek, Creek 661 and Creek 705 may affect fish via multiple pathways. Changes in water quantity may affect the extent and quality of fish habitat, which can in turn affect growth, survival and reproduction of individual fish, thereby affecting population densities in the LSA. Changes in flow timing and volume can affect fish directly by altering behaviour (e.g., migration patterns), or changing feeding efficiency and predator detection and indirectly by altering primary production and benthic invertebrate production upon which fish depend for food. Alteration of flow timing and volume may influence spawning migratory cues, altering escapement and spawning success. Changes to all parameters may be positive or negative, depending on the direction, magnitude and timing of changes in flow.

The mine site will be operated as a zero-discharge facility during operations and closure phases. Therefore, during operations and closure Davidson Creek flows will be reduced to zero at the foot of the Site D Main dam. Davidson Creek flow inputs will be reduced to the watershed downstream of the Site D Main dam, with drainage area (at the confluence with lower Chedakuz Creek) reduced from 76 km^2 to 32 km^2 during mine operations.

Flows on the mine site will be diverted from some Creek 661 tributaries into the TSF, reducing the area of Creek 661 Watershed (at the confluence with middle Chedakuz Creek) from 56 km^2 to 50 km^2 during the closure and post-closure periods.

Flows in lower Chedakuz Creek will be reduced as a result of the impoundment of upper Davidson Creek Watershed and the diversion and impoundment of some Creek 661 flows.

Flows in Creek 705 will increase as a result of the diversion of Lake 01682LNRS, the headwater lake of Davidson Creek, into Lake 01538UEUT, one of the two headwater lakes of Creek 705 Watershed. The watershed area of Creek 705 at the confluence with Fawnie Creek will increase from 45 km^2 to 48 km^2.

Instream flow models were developed to predict potential downstream flow effects for Davidson Creek, Creek 661, lower Chedakuz Creek and Creek 705. The methods and results of these models are described in detail in **Appendix 5.1.2.6D** (Instream Flow Study). Effects included the flow volumes, seasonal timing, and issues associated with flushing flows and overwintering flows.

In summary, effects on fish downstream of the mine site due to changes in flow are highly probable, but the magnitude of the effect will vary depending on watershed. The Project will impact fish and fish habitat in Davidson Creek and Creek 661, but effects are not expected for lower Chedakuz Creek. An increase in flows in Creek 705 will increase the amount of fish habitat, all other factors being equal. The effects will be of local extent because they will be restricted to the LSA, but they will be long-term because some fish habitat will be lost for the duration of the Project.

5.3.8.3.2.2.2 Mitigation Measures

Proposed mitigation measures to minimize potential Project effects on fish habitat (and hence fish) include:

- Pumping water from Tatelkuz Lake via the FSS to augment flows in middle and lower Davidson Creek; and
- Diversion of the Davidson Creek Watershed area upstream of the TSF Site C West Dam into the adjacent Creek 705 Watershed.

An additional mitigation measure with the potential to affect fish habitat will be the pumping of water from Tatelkuz Lake to the open pit during closure. This mitigation will reduce the potential for generation of Acid Rock Drainage (ARD) from the exposed open pit walls by filling the pit more quickly than would naturally occur. During operations, 33 L/s will be pumped from Tatelkuz Lake to the mine site to supply mill needs. To speed filling of the open pit, mitigation pumping from Tatelkuz Lake to the open pit will continue at this rate through closure.

Section 5.3.9.3.2.2 describes in detail the predicted effects of these mitigation measures on stream flows in the LSA. Only a brief summary is provided in this section.

Pumping of water from Tatelkuz Lake to Davidson Creek via the FSS is the critical mitigation proposed to address potential Project-related flow effects in Davidson Creek. Instream flow modelling has shown that mitigated flows will improve habitat availability for rainbow trout and kokanee in Davidson Creek during operations and closure compared to the unmitigated scenario (**Appendix 5.1.2.6D**). However, changes in stream flows relative to baseline are predicted to occur in Davidson Creek despite mitigation. Potential effects with mitigation were therefore carried forward to residual effects assessment. In general, mitigated flows represent a reduction relative to mean baseline conditions.

For rainbow trout fry rearing, this reduction in mitigated flows, relative to baseline, will increase habitat availability. For rainbow trout parr, reduced flows will increase habitat availability during spring freshet, and reduce availability from July through November. Availability of rainbow trout and kokanee spawning habitat will be reduced by 4% to 6% during operations and closure.

Flow augmentation of Davidson Creek will change habitat availability in lower Chedakuz Creek during construction, operations and closure. For rainbow trout fry rearing, reduced flows will increase the availability of habitat compared to baseline conditions. For rainbow trout parr, reduced flows will increase habitat availability during spring freshet, and reduce availability from July through November. Availability of rainbow trout and kokanee spawning habitat will be reduced by 4% to 6% during operations and closure. Since changes to fish habitat availability relative to baseline occur in lower Chedakuz Creek, this potential effect was carried forward to residual effects assessment.

No mitigation measures will be applied to Creek 661 because of the low magnitude of Project effects on flows. Therefore, potential effects of flow changes on fish habitat in that creek were also carried forward to residual effects assessment.

Flow changes resulting from diversion of Lake 01682LNRS to Lake 01538UEUT will result in a net change of less than ±5% in the baseline habitat area in the lower sections of Creek 705. Flow increases immediately downstream of Lake 01538UEUT may change channel structure and fish habitat. The most likely effects will be channel widening and bank erosion at some locations where the banks are soft. However, it is expected that the geomorphology of Creek 705 will stabilize in response to the new flow regime. This potential effect was also carried forward to residual effects assessment.

In summary, potential effects of changes in flows on fish habitat (and thence fish) of Davidson Creek, lower and middle Chedakuz Creek, Creek 661 and Creek 705 on fish habitat were all carried forward to residual effects assessment.

5.3.8.3.2.3 Potential Effects on Fish of Changes in Water Quality

5.3.8.3.2.3.1 Potential Effects

Baseline studies of surface water quality indicate that streams and lakes in the LSA contain relatively soft water, with low alkalinity, low concentration of nitrogen species and somewhat elevated phosphorus in lakes compared to BC guidelines (**Section 5.3.3**). Most trace metal concentrations are low to below detection limits. Exceptions, which are often or always above guidelines, are total aluminum (CCME guideline), dissolved aluminum (BC guideline), total cadmium (current BC guideline; well within CCME guideline), total copper, total iron (above CCME guideline), and total zinc. These exceptions are the result of naturally elevated concentrations of these metals in the bedrock and soils of the LSA. Such natural exceedances are common near mineralized zones such as the Blackwater ore body.

During construction and operations, Project activities may change baseline surface water quality (**Table 5.3.8-21**). These changes may result from surface and groundwater seepage from the TSF, runoff from East or West NAG waste rock and overburden dumps, or changes in catchment areas of Project components. Mining will also result in the deposition of mine tailings into the portions of Davidson Creek within the TSF. During the transition from closure to post-closure phases, surface water quality may also change as water is discharged from the TSF into Davidson Creek.

Table 5.3.8-21: Potential Effects on Fish Habitat of Changes in Surface Water Quality by Mine Phase

Mining Phase	Potential Direct Effects Source	Parameters	Receiving Water Body
Construction	Sediment Control Pond #5	TSS	Creek 661
	Sediment Control Pond #6	TSS	Davidson Creek
	Sediment Control Pond #7	TSS	Davidson Creek
	Sewage treatment plant treated effluent	Nutrients, Biochemical Oxygen Demand (BOD), fecal coliforms	Discharge to ground through rapid infiltration basin
Operations	TSF seepage, 2 L/s	Metals, below detection, ammonia, within natural variations	Davidson Creek
	Flooded soils of enlarged area of Lake 01682LNRS	Mercury (Hg)	Lake 01682LNRS, Lake 01538UEUT, Creek 705
	Sewage treatment plant treated effluent	Nutrients, BOD, fecal coliforms	Discharge to ground through rapid infiltration basin
Closure	Sediment Control Pond #1	TSS	TSF Pond C
	Sediment Control Pond #2	TSS	TSF Pond C
	Sediment Control Pond #5	TSS	TSF Pond C
	Sediment Control Pond #6	TSS	TSF catchment basin
	TSF seepage, 2 L/s	Metals, below detection, ammonia within natural variation	Davidson Creek
	Sewage treatment plant treated effluent	Nutrients, BOD, fecal coliforms	Discharge to ground through rapid infiltration basin
Post-Closure	TSF surface discharge	Metals, nutrients	Davidson Creek
	TSF seepage, 55 L/s	Metals	Davidson Creek
	Pit lake discharge	Metals, nutrients	TSF
	Pit lake seepage	Metals, nutrients	TSF
	East NAG dump	Metals, nutrients	TSF

Unless mitigated, changes in water quality of Davidson Creek, Creek 661 or Creek 705 may affect fish via multiple pathways (**Table 5.3.8-22**). Fish tissue metals concentrations may increase in response to elevated metals concentrations in water or prey. Changes in water quality may affect growth, survival and reproduction of individual fish, thereby affecting population densities in the LSA. Elevated TSS concentrations can affect fish directly by impairing respiration, altering behaviour (e.g., migration patterns), or changing feeding efficiency and predator detection and indirectly by altering primary production and benthic invertebrate production upon which fish depend for food. Alteration of water quality parameters may influence chemical spawning migratory cues, leading to decreased escapement and spawning success.

Table 5.3.8-22: Potential Effects on Fish of Changes in Surface Water Quality

Potential Environmental Effect	Project Phase	Likelihood of Occurrence Without Mitigation
Changes in fish tissue metals concentrations	Construction/Operations/Closure	Likely
Change in growth of fish due to changes in water quality	Construction/Operations/Closure	Likely
Change in fish embryo survival due to changes in water quality	Construction/Operations/Closure	Likely
Decreased growth, reduced disease resistance, or mortality of fish due to elevated TSS concentrations	Construction/Operations/Closure	Likely
Delayed or impaired development of eggs due to increased sedimentation	Construction/Operations/Closure	Likely
Change in fish escapement and spawning success	Construction/Operations/Closure	Likely
Change in fish densities due to changes in water quality	Construction/Operations/Closure	Likely

The potential effects on fish of changes in water quality are probable unless mitigated. The magnitude of effects would be moderate because they would affect fish downstream of Project, but the geographic extent would be local because it would be restricted to the LSA. Duration would be long-term because it will occur over the life span of the Project.

5.3.8.3.2.3.2 Mitigation Measures

The Project has been designed to minimize potential effects to fish of changes in water quality. The single most important mitigation measure is the commitment that the mine site will be operated as a no-discharge facility during operations and closure, meaning that all water that falls as rain or snow on the site will be captured and stored in the TSF.

The objective of site water management designs are to provide sufficient water to support mill water requirements and to maintain PAG materials in the TSF in a subaqueous state, while mitigating environmental impacts to fish habitat upstream and downstream of the mine infrastructure.

During construction, potential sediment export will be controlled. This will be accomplished using seven sediment control ponds that will be constructed prior to major clearing of the plant site area, as well as dams located downstream of the TSF where other control facilities are not in place. The sediment control ponds will be designed according to BC guidelines to remove suspended sediment. Three of the ponds will exfiltrate into permeable glaciofluvial deposits, which will further remove suspended solids and other contaminants. Four of the ponds will discharge to streams; the two that will discharge to Davidson Creek will only operate during the construction period. Further details regarding sediment control are available in the Sediment and Erosion Control Plan (SECP) (**Section 12.2.1.18.4.1**).

During the construction phase, the sewage treatment plant of the existing exploration camp will use an expanded septic field. This will mitigate for potential effects on Davidson Creek water quality of discharges from the expanded camp. The upgraded sewage treatment system will operate through the operations and closure phases as well. A second sewage treatment plant will be built to serve the process plant and it will use a rapid infiltration basin.

During the enlargement of Lake 01682LNRS and construction of the diversion channel to Lake 01538UEUT, the isolated work areas will be stripped of all vegetation and topsoil material up to the expected high water line. Vegetation and soil stripping will mitigate potential effects on fish from mercury mobilization and bioaccumulation in the aquatic ecosystem.

A similar mitigation protocol will be followed for construction of the freshwater reservoir.

A seepage management system will be implemented to prevent surface water discharges to receiving environments during operations (i.e., to ensure a zero surface discharge facility). Main design elements for the seepage management system include seepage collection ponds, a seepage collection trench, and an ECD below the TSF. All flows from the mine site, including drainage from the East Waste Rock Dump (which will mostly contain overburden), located in the Creek 661 Watershed, will be captured and directed to the TSF. If water quality is acceptable for discharge at closure, then drainage from the East Waste Rock Dump will be directed to Creek 661.

During operations, the Project will not have any direct surface water discharge to streams. Instead, discharge will be limited to a small amount of TSF seepage. Seepage from the Site D main dam is anticipated to be 55 L/s. This will be captured by the ECD, located downstream in Davidson Creek, and pumped back into the TSF. Only 2 L/s of seepage will bypass this latter dam. This represents 96% efficiency in recovering seepage. However, approximately 18 years after closure, the water quality in the TSF is expected to be acceptable for discharge into Davidson Creek, and an *Environmental Management Act* permit will be required for this discharge.

Water quality will be further managed through wetland development in the TSF during later operational and closure stages. Water management designs during the closure and post-closure periods will restore natural drainage patterns where possible to avoid or minimize potential effects to fish habitat from downstream flow changes.

A wetland treatment area below the TSF, developed during the late closure and post-closure periods, has also been considered to support long-term water quality objectives for the protection of fish in Davidson Creek. Such a wetland will act as a passive bio-reactor to improve water quality. **Appendix 2.6C** (Wetland Water Treatment) provides a conceptual design for the Blackwater treatment wetlands and summarizes case histories of natural and constructed wetlands that have been used successfully to treat mine water discharges. These case histories include metal mines located in BC (Silver Queen Mine), Yukon (Keno Hill Mining District), Minnesota (constructed wetland), Montana (constructed wetland), Colorado (constructed wetland) and Australia (Woodcutter's mine). Hence, they represent climatic conditions that are representative of the Blackwater area. Treatment wetlands are a natural version of passive bioreactors that use biochemical mechanisms to break down organic molecules and sequester heavy metals. **Appendix 2.6C** summarizes two case histories of bioreactors used for Canadian mines: Teck's Trail smelting operation and the Tulsequah Mine.

In the event that post-closure water quality in the TSF is not acceptable for discharge into Davidson Creek, even with treatment in constructed wetlands, then TSF water will be treated in a lime neutralization treatment plant to remove metals. In addition, fertilizer may be added to the pit lake to generate phytoplankton blooms that will take metals out of circulation. As they sink to the pit bottom, dead phytoplankton cells would accumulate metals on their surfaces and take the metals down to burial in sediments where they would be sequestered indefinitely. Fertilization is currently being used to extract and bury metals in the pit lake of the Island Copper Mine of northern Vancouver Island.

Flow augmentation of Davidson Creek with water from Tatelkuz Lake will continue until TSF seepage and supernatant (combined with Pit Lake discharge) are acceptable for discharge to Davidson Creek.

During operations, contact water from the East NAG dump will be directed to the TSF. During closure, the East NAG dump will be reclaimed and monitoring will be completed in the diversion channel east of the dump. Should this water prove acceptable for discharge to Creek 661, the diversion channel will be dismantled. Regulatory approval will be required to discharge this water to Creek 661.

Table 5.3.8-23 summarizes mitigation measures to minimize or eliminate effects of Project activates on fish due to water quality at the mine site.

There are no residual effects expected to fish from water quality during construction, operations, closure or post-closure with the successful implementation of the mitigation measures. The only exception to that generalization is a potential elevated concentration of sulphate during post-closure. All other parameters are predicted to meet BC and CCME water quality guidelines, except where background concentrations are naturally above these guidelines. While above the guidelines they are well within background natural levels and site-specific guidelines will be applied for those parameters with natural exceedances. **Section 5.3.3** describes site-specific guidelines and objectives to protect freshwater aquatic life in Davidson Creek for dissolved aluminum, total cadmium, total copper, and total zinc.

During the post-closure phase sulphate is predicted to exceed water quality guidelines in Davidson Creek. The prediction for sulphate is uncertain because water quality modelling assumes no sulphate reduction in the TSF. However, there is substantial scientific evidence that sulphate reduction does occur if anoxic conditions are present (**Section 5.3.3**). In addition, natural sulphate reduction is expected to occur in the treatment wetlands that will be built immediately downstream of the TSF.

Therefore, water quality guidelines will be met before discharge into Davidson Creek. Hence, the potential effect on fish of water quality in that creek was not carried forward into residual effects assessment.

In Creek 661, surface water quality effects are predicted to range from negligible (unmeasureable) to minor (not significant).

In Creek 705 surface water quality effects from the mine site are predicted to range from negligible (unmeasureable) to minor (not significant) because there will be no surface or groundwater connection to this water body from the mine site.

The only potential residual effect may occur as a result of diversion of Lake 1682LNRS into the Creek 705 Watershed. An increase in mercury concentration in aquatic plants and animals, including fish, may occur as a result of flooding soils in the lake enlargement plan, although this effect will be reduced by proposed mitigation measures. Therefore, the potential effect of elevated mercury concentrations in Creek 705 was carried forward into residual effects assessment.

Table 5.3.8-23: Mitigation Measures to Eliminate or Reduce Effects on Fish of Water Quality

Likely Environmental Effect	Project Phase	Mitigation/Enhancement Measure	Mitigation Success Rating
Changes in fish tissue metals concentrations	Construction/Operations/ Closure	Seepage Management System will ensure no surface discharge. ECD and treatment wetland will capture and process downstream seepage from the TSF. At Lake 01682LNRS and the diversion channel, the areas to be flooded will be stripped of all vegetation and topsoil up to the high water line to reduce mobilization of mercury and uptake by aquatic plants and animals, including fish. A similar mitigation protocol will be followed for the freshwater reservoir.	High
Change in growth of fish due to changes in water quality	Construction/Operations/ Closure	Seepage Management System will ensure no surface discharge. ECD and treatment wetland will capture and process downstream seepage from the TSF.	High
Change in fish densities due to changes in water quality	Construction/Operations/ Closure	Seepage Management System will ensure no surface discharge. ECD and treatment wetland will capture and process downstream seepage from the TSF.	High
Change in fish egg survival due to changes in water quality	Construction/Operations/ Closure	Seepage Management System will ensure no surface discharge. ECD and treatment wetland will capture and process downstream seepage from the TSF.	High

Likely Environmental Effect	Project Phase	Mitigation/Enhancement Measure	Mitigation Success Rating
Decreased growth, reduced disease resistance, or mortality of fish due to elevated total suspended sediment concentrations	Construction/Operations/ Closure	Erosion and sediment control measures, based on the Erosion and Sediment Control Plan will be used to protect erodible soils and minimize erosion of soils within the mine site. A seepage management system consisting of seepage collection ponds, a seepage collection trench, and an ECD will be installed to prevent surface water discharges or sediment contributions to downstream receiving environments.	High
Delayed or impaired development of eggs due to increased sedimentation	Construction/Operations/ Closure	Erosion and sediment control measures, based on the Erosion and Sediment Control Plan, will be used to protect erodible soils and minimize erosion of soils within the mine site. A seepage management system consisting of seepage collection ponds, a seepage collection trench, and an ECD will be installed to prevent surface water discharges or sediment contributions to downstream receiving environments.	High
Change in fish escapement and spawning success	Construction/Operations/ Closure	Seepage Management System will ensure no surface discharge. ECD and treatment wetland will capture and process downstream seepage from the TSF.	High

5.3.8.3.2.4 Potential Effects on Fish Homing of Flow Augmentation of Davidson Creek

5.3.8.3.2.4.1 Potential Effects

Davidson Creek provides spawning, incubation, and juvenile rearing habitat for two populations of rainbow trout, and spawning and incubation habitat for one population of kokanee. Reduction in flow in Davidson Creek caused by mine site development will reduce available habitat for these populations. Flow augmentation of Davidson Creek with water pumped from Tatelkuz Lake is proposed to mitigate those adverse effects.

There are concerns, however, that adding water from Tatelkuz Lake may alter the olfactory environment of Davidson Creek and thereby disrupt the ability of salmonid fish populations to recognize and home to natal spawning areas in Davidson Creek. There are four potential effects (**Table 5.3.8-24**), all of which may be temporary or permanent:

1. Spawners may not return to Davidson Creek.
2. Spawners may use only those lower reaches that contain a residual flow of Davidson Creek water rather than using all of the available spawning habitat in Davidson Creek.
3. Spawners may stray to adjacent streams to spawn (e.g., Turtle Creek).
4. Spawners may fail to complete spawning even if they find Davidson Creek.

Table 5.3.8-24: Potential Effects on Fish Homing of Flow Augmentation of Davidson Creek

Potential Environmental Effect	Project Phase	Likelihood of Occurrence Without Mitigation
Temporary or permanent reduction in number of rainbow trout and kokanee that home to natal spawning grounds in Davidson Creek	Construction/ Operations/ Closure	Likely
Reduction in upstream distance of spawning migration of rainbow trout and kokanee that home to natal spawning grounds in Davidson Creek	Construction/ Operations/ Closure	Likely
Increase in number of rainbow trout and kokanee that stray to other streams in the LSA for spawning	Construction/ Operations/ Closure	Likely
Increase in proportion of rainbow trout and kokanee spawning populations that fail to spawn successfully in Davidson Creek	Construction/ Operations/ Closure	Likely
Increase in proportion of rainbow trout and kokanee spawning populations that fail to spawn successfully in other creeks of the LSA	Construction/ Operations/ Closure	Likely

5.3.8.3.2.4.2 Mitigation Measures

A study was conducted to address these concerns (**Appendix 5.1.2.6E**). It is briefly summarized here. It has four parts:

- Summary of the scientific literature on salmonid imprinting and use of olfaction in homing;
- Multivariate statistical analysis of the differences in water chemistry between receiving water (Davidson Creek) and source water (Tatelkuz Lake);
- Assessment of the likelihood of changes in homing behaviour of Davidson Creek salmonids as a result of flow augmentation; and
- Preliminary monitoring and adaptive management approach to document and mitigate potential effects to Davidson Creek rainbow trout and kokanee.

The consensus of the scientific literature is that olfactory cues are important for salmonid homing to their natal streams, at least in freshwater if not in the open ocean, and that the chemicals on which they cue are a complex mixture that may include chemicals produced by salmonids themselves. Imprinting on olfactory cues occurs during the time fry and juveniles reside in their natal stream, which is 1 or 2 weeks for kokanee but up to 3 years for rainbow trout.

On the other hand, salmonid fish, as a group, display a behaviour known as straying in which a small proportion (approximately 5%) of spawners in any returning cohort do not spawn in their natal stream but seek spawning habitat elsewhere. Hence, salmonid fish are plastic in their behaviour and are capable of adapting to new circumstances. Otherwise, they would never be able to colonize new habitat when it opens up or recover when old habitat is modified by natural geomorphological processes. Hence, a cessation of rainbow trout and kokanee spawning in Davidson Creek is unlikely. Instead, strays from nearby streams such as Turtle Creek, middle Chedakuz Creek and Creek 661 will inevitably migrate into Davidson Creek to spawn, as they probably already do at present.

There are differences in water chemistry between Tatelkuz Lake and Davidson Creek, and these differences appear to persist across seasons. These results suggest that there is potential for the olfactory environment of Davidson Creek to be altered by augmentation from Tatelkuz Lake.

The biggest differences in water chemistry will occur immediately below the TSF, where the only source of water will be Tatelkuz Lake. Further downstream, surface run-off and groundwater originating within the Davidson Creek Watershed will mix with water pumped from Tatelkuz Lake, and will contribute to the olfactory environment. Dilution of Tatelkuz Lake water in Davidson Creek is expected to vary in time and space. Based on monthly baseline estimates of flow in Davidson Creek and expectations of the volume of water that will be required to maintain fish habitat, water originating from Davidson Creek will comprise 17 to 42% of flows in middle Davidson Creek, 20 to 55% of flows in lower Davidson Creek, and 26 to 61% of flows at the confluence with lower Chedakuz Creek. The proportion of water originating from Tatelkuz Lake will typically be greatest during the June rainbow trout migration and spawning period and at moderate levels during the July-August kokanee spawning period. These calculations indicate that Davidson Creek olfactory cues will persist during flow augmentation.

An adaptive management approach is recommended that incorporates two components:

- Monitor the two salmonid populations to evaluate the effects to salmonid homing in Davidson Creek; and
- In the event of observed adverse effects, initiate management options such as adult or egg transfers and the use of artificial homing agents.

In summary, the use of flow augmentation to mitigate reductions of flow in Davidson Creek is unlikely to disrupt homing of salmonids to spawning grounds in a way that has long-term effects. The maintenance of some home-stream water in Davidson Creek and the plastic nature of salmonid homing make it likely that Davidson Creek will continue to attract rainbow trout and kokanee spawners after construction and during operations and closure of the Project. What is less certain is whether spawners will migrate upstream against a decreasing olfactory gradient. Therefore, this potential effect was carried forward into residual effects assessment.

5.3.8.3.2.5 Potential Effects on Fish of Diversion of Lake 01682LNRS to Lake 01538UEUT

5.3.8.3.2.5.1 Potential Effects

The two potential effects to the rainbow trout populations presently residing in lakes 01682LNRS and 01538UEUT of the diversion are (1) exchange of pathogens (i.e., parasites, viruses, bacteria and fungi) that may result in increased mortality and morbidity (until they adapt to the new pathogens) and (2) mixing of genes among the two populations that may diminish their genetic uniqueness.

Another potential effect may be the transfer of benthic invertebrates between the two lakes, including the possible movement of the blue-listed Rocky Mountain Capshell from Lake 01682LNRS, where it has been found in low numbers, to Lake 01538UEUT, where it has not been found. However, the apparent absence of Rocky Mountain Capshell from Lake 01538UEUT may be a sampling artifact, i.e., the organism may be present but sufficicently rare that it was not found during a standard benthic invertebrate survey in 2012.

Another potential effect may be the extirpation of Rocky Mountain Capshell from Lake 01682LNRS as a result of predation by longnose suckers migrating from Lake 01538UEUT to Lake 01682LNRS. This is highly unlikely because rainbow trout feed on benthic invertebrates as well as zooplankton. Hence, if Rocky Mountain Capshell is vulnerable to fish predation it would already be extirpated from Lake 01682LNRS.

5.3.8.3.2.5.2 Mitigation Measures

There are no direct mitigation measures for these potential effects, but there are several lines of evidence that indicate possible historical exchange of fish between the two watersheds.

There are no records in FISS of barriers to fish migration between the Chedakuz Creek Watershed and Fawnie Creek Watershed. Both Chedakuz and Fawnie creeks flow into the Nechako Reservoir (although water from Fawnie Creek has to flow through the Entiako River to get there). Therefore, there is no physical reason apart from distance that rainbow trout cannot swim from one watershed to the adjacent watershed through the Nechako Reservoir.

The water surface elevation of Lake 01682LNRS is less than 1 m higher than that of Lake 01538UEUT, suggesting that exchange of water and fish between the two lakes may have occurred in the past in the past during extremely wet years.

The microsatellite DNA study conducted on kokanee of Chedakuz and Fawnie watersheds showed clear evidence for exchange of genes between the two watersheds. Although the pathogen communities of kokanee and rainbow trout were not studied as part of baseline work, it is reasonable to assume from the lack of barriers to migration and the kokanee genetic analysis that the fish pathogen communities of the two watersheds are similar.

There is no evidence from baseline studies that either of the rainbow trout populations that overwinter in lakes 01538UEUT and 01682LNRS is unique in any way. All differences in mean body size (rainbow trout in Davidson Creek are smaller than those in Creek 705) are more simply explained as a result of lower water temperatures in Davidson Creek than in Creek 705. Therefore, there are no reasons to assume that exchange of genes between the rainbow trout populations of lakes 01538UEUT and 01682LNRS has resulted, and will result, in the loss of unique characteristics.

The possible expansion of Rocky Mountain Capshell from Lake 01682LNRS to Lake 01538UEUT (if it is not already there in small numbers) would be a positive event because it would increase the area of distribution of the species and hence its resilience to local extirpation.

In summary, the rainbow trout populations of lakes 01538UEUT and 01682LNRS are not separated by barriers to migration; hence, there are unlikely to be any adverse effects to those populations from the introduction of pathogens or mixing of genes as a result of the diversion of Lake 01682LNRS into Lake 01538UEUT.

Moreover, if the diversion is not carried out, then the population of rainbow trout that overwinters in Lake 01682LNRS will be cut off from spawning and fry rearing habitat in upper Davidson Creek and so may eventually be extirpated. The diversion will provide spawning and fry rearing habitat and hence will conserve that population. It will also assist in conservation of the Rocky Mountain Capshell. Therefore, this potential effect was not carried forward into residual effects assessment.

It is recognized that the diversion of Lake 01682LNRS to Lake 01538UEUT may need to undergo DFO intra-basin licensing.

5.3.8.3.2.6 Potential Effects on Fish of Davidson Creek of Changes in Water Temperature

5.3.8.3.2.6.1 Potential Effects

Water temperatures in Davidson Creek will change as a result of flow augmentation by water pumped from below the epilimnion of Tatelkuz Lake (**Section 5.3.3**). Water quality modelling shows that water pumped from depths between 8 and 12 m in Tatelkuz Lake will be generally warmer in winter and colder in summer than water in Davidson Creek (**Table 5.3.8-25**). (The three water quality monitoring stations shown in that table are located as follows: WQ10 is downstream of the future location of the TSF outlet, WQ7 is near the confluence with lower Chedakuz Creek, and WQ26 is mid-way between stations WQ10 and WQ7.) Temperatures in winter are predicted to be 2.2°C to 3.2°C warmer, depending on the intake depth. Temperatures in spring are predicted to be -0.1°C to 4.6°C warmer than baseline, and those in summer are predicted to be -3.0°C to 4.6°C colder than baseline. Temperatures in autumn are predicted to be -0.4°C to 7.6°C warmer than baseline.

Water temperatures will be highly dependent on intake depth. For example, peak summer temperatures are predicted to range from 12°C to 14°C for a depth of 8 m, 10°C to 12°C for a depth of 10 m, and 7°C to 9°C for a depth of 12 m (**Figure 5.3.8-10**). This is because Tatelkuz Lake is stratified from June to September.

Predicted winter temperatures differ by 1°C or less among intake depths because of the lack of winter stratification of Tatelkuz Lake. Predicted spring and autumn temperatures have intermediate levels of depth-dependence between winter and summer.

Comparison of those predicted temperatures with mean observed temperatures in Davidson Creek from 2011 to 2013, as shown in **Figure 5.3.8-11**, show that the predicted temperatures for a 10 m intake depth are the closest match to observed temperatures,. For all three depths, however, predicted winter temperatures will still be 2°C to 3°C higher than baseline temperatures.

At post-closure, water will no longer be pumped from Tatelkuz Lake, and Davidson Creek in-stream fish flows will be met by discharge and seepage from the TSF. Temperature of the discharged water will then be governed by the combined surface water temperature of the post-closure pit lake and the TSF. To predict post-closure temperatures, it was assumed that they will be similar to water temperatures in lakes of the LSA that are similar in elevation to the TSF because elevation is the main driver of water temperature in the LSA (**Section 5.1.2.6**). Snake Lake is the best candidate for a lake similar to the TSF (**Figure 5.3.8-12**).

During May to early November in 2012 and May to early August in 2013 surface temperatures in Snake Lake were measured on a 15 minute basis. Daily mean temperatures show that the mean (+95% CL) exceeded 20°C in July and August.

It was also assumed that those temperatures will be moderated by the temperature of TSF dam seepage. That groundwater is always cooler than Snake Lake surface water during summer. The mean (+95%CL) predicted post-closure water temperatures for the plunge pool at the discharge point of the freshwater reservoir will not exceed 19.4°C (**Table 5.3.8-26**). Predicted temperatures at station WQ10 will be approximately 1°C higher than baseline temperatures.

Table 5.3.8-25: Predicted Differences between Background and Operations-Closure Temperatures in Davidson Creek

Month	WQ10			WQ26			WQ7		
	8 m Intake	10 m Intake	12 m Intake	8 m Intake	10 m Intake	12 m Intake	8 m Intake	10 m Intake	12 m Intake
Jan	2.8	2.9	3.0	2.7	2.8	2.9	2.3	2.4	2.5
Feb	2.9	2.9	3.0	2.4	2.4	2.4	2.3	2.3	2.4
Mar	3.1	3.1	3.2	2.6	2.6	2.6	2.3	2.3	2.3
Apr	4.7	3.7	2.8	3.1	2.5	2.0	2.8	2.3	2.1
May	4.9	2.9	2.4	2.2	0.6	-1.0	3.6	2.0	1.0
Jun	4.3	2.4	0.6	3.0	1.3	-0.7	3.3	1.7	-0.2
Jul	1.1	-0.1	-1.5	-0.1	-1.1	-2.7	-0.5	-1.6	-3.3
Aug	3.1	-0.5	-1.8	1.6	-1.3	-3.0	2.4	-0.4	-1.7
Sep	7.6	5.1	1.6	5.0	3.0	-0.4	6.8	5.0	3.0
Oct	7.2	4.2	3.9	4.7	2.3	1.4	5.2	3.0	2.6
Nov	7.5	4.5	4.8	6.4	4.0	4.5	5.6	3.5	3.9
Dec	5.0	4.0	3.7	4.1	3.3	3.0	3.8	3.0	2.8

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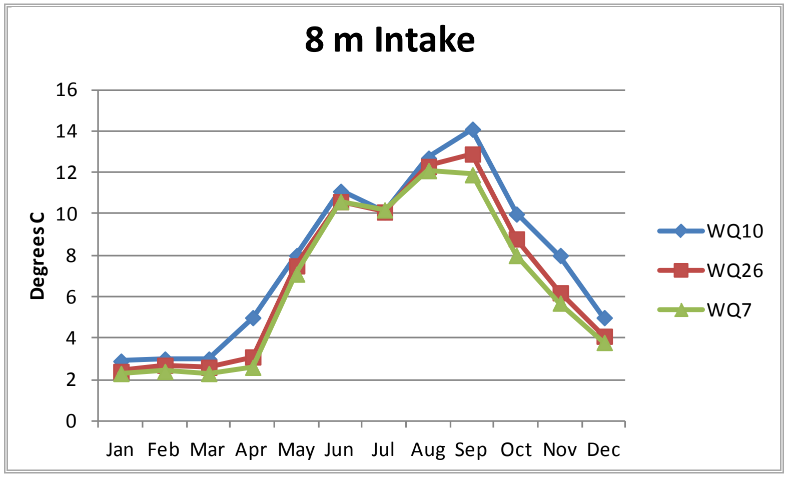
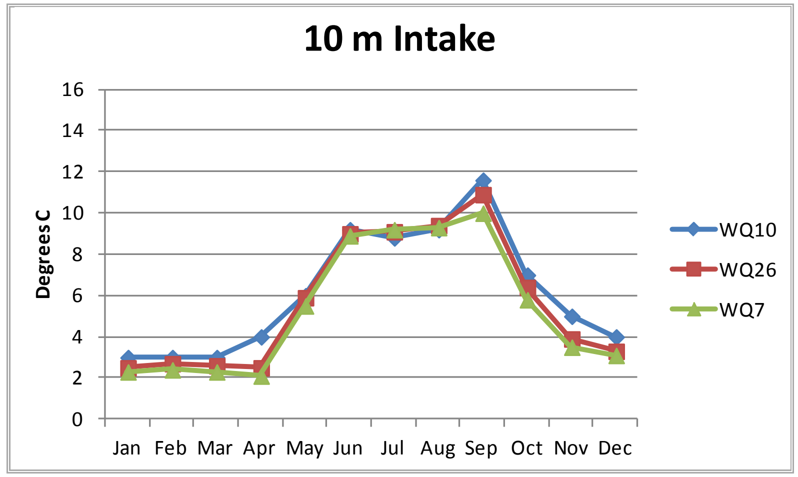




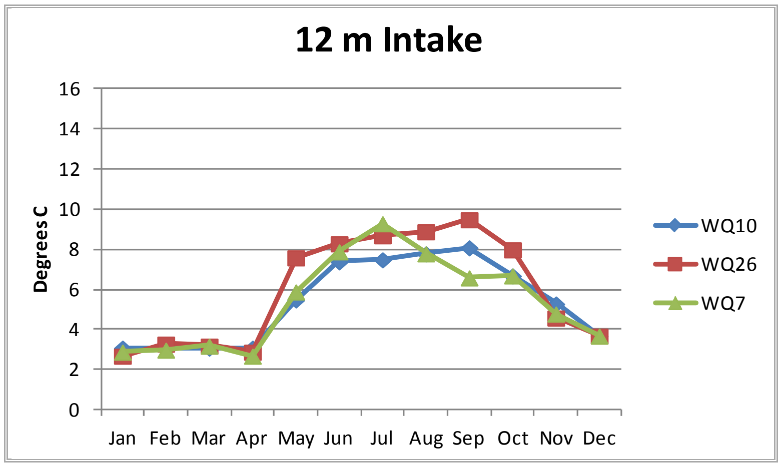


Figure 5.3.8-10: Predicted Monthly Temperature Comparisons in Davidson Creek with 8 m, 10 m and 12 m Water Intakes in Tatelkuz Lake

Changes in water temperature of Davidson Creek during construction, operations, closure and post-closure will have multiple effects on fish, as follows:

- Warmer winter temperatures will increase the rate of kokanee embryo development and result in earlier emergence times for kokanee fry. They will also increase growth of juvenile rainbow trout overwintering in Davidson Creek;
- Cooler spring temperatures will not affect rainbow trout spawn timing, which is the same in all streams of the LSA despite wide differences among streams in June water temperatures. In any event, spring water temperatures for all intake depths are predicted to be similar to baseline water temperatures; and
- Cooler summer water temperatures will reduce growth of juvenile rainbow trout. They may also affect the spawning timing of kokanee, although that effect is questionable because the kokanee spawning run is initiated by environmental cues originating in Tatelkuz Lake.

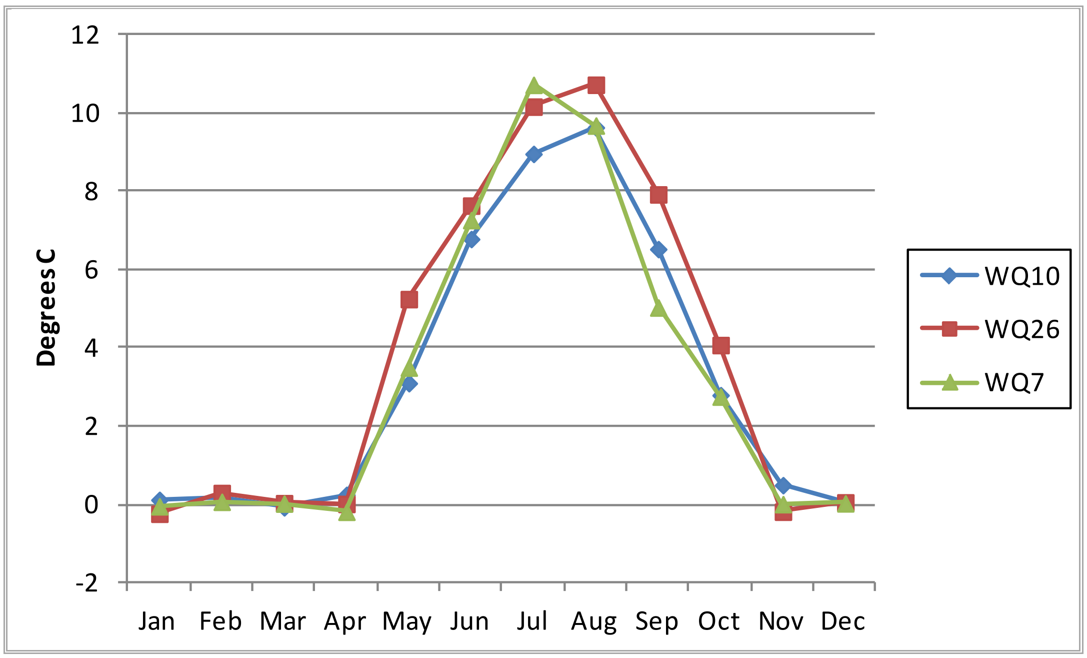
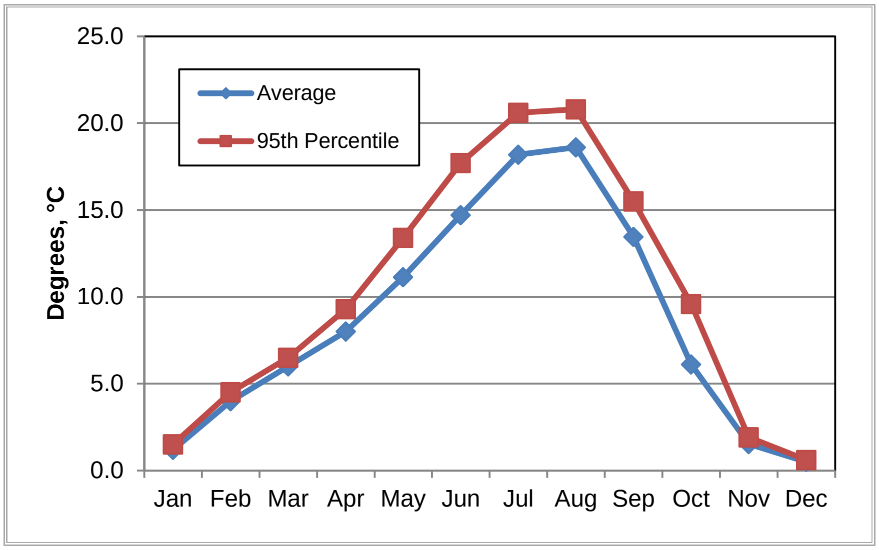


Figure 5.3.8-11: Measured Temperatures at Three Locations on Davidson Creek



Month	Average	95th Percentile
Jan	1.2	1.5
Feb	4.0	4.5
Mar	6.0	6.5
Apr	8.0	9.3
May	11.1	13.4
Jun	14.7	17.7
Jul	18.2	20.6
Aug	18.6	20.8
Sep	13.4	15.49
Oct	6.1	9.59
Nov	1.5	1.92
Dec	0.5	0.6
1.2	Estimated	
11.1	Measured	

Figure 5.3.8-12: Measured and Estimated Snake Lake Surface Water Temperature

Baseline temperatures in Davidson Creek are generally lower than the BC optimum ranges for rainbow trout (**Figure 5.3.8-13**), but they fall within the BC optimum ranges for kokanee (**Figure 5.3.8-14**). (Note that the baseline temperature envelope shown in both figures was based on pooled water temperatures measured in lower and middle Davidson Creek.)

In summary, flow augmentation will produce winter water temperatures that will be warmer than baseline regardless of intake depth. Summer water temperatures will move closer to the BC optima for rainbow trout for an intake depth of 8 m and farther away for an intake depth of 12 m. A similar conclusion can be made for kokanee, although the scale of the changes compared to the BC optima will be lower than for rainbow trout.

Post-closure temperatures will be similar to baseline in the winter and slightly higher in summer.

Changes in water temperature may cause changes in spawning timing, emergence timing, and growth rates. These, in turn, may produce demographic effects measureable as changes in fish number and density (**Table 5.3.8-27**).

Table 5.3.8-26: Calculated Davidson Creek Water Temperature (°C) at the Plunge Pool with TSF Discharge and Seepage

Month	Discharge (m^3/month)	Discharge (L/s)	Seep (L/s)	Percent Discharge	Percent Seep	TSF Temp. (°C)		GW Temp. (°C)		Plunge Pool Temp. (°C)		Davidson Creek Temp. (°C) at WQ10	
						Mean	95th %ile	Mean	95th %ile	Mean	95th %ile	Baseline	Operations/Closure
Jan	139,592	52.1	55.8	48%	52%	1.2	1.5	6.0	8.4	3.7	5.1	0.02	0.13
Feb	112,759	46.6	55.8	46%	54%	4.0	4.5	6.0	8.4	5.1	6.6	0.04	0.15
Mar	160,917	60.1	55.8	52%	48%	6.0	6.5	6.7	8.4	6.4	7.4	0.04	-0.07
Apr	1,038,831	400.8	55.8	88%	12%	8.0	9.3	6.4	8.4	7.8	9.2	0.03	0.25
May	2,017,618	753.3	55.8	93%	7%	11.1	13.4	6.2	8.4	10.8	13.0	1.07	3.11
Jun	1,985,895	766.2	55.8	93%	7%	14.7	17.7	8.1	9.3	14.2	17.1	5.05	6.79
Jul	369,218	137.9	55.8	71%	29%	18.2	20.6	10.3	13.3	15.9	18.5	8.81	8.96
Aug	209,019	78	55.8	58%	42%	18.6	20.8	12.9	17.4	16.2	19.4	8.63	9.64
Sep	227,601	87.8	55.8	61%	39%	13.4	15.49	7.9	11.2	11.3	13.8	6.40	6.53
Oct	283,460	105.8	55.8	65%	35%	6.1	9.59	7.2	10.0	6.5	9.7	1.98	2.80
Nov	228,831	88.3	55.8	61%	39%	1.5	1.92	6.5	9.3	3.5	4.8	0.21	0.50
Dec	160,028	59.7	55.8	52%	48%	0.5	0.6	5.9	8.6	3.1	4.4	0.03	0.05

Note: Taken from **Table 5.3.3-23** of **Section 5.3.3**
TSF discharge and seepage estimates from Knight Piésold
TSF Temperature assumed to be Snake Lake surface temperature
Disch = discharge; Seep = groundwater seepage; temp = temperature (°C); L/s = litres per second; 95th %ile = 95th percentile

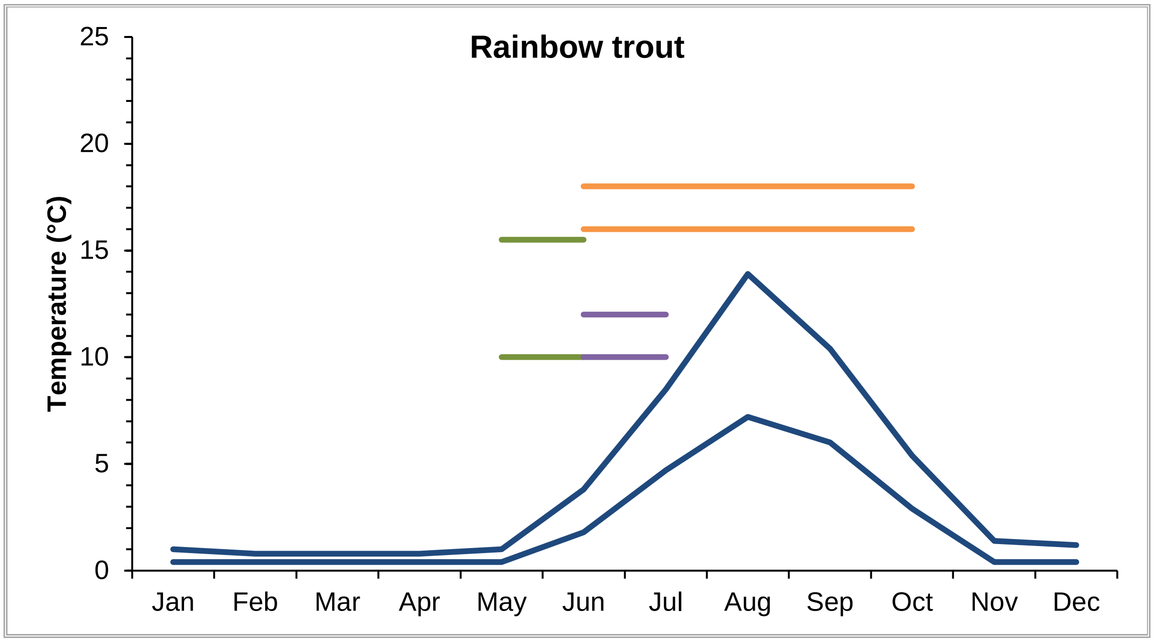


Figure 5.3.8-13: Baseline Water Temperature Envelope of Lower and Middle Davidson Creek (blue) Compared to BC Guidelines for Rainbow Trout Spawning (Green), Incubation (Purple), and Rearing (Orange)

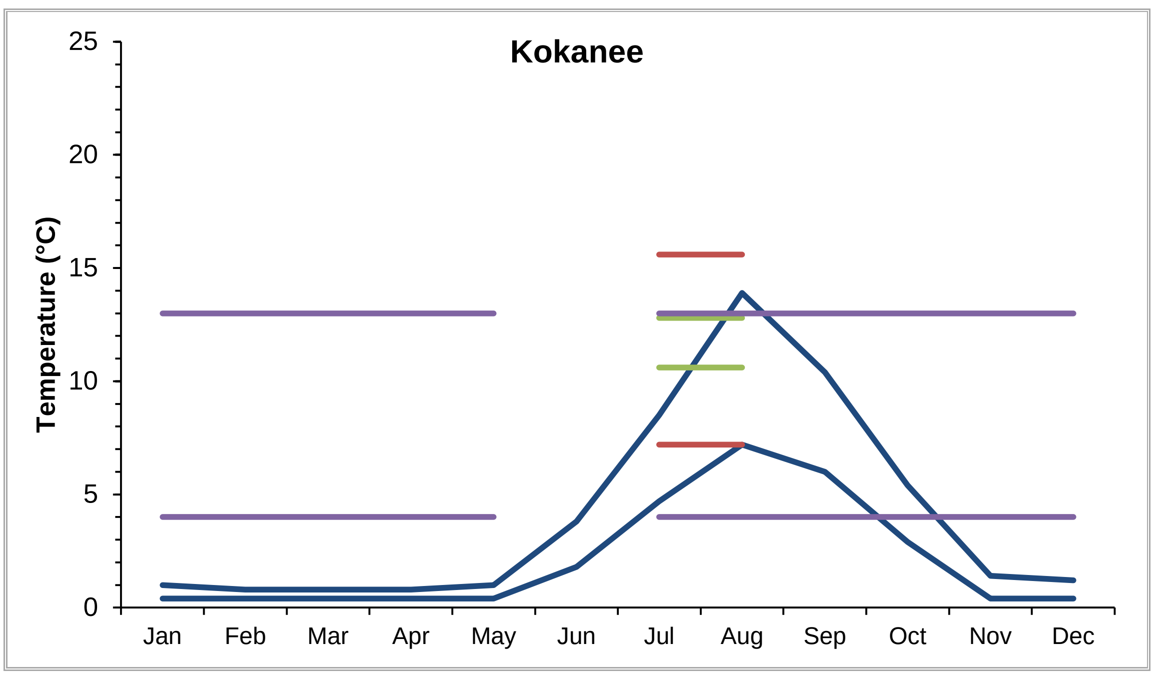


Figure 5.3.8-14: Baseline Water Temperature Envelope of Lower and Middle Davidson Creek (blue) Compared to BC Guidelines for Kokanee Migration (red), Spawning (green), and Incubation (purple)

Table 5.3.8-27: Potential Effects on Fish of Changes in Water Temperature of Davidson Creek Caused by Flow Augmentation

Potential Environmental Effect	Project Phase	Likelihood of Occurrence before Mitigation
Change in growth rates of fish	Construction/ Operations/Closure	Likely
Change in fish embryo survival and incubation times	Construction/ Operations/Closure	Likely
Change in fish escapement, spawning timing and spawning success	Construction/ Operations/Closure	Likely
Change in fish densities	Construction/ Operations/Closure	Likely

5.3.8.3.2.6.2 Mitigation Measures

During late construction (when the FSS is operational), operations and closure, water will be pumped from Tatelkuz Lake at an intake depth (~10 m) that will result in water temperatures in Davidson Creek that will be most similar to baseline temperatures (**Table 5.3.8-28**).

The secondary mitigation measure will be the operation of the TFCS, consisting of temperature and flow measurement devices and associated control logic feedback loops on the discharge pipeline. A reservoir bypass line will connect directly to the water supply pipeline to allow for direct discharge of the required IFN during reservoir maintenance. It can also be used to provide cooler water as required for fisheries in Davidson Creek.

That system has yet to be designed so its ability to control temperature and flows is not yet known. Therefore, for the purpose of effects assessment, it was assumed that it will have no effect. This is a conservative assumption because it means that the magnitude of actual effects will be smaller than predicted.

The success of these two mitigation measures in reducing temperature change from baseline is classified as moderate due to the uncertainties involved in predicting water temperature (described in **Section 5.3.3**).

Once water enters Davidson Creek it will continue to be influenced by natural factors such as air temperature, solar heating, and groundwater upwelling.

Since winter water temperatures in Davidson Creek will be higher than baseline during flow augmentation, regardless of intake depth, these effects were carried forward to residual effects assessment.

Table 5.3.8-28: Mitigation Measures to Reduce Effects on Fish of Temperature Changes Caused by Mine Site Activities

Likely Environmental Effect	Project Phase	Mitigation/ Enhancement Measure	Mitigation Success Rating
Change in growth of fish	Construction/ Operations/ Closure	Tatelkuz Lake FSS intake will be located at a depth that will produce temperatures appropriate for Davidson Creek. Operation of TFCS.	Moderate
Change in fish embryo survival and incubation times	Construction/ Operations/ Closure	Tatelkuz Lake FSS intake will be located at a depth that will produce temperatures appropriate for Davidson Creek. Operation of TFCS.	Moderate
Change in fish escapement, spawning timing and spawning success	Construction/ Operations/ Closure	Tatelkuz Lake FSS intake will be located at a depth that will produce temperatures appropriate for Davidson Creek. Operation of TFCS.	Moderate
Change in fish densities due to changes in water temperature	Construction/ Operations/ Closure	Tatelkuz Lake FSS intake will be located at a depth that will produce temperatures appropriate for Davidson Creek. Operation of TFCS.	Moderate

5.3.8.3.3 Mine Access Road

5.3.8.3.3.1 Potential Effects on Fish

All five permanent streams crossed by the mine access road are either confirmed or assumed to be fish-bearing (**Table 5.3.8-13**). The four non-classified drainages do not support fish and, therefore, are not discussed further.

Potential effects on fish (as opposed to fish habitat) of construction, operations, and closure of the new mine access road at the five permanent watercourses along its route were based on the DFO *Pathways of Effects* diagrams for five near-water activities: *Cleaning or Maintenance of Bridges or Other Structures* (DFO, 2010i), *Vegetation Clearing* (DFO, 2010e), *Use of Industrial Equipment* (DFO, 2010h), *Placement of Material or Structures in Water* (DFO, 2010b) and *Grading* (DFO, 2010f). They include the following:

- Impediments or barriers to upstream and downstream fish passage at stream crossings;
- Direct fish mortalities or injuries resulting from instream construction activities or stream ford crossings by heavy machinery, if these activities are required;
- Indirect effects on fish as a result of increased TSS concentrations caused by clearing of vegetation, grading of road surfaces, and exposure of soils along the creek banks, and mobilization of sediments in the stream channels due to fording or site preparation by heavy machinery and due to input of sediments to creeks during road grading:
  - Effects on fish include impaired respiration, altered behaviour (e.g., migration patterns) changed feeding efficiency, and predator detection;

- o Effects on developing fish embryos includes reduced oxygen availability and mortality, as a result of deposition of sediments; and
- o Indirect effects on primary production and benthic invertebrate production upon which fish depend for food as a result of increased TSS concentrations.

- Decreased fish health, growth, and/or survival as a result of spills or leaks of deleterious substances, including fuel, oil, and grease.

(Note that this list of potential effects differs from the list shown for fish in **Section 5.3.9.3.3.1** because it includes strictly fish-related potential effects such as barriers to upstream or downstream passage, direct mortality to fish, and potential effects to fish respiration and embryo survival.)

Without mitigation, the proposed mine access route may adversely affect rainbow trout at the crossings of the five fish-bearing streams along the proposed route (**Table 5.3.8-29**). Only effects to rainbow trout are considered, because kokanee are not present in the five watercourses.

Table 5.3.8-29: Potential Effects on Fish of the Mine Access Road without Mitigation

Potential Environmental Effect	Project Phase	Likelihood of Occurrence without Mitigation
Interruption of fish passage at stream crossing sites	Construction/Closure	Likely
Direct mortality or injury to fish at the crossing site due to construction activities	Construction/Closure	Likely
Decreased growth, reduced disease resistance, or mortality of fish due to elevated TSS concentrations	Construction/Operations/ Closure	Likely
Delayed or impaired development of eggs due to increased sedimentation	Construction/Operations/ Closure	Likely
Reduced growth and survival caused by spills or leakage of fuels or deleterious substances into streams	Construction/Operations/ Closure	Likely

5.3.8.3.3.2 Mitigation Measures

To minimize or eliminate each of these potential effects to rainbow trout, the following mitigation measures will be implemented during the construction, operation, and closure of the route and the stream crossings required at the five permanent watercourses along the route (**Table 5.3.8-30**).

Table 5.3.8-30: Mitigation Measures to Eliminate or Reduce Potential Effects to Fish due to the Mine Access Road

Potential Environmental Effect	Project Phase	Mitigation/ Enhancement Measure	Mitigation Success Rating
Direct mortality or injury to fish at the crossing site due to construction activities	Construction/ Closure	If instream construction is required, then work areas will be isolated and fish salvage will be completed. Instream works will be avoided or minimized to the maximum extent possible. Machinery will be allowed to ford the stream for one-time access to construct a stream crossing. Temporary single span bridges may be used.	High
Decreased growth, reduced disease resistance, or mortality of fish due to elevated TSS concentrations	Construction/Operations/ Closure	Erosion and sediment control measures (e.g., riprap armouring, erosion control matting, and hydro seeding) will be used to protect erodible soils. Grader operators will follow guidelines to prevent sediment deposition in accordance with the road grading environmental management plan.	High
Delayed or impaired development of embryos due to increased sedimentation	Construction/Operations/ Closure	Erosion and sediment control measures (e.g., riprap armouring, erosion control matting, and hydro seeding) will be used to protect erodible soils. Grader operators will follow guidelines to prevent sediment deposition in accordance with the road grading environmental management plan.	High
Interruption of fish passage at the watercourse crossing sites	Construction/Closure	Instream works will be avoided or minimized. Instream works, if necessary, will be conducted during the reduced risk timing window for rainbow trout (15 July to 15 April of the following year) to avoid interruptions to spawning migrations.	High
Reduced growth and survival caused by spills or leakage of fuels or deleterious substances into watercourses.	Construction/Operations/Closure	An emergency spill response kit will be kept on-site during any construction. Fuels will be stored and refuelling will be conducted outside of riparian areas at all times. Ensure that machinery arrives on site in a clean condition and is maintained free of fluid leaks.	High

All proposed stream crossing techniques will follow guidelines set out in the *Fish-Stream Crossing Guidebook* (BC MOF, 2012). Fish-bearing stream protection practices will be implemented during all phases of construction, operations, and closure in accordance with Section 5 of that guidebook.

Erosion control measures presented below will be implemented to protect erodible soils and minimize sediment inputs to watercourses. Additional erosion control measures detailed in the SECP (**Section 12.2.1.18.4.1**) will also be employed.

Clear-span bridges will be constructed and maintained following guidelines and mitigation measures outlined in DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013a), including:

- Approaches to the water body will be designed and constructed such that they are perpendicular to the watercourse to minimize loss or disturbance to riparian vegetation;

- Structures will not be built on meander bends, braided streams, alluvial fans, active floodplains or any other area that is inherently unstable and may result in erosion and scouring of the streambed or the built structures;
- Abutments of all bridges will be located above the high water level of each watercourse;
- Cross drains will typically be placed in seepage zones and in areas of low elevation to minimize disruption to local drainage patterns;
- Fords by construction machinery may be necessary to allow one-time access to construct stream crossings;
- Road surfaces will be monitored for increased erosion and sedimentation and repairs will be made if needed; and
- Bridge and culvert installation will be timed so that instream works will be completed within the BC MOE reduced risk timing window for rainbow trout (15 July to 15 April of the following year) for Region 7 (Omineca) (BC MOE, 2004). Culvert design will be contingent on the nature of the crossing.

All of the mitigation measures proposed above are commonly and widely used around BC during road construction. None of these measures are unique nor are they unsuitable for the streams to be crossed by the proposed mine access road. For these reasons, all of these mitigation measures are anticipated to be highly effective for eliminating or, at most, leaving only negligible residual effects to fish habitat in the five permanent streams along the mine access road. Confidence in this assessment is high and, for this reason, potential effects of the mine access road on fish were not carried forward to the residual effects assessment.

5.3.8.3.4 Freshwater Supply System (FSS)

There are four potential classes of effects on fish by the FSS caused by the following:

- Physical footprint of the intake structure on the shoreline of Tatelkuz Lake;
- Changes in water surface elevation (WSE) of Tatelkuz Lake due to the volume of water pumped from Tatelkuz Lake;
- Stream crossings along the water pipeline corridor; and
- Physical footprint of the freshwater reservoir on the mine site.

This section assesses each class of potential effects, other than changes in stream flows, which were addressed previously in **Section 5.3.8.3.2.2**.

5.3.8.3.4.1 Potential Effects on Fish of the Tatelkuz Lake Intake Structure

5.3.8.3.4.1.1 Potential Effects

Construction of the Tatelkuz Lake inlet structure and the associated laydown area, and its decommissioning during closure, may result in sediment input to the lake (**Table 5.3.8-31**). Increased concentrations of TSS in the lake can affect fish by impairing respiration, altering behaviour (e.g., migration patterns), and changing feeding efficiency and predator detection. Deposition of sediment on developing fish embryos may reduce oxygen availability and cause mortality.

Table 5.3.8-31: Potential Effects on Fish of the Tatelkuz Lake Inlet Structure

Potential Environmental Effect	Project Phase	Likelihood of Occurrence Without Mitigation
Adverse effects on fish health and mortality of fish embryos caused by increased sediment erosion from areas disturbed during construction and closure	Construction/Closure	Likely
Reduced growth and survival caused by spills or leakage of fuels or deleterious substances into Tatelkuz Lake	Construction/Operations/Closure	Likely
Mortality due to impingement of fish on intake pipe screens and entrainment into pumps	Construction/Operations/Closure	Likely

The use of heavy machinery during construction and closure of the intake facility may cause erosion of sediments into the lake and release spills of oil and grease into the lake (DFO, 2010h).

Finally, direct mortality of fish may be caused by impingement of fish on the intake screens of the pipes or by entrainment of fish through the pipes and into pumps.

5.3.8.3.4.1.2 Mitigation Measures

To minimize or eliminate the potential effects of sedimentation to fish in Tatelkuz Lake, the following mitigation measures taken from DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013a) will be implemented during construction, operations and closure of the intake structure (**Table 5.3.8-32**):

- Where feasible, schedule work to avoid wet, windy and rainy periods that may increase erosion and sedimentation;
- Install effective erosion and sediment control measures before starting work to prevent sediment from entering the water body;
- Implement measures for containing and stabilizing waste material from construction materials above the high water mark of nearby waterbodies;

- Conduct regular inspection and maintenance of erosion and sediment control measures and structures during the course of construction and closure;
- Repair erosion and sediment control measures and structures if damage occurs;
- Remove non-biodegradable erosion and sediment control materials once site is stabilized;
- Minimize clearing of riparian vegetation;
- Minimize removal of natural woody debris, rocks, sand or other materials from banks, the shoreline or the bed of the lake below the ordinary high water mark;
- Ensure machinery arrives on site in clean condition and is maintained free of fluid leaks, invasive species and noxious weeds;
- Whenever possible, operate machinery on land above the high water mark in a manner that minimizes disturbance to the banks and bed of the waterbody; and
- Wash, refuel and service machinery and store fuel and other materials for the machinery in such a way to prevent any deleterious substances from entering the water.

Table 5.3.8-32: Mitigation Measures to Eliminate or Reduce Potential Effects to Fish due to the Tatelkuz Lake Inlet Structure

Likely Environmental Effect	Project Phase	Mitigation/Enhancement Measures	Mitigation Success Rating
Adverse effects on fish health and mortality of fish embryos caused by increased sediment erosion from areas disturbed during construction and closure	Construction/Closure	Implementation of erosion and sediment control measures.	High
Reduced growth and survival caused by spills or leakage of fuels or deleterious substances into Tatelkuz Lake	Construction/ Operations/ Closure	An emergency spill response kit will be kept on-site during all construction and closure activities near watercourses. Ensure that machinery arrives on site in a clean condition and is maintained free of fluid leaks. Fuels will be stored off-site and refuelling will be conducted outside of instream and riparian areas.	High
Mortality due to impingement of fish on intake pipe screens and entrainment into pumps	Construction/ Operations/ Closure	Screens as required by DFO (1995, 2013) for intake pipes.	High

The intake pipes from Tatelkuz Lake will follow the DFO (1995, 2013a) requirements by placing a screen on the intake pipe to prevent impingement and entrainment. Design of pipes and screens will include the following:

- Openings in the guides and seals will be less than opening criteria to make “Fish tight”;
- Screens will be located a minimum of 300 mm above the bottom of the lake to prevent entrainment of sediment and aquatic organisms associated with the bottom area;

- Structural support will be provided to the screen panels to prevent sagging and collapse;
- Screens will have manifolds installed in them to ensure even water velocity distribution across the screen surface. The ends of the structure will be made out of solid materials and the end of the manifold will be capped;
- Heavier cages will be fabricated out of bar or grating to protect the finer fish screen. Spacing of 150 mm between bars is typical;
- Provisions will be made for removal, inspection and cleaning of the screens;
- Regular maintenance and repair of the seals and screens will be carried out to prevent debris-fouling and impingement of fish; and
- Pumps will be shut down when fish screens are removed for inspection and cleaning.

All of the mitigation measures proposed above are commonly and widely used around BC. None of these measures are unique nor are they unsuitable for the lake intake pipes. For these reasons, all of these mitigation measures are anticipated to be highly effective for eliminating or, at most, leaving only negligible residual effects to fish habitat from the intake structure and pipe. Confidence in this assessment is high and, for this reason, potential effects of the Tatelkuz Lake intake on fish habitat were not carried forward to residual effects assessment.

5.3.8.3.4.2 Potential Effects on Fish of Changes in Water Surface Elevation (WSE) of Tatelkuz Lake

5.3.8.3.4.2.1 Potential Effects

Tatelkuz Lake supports 10 species of fish including kokanee, rainbow trout, mountain whitefish, northern pikeminnow, slimy sculpin, longnose sucker, brassy minnow, largescale sucker, white sucker, and burbot (**Section 5.1.2.6** and **Appendix 5.1.2.6B**). Variation of the WSE of Tatelkuz Lake caused by pumping water to the mine site may have direct and indirect effects on those fish (**Table 5.3.8-33**).

These potential effects differ from those listed for the fish VC in **Table 5.3.9-42** because effects assessment in **Section 5.3.9** was focused on fish habitat, not fish.

The magnitude, frequency and ultimate consequence of these potential effects on fish depends on the magnitude and frequency of the drawdown. For hydroelectric reservoirs with annual drawdown on the order of tens of metres, these potential effects have strong impacts on fish in the littoral zone, but for Tatelkuz lake, where annual drawdown will be on the order of tens of centimetres, these potential effects will have much less impact on fish residing in the littoral zone.

Due to the magnitude of withdrawals and modelling based on a detailed lake bathymetry, potential effects will only occur in the upper 1 m of the littoral zone. (The littoral zone is defined as the habitat within 6 m of the lake surface.)

Table 5.3.8-33: Potential Effects on Fish of Water Diversion from Tatelkuz Lake

Potential Environmental Effect	Project Phase	Likelihood of Occurrence Without Mitigation
Mortality of fish embryos caused by dewatering of some areas of the littoral zone	Construction/Operations/ Closure	Unlikely
Displacement or stranding of fish caused by dewatering of some areas of the littoral zone	Construction/Operations/ Closure	Unlikely
Reduction of BMI production that provides prey for fish due to reduction in littoral habitat	Construction/Operations/ Closure	Likely
Decreased growth, reduced disease resistance, or mortality of fish due to elevated TSS caused by erosion of shoreline	Construction/Operations/ Closure	Likely

Potential effects of water extraction all flow from the dewatering of some areas of the upper 1 m of the littoral zone of Tatelkuz Lake and of lower Chedakuz Creek, leading to possible mortality of eggs and displacement or stranding of fish. These two potential effects are unlikely because fish will rarely place eggs so close to the water surface if there is a danger of exposure to air, and because the rate of change of the WSE will be too slow to cause stranding of fish.

Loss of BMI production (which is prey for fish), and adverse effects on fish health due to increased TSS caused by erosion of sediment are possible and not improbable.

To assess the probability of those potential effects, the rest of this section evaluates the use of the littoral zone of Tatelkuz Lake by the two indicator species – rainbow trout and kokanee – and by mountain whitefish. All three species use littoral zone habitat in Tatelkuz Lake for feeding and rearing. Rainbow trout are obligatory stream spawners; their juveniles rear in streams before migrating to residence lakes. Kokanee in the aquatics LSA also spawn in tributary streams. They are the single most abundant fish species in stream habitat when they emerge from Tatelkuz Lake to spawn in late summer and fall. Although beach spawning in lakes has been reported for some kokanee populations (e.g., in Okanagan Lake), there are no records of kokanee beach spawning in Tatelkuz Lake nor any TK information to suggest that kokanee beach spawning occurs in that lake. There are also no records or TK information to suggest that mountain whitefish – the third most common fish species in Tatelkuz Lake and a component of recreational and Aboriginal fisheries – spawns in the littoral zone of Tatelkuz Lake. It is more likely that mountain whitefish spawn in Chedakuz Creek. However, an assessment of the potential effects of lake drawdown on mountain whitefish spawning was conducted to be conservative.

Assessment was based on comparing the amount and quality of predicted Tatelkuz Lake littoral zone fish habitat with and without pumping and under scenarios of average precipitation and 1:50 “dry” years. “Wet” years are not considered because wetter conditions increase the amount and quality of littoral zone fish habitat compared to the average scenario. **Section 5.3.9.4.2** describes in detail how fish habitat area was modelled. This section summarises those results in terms of Habitat Units (HU) derived by multiplying habitat area by Habitat Suitability Indices (HSI) (see **Appendix 5.1.2.6C**).

HSI indexes fish habitat quality as a function of variables such as depth, substrate type and the presence or absence of vegetation cover. HU were the currency of comparisons between baseline and Project conditions, and were calculated for littoral fish habitat in Tatelkuz Lake by multiplying the total area in the 0 to 1 m depth stratum by HSI for kokanee and rainbow trout, following standard methods for the quantification of lake habitat (Bradbury et al., 2001).

HSI rankings were based on a review of the scientific literature on habitat preferences of lake-dwelling fish (Roberge et al, 2001), and on a hydroacoustic and fish sampling program in Tatelkuz Lake in July 2013 (**Section 5.1.2.6**; **Appendix 5.1.2.6B**; **Table 5.3.8-34**). Rainbow trout abundance (as indexed by gillnet CPUE) in Tatelkuz Lake was highest in nearshore (0 m to 5 m) habitat during the day. Juveniles prefer cover in the form of cobble/boulder substrates and the presence of woody debris. Empty cells in **Table 5.3.8-34** indicate no data were available.

Baseline studies on kokanee in Tatelkuz Lake indicated that they use nearshore 0 to 5 m-deep habitat, but were most abundant in the offshore 0 to 5 m depth layer (**Section 5.1.2.6** and **Appendix 5.1.2.6B**) (**Table 5.3.8-35**). Beach or shoal spawning of kokanee in Tatelkuz Lake was not observed during baseline studies in 1977 and 2013, and none was reported in the historical literature or by TK respondents. However, the conservative assumption for this analysis was that some beach spawning may occur in some years.

Table 5.3.8-34: Rainbow Trout HSI for Lake Habitat

Zone	Habitat Features	Ratings[1]			
		Spawning	YOYs	Juveniles	Adults
Littoral	**Depths**				
	0-1 m	M	H	M	L
	1-2 m	M	H	H	H
	2-5 m	L	M	H	H
	5-10 m		L	L	M
	>10 m				L
	Substrates				
	Bedrock (>4,000 mm)				
	Boulder (>256 mm)		L	H	H
	Cobble (64 to 256 mm)		H	H	H
	Gravel (2 to 64 mm)	H	M	M	M
	Sand (<2 mm)	L	L	L	L
	Silt				
	Muck				
	Clay				
	Cover				
	Submergents				
	Emergents				
	Overhead		M	M	M
	In situ[2]		H	H	H

Source: Roberge et al. (2001)

Note: [1]ratings are: N = nil (rarely associated); L = low (infrequently associated);
M = Moderate (frequently associated); H = high (nearly always associated).
[2] includes riparian vegetation, undercut banks, and large woody debris (LWD) within 1 m of water surface

Table 5.3.8-35: Kokanee HSI for Lake Habitat

Zone	Habitat Features	Ratings(1)			
		Spawning	YOYs	Juveniles	Adults
Littoral	**Depths**				
	0-1 m	H	H	H	H
	1-2 m	L	H	H	H
	2-5 m		H	H	H
	5-10 m		H	H	H
	>10 m		H	H	H
	Substrates				
	Bedrock (>4,000 mm)				
	Boulder (>256 mm)				
	Cobble (64 to 256 mm)	H	M		
	Gravel (2 to 64 mm)	H	M		
	Sand (<2 mm)				
	Silt				
	Muck				
	Clay				
	Cover				
	Submergents				
	Emergents				
	Overhead				
	In situ(2)				

Source: Roberge et al. (2001).

Note: (1) Ratings are: N = nil (rarely associated); L = low (infrequently associated); M = moderate (frequently associated); and H = high (nearly always associated).
(2)includes riparian vegetation, undercut banks, and LWD within 1 m of water surface.

HSI were assigned numerical values, as follows: nil (N) = 0.00, low (L) = 0.33, medium (M) = 0.67, high (H) = 1.00. Aggregate HSI values were calculated for habitat categories combining depth and substrate. **Appendix 5.1.2.6C** provides the details of this analysis.

To calculate a HSI for each category of depth, substrate and vegetation, the numerical HSI value was averaged between each category (**Table 5.3.8-36**). If there was no value reported for one of two of the categories, then the single non-zero value was carried forward. When averaging a depth with a substrate that was assigned an HSI of zero, a zero was assigned if logical. For example, if a depth of 0-1 m is given a high HSI (1.0) for rainbow trout, while boulder is given a low HSI (0.0) it is unlikely that rainbow trout will use boulder habitat if this substrate was present at a depth at which they would normally rear (Roberge et al., 2001).

Table 5.3.8-36: HSI for each Littoral Habitat Category for Each Fish Indicator Species

Species	Life Stage	Littoral Habitat Class											
		Bc-NV	Bc-SV	Cb-NV	Cb-SV	Cg-NV	Fg-EV	Fg-NV	Fg-SV	Gc-NV	Gf-EV	Gf-NV	Gf-SV
RB	Spawning	0.13	0.13	0.38	0.38	0.58	0.58	0.58	0.58	0.75	0.75	0.75	0.75
	YOY	0.75	0.75	0.92	0.92	0.96	0.71	0.71	0.71	0.88	0.79	0.79	0.79
	Juvenile	0.71	0.71	0.79	0.79	0.79	0.54	0.54	0.54	0.71	0.63	0.63	0.63
	Adult	0.54	0.54	0.62	0.62	0.58	0.33	0.33	0.33	0.41	0.33	0.33	0.33
KO	Spawning	0.25	0.25	0.75	0.75	1.00	0.25	0.25	0.25	1.00	0.75	0.75	0.75
	YOY	0.21	0.21	0.63	0.63	0.84	0.21	0.21	0.21	0.84	0.63	0.63	0.63
	Juvenile	0.25	0.25	0.75	0.75	1.00	0.25	0.25	0.25	1.00	0.75	0.75	0.75
	Adult	0.25	0.25	0.75	0.75	1.00	0.25	0.25	0.25	1.00	0.75	0.75	0.75

Note: Only for 0-1 m depth class. RB = rainbow trout; KO = kokanee; YOY = young of the year, Gf = gravel dominant/fines subdominant; Gc = Gravel dominant/cobble subdominant; Cg = Cobble dominant/gravel subdominant; Cb = Cobble dominant/boulder subdominant; Bc = Boulder dominant/cobble subdominant; Fg = Fines dominant/gravel subdominant; NV = no vegetation; EV = emergent vegetation; SV = submergent vegetation.

Vegetation was not assigned a HSI for either rainbow trout or kokanee and was therefore left out of the calculation. Where there was no value for vegetation, habitat with the same substrate classification but different vegetation classification was given the same value. Because the littoral habitat was classified by dominant and subdominant substrates, a weighted mean of the two substrate HSI scores was calculated. Dominant substrate was given 0.75 while subdominant was assigned a weight of 0.25.

Finally, HU were calculated by multiplying the HSI for each life stage and littoral habitat class by the area of that littoral habitat class available in the 0 to 1 m depth strata. HU were summarized by each fish indicator species, all life stages, and each project phase for both an average annual year and a 1:50 year dry (**Table 5.3.8-37**).

For rainbow trout there is a less than 2.6% loss of HU from baseline conditions for any phase of the project (**Table 5.3.8-37** and **Figure 5.3.8-15** and **Figure 5.3.8-16**). There are negligible changes in HU during the construction phase (maximum of -0.01%) and the post-closure phase (0.00%) compared to baseline, for both the average scenario and the 1:50 dry year scenario.

During an average year, the largest reduction in HU compared to baseline conditions will occur in winter. For all other seasons, species and life stage combinations (with the exception of adult rainbow trout during the spring) show increased numbers of HU.

For the 1:50 dry year scenario, all seasons show reduced HU compared to baseline conditions.

For kokanee, there is a less than 1.6% loss of HU from baseline conditions for any phase of the project (**Table 5.3.8-38** and **Figure 5.3.8-17** and **Figure 5.3.8-18**). The largest departure from baseline conditions occurs in spring (May).

In summary, the potential effects on fish of changes in WSE of Tatelkuz Creek as a result of pumping water from the lake to the mine site fall within the natural range of variability and so were assessed as negligible in magnitude.

Table 5.3.8-37: Change in Rainbow Trout HU in the 0 to 1 m Depth Stratum of Tatelkuz Lake between Baseline and Project Phases

Scenario	Life Stage	Season	Project Phase								
			Baseline	Construction		Operations		Closure		Post-Closure	
			HU	HU	(% change)	HU	(% change)	HU	(% change)	HU	(% change)
Average Annual	Spawning	Winter (Jan)	211,534	211,534	0.00	211,015	-0.25	211,130	-0.19	211,534	0.00
		Spring (May)	204,972	204,967	0.00	205,661	0.34	205,657	0.33	204,972	0.00
		Summer (Jul)	211,340	211,343	0.00	212,233	0.42	212,193	0.40	211,340	0.00
		Fall (Oct)	211,400	211,399	0.00	211,537	0.06	211,523	0.06	211,400	0.00
	YOY	Winter (Jan)	162,736	162,736	0.00	162,124	-0.38	162,256	-0.30	162,736	0.00
		Spring (May)	154,081	154,062	-0.01	155,573	0.97	155,564	0.96	154,081	0.00
		Summer (Jul)	162,461	162,464	0.00	163,518	0.65	163,467	0.62	162,461	0.00
		Fall (Oct)	162,786	162,786	0.00	162,734	-0.03	162,749	-0.02	162,786	0.00
	Juvenile	Winter (Jan)	168,187	168,187	0.00	167,774	-0.25	167,866	-0.19	168,187	0.00
		Spring (May)	164,464	164,465	0.00	164,675	0.13	164,675	0.13	164,464	0.00
		Summer (Jul)	168,260	168,261	0.00	168,828	0.34	168,803	0.32	168,260	0.00
		Fall (Oct)	168,097	168,097	0.00	168,189	0.05	168,180	0.05	168,097	0.00
	Adult	Winter (Jan)	107,600	107,600	0.00	107,443	-0.15	107,480	-0.11	107,600	0.00
		Spring (May)	105,966	105,972	0.01	105,837	-0.12	105,838	-0.12	105,966	0.00
		Summer (Jul)	107,509	107,510	0.00	107,807	0.28	107,794	0.26	107,509	0.00
		Fall (Oct)	107,462	107,461	0.00	107,603	0.13	107,584	0.11	107,462	0.00
1:50 Year Dry	Spawning	Winter (Jan)	209,705	209,705	0.00	207,048	-1.27	207,821	-0.90	209,705	0.00
		Spring (May)	211,532	211,528	0.00	208,995	-1.20	209,065	-1.17	211,532	0.00
		Summer (Jul)	210,225	210,219	0.00	207,060	-1.51	207,530	-1.28	210,225	0.00
		Fall (Oct)	205,588	205,595	0.00	200,930	-2.27	201,930	-1.78	205,588	0.00
	YOY	Winter (Jan)	160,802	160,801	0.00	158,375	-1.51	159,059	-1.08	160,802	0.00
		Spring (May)	162,739	162,743	0.00	160,130	-1.60	160,196	-1.56	162,739	0.00

Scenario	Life Stage	Season	Project Phase								
			Baseline	Construction		Operations		Closure		Post-Closure	
			HU	HU	(% change)	HU	(% change)	HU	(% change)	HU	(% change)
		Summer (Jul)	161,305	161,300	0.00	158,386	-1.81	158,798	-1.55	161,305	0.00
		Fall (Oct)	157,118	157,123	0.00	153,066	-2.58	153,924	-2.03	157,118	0.00
	Juvenile	Winter (Jan)	166,750	166,750	0.00	164,693	-1.23	165,289	-0.88	166,750	0.00
		Spring (May)	168,186	168,183	0.00	166,198	-1.18	166,253	-1.15	168,186	0.00
		Summer (Jul)	167,154	167,150	0.00	164,702	-1.47	165,064	-1.25	167,154	0.00
		Fall (Oct)	163,568	163,573	0.00	159,970	-2.20	160,744	-1.73	163,568	0.00
	Adult	Winter (Jan)	106,945	106,945	0.00	105,815	-1.06	106,154	-0.74	106,945	0.00
		Spring (May)	107,596	107,591	0.00	106,654	-0.88	106,683	-0.85	107,596	0.00
		Summer (Jul)	107,153	107,151	0.00	105,821	-1.24	106,028	-1.05	107,153	0.00
		Fall (Oct)	105,158	105,161	0.00	103,078	-1.98	103,532	-1.55	105,158	0.00

Note: HU = habitat unit; % = percent; YOY = young of the year; Jan = January; Jul = July; Oct = October

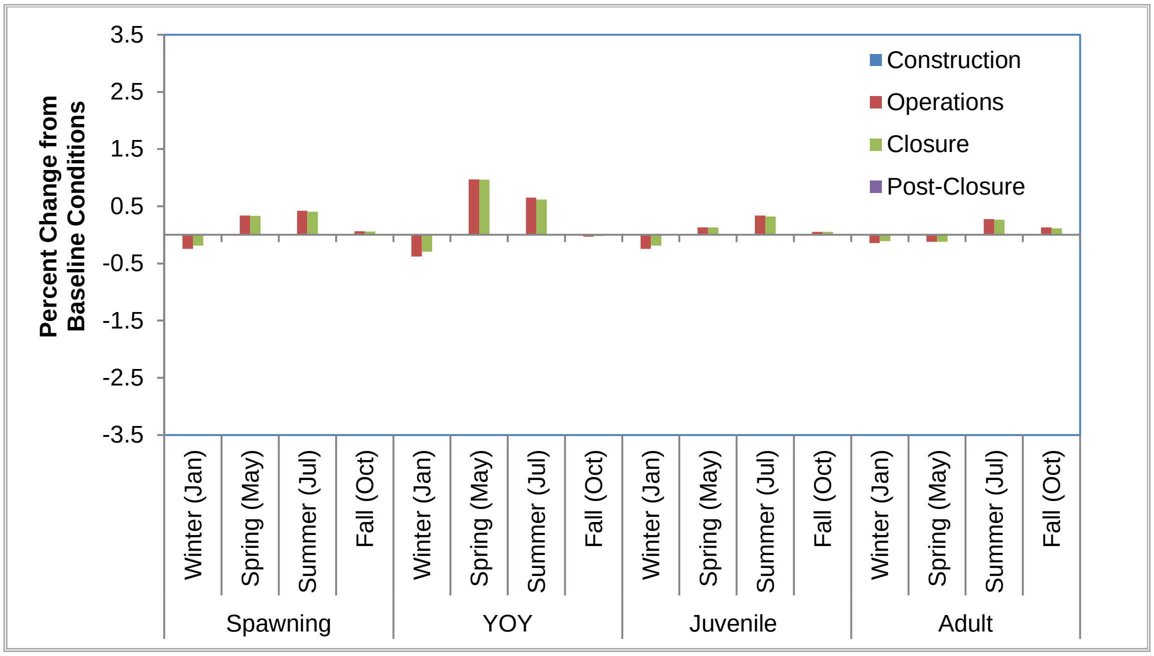


Figure 5.3.8-15: Percent Change in Rainbow Trout HU from Baseline Conditions in an Average Year

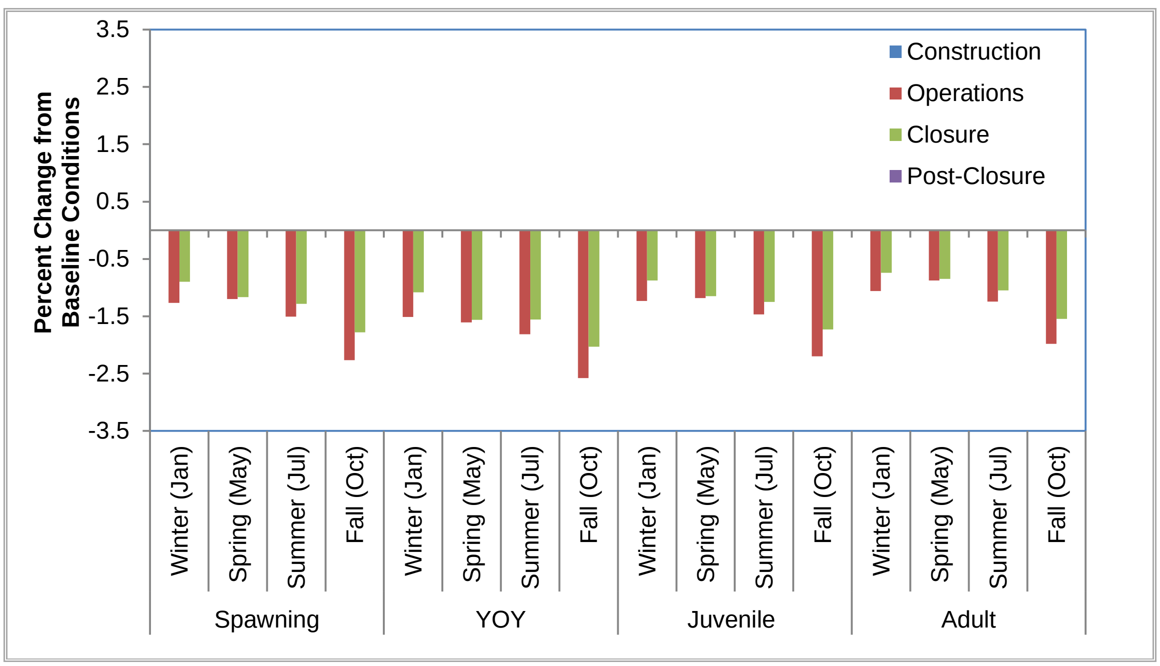


Figure 5.3.8-16: Percent Change in Rainbow Trout HU from Baseline Conditions in a 1:50 Dry Year

Table 5.3.8-38: Change in Kokanee HU in 0 to 1 m Depth Stratum of Tatelkuz Lake between Baseline and Project Phases

Scenario	Life Stage	Season	Project Phase								
			Baseline	Construction		Operations		Closure		Post-Closure	
			HU	HU	(% change)	HU	(% change)	HU	(% change)	HU	(% change)
Average Annual	Spawning	Winter (Jan)	156,063	156,063	0.00	155,362	-0.45	155,507	-0.36	156,063	0.00
		Spring (May)	159,916	159,942	0.02	158,442	-0.92	158,455	-0.91	159,916	0.00
		Summer (Jul)	157,409	157,409	0.00	157,507	0.06	157,508	0.06	157,409	0.00
		Fall (Oct)	156,466	156,467	0.00	156,049	-0.27	156,120	-0.22	156,466	0.00
	YOY	Winter (Jan)	130,313	130,312	0.00	129,727	-0.45	129,848	-0.36	130,313	0.00
		Spring (May)	133,530	133,552	0.02	132,299	-0.92	132,310	-0.91	133,530	0.00
		Summer (Jul)	131,437	131,437	0.00	131,518	0.06	131,519	0.06	131,437	0.00
		Fall (Oct)	130,649	130,650	0.00	130,301	-0.27	130,360	-0.22	130,649	0.00
	Juvenile	Winter (Jan)	156,063	156,063	0.00	155,362	-0.45	155,507	-0.36	156,063	0.00
		Spring (May)	159,916	159,942	0.02	158,442	-0.92	158,455	-0.91	159,916	0.00
		Summer (Jul)	157,409	157,409	0.00	157,507	0.06	157,508	0.06	157,409	0.00
		Fall (Oct)	156,466	156,467	0.00	156,049	-0.27	156,120	-0.22	156,466	0.00
	Adult	Winter (Jan)	156,063	156,063	0.00	155,362	-0.45	155,507	-0.36	156,063	0.00
		Spring (May)	159,916	159,942	0.02	158,442	-0.92	158,455	-0.91	159,916	0.00
		Summer (Jul)	157,409	157,409	0.00	157,507	0.06	157,508	0.06	157,409	0.00
		Fall (Oct)	156,466	156,467	0.00	156,049	-0.27	156,120	-0.22	156,466	0.00
1:50 Year Dry	Spawning	Winter (Jan)	154,220	154,220	0.00	152,605	-1.05	153,015	-0.78	154,220	0.00
		Spring (May)	156,077	156,095	0.01	153,723	-1.51	153,771	-1.48	156,077	0.00
		Summer (Jul)	154,616	154,611	0.00	152,611	-1.30	152,851	-1.14	154,616	0.00
		Fall (Oct)	151,923	151,926	0.00	149,540	-1.57	150,067	-1.22	151,923	0.00
	YOY	Winter (Jan)	128,774	128,774	0.00	127,425	-1.05	127,767	-0.78	128,774	0.00
		Spring (May)	130,324	130,340	0.01	128,359	-1.51	128,399	-1.48	130,324	0.00

Scenario	Life Stage	Season	Project Phase								
			Baseline	Construction		Operations		Closure		Post-Closure	
			HU	HU	(% change)	HU	(% change)	HU	(% change)	HU	(% change)
		Summer (Jul)	129,104	129,100	0.00	127,430	-1.30	127,631	-1.14	129,104	0.00
		Fall (Oct)	126,856	126,858	0.00	124,866	-1.57	125,306	-1.22	126,856	0.00
	Juvenile	Winter (Jan)	154,220	154,220	0.00	152,605	-1.05	153,015	-0.78	154,220	0.00
		Spring (May)	156,077	156,095	0.01	153,723	-1.51	153,771	-1.48	156,077	0.00
		Summer (Jul)	154,616	154,611	0.00	152,611	-1.30	152,851	-1.14	154,616	0.00
		Fall (Oct)	151,923	151,926	0.00	149,540	-1.57	150,067	-1.22	151,923	0.00
	Adult	Winter (Jan)	154,220	154,220	0.00	152,605	-1.05	153,015	-0.78	154,220	0.00
		Spring (May)	156,077	156,095	0.01	153,723	-1.51	153,771	-1.48	156,077	0.00
		Summer (Jul)	154,616	154,611	0.00	152,611	-1.30	152,851	-1.14	154,616	0.00
		Fall (Oct)	151,923	151,926	0.00	149,540	-1.57	150,067	-1.22	151,923	0.00

Note: HU = habitat unit; % = percent; YOY = young of the year; Jan = January; Jul = July; Oct = October

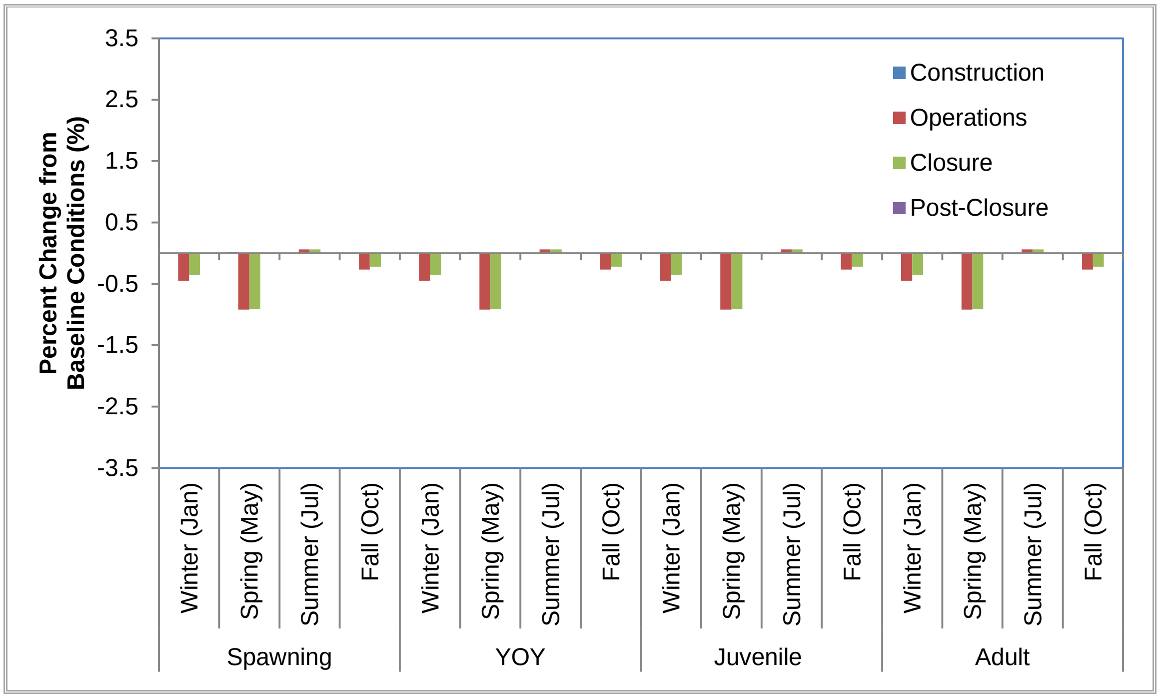


Figure 5.3.8-17: ***Percent Change in Kokanee HU from Baseline Conditions in an Average Year***

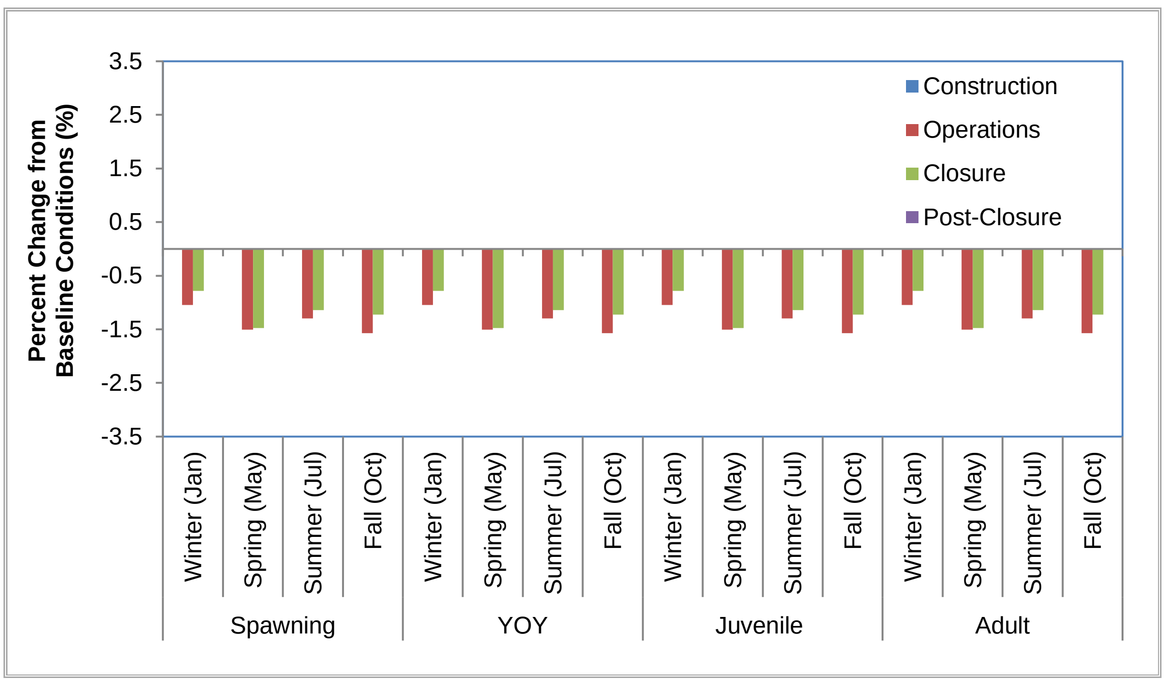


Figure 5.3.8-18: ***Percent Change in Kokanee HU from Baseline Conditions in a 1:50 Dry Year***

Mountain whitefish spawn in the late fall or early winter. In lakes they frequent the upper 6 m of water (Scott and Crossman, 1975). From baseline studies in Tatelkuz Lake conducted in the summer of 2013, mountain whitefish residents have similar habitat preferences as rainbow trout, choosing near shore 0 to 5 m deep habitat during the day (**Appendix 5.1.2.6B**).

Locations of mountain whitefish spawning in the Chedakuz Watershed have not yet been identified with certainty. Hoop net, beach seine and electrofishing surveys of mountain whitefish spawners were conducted in tributaries to Chedakuz Creek in October and November of 2012. This timing is consistent with the beginning of mountain whitefish spawning in BC (November to January) and the water temperatures when peak spawning is known to occur (3 to 5ºC)(Roberge et al. 2002). However, very few mountain whitefish spawners were found, indicating that they may prefer habitat in larger streams such as Chedakuz Creek, which was not sampled in fall of 2012, or that they spawn in tributary streams later in the year or that they spawn on beaches in Tatelkuz Lake. No beach spawning has been reported for any fish species in Tatelkuz Lake.

To be conservative, this assessment assumed that some mountain whitefish spawn on beaches in Tatelkuz Lake. Their preference for cobble and gravel spawning substrates indicates that the most suitable habitat in Tatelkuz Lake would be along the east and west shorelines. The north and south ends are mostly sand and silt and would be unsuitable for spawning (See Figure 5.10-1 in **Appendix 5.1.2.6B**.) The area of suitable substrate along the littoral zone is 309,895 m^2. The HSI for spawning mountain whitefish is presented in **Table 5.3.8-39.**

To determine the effects of drawdown of Tatelkuz Lake on the potential mountain whitefish spawning habitat, the lacustrine littoral habitat was quantified, the spawning HSI applied and the habitat units calculated. As drawdown would only affect the 0 to 1 m depth strata in the lake, this was the only depth strata modelled to determine the potential effects to spawning mountain whitefish habitat because all other deeper layers would still be available for use. The eleven littoral zone habitat classes to which the HSI is applied are presented in Section 5.10.2 of **Appendix 5.1.2.6B**.

HSI values were assigned numerical values, as follows: nil (N) = 0.00, low (L) = 0.33, medium (M) = 0.67, high (H) = 1.00. Aggregate HSI values were calculated for habitat categories combining depth and substrate. To calculate a HSI for each category of depth, substrate and vegetation, the numerical HSI value was averaged between each category. Because littoral habitat was classified by dominant and subdominant substrates, a weighted mean of the two substrates HSI scores were calculated. Dominant substrate was given 0.75 while subdominant was assigned a weight of 0.25 (**Table 5.3.8-40**).

Finally, HU were calculated by multiplying the HSI for each life stage and littoral habitat class by the area of that littoral habitat class available in the 0 to 1 m depth strata. HU were summarized by life stage for each project phase (construction, operations, closure and post-closure) for both an average annual year and a 1:50 year dry. Only the seasons in which mountain whitefish are most likely to spawn were included in the analysis. These were represented in the modelling by fall (October) and winter (January).

Table 5.3.8-39: Mountain Whitefish Habitat Suitability Index for Lacustrine Habitat

Zone	Habitat features	Ratings[1] Spawning
Littoral	**Depths**	
	0-1 metre	H
	1-2 metres	H
	2-5 metres	M
	5-10 metres	L
	>10 metres	
	Substrates	
	Bedrock (>4000 mm)	
	Boulder (>256 mm)	
	Cobble (64 to 256 mm)	H
	Gravel (2 to 64 mm)	H
	Sand (< 2 mm)	M
	Silt	
	Muck	
	Clay	
	Cover	
	Submergents	
	Emergents	
	Overhead	
	In situ[4]	
Non-littoral	**Off-shore**	
	Pelagic[2]	N
	Profundal[3]	N

Source: Roberge et al. 2001.

Notes: [1] ratings are: N = nil (rarely associated); L = low (infrequently associated); M = moderate (frequently associated); H = high (nearly always associated)

[2] open-water region no directly influenced by shore or lake bottom

[3] bottom 2 metres of lake with fine sediments and no vegetation; not influenced by shore and deeper than 4 m littoral zone

For mountain whitefish there is a less than 2.42% change in loss of HU from baseline conditions for any phase of the project (**Table 5.3.8-41** and **Figure 5.3.8-19**).

There are no or negligible changes in the amount of mountain whitefish spawning habitat for construction and post-closure phases of the Project. During operations and closure, winter (January) has the greatest reduction in HU from baseline conditions in an average annual year. Fall has an increased HU as the amount of habitat that is favourable to mountain whitefish is located at lower depths in the littoral zone.

During 1 in 50 year dry scenario, operations and closure show loss of HU for all seasons compared to baseline conditions.

Table 5.3.8-40: Summary of the Spawning Habitat Suitability Index (HSI) for Mountain Whitefish according to the Littoral Habitat Classes Found in Tatelkuz Lake 0 to 1 Depth Strata

Life stage	Littoral Habitat Class											
	Bc-NV	Bc-SV	Cb-NV	Cb-SV	Cg-NV	Fg-EV	Fg-NV	Fg-SV	Gc-NV	Gf-EV	Gf-NV	Gf-SV
Spawning	0.25	0.25	0.75	0.75	1.00	0.88	0.88	0.88	1.00	0.96	0.96	0.96

Note: Gf-gravel dominant/fines subdominant; Gc-Gravel dominant/cobble subdominant; Cg-Cobble dominant/gravel subdominant; Cb-Cobble dominant/boulder subdominant; Bc-Boulder dominant/cobble subdominant; Fg-Fines dominant/gravel subdominant; NV-no vegetation; EV-emergent vegetation; SV-submergent vegetation

Table 5.3.8-41: Summary of Potential Habitat Unit Effects for Mountain Whitefish in the 0 to 1 m Depth Strata in Tatelkuz Lake

Scenario	Life Stage	Season	Project Phase								
			Baseline	Construction		Operations		Closure		Post-Closure	
			HU	HU	(% Change)	HU	(% Change)	HU	(% Change)	HU	(% Change)
Average Annual	Spawning	Winter (Jan)	245,113	245,113	0.00	244,460	-0.27	244,605	-0.21	245,113	0.00
		Fall (Oct)	244,955	244,954	0.00	245,116	0.07	245,100	0.06	244,955	0.00
1 in 50 Year Dry	Spawning	Winter (Jan)	242,826	242,825	0.00	239,526	-1.36	240,484	-0.96	242,826	0.00
		Fall (Oct)	237,717	237,725	0.00	231,959	-2.42	233,188	-1.91	237,717	0.00

Note: HU- habitat unit; % - percent; YOY- young of the year; Jan- January; Jul- July; Oct- October

As this assessment predicts less than 5% change to Tatelkuz Lake littoral habitat and is within the natural fluctuations of the lake levels, the effect to mountain whitefish spawning habitat of drawdown in Tatelkuz Lake is assessed as constituting no serious harm to mountain whitefish.

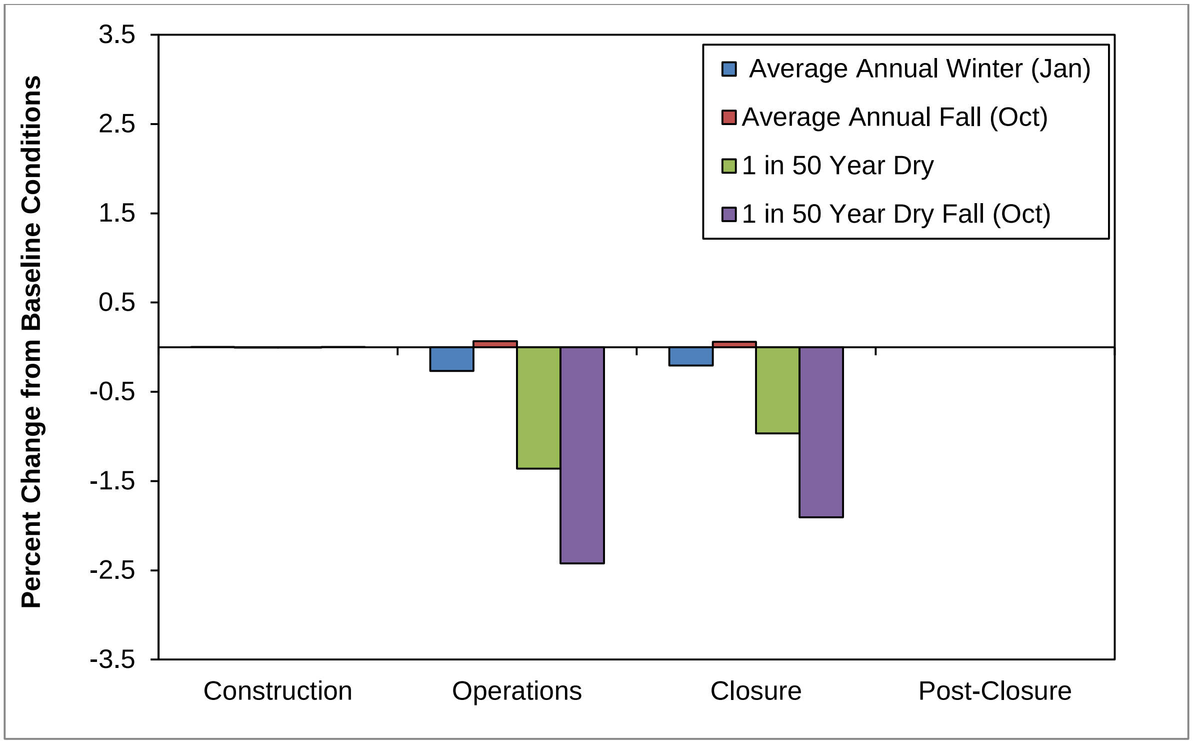


Figure 5.3.8-19: The Percent Change from Baseline Conditions of Available Potential Spawning Habitat Units for Mountain Whitefish in an Average Annual Year and 1 in 50 Year Dry Year.

5.3.8.3.4.2.2 Mitigation Measures

A trade-off study was completed to select the water source which would result in the smallest potential Project effects (Knight Piésold, 2013). Tatelkuz Lake was selected because the required withdrawal rates would result in the least effect on flows, lake volumes and associated environmental conditions.

The only mitigation measure that is proposed to limit potential effects of water extraction on fish is to limit the volume of water that will be withdrawn should adverse effects on the littoral zone be anticipated (e.g., as a result of a forecasted dry year) or become apparent as a result of monitoring the lake WSE and littoral zone characteristics (**Table 5.3.8-42**). An annual time step for changes to pumping rate is proposed.

Table 5.3.8-42: Mitigation Measures to Eliminate or Reduce Potential Effects to Fish due to Lower Water Surface Elevations in Tatelkuz Lake

Likely Environmental Effect	Project Phase	Mitigation/Enhancement Measures	Mitigation Success Rating
Mortality of fish embryos caused by dewatering of some areas of the littoral zone	Construction/Operations/ Closure	Limit withdrawal of water	High
Displacement or stranding of fish caused by dewatering of some areas of the littoral zone	Construction/Operations/ Closure	Limit withdrawal of water	High
Reduction of BMI production that provides prey for fish due to reduction in littoral habitat	Construction/Operations/ Closure	Limit withdrawal of water	Moderate
Decreased growth, reduced disease resistance, or mortality of fish due to elevated TSS caused by erosion of shoreline	Construction/Operations/ Closure	Limit withdrawal of water	Moderate

In summary, there are negligible residual effects for construction and post-closure phases. Therefore, those residual effects were not carried forward into the residual effects assessment. However, during operations and closure phases there are no mitigation measures that will prevent a loss of HU in the upper 1 m of the littoral zone of Tatelkuz Lake during the 1:50 dry year, even if that loss is predicted to be negligible in magnitude. Therefore, the HU loss during operations and closure were carried forward into residual effects assessment.

5.3.8.3.4.3 Potential Effects on Fish of the Freshwater Pipeline Corridor

5.3.8.3.4.3.1 Potential Effects

The freshwater pipeline will cross nine streams from Tatelkuz Lake to the freshwater reservoir on the mine site. Most of these crossings are pre-existing because the pipeline will follow an existing road. In some cases, the streams will be crossed with existing bridges. In others, existing culverts will be upgraded to clear-span bridges. However, trenching may be used for smaller streams (e.g., PL-6).

Because the crossings will be done with existing bridges, new clear-span bridges or trenching, and there will be no directional drilling, the potential effects of construction, operations, and closure of the freshwater pipeline at the seven permanent watercourses along its route are based on DFO's *Pathways of Effects* advisory series (DFO, 2010a, 2010b, 2010c, 2010d, 2010e, 2010f, 2010g, 2010h, 2010i). The freshwater pipeline will be removed upon closure, but the road crossings will remain as part of the FSR.

In the absence of mitigation measures, the proposed freshwater pipeline may negatively impact rainbow trout at and downstream of stream crossings (**Table 5.3.8-43**).

Table 5.3.8-43: Potential Effects on Fish of the Water Pipeline

Potential Environmental Effect	Project Phase	Likelihood of Occurrence Without Mitigation
Direct mortality or injury to fish at a crossing site due to construction activities or decommissioning activities	Construction/Closure	Likely
Decreased growth, reduced disease resistance, or mortality of fish due to elevated TSS concentrations	Construction/Operations/Closure	Likely
Delayed or impaired development of embryos due to increased sedimentation	Construction/Operations/Closure	Likely
Interruption of fish passage through watercourse crossing sites during construction or closure	Construction/Closure	Likely
Decreased growth, reduced disease resistance, or mortality of fish due to spills or leakage of fuels or deleterious substances into watercourses	Construction/Operations/Closure	Likely

These potential effects differ from those listed for the fish habitat VC in **Table 5.3.9-49** because effects assessment in **Section 5.3.9** was focused on fish habitat not fish.

5.3.8.3.4.3.2 Mitigation Measures

All proposed stream crossings techniques will follow guidelines set out in the *Fish-Stream Crossing Guidebook* (BC MOF, 2012). Fish-bearing stream protection practices will be implemented during all phases of construction in accordance with Section 5 of that guidebook (**Table 5.3.8-44**).

Table 5.3.8-44: Mitigation Measures to Eliminate or Reduce Potential Effects to Fish due to Stream Crossings of the Water Pipeline

Likely Environmental Effect	Project Phase	Mitigation/Enhancement Measures	Mitigation Success Rating
Direct mortality or injury to fish at the crossing site due to construction and closure activities	Construction/ Closure	If instream construction is required, then work areas will be isolated and fish salvage will be completed. Instream works will be avoided or minimized to the maximum extent possible.	High

Likely Environmental Effect	Project Phase	Mitigation/Enhancement Measures	Mitigation Success Rating
Decreased growth, reduced disease resistance, or mortality of fish due to elevated TSS concentrations	Construction/ Operations/Closure	Erosion and sediment control measures (e.g., riprap armouring, erosion control matting, and hydro seeding) will be used to protect erodible soils. Grader operators will follow guidelines to prevent sediment deposition.	High
Delayed or impaired development of embryos due to increased sedimentation	Construction/ Operations/Closure	Erosion and sediment control measures (e.g., riprap armouring, erosion control matting, and hydro seeding) will be used to protect erodible soils. Grader operators will follow guidelines to prevent sediment deposition.	High
Interruption of fish passage at the watercourse crossing sites during construction and closure	Construction/ Closure	Instream works will be avoided or minimized. Instream works, if necessary, will be conducted during the reduced risk timing window for rainbow trout (15 July to 15 April of the following year) to avoid interruptions to spawning migrations	High
Decreased growth, reduced disease resistance, or mortality of fish due to spills or leakage of fuels or deleterious substances into watercourses	Construction/ Operations/Closure	An emergency spill response kit will be kept on-site during construction. Fuels will be stored and refuelling will be conducted outside of riparian areas at all times. Ensure that machinery arrives on site in a clean condition and is maintained free of fluid leaks.	High

To minimize or eliminate these potential effects to rainbow trout, the following mitigation measures will be implemented during the construction, operation, and closure of the fresh water pipeline stream crossings:

- Erosion and sediment control measures (e.g., riprap armouring, erosion control matting, and hydro seeding) will be used to protect erodible soils;
- Abutments of all bridges will be located above the high water level of each watercourse;
- Clear-span bridges will be constructed and maintained following guidelines and mitigation measures outlined in DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013a), including:
    - Design and construct approaches to the waterbody such that they are perpendicular to the watercourse to minimize loss or disturbance to riparian vegetation;
    - Avoid building structures on meander bends, braided streams, alluvial fans, active floodplains or any other area that is inherently unstable and may result in erosion and scouring of the stream bed or the built structures;

- Bridge and culvert installation will be timed so that instream works will be completed within the BC MOE reduced risk timing window for rainbow trout (15 July to 15 April of the following year) for Fish and Wildlife in Region 7- Omineca (BC MOE, 2004);
- If stream crossings fords are required for the movement of construction vehicles or equipment, these crossings will be carried out in accordance with the DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013a), including:
  - Limiting machinery fording of any watercourse to a onetime event (i.e., over and back), and only if not alternative crossing method is available; and
  - If repeated crossings are required or if the watercourse has steep of highly-erodible banks, construct a temporary crossing structure.

Erosion control measures presented above will be implemented to protect erodible soils and minimize sediment inputs to watercourses. Additional erosion control measures detailed in the SECP section of the Construction Management Plan will also be employed where applicable (**Section 12.2.1.18.4.1**).

All of these mitigation measures are anticipated to be highly effective for eliminating or leaving only negligible residual effects to fish at each permanent crossing. These mitigation measures are commonly and widely used around BC. Fish passage will be improved at one crossing, PL-8, where an existing perched culvert will be replaced with a bridge. Infrastructure at other existing crossings will be upgraded. Confidence in this assessment is high. Therefore, the potential effects of the fresh water pipeline crossings were not carried forward to the residual effects assessment.

5.3.8.3.4.4 Potential Effects on Fish of the Freshwater Reservoir

5.3.8.3.4.4.1 Potential Effects

Potential effects to fish from the dam and freshwater reservoir may occur during the construction, operation and closure phases, as follows (**Table 5.3.8-45**):

- Loss of fish habitat (and hence of fish production from that habitat) as a result of the building the footprint of the freshwater reservoir on Davidson Creek;
- Direct fish mortality resulting from instream construction activities (during both Construction and Closure phases) or fording by heavy machinery;
- Indirect effects on fish, including impaired respiration, altered behavior (e.g., migration patterns) or habitat, or changed feeding efficiency as a result of elevated TSS concentrations due to increased erosion and transport of sediment. This is possible due to clearing of vegetation, exposure of soils along the creek, and mobilization of sediments in stream channels due to fording or site preparation by heavy machinery during dam construction and operation;
- Indirect effects on fish as a result of reductions in periphyton and BMI production (upon which fish depend for food) due to elevated TSS concentrations;

- Mortality of fish embryos as a result of reduced oxygen availability due to deposition of sediments;
- Obstruction of fish passage upstream at the dam site. Tributaries that flow into Davidson Creek between the TSF site and the reservoir and part of Reach 6, Reach 7 and Reach 8 will be inaccessible to fish;
- Reduced growth and survival caused by spills or leaks of deleterious substances, including fuel, oil and grease; and
- Mortality of fish entrained or impinged on outlet pipes.

These potential effects differ from those listed for the fish habitat VC in **Table 5.3.9-51** because effects assessment in **Section 5.3.9** was focused on fish habitat, not fish.

Table 5.3.8-45: Potential Effects on Fish of the Freshwater Reservoir

Potential Environmental Effect	Project Phase	Likelihood of Occurrence Without Mitigation
Loss of fish habitat (and hence of fish production) from creeks buried under the footprint of the reservoir	Construction	Likely
Direct mortality or injury to fish due to instream construction activities or fording by heavy machinery at the dam site	Construction/ Closure	Likely
Decreased growth, reduced disease resistance, mortality of fish and fish embryos, and reduction in BMI production due to elevated TSS concentrations and increased sediment deposition	Construction/ Closure	Likely
Permanent loss of upstream fish passage at the dam in Davidson Creek and tributaries between the TSF site and the dam	Construction/ Operations	Likely
Decreased growth, reduced disease resistance, mortality of fish and fish embryos caused by spills or leakage of fuels or deleterious substances into watercourses	Construction/Closure	Likely
Mortality of fish due to entrainment or impingement on outlet pipes	Construction/ Operations/ Closure	Likely

5.3.8.3.4.4.2 Mitigation Measures

Loss of fish habitat in Davidson Creek and tributaries between the TSF and the dam is addressed in the FMOP (**Appendix 5.1.2.6C**).

To minimize the loss of fish in these streams during construction, operation and closure of the freshwater reservoir and dam, the following guidelines and mitigation measures outlined in DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013a) will be implemented (**Table 5.3.8-46**):

- Retain a qualified environmental professional to ensure applicable permits for relocating fish are obtained and to capture any fish trapped within an isolated/enclosed area at the work site and safely relocate them to an appropriate location in the same waters;

- Construction of the dam will be timed so that instream works will be completed within the BC MOE reduced risk timing window of 15 July to 15 April of the following year for rainbow trout in Region 7- Omineca (BC MOE, 2004), unless fish salvage is done;
- Erosion and sediment control measures (e.g., erosion control matting and hydro seeding) will be used to protect erodible soils around the dam. Riprap and other erosion and sediment control measures will be incorporated into all dam structures. Silt fencing and/or hay bales will be used to limit sediment from reaching fish-bearing watercourses where required;
- Limiting machinery fording of any watercourse to a onetime event (i.e., over and back), and only if not alternative crossing method is available; and
- Screen any water outlet pipes to prevent entrainment or impingement of fish.

Table 5.3.8-46: Mitigation Measures to Eliminate or Reduce Potential Effects to Fish due to the Freshwater Reservoir

Likely Environmental Effect	Project Phase	Mitigation/Enhancement Measures	Mitigation/Offsetting Success Rating
Loss of fish habitat (and hence of fish production) from creeks buried under the footprint of the reservoir	Construction	Loss of habitat upstream from the dam are included in the FMOP	High
Direct mortality or injury to fish at the crossing sites due to instream construction activities or fording by heavy machinery at the dam site	Construction	Instream works will be conducted during the Reduced Risk Timing Window for rainbow trout (15 July to 15 April of the following year) Work areas will be isolated and fish salvage will be completed prior to construction	High
Decreased growth, reduced disease resistance, or mortality of fish due to elevated TSS concentrations and increased sediment deposition	Construction/Closure	Erosion and sediment control measures (e.g., riprap armouring, erosion control matting, and hydro seeding) will be used to protect erodible soils around the dam and the fresh water reservoir	High
Permanent loss of upstream fish passage at the dam in Davidson Creek and tributaries between the TSF site and the dam	Construction/Operations	Loss of habitat upstream from the dam are included in the FMOP	High
Spills or leakage of fuels or deleterious substances into watercourses.	Construction	An emergency spill response kit will be kept on-site during all construction activities near watercourses Ensure that machinery arrives on site in a clean condition and is maintained free of fluid leaks	High

Likely Environmental Effect	Project Phase	Mitigation/Enhancement Measures	Mitigation/Offsetting Success Rating
		Fuels will be stored off-site and refuelling will be conducted outside of instream and riparian areas.	
Entrainment or impingement of fish on outlet pipes leading to mortality	Construction/Operations/ Closure	Outlet pipes will be designed so that fish cannot enter them.	High

In addition, reservoir slopes will be covered with riprap or otherwise protected to prevent sediment-laden water from being released downstream.

Loss of habitat upstream from the dam will affect only rainbow trout. Baseline studies found kokanee in Reaches 1 to 4 (**Section 5.1.2.6**), which are downstream of the dam and freshwater reservoir. Baseline studies for rainbow trout found CPUE decreased with upstream distance for Reaches 1 to 9, indicating the lower reaches of Davidson Creek have the highest densities of rainbow trout. Loss of habitat for rainbow trout, and hence of rainbow trout production, is addressed in the FMOP.

Many of the mitigation measures proposed above are commonly and widely used around BC. All of these mitigation measures are anticipated to be highly effective for eliminating or, at most, leaving only negligible residual effects downstream from the dam and freshwater reservoir.

In summary, the effect to fish from the dam and freshwater reservoir is considered low. Confidence in this assessment is high. Therefore, the potential effects on fish of the freshwater reservoir were not carried forward to residual effects assessment.

5.3.8.3.5 Airstrip and Airstrip Access Road

5.3.8.3.5.1 Potential Effects on Fish

The airstrip will be built on a site with no existing fish-bearing watercourses. Therefore, potential effects to fish habitat are limited to the airstrip access road and downstream receiving fish-bearing waters.

There is only one fish-bearing stream crossing along the access road - site AA-002.

Potential effects to fish at that site may result from activities required to construct, operate, and close the airstrip access road. They were assessed using the DFO *Pathways of Effects* diagrams (DFO, 2010a, 2010b, 2010c, 2010d, 2010e, 2010f, 2010g, 2010h, 2010i) (**Table 5.3.8-47**):

- Impediments or barriers to upstream and downstream fish passage at stream crossings;
- Direct fish mortalities or injuries resulting from instream construction activities or stream ford crossings by heavy machinery, if these activities are required;

- Indirect effects on fish, including impaired respiration, altered behaviour (e.g., migration patterns), changed feeding efficiency and predator detection, may be caused by increased TSS concentrations. Those TSS concentrations may be due to clearing of vegetation, grading of road surfaces, and exposure of soils along the creek banks, and mobilization of sediments in the stream channels due to fording or site preparation by heavy machinery and due to input of sediments to creeks during road grading;
- Indirect effects on fish by altering primary production and benthic invertebrate production (upon which fish depend for food) as a result of elevated TSS concentrations;
- Fish embryo mortality caused by reduced oxygen availability due to deposition of sediment; and
- Decreased fish health, growth, and/or survival caused by spills or leaks of deleterious substances, including fuel, oil, and grease.

Table 5.3.8-47: Potential Effects to Fish from the Airstrip Access Road without Mitigation

Potential Environmental Effect	Project Phase	Likelihood of Occurrence Without Mitigation
Impediments or barriers to upstream and downstream fish passage at stream crossings	Construction/Closure	Likely
Direct mortality or injury to fish at crossing sites due to instream construction activities or fording by heavy machinery	Construction/Operations/ Closure	Likely
Decreased health, growth, and survival of fish due to elevated TSS concentrations	Construction/Operations/ Closure	Likely
Decreased survival of fish embryos due to increased deposition of fine sediments in stream channels	Construction/Operations/ Closure	Likely
Decreased health, growth, and survival of fish due to spills or leakage of fuels or deleterious substances into streams at stream crossings	Construction/Closure	Likely

5.3.8.3.5.2 Mitigation Measures

All proposed stream crossing techniques will follow guidelines set out in the *Fish-Stream Crossing Guidebook* (BC MOF, 2012). Fish-bearing stream protection practices will be implemented during all phases of construction in accordance with Section 5 of that guidebook.

Erosion control measures presented below will be implemented to protect erodible soils and minimize sediment inputs to watercourses. Additional erosion control measures detailed in the SECP of the Construction Management Plan will also be employed where applicable (**Section 12.2.1.18.4.1**).

To minimize or eliminate the potential effects to fish, the following mitigation measures will be implemented during the construction, operation, and closure of the airstrip access road

(**Table 5.3.8-48**). Due to the absence of watercourses at the airstrip, construction of surface water control ditches and collection ponds is the only required mitigation measure specifically for protection of fish at the airstrip site. All of the mitigation measures proposed above are commonly and widely used around BC during road construction. None of these measures are unique nor are they unsuitable for the streams to be crossed by the proposed airstrip access road. For these reasons, all of these mitigation measures are anticipated to be highly effective for eliminating or, at most, leaving only negligible residual effects to fish in the single fish-bearing stream along the airstrip access road. Confidence in this assessment is high. Therefore, potential effects of the airstrip access road on fish were not carried forward to the residual effects assessment:

- A clear-span structure (e.g., bridge or open-bottom culvert) will be installed to replace the existing closed-bottom culvert at the single fish-bearing stream along the airstrip access road. This structure will be installed following guidelines set out in the *Fish-Stream Crossing Guidebook* (BC MOF, 2012) and will remove the current barrier to upstream fish passage that exists at this site and will prevent any impediment to fish passage in the future;
- Abutments of all bridges will be located above the high water level of each watercourse;
- If replacement of the existing watercourse crossing structures on the non-classified drainages is required, sufficiently sized and embedded corrugated steel pipe culverts will be installed.
- Crossing structure installation will be timed so that instream works will be completed within the BC MOE reduced risk timing window for rainbow trout of 15 July to 15 April of the following year in Region 7- Omineca (BC MOE, 2004).
- Fords by construction machinery may be necessary to allow one-time access to construct stream crossings.
- Any maintenance activities required for the existing watercourse crossings will follow guidelines and mitigation measures set out in accordance with DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013a).

Due to the absence of watercourses at the airstrip, construction of surface water control ditches and collection ponds is the only required mitigation measure specifically for protection of fish at the airstrip site.

All of the mitigation measures proposed above are commonly and widely used around BC during road construction. None of these measures are unique nor are they unsuitable for the streams to be crossed by the proposed airstrip access road. For these reasons, all of these mitigation measures are anticipated to be highly effective for eliminating or, at most, leaving only negligible residual effects to fish in the single fish-bearing stream along the airstrip access road. Confidence in this assessment is high. Therefore, potential effects of the airstrip access road on fish were not carried forward to the residual effects assessment.

Table 5.3.8-48: Mitigation Measures to Eliminate or Reduce Potential Effects to Fish due to the Airstrip Access Road

Environmental Effect	Project Phase	Mitigation/Enhancement Measure	Mitigation Success Rating
Impediments or barriers to upstream and downstream fish passage at stream crossings	Construction/ Operations	Install open-bottom structure to replace improperly installed closed-bottom culvert at the single fish-bearing stream along the airstrip access road.	High
Direct mortality or injury to fish at the crossing site due to instream construction activities and fording by heavy machinery	Construction/ Closure	Instream works will be avoided or minimized. Machinery will be allowed to ford the stream for one-time access to construct stream crossings. If instream construction is required, work areas will be isolated and fish salvage will be completed	High
Decreased health, growth, and survival of fish due to elevated total suspended sediment concentrations	Construction/ Operations/ Closure	Erosion and sediment control measures (e.g., erosion control matting and hydro seeding) will be used to protect erodible soils.	High
Decreased growth and survival of fish eggs due to increased deposition of fine sediments in stream channels	Construction/ Operations/ Closure	Erosion and sediment control measures (e.g., erosion control matting and hydro seeding) will be used to protect erodible soils.	High
Decreased health, growth, and survival of fish due to spills or leakage of fuels or deleterious substances into watercourses at watercourse crossings	Construction/ Closure	An emergency spill respo.nse kit will be kept on-site during construction and closure Fuels will be stored off-site and all refuelling will be conducted outside of riparian and instream areas. Ensure that machinery arrives on site in a clean condition and is maintained free of fluid leaks.	High

5.3.8.3.6 Transmission Line

5.3.8.3.6.1 Potential Effects on Fish

The proposed transmission line will cross 143 streams. Fifty of these streams are fish-bearing (i.e., S1 to S4) and include rivers and creeks such as the Stellako River, the Nechako River, Big Bend Creek, Esker Creek, Fifteen Creek, Greer Creek, Smith Creek, Swanson Creek, Tahultzu Creek, Turtle Creek, and Chedakuz Creek. The remaining 93 streams are either NCD or non-fish-bearing (i.e., S5 or S6). An additional 18 stream crossings will be required for the Stellako and Mills Ranch reroutes. Detailed descriptions of these crossing sites are shown in Annex 5.8-1 of **Appendix 5.1.2.6B**.

Existing crossing structures will be used to cross the Stellako and Nechako rivers and the majority of other streams. New crossings will be required at 35 streams along the new temporary access roads.

At each stream crossing along the transmission line ROW, riparian vegetation may be cleared so that it does not impede construction of the transmission line or the access road stream crossing or pose a threat to the transmission line if vegetation were to fall. Similarly, riparian vegetation will need to be removed to allow construction of the 35 new stream crossings required for the new temporary access roads.

Potential effects to fish at stream crossings along the transmission line ROW and at existing and temporary access roads may occur during Construction, Operation, and Closure phases. Specifically, potential effects to fish habitat along the transmission line ROW include the following (**Table 5.3.8-49**):

- Impediments or barriers to upstream and downstream fish passage at stream crossings;
- Direct fish mortalities or injuries resulting from instream construction activities or stream ford crossings by heavy machinery, if these activities are required;
- Indirect effects on fish, including impaired respiration, altered behaviour (e.g., migration patterns), changed feeding efficiency and predator detection, may be caused by increased TSS concentrations. Those TSS concentrations may be due to clearing of vegetation, grading of road surfaces, and exposure of soils along the creek banks, and mobilization of sediments in the stream channels due to fording or site preparation by heavy machinery during culvert/road construction and due to input of sediments to creeks during road grading;
- Indirect effects on fish by altering primary production and benthic invertebrate production (upon which fish depend for food) as a result of elevated TSS concentrations;
- Fish embryo mortality caused by reduced oxygen availability due to deposition of sediment; and
- Decreased fish health, growth, and/or survival caused by spills or leaks of deleterious substances, including fuel, oil, and grease.

Table 5.3.8-49: Potential Effects to Fish from the Transmission Line

Potential Environmental Effect	Project Phase	Likelihood of Occurrence before Mitigation
Impediments or barriers to upstream and downstream fish passage at stream crossings	Construction/ Operations	Likely
Direct mortality or injury to fish at the crossing sites due to instream construction activities or fording by heavy machinery at stream crossings	Construction/ Closure	Likely
Decreased growth, reduced disease resistance, or mortality of fish due to elevated TSS concentrations and increased sediment deposition	Construction/ Closure	Likely
Temporary interruption of fish passage at stream crossing sites	Construction/ Operations	Likely
Decreased growth, reduced disease resistance, or mortality of fish due to spills or leakage of fuels or deleterious substances into watercourses	Construction/ Closure	Likely

These potential effects differ from those listed for the fish habitat VC in **Table 5.3.9-55** because effects assessment in **Section 5.3.9** was focused on fish habitat, not fish.

5.3.8.3.6.2 Mitigation Measures

Stream crossings will be constructed and maintained following guidelines and mitigation measures outlined in DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013a).

Erosion control measures presented below will be implemented to protect erodible soils and minimize sediment inputs to watercourses. Additional erosion control measures detailed in the SECP section of the Construction Management Plan will also be employed where applicable (**Section 12.2.1.18.4.1**).

To minimize or eliminate each of these potential effects to fish, the following mitigation measures will be implemented during the construction, operation, and closure of the transmission line and its associated access roads (**Table 5.3.8-50**):

- Erosion and sediment control measures (e.g., erosion control matting and hydro seeding) will be used to protect erodible soils around stream crossings. Riprap and other erosion and sediment control measures will be incorporated into all new temporary stream crossing designs where required. Silt fencing will be used to limit sediment from reaching fish-bearing watercourses where required;
- Existing crossing structures will be used to cross the Stellako and Nechako Rivers;
- Fords by construction machinery may be necessary to allow one-time access to construct stream crossings;
- Clear-span bridges with abutments above the high water mark may be installed along new access roads. All structures will be sized, installed and maintained following guidelines and mitigation measures outlined in the *Fish-Stream Crossing Guidebook* (BC MOF, 2012) and *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013a) including:
    - Design and construct approaches to the water body such that they are perpendicular to the watercourse to minimize loss or disturbance to riparian vegetation; and
    - Avoid building structures on meander bends, braided streams, alluvial fans, active floodplains or any other area that is inherently unstable and may result in erosion and scouring of the stream bed or the built structures.
- Stream crossing construction will be timed so that instream works, if required, will be completed within the reduced risk timing window of 15 July to 15 April of the following year for rainbow trout in Region 7- Omineca (BC MOE, 2004);
- Riparian vegetation at stream crossings and under the transmission line ROW will be managed in accordance with *Approved Work Practices for Managing Riparian Vegetation* (BC Hydro et al., 2003). This will include:
    - Retaining as much vegetation as possible;

- Pruning or topping trees growing near the transmission line cable, while leaving the stumps and root wads in place; and
- Re-vegetating disturbed areas with native species as soon as possible after disturbance.

All of the mitigation measures proposed above are commonly and widely used around BC during transmission line construction, maintenance and closure, including construction, maintenance and closure of access roads. None of these measures are unique nor are they unsuitable for the streams to be crossed by the proposed transmission line or its access roads. For these reasons, all of these mitigation measures are anticipated to be highly effective for eliminating or, at most, leaving only negligible residual effects to fish at streams crossed by the transmission line. Confidence in this assessment is high. Therefore, potential effects on fish of the transmission line and its access roads were not carried forward to residual effects assessment.

Table 5.3.8-50: Mitigation Measures to Eliminate or Reduce Potential Effects to Fish due to the Transmission Line ROW

Likely Environmental Effect	Project Phase	Mitigation/Enhancement Measures	Mitigation Success Rating
Direct mortality or injury to fish due to instream construction activities or fording by heavy machinery at stream crossings	Construction	Existing stream crossings will be used wherever possible. Instream works will be avoided or minimized. Instream works, if necessary, will be conducted during the reduced risk timing window for rainbow trout (15 July to 15 April of the following year). If instream construction is required, then work areas will be isolated and fish salvage will be completed prior to construction.	High
Decreased growth, development, reduced disease resistance, or mortality of fish due to elevated suspended sediment concentrations and increased sediment deposition	Construction/ Closure	Erosion and sediment control measures (e.g., riprap armouring, erosion control matting, and hydro seeding) will be used to protect erodible soils. Silt fencing will be used to limit the amount of sediment reaching fish-bearing streams. Instream works, if necessary, will be conducted during the reduced risk timing window for rainbow trout (15 July to 15 April of the following year).	High
Temporary interruption of fish passage at stream crossing sites	Construction/ Operations	Instream works, if necessary, will be conducted during the reduced risk timing window for rainbow trout (15 July to 15 April of the following year). Fording by machinery will be allowed for one-time access to construct stream crossings. Clear-span bridges may be used for long-term crossing of fish-bearing streams.	High

Likely Environmental Effect	Project Phase	Mitigation/Enhancement Measures	Mitigation Success Rating
Decreased growth, development, reduced disease resistance, or mortality of fish due to spills or leakage of fuels or deleterious substances into streams	Construction/ Closure	An emergency spill response kit will be kept on-site during all construction and closure activities near streams. Ensure that machinery arrives on site in a clean condition and is maintained free of fluid leaks. Fuels will be stored off-site and refuelling will be conducted outside of instream and riparian areas.	High

5.3.8.3.7 Kluskus FSR and Kluskus-Ootsa FSR

5.3.8.3.7.1 Potential Effects on Fish

Ditch construction, road surface grading, and bridge or culvert installation and maintenance may affect fish habitat at stream crossings along the existing Kluskus FSR, the existing Kluskus-Ootsa FSR, and the re-aligned section of the Kluskus-Ootsa FSR.

Potential effects to fish at these stream crossings may result from activities required for construction, operation, and closure of stream crossings along the Kluskus and Kluskus-Ootsa FSRs, and at stream crossings along the proposed Kluskus-Ootsa FSR realignment. Specifically, potential effects to fish at fish-bearing stream along these roads include, based on the DFO *Pathways of Effects* diagrams (DFO, 2010a, 2010b, 2010c, 2010d, 2010e, 2010f, 2010g, 2010h, 2010i), are the following (**Table 5.3.8-51**):

- Impediments or barriers to upstream and downstream fish passage at stream crossings;
- Direct fish mortalities or injuries resulting from instream construction activities or stream ford crossings by heavy machinery, if these activities are required;
- Indirect effects on fish, including impaired respiration, altered behaviour (e.g., migration patterns), changed feeding efficiency and predator detection, may be caused by increased TSS concentrations. Those TSS concentrations may be due to clearing of vegetation, grading of road surfaces, and exposure of soils along the creek banks, and mobilization of sediments in the stream channels due to fording or site preparation by heavy machinery during culvert/road construction and due to input of sediments to creeks during road grading;
- Indirect effects on fish by altering primary production and benthic invertebrate production (upon which fish depend for food) as a result of elevated TSS concentrations;
- Fish embryo mortality caused by reduced oxygen availability due to deposition of sediment; and
- Decreased fish health, growth, and/or survival due to spills or leaks of deleterious substances, including fuel, oil, and grease.

Table 5.3.8-51: Potential Effect to Fish from Upgrading and Realigning the Kluskus and Kluskus-Ootsa FSRs

Potential Environmental Effect	Project Phase	Likelihood of Occurrence before Mitigation
Impediments or barriers to upstream and downstream fish passage at stream crossings	Construction/ Operations	Likely
Direct mortality or injury to fish at the crossing sites due instream construction or ford crossings	Construction/Closure	Likely
Decreased health, growth, and survival of fish due to elevated levels of suspended sediments	Construction/Operations/ Closure	Likely
Decreased growth and survival of fish eggs due to increased sedimentation	Construction/Operations/ Closure	Likely
Temporary or permanent interruption of fish passage at stream crossing sites	Construction/Operations/ Closure	Likely
Decreased health, growth, and survival of fish due to spills or leakage of fuels or deleterious substances into streams	Construction/Closure	Likely

5.3.8.3.7.2 Mitigation Measures

All proposed stream crossing techniques will follow guidelines set out in the *Fish-Stream Crossing Guidebook* (BC MOF, 2012). Fish-bearing stream protection practices will be implemented during all phases of construction in accordance with Section 5 of this guidebook.

Erosion control measures presented below will be implemented to protect erodible soils and minimize sediment inputs to watercourses. Additional erosion control measures detailed in the SECP section of the Construction Management Plan will also be employed where applicable (**Section 12.2.1.18.4.1**).

To minimize or eliminate each of these potential effects to fish, the following mitigation measures will be implemented during the construction, operation, and closure of the Kluskus and Kluskus-Ootsa FSRs, including the realigned section of the Kluskus-Ootsa FSR (**Table 5.3.8-52**):

- An existing perched culvert located at site AE-013 on the section of the Kluskus-Ootsa FSR to be realigned will be removed. Installation of a new upstream crossing structure will eliminate a barrier to fish passage and improve fish access upstream of the existing culvert;
- Erosion and sediment control measures (e.g., erosion control matting and hydro seeding) will be used to protect erodible soils around stream crossings. Riprap and other erosion and sediment control measures will be incorporated into the stream crossing designs where required. Silt fencing will be used to limit sediment from reaching watercourses where required;

- If required, any instream works will be timed so that works will be completed within the reduced risk timing window for rainbow trout of 15 July to 15 April of the following year in Region 7- Omineca (BC MOE, 2004);
- Clear-span bridges with abutments above the high water mark or open-bottom culverts will be installed on fish-bearing streams. Further mitigation measures outlined in *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013a) will be followed during installation of these stream crossing structures, including:
  - Design and construct approaches to the waterbody such that they are perpendicular to the watercourse to minimize loss or disturbance to riparian vegetation; and
  - Avoid building structures on meander bends, braided streams, alluvial fans, active floodplains or any other area that is inherently unstable and may result in erosion and scouring of the stream bed or the built structures.
- Machinery may be allowed to ford streams for one-time access to construct stream crossings; and
- An emergency spill response kit will be kept on-site during construction, fuels will be stored off-site, all refuelling will be conducted outside of riparian and instream areas, and all machinery that arrives on site will be in a clean condition and maintained free of fluid leaks, so as to minimize spills or leaks of deleterious substances leading to decreased fish health, growth, and/or survival.

All of the mitigation measures proposed above are commonly and widely used around BC during road construction. None of these measures are unique nor are they unsuitable for the streams to be crossed by the FSRs and the proposed realignment. For these reasons, all of these mitigation measures are anticipated to be effective for eliminating or, at most, leaving only negligible residual effects to fish habitat in the permanent streams along the FSRs. Confidence in this assessment is high and, for this reason, potential effects of the FSRs on fish were not carried forward to the residual effects assessment.

Table 5.3.8-52: Mitigation Measures to Eliminate or Reduce Potential Effects to Fish from the Kluskus and Kluskus-Ootsa FSRs

Likely Environmental Effect	Project Phase	Mitigation/Enhancement Measures	Mitigation Success Rating
Direct mortality or injury to fish at the crossing site due to instream construction or ford crossings	Construction/ Operations	Instream works will be avoided or minimized. If instream construction is required, work areas will be isolated and fish salvage will be completed. Instream works, if necessary, will be conducted during the Reduced Risk Timing Window for rainbow trout (15 July to 15 April of the following year) to avoid interruptions to spawning migrations. Clear-span bridges requiring no instream construction will be installed at all new crossing sites on fish-bearing streams.	High
Decreased health, growth, and survival of fish due to elevated total suspended sediment concentrations	Construction/ Operations/ Closure	Erosion and sediment control measures, including riprap armouring, erosion control matting, and hydro seeding, will be used to protect erodible soils. Silt fencing will be used to limit sediments reaching fish-bearing streams. Grader operators will follow guidelines to prevent sediment deposition in accordance with the road grading environmental management plan (EMP).	High
Decreased growth and survival of fish eggs due to increase sedimentation	Construction/ Operations/ Closure	Erosion and sediment control measures, including riprap armouring, erosion control matting, and hydro seeding, will be used to protect erodible soils. Silt fencing will be used to limit sediments reaching fish-bearing streams. Grader operators will follow guidelines to prevent sediment deposition in accordance with the road grading environmental management plan (EMP).	High
Temporary or permanent interruption of fish passage at the watercourse crossing sites	Construction/ Operations/ Closure	Clear-span bridges or open-bottom culverts will be installed at all new crossing sites on fish-bearing streams.	High
Decreased health, growth, and survival of fish due to spills or leakage of fuels or deleterious substances into watercourses.	Construction/ Closure	An emergency spill response kit will be kept on-site during construction. Fuels will be stored off-site and all refuelling will be conducted outside of riparian and instream areas. Ensure that machinery arrives on site in a clean condition and is maintained free of fluid leaks.	High

5.3.8.3.8 Summary of Potential Residual Effects

The analyses of this section identified five residual effects on the fish VC that may not be completely eliminated through mitigation (**Table 5.3.8-53**).

Table 5.3.8-53: Residual Effects on Fish VC

Project Component	Residual Effect
Mine site	Loss of fish on the mine site
	Disruption of salmonid homing to Davidson Creek
	Mercury mobilization in Lake 01682LNRS
FSS	Changes in water temperature in Davidson Creek
	Reduction in littoral fish habitat of Tatelkuz lake
Mine access road	None
Airstrip and airstrip access road	None
Transmission line	None
Kluskus FSR and Kluskus-Ootsa FSR	None

5.3.8.3.9 Identification and Description of Potential Adverse Effects from Other Past, Present, and Certain or Reasonably Foreseeable Future Project or Activities

Table 4.3-11 in **Section 4** shows the Summary Project Inclusion List developed for cumulative effects assessment. Of the 13 projects on that list, ten have potential to interact cumulatively with the fish VC. A brief description of each of these projects, their location and timing relative to the Blackwater Project (to show potential spatial and temporal overlap), and their potential adverse effects to fish are provided in **Table 5.3.8-54**.

Table 5.3.8-54: Potential Adverse Effects from Other Past, Present, and Certain or Reasonably Foreseeable Projects or Activities in the vicinity of the Blackwater Project

Project Name	Project Description	Location relative to Blackwater Project	Timing Relative to Blackwater Project	Potential Adverse Effect to Fish
Pacific Gas Looping Project	Natural gas transmission pipeline between Summit Lake, BC, and Kitimat, BC	Intersects transmission line LSA	Future	• Chemical and fuel spills • Harm from instream works and sediment suspension and deposition
Mining-existing	Surface molybdenum mine near Fraser Lake approximately 65 km west of Vanderhoof	Outside RSA	Ongoing	• Chemical and fuel spills • Flow modification (interruption, augmentation) • Temperature changes due to flow modification
Mining-exploration	Diamond drilling for sampling ore body at exploration sites, and reclamation of drill site and access trail upon completion of exploration activity	In LSA and RSA	Ongoing	• Chemical and fuel spills • Harm from instream works and from sediment suspension and deposition
Forestry	Cut block timber harvesting, road building, culvert replacement, and woodlot tenures	In LSA and RSA	Ongoing	• Chemical and fuel spills • Decreased nutrient supply and increased temperatures due to loss of cover and shade • Increased flashiness due to reduced water uptake • Harm from instream works and from sediment suspension and deposition • Blockage of fish passage at FSR crossings of streams
Hunting, trapping, and guide outfitting	Game hunting, maintenance of game trap lines, provision of guided fishing trips	In LSA and RSA	Ongoing	• Direct fish mortality • Overharvesting, loss of breeding opportunities • Harm from use of stream channel by recreational vehicles and from sediment suspension and deposition
Fishing and hunting lodges	Commercial lodges providing cabin rentals, camping, fishing, boating, sightseeing, hiking, all-terrain vehicle use, horseback riding and other eco-tourism activities	In LSA and RSA	Ongoing	• Direct fish mortality • Overharvesting, loss of breeding opportunities • Harm from use of stream channel by recreational vehicles and from sediment suspension and deposition
Recreation	All-terrain vehicle use, snowmobiling, hiking, camping, cross-country skiing, horseback	In LSA and RSA	Ongoing	• Direct fish mortality • Overharvesting, loss of breeding opportunities

Project Name	Project Description	Location relative to Blackwater Project	Timing Relative to Blackwater Project	Potential Adverse Effect to Fish
	riding, fishing, hunting, interpretive cultural heritage experiences, and eco-tourism			• Harm from use of stream channel by recreational vehicles and from sediment suspension and deposition
Agriculture	Rangeland tenures for raising cattle and horses; livestock ranching; commercial production of animals; soil-bound and greenhouse production of fruit, vegetable, cereal, seed, and forage crops	In LSA and RSA	Ongoing	• Nutrient enrichment from manure • Harm from instream works and from sediment suspension and deposition • Destruction of riparian habitats leading to changes in cover and shading for streams
Transportation	Two FSRs, a network of logging roads connecting timber harvesting tenures, mine access roads, and exploration access trails	In LSA and RSA	Ongoing	• Chemical and fuel spills • Harm from instream works and from sediment suspension and deposition • Increased erosion, and sediment suspension and deposition due to road construction and maintenance • Increased access to fish populations
Crown-land tenures	Agriculture, environment, institutional, quarrying, residential, wells, points of diversion (POD)	In LSA and RSA	Ongoing	• Nutrient enrichment from manure • Chemical and fuel spills • Harm from instream works and from sediment suspension and deposition • Increased erosion, and sediment suspension and deposition due to road construction and maintenance • Flow modification (interruption, augmentation) • Temperature changes due to flow modification • Increased access to fish populations

5.3.8.4 Residual Effects and their Significance

This section assesses the significance of those five residual effects on the fish VC considering context, magnitude, geographic extent, duration, reversibility, and frequency. The likelihood of each residual effect is assessed and significance is assigned. The level of confidence and risk in the determination of significance and its likelihood are discussed. Rating criteria are defined in **Section 4.3.5**, and summarized in **Table 5.3.8-55**.

Table 5.3.8-55: Rating Criteria to Assess Significance of Residual Effects to Fish

Rating Criteria	Description
Context	
Low	• VC has high resilience to stress; not a listed species
Medium	• VC has medium resilience to stress; blue-listed species
High	• VC has low resilience to stress; red-listed species.
Magnitude	
Negligible	• No detectable change from baseline
Low	• Differs from mean baseline values, but is within range of natural variation, and below guideline or threshold
Medium	• Differs from mean baseline values, approaches limits of natural variation, but is below or equal to guideline or threshold
High	• Differs from mean baseline values, is outside range of natural variation, and beyond guideline or threshold
Geographic Extent	
Point	• Organism level; linear scale <5 m; confined to one stream reach in the LSA
Site-Specific	• Effects confined to the Project site
Local	• Effect is confined to the LSA; local population; linear scale <100 m
Regional	• Effect is confined to the RSA; multiple populations or species
Duration	
Short-term	• Less than two years (construction)
Medium-term	• From 2 to less than 17 years (operations)
Long-term	• From 17 to less than 35 years (closure)
Chronic (permanent)	• From 36 years and beyond (post-closure)
Reversibility	
Yes	• Effect is reversible over one to a few life cycles after the impact ceases
No	• Effect is not reversible over the time scales listed
Frequency	
Once	• Effect occurs on one occasion
Intermittent	• Effect occurs several times
Continuous	• Effect occurs continuously
Likelihood	
Low	• Low likelihood a residual effect will occur
Moderate	• Moderate likelihood a residual effect will occur
High	• High likelihood a residual effect will occur

Rating Criteria	Description
Significance	
Not significant (negligible)	• Effects are point-like or local in geographic extent, with a low context rating, and a negligible magnitude, short-term, reversible, and with a low frequency (once or intermittent)
Not significant (minor)	• Effects are local in geographic extent, with a low magnitude, and low context rating, short-term to chronic, reversible, and with a low frequency (once or intermittent)
Not significant (moderate)	• Effects are local to regional in geographic extent, and medium in magnitude, medium context rating, medium-term to chronic, reversible, and occur at all frequencies
Significant	• Effects occur to VCs with a medium to high context, high magnitude, regional in geographic extent, long-term to chronic, non-reversible, and occur at all frequencies.

Note: m = metre; m^2 = square metre; % = percent; VC = Valued Component

Once the evaluation of significance is determined, the level of confidence in the prediction is considered. Level of confidence can be high, moderate, or low and describes the certainty of the predicted outcome, allowing the decision-maker to evaluate risk. Uncertainty can be addressed through follow-up or monitoring programs.

The levels of confidence associated with the determinations of significance and likelihood are typically based on professional judgement and knowledge of the sources and nature of uncertainty as compounded through all steps in the effects assessment. Confidence and risk are evaluated for each residual effect prediction and each cumulative effect prediction. When there is a low confidence in residual effect prediction the necessity of additional risk analysis may be proposed (**Table 5.3.8-56**).

Table 5.3.8-56: Confidence

Confidence	
High	All of the following must be met: • VC is well understood • Project-VC interaction is well understood • Mitigation has been proven effective
Moderate	• VC understood in similar ecosystems and effects documented in the larger regional area or in the literature • Mitigation proven effective elsewhere
Low	• VC is not well understood • Project-VC interaction is not well understood • Mitigation has not been proven effective

5.3.8.4.1 Loss of Fish on the Mine Site

The proposed avoidance and mitigation measures (e.g., fish salvage and translocation) will reduce potential loss of fish. However, there will be unavoidable loss of fish access to habitat in the Davidson Creek and Creek 661 headwaters on the mine site and upstream of the mine site. This loss of habitat will have a high magnitude, local, long-term and irreversible residual effect on fish habitat in the upper Davidson Creek Watershed and in the headwaters of Creek 661.

These losses of fish habitat will be offset with fish habitat restoration, enhancement, and creation. Those measures are described in detail in the FMOP (**Appendix 5.1.2.6C**).

Fish habitat under the mine footprint and upstream of it will be permanently altered or lost during construction, operations, closure and post-closure phases. Therefore, the magnitude of the effect is high in all phases (**Table 5.3.8-57**).

Context is low because there are no listed fish species in either Davidson Creek or Creek 661. Brassy minnow, a blue-listed species, is the only listed fish species in the LSA, but it is present in Tatelkuz Lake, not Davidson Creek. The Rocky Mountain Capshell (*Acroloxus coloradensis*), a type of freshwater limpet that is blue-listed in BC, has been found in Lake 01682LNRS, but not in Davidson Creek.

Geographic extent is local because the effect is confined to the headwater reaches of Davidson Creek and Creek 661.

Duration extends throughout all phases; therefore it is short-term during construction, medium-term during operations, long-term during closure and chronic (or permanent) in post-closure.

The effect is irreversible, and the frequency is continuous.

Table 5.3.8-57: Significance of Residual Effects on Rainbow Trout of the Mine Site Footprint

Categories for Significance Determination	Project Phase			
	Construction	**Operations**	**Closure**	**Post-Closure**
Context	Low	Low	Low	Low
Magnitude	High	High	High	High
Geographic Extent	Local	Local	Local	Local
Duration	Short-term	Medium-term	Long-term	Permanent
Reversibility	No	No	No	No
Frequency	Continuous	Continuous	Continuous	Continuous
Likelihood Determination	Moderate	Moderate	Moderate	Moderate
Significance Determination	Not Significant (minor)	Not Significant (minor)	Not Significant (minor)	Not Significant (minor)
Statement of the level of Confidence for Significance	High	High	High	High

The FMOP will offset the lost fish habitat by constructing two overwintering and rearing ponds near the mid-reaches of Davidson Creek and by creating or restoring additional fish habitat elsewhere in the LSA, the RSA and in the region (**Appendix 5.1.2.6C**).

This effect on fish of mine site development is assessed as not significant (minor) for rainbow trout, largely because the lost habitat will be replaced by new fish habitat, as described by the FMOP. (There are no kokanee on the mine site.)

The likelihood of this determination is high because the FMOP is based on proven concepts that have been used successfully in other offsetting plans for mines in BC. Confidence in this assessment is high.

The residual effect on rainbow trout of habitat loss in the mine site was carried forward into cumulative effects assessment because it was assigned a significance rating higher than "not significant (negligible)" (see **Section 4.3.6**).

5.3.8.4.2 Disruption of Salmonid Fish Homing in Davidson Creek

This residual effect is restricted to operations and closure phases (**Table 5.3.8-58**). Flow augmentation will begin during construction and will end at the end of closure.

Table 5.3.8-58: Significance of Residual Effect on Homing of Fish to Davidson Creek

Categories for Significance Determination	Project Phase	
	Operations	**Closure**
Rainbow Trout		
Context	Low	Low
Magnitude	Medium	Medium
Geographic Extent	Local	Local
Duration	Medium-term	Long-term
Reversibility	Yes	Yes
Frequency	Continuous	Continuous
Likelihood Determination	High	High
Significance Determination	Not Significant (Moderate)	Not Significant (Moderate)
Statement of the level of Confidence for Significance	Moderate	Moderate
Kokanee		
Context	Low	Low
Magnitude	Medium	Medium
Geographic Extent	Local	Local
Duration	Medium-term	Long-term
Reversibility	Yes	Yes
Frequency	Continuous	Continuous
Likelihood Determination	High	High
Significance Determination	Not Significant (Moderate)	Not Significant (Moderate)
Statement of the level of Confidence for Significance	Moderate	Moderate

Context of this effect is low because there are no fish species of special conservation concern in Davidson Creek. Brassy minnow, a blue-listed species, is the only listed fish species in the LSA, but it is present in Tatelkuz Lake, not Davidson Creek. The Rocky Mountain Capshell, a type of freshwater limpet that is blue-listed in BC, has been found in Lake 01682LNRS, but not in Davidson Creek.

Magnitude of this effect is medium because the proportion of spawners of both indicator species that will return to spawn in Davidson Creek may fall below baseline run sizes after flow augmentation begins, and the extent of disruption is difficult to predict. To be conservative, it is assumed that numbers of spawners may temporarily fall below the threshold required to maintain the population in perpetuity. However, over the long-term, numbers of spawners are expected to remain within the limits of natural variability due to the continued presence of Davidson Creek water within the augmented flows, the plasticity of salmonid homing behaviour, and, if required, the application of management tools such as embryo transfer to restore run sizes.

Geographic extent of the residual effect is assessed as local because it is largely confined to Davidson Creek, although those spawners who cannot locate their natal spawning grounds in Davidson Creek may end up straying to adjacent creeks in the LSA such as Turtle Creek or lower Chedakuz Creek.

Duration of the residual effect is of medium-term (>2 years but <17 years) during operations, but long-term (>17 years to <37 years) during closure.

All potential residual effects are reversible. Once the TSF begins to discharge into Davidson Creek and pumping from Tatelkuz Lake ceases, the olfactory environment in Davidson Creek will return to a new baseline status that will persist in perpetuity. Fish populations will re-adjust to the new olfactory regime.

Frequency of the potential residual effects is continuous because spawning of rainbow trout and kokanee will occur in Davidson Creek every year throughout the construction, operation and closure phases. This is a conservative assumption because spawning is intermittent within a annual time scale, occurring only in June for rainbow trout and in July and August for kokanee).

In summary, the residual Project effect of flow augmentation using Tatelkuz Lake water on homing behaviour is assessed as not significant for both rainbow trout and kokanee because it is assessed as unlikely, and capable of being managed should it occur. A “moderate” qualifier is attached to that assessment of non-significance because the effect is of low context, medium magnitude, local extent, medium-term in duration, reversible and continuous.

The likelihood of some disruption of homing in both indicator species is high, although it is difficult to predict the magnitude of that disruption. Confidence in this assessment is moderate due to the presence of Davidson Creek water in the augmented creek and because there is an absence of precedents for the effects on salmonid homing of pumping water between adjacent watersheds.

The residual effect on salmonid homing to Davidson Creek during flow augmentation was carried forward into cumulative effects assessment because it was assigned a significance rating higher than "not significant (negligible)" (**Section 4.3.6**).

5.3.8.4.3 Mercury Mobilization in Lake 01682LNRS

Mercury concentrations in rainbow trout of Lake 01682LNRS may increase over the operations phase and then decrease over the closure and post-closure phases as a result of enlarging the lake. (Kokanee are not present in the Creek 705 Watershed.) Once the soil is flooded by enlargement of Lake 01682LNRS, bacteria in the soil will begin to methylate mercury stored in the soil, and methyl-mercury will then be taken up by aquatic plants and BMI and eventually by fish, mainly rainbow trout. Eventually, mercury concentrations will fall back to baseline levels – a process that typically takes 30 to 40 years (Azimuth, 2012).

The context of this residual effect is medium because, although there are no listed fish species in Lake 01682LNRS or the Creek 705 Watershed, specimens of a blue-listed mollusc – the Rocky Mountain Capshell – have been found in Lake 01682LNRS (**Table 5.3.8-59**).

Specimens of Rocky Mountain Capshell were observed in a single sample of littoral zone BMI collected with a kick-net in August 2012 (**Appendix 5.1.2.6A**). It was a rare species in that sample, representing only 0.3% of the number of organisms (i.e., 17 individuals were counted within the 5,301 benthic invertebrates in the sample).

Table 5.3.8-59: Significance of Residual Effects on Rainbow Trout from Elevated Methylmercury in Lake 01682LNRS

Categories for Significance Determination	Project Phase			
	Construction	**Operations**	**Closure**	**Post-Closure**
Context	Medium	Medium	Medium	Medium
Magnitude	Low	Low	Low	Low
Geographic Extent	Local	Local	Local	Local
Duration	Short-term	Medium-term	Medium-term	Medium-term
Reversibility	Yes	Yes	Yes	Yes
Frequency	Continuous	Continuous	Continuous	Continuous
Likelihood Determination	High	High	High	High
Significance Determination	Not Significant (Minor)	Not Significant (Minor)	Not Significant (Minor)	Not Significant (Minor)
Statement of the level of Confidence for Significance	Moderate	Moderate	Moderate	Moderate

This species is recognized as a species of Special Concern by the BC Conservation Data Centre (BC CDC) (BC CDC, 2014). It has a Provincial S3 conservation status (i.e., blue-listed) and a Global status of G3 (BC CDC, 2014). The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) classifies it as "Not at Risk". It was assigned to the Provincial blue-list because it is the only species of the Family Acroloxidae found in North America, and in BC it is found only in the east-central region (Klinkenberg, 2012). Its habitat is high-altitude oligotrophic and mesotrophic lakes and ponds. It is found in rocky, exposed portions of lakes in shallow water on the underside of rocks and vegetation on wave-swept shores. Populations are not endangered, but their habitat type is limited.

Magnitude is low because mercury and methylmercury concentrations are expected to increase in tissues of rainbow trout, but at their peak they are not expected to reach concentrations that could significantly affect any aspect of rainbow trout growth, survival or reproduction. This is because, as reported by Azimuth (2012), there is little evidence that the elevated mercury concentrations typically observed in tissue of fish resident in newly-created reservoirs has any effect on their ecology. The main scientific and social concern has always been for the health of humans, particularly pregnant women, who may consume large quantities of fish harvested from such reservoirs on a continuous basis over a long time period.

Long-term human consumption of rainbow trout from lakes 01682LNRS and 01538UEUT is an unlikely scenario because until the mine site is abandoned (i.e., the *Mines Act* permit is closed) the mine site will be off limits to the general public. Lakes 01682LNRS and 01538UEUT and Davidson Creek upstream of the mine access road will not be accessible for any food fishing. That will be at least 18 years after mine closure or about 35 years total from mine opening.

The geographic extent is local because it is restricted to the two headwater lakes (01682LNRS and 01538UEUT) and the mainstem of Creek 705.

Typically, the period of elevated mercury concentrations in a new reservoir lasts for 30 to 40 years (Azimuth, 2012). This period corresponds to the Project life span. Hence, duration is predicted to be short-term during construction and medium term through operations, closure and post-closure.

The effect is reversible because mercury concentrations are expected to fall back to baseline concentrations in the post-closure period.

This potential residual effect is predicted to be not significant (minor) because it is low in magnitude, local in extent, medium-term in duration, and reversible.

The likelihood of this residual effect occurring is high, but confidence in this assessment is moderate. Although the phenomenon of mercury mobilization in new reservoirs has been observed repeatedly throughout the world over the last 50 years, particularly in the hydroelectric reservoirs of Quebec and BC, it remains difficult to reliably predict the degree of mercury mobilization above baseline (Azimuth, 2012), and hence the concentration of mercury in fish tissues.

The residual effect of mercury mobilization in Lake 01682LNRS was carried forward into cumulative effects assessment because it was assigned a significance rating higher than “not significant (negligible)” (**Section 4.3.6**).

5.3.8.4.4 Changes in Water Temperature in Davidson Creek

The potential residual effect of changes in water temperature on fish in Davidson Creek will occur during operations, closure and post-closure phases. During operations and closure water temperature is predicted to increase in the winter and decrease in the summer as a result of flow augmentation using water pumped from below the epilimnion of Tatelkuz Lake. Upon post-closure, water temperatures are predicted to return to baseline in winter but remain elevated during the other three seasons.

Higher temperatures during winter will reduce incubation times of kokanee embryos and result in earlier emergence of kokanee fry. They will increase growth rates of juvenile rainbow trout overwintering in Davidson Creek. Lower temperatures during spring will not affect spawn timing of rainbow trout in Davidson Creek because all of the seven populations in the LSA spawn in June despite having highly variable mean water temperatures during that month. Lower water temperatures in June may lengthen incubation time of rainbow trout embryos and delay fry emergence. Lower temperatures in summer and autumn will reduce growth of juvenile rainbow trout.

Context for this assessment was rated low because there are no listed fish species in Davidson Creek (**Table 5.3.8-60**).

Magnitude is also rated as low because predicted water temperatures will fall within the natural range of variation.

Geographic extent is local because it is limited to Reaches 1 to 6 of lower and middle Davidson Creek.

Changes to water temperature are irreversible because summer water temperatures will be permanently elevated in the post-closure phase, although temperatures during that phase will still fall within the range of natural variation of streams and lakes of the LSA.

Frequency is continuous because flow augmentation will be continuous through operations and closure, and discharge from the TSF will be continuous during post-closure.

This potential residual effect is predicted to be not significant because it is low in magnitude and local in extent, even though it is chronic in duration and irreversible. A “minor” qualifier is attached to this assessment because the modified temperature regime is just as likely to produce positive effects on fish growth, survival and reproduction as negative effects.

The likelihood of temperature change in Davidson Creek as a result of Project activities is high, but confidence in this assessment is moderate because of limitations in the data and in the model used to predict water temperatures in all phases.

The residual effect of changes in water temperature of Davidson Creek was carried forward into cumulative effects assessment because it was assigned a significance rating higher than “not significant (negligible)” (**Section 4.3.6**).

Table 5.3.8-60: Significance of Residual Effects of Water Temperature on Fish Habitat in Davidson Creek

Categories for Significance Determination	Project Phase			
	Construction	**Operations**	**Closure**	**Post-Closure**
Rainbow Trout				
Context	Low	Low	Low	Low
Magnitude	Low	Low	Low	Low
Geographic Extent	Local	Local	Local	Local
Duration	Chronic	Chronic	Chronic	Chronic
Reversibility	N/A	N/A	N/A	No
Frequency	Once	Intermittent	Intermittent	Continuous
Likelihood Determination	High	High	High	High
Significance Determination	Not significant (minor)	Not significant (minor)	Not significant (minor)	Not significant (minor)
Statement of the level of Confidence for Significance	Moderate	Moderate	Moderate	Moderate
Kokanee				
Context	Low	Low	Low	Low
Magnitude	Low	Low	Low	Low
Geographic Extent	Local	Local	Local	Local
Duration	Short-term	Medium-term	Long-term	Chronic
Reversibility	No	No	No	No
Frequency	Continuous	Continuous	Continuous	Continuous
Likelihood Determination	High	High	High	High
Significance Determination	Not significant (minor)	Not significant (minor)	Not significant (minor)	Not significant (minor)
Statement of the level of Confidence for Significance	Moderate	Moderate	Moderate	Moderate

5.3.8.4.5 Reduction in Littoral Fish Habitat of Tatelkuz Lake

Changes in WSE of Tatelkuz Lake due to pumping of water to the mine site are expected to have residual effects on rainbow trout and kokanee in Tatelkuz Lake due to reduction in habitat quantity and quality in the upper 1 m of the littoral zone. The number of rainbow trout HU will be reduced in the winter during an average year for each life stage, and be reduced for all seasons in a 1:50 dry year. The number of kokanee HU will be reduced in all seasons with the exception of summer in an average annual year and in all seasons in a dry year.

Changes in WSE will only affect the 0 to 1 m depth stratum of the littoral zone. Changes in HU for each of the two indicator species will not exceed 2.6% for any phase of the project.

Effects are restricted to operations and closure phases because pumping of Tatelkuz Lake water to the freshwater reservoir will begin in the middle of the construction phase and will end at the end of the closure phase (**Table 5.3.8-61**).

Context of this effect is medium because of the presence of brassy minnow, a blue-listed species, in Tatelkuz Lake. Brassy minnow prefer shallow, littoral zone habitat.

The magnitude of these changes is negligible because, although the number of HU differs from mean baseline values, it is within the range of natural variation. The predicted change (<3%) is so small that it is unlikely it can be measured.

Geographic extent of the residual effect is local because it is confined to the LSA.

Duration of the residual effect in Tatelkuz Lake is of medium-term (>2 years but <17 years) during operations, but long-term (>17 years to <35 years) during closure.

Table 5.3.8-61: Significance of Residual Effect on Fish using Upper 1 m of Littoral Habitat in Tatelkuz Lake

Categories for Significance Determination	Project Phase	
	Operations	**Closure**
Rainbow Trout		
Context	Medium	Medium
Magnitude	Negligible	Negligible
Geographic Extent	Local	Local
Duration	Medium-term	Long-term
Reversibility	Yes	Yes
Frequency	Continuous	Continuous
Likelihood Determination	High	High
Significance Determination	Not Significant (Negligible)	Not Significant (Negligible)
Statement of the level of Confidence for Significance	High	High
Kokanee		
Context	Medium	Medium
Magnitude	Negligible	Negligible
Geographic Extent	Local	Local
Duration	Medium-term	Long-term
Reversibility	Yes	Yes
Frequency	Continuous	Continuous
Likelihood Determination	High	High
Significance Determination	Not Significant (Negligible)	Not Significant (Negligible)
Statement of the level of Confidence for Significance	High	High

All potential residual effects are reversible once pumping ceases at the end of the closure phase. Once the pit has been filled with water and the FSS removed, then WSE of Tatelkuz Lake will return to baseline conditions.

Frequency of the potential residual effects is continuous because pumping will be continuous throughout the mine life and will only cease at the end of closure.

Likelihood is high that there will be reductions in the number of HU in the upper 1 m of Tatelkuz Lake because pumping water from Tatelkuz Lake will inevitable reduce total volume compared to the non-pumping scenario, even if the volume pumped is a very small proportion of total lake volume and total inflow to the lake.

The adverse residual effects on fish due to changes in WSE of Tatelkuz Lake are considered not significant for both indicator fish species. A “negligible” qualifier is attached to that assessment because the effect is of negligible magnitude, local, reversible, but continuous during the pumping period.

Confidence in this assessment is high because using HU as a predictive tool is a methodology that has been used extensively in streams and lakes of BC, and because the overall change from baseline conditions does not exceed 3%.

The adverse residual effect on fish due to changes in WSE of Tatelkuz Lake was not carried forward into cumulative effects assessment because it was assigned a rating of “not significant (negligible)” (**Section 4.3.6**).

5.3.8.5 Cumulative Effects

Potential cumulative effects on fish must be considered when Project-related residual effects on fish overlap temporally or spatially with known or likely residual effects from past, present, or reasonably foreseeable projects. This section determines the need for assessing cumulative effects; assesses potential cumulative effects; and, if applicable, assesses cumulative effects and evaluate these effects using the same criteria and steps as noted in **Section 5.3.8.4** above. Potential cumulative effects on fish were assessed within the Project aquatic cumulative effect study area (CESA) which is the same as the aquatic RSA.

5.3.8.5.1 Rationale for Assessing Cumulative Effects

Of the five residual effects on fish, none were assessed as significant in **Section 5.3.8.4**. One (changes in WSE of Tatelkuz Lake) was characterized as “not significant (negligible)” and was not carried forward to cumulative effects assessment (**Table 5.3.8-62**). Of the remaining four, three were characterized as minor and one was characterized as moderate. The remaining four were carried forward to cumulative effects assessment.

Table 5.3.8-62: Project-Related Residual Effects on the Fish VC: Rationale for Carrying Forward into the CEA

Project Component	Project Phase	Residual Effect	Rationale	Carried Forward in Cumulative Effects Assessment
Mine site	C, O, D/C, P	Loss of fish and fish habitat on the mine site	Fish habitat under the mine footprint will be permanently lost, and rainbow trout will have to be moved to lower reaches of Davidson Creek. This effect was assessed as not significant (minor) for rainbow trout, because the lost habitat will be replaced by new fish habitat in offset measures.	Yes
Mine site	O, D/C	Disruption of salmonid homing to Davidson Creek	Rainbow trout and kokanee are expected to continue spawning in middle and lower Davidson Creek even though the olfactory environment will be altered by water pumped from Tatelkuz Lake. However, some disruption to homing and spawning success throughout the length of the creek may occur. This effect was assessed as not significant (moderate) because the effect will end once pumping of Tatelkuz Lake water stops, and because it can be managed during mine life.	Yes
Mine site	C, O, D/C, P	Mercury mobilization in Lake 01682LNRS	Mercury concentrations in tissue of rainbow trout may increase as a result of mobilization of mercury from flooded soils in the enlarged lake. This effect was assessed as not significant (minor) because mercury concentrations will not reach concentrations that would affect the health of fish, nor will humans be affected because access to Lake 01682LNRS and Lake 01538UEUT will be restricted during mine life. Eventually, mercury concentrations will fall to baseline levels in the post-closure phase approximately 30-40 years after lake enlargement.	Yes
Mine site	O, D/C, P	Changes in water temperature in Davidson Creek	During flow augmentation, water temperature in Davidson Creek is predicted to increase in the winter and decrease in the summer because water will be pumped from below the epilimnion of Tatelkuz Lake. Upon post-closure, water temperatures are predicted to return to baseline in winter but remain elevated during the other	Yes

Project Component	Project Phase	Residual Effect	Rationale	Carried Forward in Cumulative Effects Assessment
			three seasons. This effect was assessed as not significant (minor) because it is low in magnitude and local in extent and because the modified temperature regime is just as likely to produce positive effects on fish growth, survival and reproduction as negative effects.	
FSS	O, D/C	Changes in WSE of Tatelkuz Lake	Changes in WSE caused by pumping water to the mine site will affect the 0 to 1 m depth stratum of the littoral zone. This effect was assessed as not significant (negligible) because the predicted change in habitat units (<3%) is within the range of natural variation and is so small that it is unlikely it can be measured. The effect is temporary and reversible once pumping stops and the end of the closure phase.	No

Note: C = construction; O = operations; D/C = decommissioning and closure; P = post-closure.

5.3.8.5.2 Potential Cumulative Effects

To be classified as potential cumulative effects, the four residual effects classified as significant (minor) and significant (moderate) have to interact with other projects or activities in the CESA as a result of spatial or temporal overlap. **Table 4.3-11** shows the Summary Project Inclusion List developed for cumulative effects assessment. Of the 13 items on that list, ten have potential relevance to the fish VC, as follows:

- Pacific Gas Looping Project;
- Mining – existing;
- Mining – exploration;
- Forestry – logging;
- Hunting, trapping and guide outfitting;
- Fishing and hunting lodges;
- Recreation;
- Agriculture;
- Transportation; and
- Crown land tenures.

Table 5.3.8-63 shows the degree to which the two indicators of the fish VC interact with the four residual effects for the projects and activities listed above.

5.3.8.5.2.1 Pacific Gas Looping Project

Pacific Northern Gas Ltd. is proposing a natural gas transmission pipeline between Summit Lake, BC, and Kitimat, BC. That project is currently in the pre-application phase of the BC environmental assessment process. Based on the information provided in Pacific Northern Gas Ltd.'s pre-application, the pipeline will cross the Stellako River, which will also be crossed by the proposed Blackwater transmission line.

With the implementation of Best Management Practices (BMP) during the construction of the Project's transmission line and Pacific Northern Gas Ltd.'s pipeline, as well as the ability to site transmission towers well away from water crossings, no cumulative instream works or sedimentation into the Stellako River is anticipated.

During the operations phase, maintenance activities along the Project's transmission line will incorporate BMPs to minimize the potential for sediment to enter the river. Similarly, it is expected that pipeline operations will also implement BMPs, which will minimize potential for increasing sediment loads in the Stellako River.

No other aspect of the Pacific Gas Looping Project will interact with the four potential residual effects on the fish VC (**Table 5.3.8-63**). Therefore, potential cumulative effects on fish and fish habitat of that gas pipeline were not considered further.

5.3.8.5.2.2 Mining – Existing

There are no past mineral producers or other active producers other than that of the Project within the aquatics CESA. Therefore, potential cumulative effects of existing mining on the fish VC were not considered further (**Table 5.3.8-63**).

5.3.8.5.2.3 Mining – Exploration

Exploration activities for the Project have resulted in land disturbance, which could potentially have affected fish (and fish habitat) in adjacent watercourses. New Gold developed and implemented regulatory approved environmental management plans for their exploration permits. Existing access trails and drill pads require reclamation under the license and reclamation is underway, usually within a year or less of completion of site disturbance. Thus, there is unlikely to be any cumulative effects on fish and fish habitat from exploration activities that pre-date Project construction.

New Gold is continuing to explore deposits other than the Blackwater ore body both within and outside the aquatic CESA. Should one or more of those ore bodies be assessed as economically viable sometime in the future, then they would require separate environmental assessments to be conducted sometime in the future.

Table 5.3.8-63: Project-Related Residual Effects on Fish VC – Rationale for Carrying Forward into Cumulative Effects Assessment

Indicator	Project Phase	Potential Residual Effect	Pacific Gas Looping Project	Mining - existing	Mining - exploration	Forestry - logging	Hunting, Trapping and Guide Outfitting	Hunting and Fishing Lodges	Recreation	Agriculture	Transportation	Crown land tenures	Inclusion in CEA?
Rainbow trout	C, O, D/C, P	Loss of fish and fish habitat on mine site	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Disruption of salmonid homing	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Mercury mobilization in Lake 01682LNRS	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Changes in water temperature in Davidson Creek	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
Kokanee	C, O, D/C, P	Disruption of salmonid homing	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Changes in water temperature in Davidson Creek	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No

Note: C = construction, O = operation, D/C = decommissioning/closure, P = post-closure, and NI = no interaction.

For those ore bodies that are economically viable and that may exist within the aquatic CESA, it may be more advantageous to process their ore on the Project mine site using pre-existing facilities than build new facilities. In that case, the only aspect of the Project that would change is an extension of the Operations phase and a delay in Project closure. Ore would be transported to the mine site using existing roads and the resultant tailings would be stored in the existing TSF. The TSF may have to be increased in volume, but that would not require expanding the mine site. Flow augmentation and temperature control of Davidson creek would continue. The Creek 705 Watershed would not be altered by the extended duration of the Project's Operations phase. There would be no interactions with the four potential residual effects (**Table 5.3.8-63**).

Therefore, potential cumulative effects on the fish VC of mining exploration activities were not considered further.

5.3.8.5.2.4 Forestry – Logging

Timber harvesting is a fairly recent resource use in the Davidson Creek regional management zone, beginning in the late 1980s. Active forestry operations near to the Project mine site have been conducted by L&M Lumber, who developed a road system in the Davidson Creek drainage (New Gold, 2012).

Forestry-related activities within the RSA include cut block timber harvesting, road building and culvert replacement, and woodlot tenures. Retired, active and future (harvesting inventory) logging tenures represent approximately 26% (37,000 ha) of the aquatic mine site CESA, with 9.8% (13,821 ha) representing active tenures. Logging road tenures represent only 1,361 ha of the CESA or 1% of its total area.

Woodlot tenures give the right to an individual to harvest timber on Crown land in exchange for their agreement to manage the private land portion of the tenure in accordance with provincial forestry legislation such as the *Forest and Range Practices Act*. There are eight active woodland tenures within the RSA, representing 510 ha of the CESA or 0.36% of its area.

Logging practices on Crown land have to comply with the Forest Practices Code guidelines. Logging practices on private land do not have to comply; but land owners are encouraged to do so. The code provides BMPs and habitat management guidelines which mitigate the effects of forest practices.

Potential effects to fish as a result of logging activities include:

- Increased TSS and sedimentation at stream crossings of forestry roads and at locations where stream banks erode;
- Increased "flashiness" of the flow regime (i.e., higher, quicker peak flows and longer, drier low flows) due to reduced water uptake by trees and decreased water storage in the soil. This potential effect would only happen in watersheds in which the majority of the land had been cleared in the form of cut blocks;
- Increases in summer water temperatures due to loss of riparian cover and shade; and

- Decrease in over-head cover and allochthonous inputs (i.e., leaf litter and terrestrial insects) due to the loss of, or alteration of riparian belt.

Since logging has been occurring in the RSA for decades, any sedimentation effect has already been incorporated into baseline characterization of fish populations and fish habitat in the LSA.

There are no anticipated interactions between forestry activities and the four potential residual effects for the following reasons (**Table 5.3.8-63**):

- Forestry activities will not affect the size, location and boundaries of the mine site;
- Forest companies will not have access to the banks of Davidson Creek to potentially affect the olfactory environment or water temperatures of that stream;
- Forestry companies will not have access to Lake 01682LNRS and Lake 01538UEUT during the life of the Project; and
- Forestry activities will not affect the duration of any Project phases.

Therefore, potential cumulative effects on the fish VC of forestry-related activities were not considered further.

5.3.8.5.2.5 Hunting, Trapping and Guide Outfitting

The Vanderhoof area is a popular fishing destination due to the area's network of streams, rivers, and lakes. They are five guide outfitter operations within the CESA who offer guided fishing trips to local streams and lakes. The combined fish harvest of those outfitting operations is not known due to the absence of any creel surveys in the CESA. Trapping is also prevalent in the area.

Hunting, trapping and guide outfitting have been occurring in the CESA for decades, hence the baseline estimates of fish species richness and fish population numbers in the LSA that were obtained from 2011-2013 include any effects from those previous activities.

Access of hunters, trappers, and guide outfitters to Project facilities will be restricted during all Project phases. Therefore, there will be no interactions with the four potential residual effects on the fish VC (**Table 5.3.8-63**), and cumulative effects on fish of hunting, trapping and guide outfitting were not carried forward to cumulative effects assessment.

5.3.8.5.2.6 Hunting and Fishing Lodges

Two commercial lodges are present within the aquatics CESA:

- **Tatelkuz Resort:** Located on the northwest shores of Tatelkuz Lake, it is a wilderness resort (log cabins and a lodge) and working cattle/dude ranch, offering fishing and boating on Tatelkuz Lake, hiking and picnicking in a remote wilderness setting and horseback riding. The owners also hold the majority of the rangeland tenure overlapping with the aquatics CESA; and

- **Laidman Lake Ecolodge:** Located approximately 18 km southwest of the mine site. It offers cabin rentals, camping, fishing, sightseeing, and hiking, all-terrain vehicle use, snowmobiling, snowshoeing, and a variety of other eco-tourism activities.

The activities of these two lodges will not interact with the four potential residual effects on fish for the same reasons listed above for hunting, trapping and guide outfitters (**Table 5.3.8-63**). Therefore, cumulative effects on the fish VC of hunting and fishing lodges were not carried forward to cumulative effects assessment.

5.3.8.5.2.7 Recreation

Recreational activities within the aquatics CESA include all-terrain vehicle use, snowmobiling, hiking, camping, cross-country skiing, horseback riding, fishing, hunting, interpretive cultural heritage experiences, and eco-tourism. Facilities for these activities include recreational areas, campsites, and lodges.

There are five recreational sites and reserves within the CESA, of which only three are accessible by roads (Top Lake, Laidman Lake and Kuyakuz Lake). Known recreational fishing locations include Top and Tatelkuz lakes, lower and middle Chedakuz Creek, and middle and lower Davidson Creek.

Recreational activities in the CESA do not affect fish habitat in streams of the CESA. If carried out safely, all-terrain vehicle use, snowmobiling, horseback riding, cross-country skiing and hiking have negligible residual effects on fish habitat. Heavy blowdown of timber as a result of the mountain pine beetle infestation restricts much of that activity to established trails and to a limited number of stream crossings. Other activities such as hunting and eco-tourism are not expected to interact with fish habitat.

There is no information available on magnitudes of recreational harvest for any waterbody in the CESA, but it is reasonable to assume that most fishing effort is exerted on lakes and streams with road or trail access. Tatelkuz, Kuyakuz, Top and Laidman lakes are all connected to the FSR network.

None of these activities will interact with the four potential residual effects on fish for the same reasons listed above for hunting, trapping and guide outfitters (**Table 5.3.8-63**). Therefore, cumulative effects on the fish VC of recreational activities were not carried forward to cumulative effects assessment.

5.3.8.5.2.8 Agriculture

There has been much growth over the last 20 years in agricultural lands in the Nechako Valley (New Gold, 2012). The Land Resource Management Plan and Vanderhoof Crown Land Plan have set aside Agricultural Development Areas and Agricultural Land Reserve within which farming is encouraged and non-agricultural uses controlled. The Nechako Valley Agricultural Land Reserve overlaps over 160 ha of the CESA, accounting for less than 1% of the total CESA.

Three types of agriculture occur within the CESA:

- Extensive –this type of agricultural practice uses Crown land for soil-bound cultivation to produce cereal, seed, forage, vegetable or fruit crops for mechanical harvesting;
- Intensive –this type of agricultural practice uses small (<15 ha) Crown land parcels for the commercial production of animals, fruits, and/or vegetables (e.g., poultry farms, dairy farms, market gardens, greenhouses, nurseries, piggeries, and feed); and
- Grazing – there are 11 active rangeland tenures overlapping with the CESA. The rangeland tenure that overlaps by far the most with the RSA is owned by the same individual who owns and operates the Tatelkuz Lake Ranch Resort.

Extensive and Intensive agriculture together represent 144 ha (or less than 0.1%) of the area of the aquatic CESA. Grazing is by far the most important type of agricultural activity within the CESA, overlapping with 61,477 ha of the aquatic CESA or 44% of its total area.

Rangeland is mainly used for raising cattle and sometimes horses. Cattle are either left to roam through the forest or kept in managed pastures. Livestock ranching, however, is subject to the *Agricultural Waste Control Regulation* under the *Environmental Management Act*, as well as the *Water Act*, and the *Fisheries Act*. The Code of Agricultural Practice for Waste Management describes practices for managing agricultural waste in an environmentally sound manner. In addition, the BC Cattlemen's Association promotes BMPs to protect and enhance riparian vegetation and mitigate agricultural effects on streams and lakes through the Farmland-Riparian Interface Stewardship Program.

A ranch is located at the northern end of Tatelkuz Lake near the mouth of Davidson Creek. It may be having some effect on fish and fish habitat in lower Chedakuz Creek through nutrient enrichment from manure. This was suggested by the high periphyton biomass measured in 2011 at a site in lower Chedakuz Creek downstream of the confluence with Turtle Creek (**Appendix 5.1.2.6A**). It was high enough compared to other sites in the LSA and RSA to indicate possible nutrient enrichment from nearby pastures. Cows may also have trampled stream banks and riparian zones.

None of these agricultural activities will interact with the four potential residual effects on fish because farmers and ranchers will not have access to Project infrastructure (**Table 5.3.8-63**). Therefore, cumulative effects on the fish VC of recreational activities were not carried forward to cumulative effects assessment.

5.3.8.5.2.9 Transportation

Two FSRs pass through the aquatics RSA: (1) the Kluskus-Ootsa FSR, which crosses the RSA from the northeast to the southwest, and (2) the Kluskus-Tsacha (Blue Road), which intersects with the southeast corner of the RSA, just south of Kuyakuz Lake.

Existing access roads to the mine include the Davidson Creek Road, branching south from the Kluskus-Ootsa FSR to the mine site, and an existing exploration road, branching east from the

Kluskus-Ootsa FSR to the mine site. There also exists a network of logging roads connecting timber harvesting tenures within the CESA.

FSRs are used for miscellaneous traffic associated with recreational land use and other commercial and industrial activities in the area, including timber harvesting and mining exploration. However, traffic south of the Kluskus-Ootsa FSR is managed under access restriction, limiting vehicle access to this area to only that which is associated with resource development activities.

The principal users of the Kluskus FSR and the Kluskus-Ootsa FSR are, and will continue to be, forest companies.

No transportation activities will interact with the four potential residual effects on fish for the same reasons listed above for forestry activities (**Section 5.3.8.5.2.4**; **Table 5.3.8-63**). Therefore, cumulative effects on the fish VC of transportation activities were not carried forward to cumulative effects assessment.

5.3.8.5.2.10 Crown Land Tenures

A total of 25 provincial crown tenures are in place for various activities (agriculture, residential, etc.) in the access road and transmission line RSAs. The potential interactions of the activities conducted on these land tenures with the four potential residual effects on fish have been listed above in **Section 5.3.8.5** (**Table 5.3.8-63**). Therefore, cumulative effects on the fish VC of Crown land tenures were not carried forward to cumulative effects assessment.

5.3.8.6 Limitations

This section presents assumptions and limitations relative to the assessment of Project effects and the assessment of cumulative effects. Limitations to the assessments described in this section are primarily technical in origin. **Section 5.3.8.1.3.4** describes in detail the technical limitations – they will not be repeated here.

Technical limitations include the following: (1) lack of case histories of flow augmentation in which water is pumped from one part of a watershed to another part of the same watershed and in which rainbow trout and kokanee are the dominant fish species; and (2) assumptions required for the models used to predict fish number in Tatelkuz Lake using hydroacoustics techniques.

5.3.8.7 Conclusion

This section provides a conclusion regarding the significance of residual effects and cumulative effects if applicable. Potential effects of Project activities on fish of the LSA were assessed with and without the application of mitigation measures. Five residual effects were identified that could not be completed mitigated:

- Loss of fish (and fish habitat) on the mine site due to construction of Project facilities. This was assessed as not significant (minor) for rainbow trout (there are no kokanee on the mine site) because these losses of fish habitat will be offset with habitat restoration, enhancement, and creation, as described in the *Fisheries Mitigation and Offset Plan*;

- Disruption of salmonid homing to Davidson Creek as a result of flow augmentation of Davidson Creek by water pumped from Tatelkuz Lake. This was assessed as not significant (moderate) for both rainbow trout and kokanee because it is assessed as unlikely, but capable of being managed should it occur;
- Mobilization of mercury in Lake 01682LNRS due to flooding of the lake perimeter. This was assessed as not significant (minor) because it is low in magnitude, local in extent, medium-term in duration, and reversible;
- Changes in water temperature in Davidson Creek as a result of flow augmentation of Davidson Creek by water pumped from depths of 8 to 12 m in Tatelkuz Lake This was assessed as not significant (minor) because it is low in magnitude and local in extent, even though it is chronic in duration and irreversible. A “minor” qualifier was attached because the modified temperature regime is just as likely to produce positive effects on fish growth, survival and reproduction as negative effects; and
- Reduction in littoral fish habitat of Tatelkuz Lake due to water pumped to the mine site. This was assessed as not significant for both rainbow trout and kokanee. A “negligible” qualifier was attached because the effect is of negligible magnitude, local, reversible, but continuous during the pumping period.

The four residual effects assessed as significant (minor) and significant (moderate) were then compared to activities expected to occur in the aquatics RSA in the future. No spatial or temporal overlaps were found, hence cumulative effects assessment stopped at that point.

To test these predictions two aquatic monitoring programs with fish and fish habitat components were outlined: a Construction Monitoring Plan and an Aquatic Effects Monitoring Program (AEMP).

5.3.8.8 Follow-Up Monitoring

Scientific uncertainty associated with these assessments of Project effects on the fish VC will be addressed through the Aquatic Effects Monitoring Program (AEMP), which is described in detail in **Sections 13.3.2** to **13.3.6** of the Application. The purpose of the AEMP is to test predictions of the EA regarding potential Project effects on water flows, water quality, sediment quality, fish and fish habitat during operations, closure and early post-closure phases. The AEMP will integrate all monitoring of aquatic resources into a single program, thereby providing a single instrument for regulatory review of aquatic effects. The AEMP presented in this Application is a preliminary version that will be developed into final versions by New Gold in consultation with regulatory agencies and taking into account public and Aboriginal concerns.

A key element of the AEMP will be a program of adaptive management to ensure that the methods of measurement and analysis change according to the results of measurement.

Sections 13.3.2 through **13.3.6** describe preliminary AEMP components for surface water flow, surface water quality, sediment quality, groundwater flow, and groundwater quality. **Section 13.3.3**

includes discussion of regulatory triggers for further study or adaptive management and mitigative action for exceedances in water quality guidelines. Any exceedance of parameters not periodically exceeded in the baseline data will be investigated and mitigative action taken if appropriate; for instance, a spike in TSS may cause exceedances due solely to that cause which may be easily correctable. Increasing trends that suggest guidelines or objectives are being approached on a sustained basis will be a trigger for investigation of cause and management changes to address.

Section 13.3.8.2 includes an outline of standard methods to be used for comparing monitoring and baseline data to identify trends over time in fish tissue metals concentrations (i.e., before-after-control-impact (BACI) monitoring designs and appropriate statistical methods including multi-way analysis of variance [MANOVA] and principal component analysis [PCA; which was also used to analyze baseline data]).

As much as possible, sampling sites, sampling methodology, sampling frequency and sample sizes will follow those used for baseline studies so that the monitoring data and baseline data can be compared directly. Fish components of the AEMP may include the following:

- Rainbow trout and kokanee spawner surveys in Davidson Creek, conducted once each year in June (rainbow trout) and July-August (kokanee). These surveys will run for as many years as are required to establish that rainbow trout and kokanee spawners are returning to flow-augmented Davidson Creek in similar numbers and at similar times as during baseline years. After that date, frequency of monitoring may be reduced to every second year or fifth year or stopped entirely;
- Rainbow trout densities, body size and age at sites in Davidson Creek, Creek 661, lower Chedakuz Creek, and Creek 705, measured once each year in early July after the rainbow trout spawning migration is completed but before the kokanee spawning migration begins. These surveys will run for as many years as are required to establish that densities and biological characteristics of juvenile rainbow trout rearing in streams directly affected by Project activities are similar to those during baseline years. After that date, frequency of monitoring may be reduced to every second year or fifth year or stopped entirely;
- Gillnet catch per unit effort (CPUE) in Tatelkuz Lake of rainbow trout, kokanee and mountain whitefish to assess changes in relative population number compared with baseline. Gillnet CPUE would also be measured in lakes 01682LNRS and 01538UEUT for the same reason. These surveys would be conducted once every 5 years in mid-summer throughout the operations phase; and
- Rainbow trout fish tissue metals concentrations measured in Davidson Creek, Creek 661, and lakes 01682LNRS and 01538UEUT, and mountain whitefish tissue metals from Tatelkuz Lake, measured once every 5 years in mid-summer. This sampling would be co-ordinated with the fish tissue sampling component of the country foods monitoring program. These surveys would be conducted once every 5 years in mid-summer throughout the operations phase.

In the unlikely event that homing of salmonids to Davidson Creek is disrupted, **Appendix 5.1.2.6E** includes an adaptive management plan, developed under definition of the Canadian

Environmental Assessment Agency. The plan will build upon results of the rainbow trout and kokanee spawner surveys and density measurements to assess status, determine the effectiveness of management measures, and inform additional management action if needed. Monitoring will be conducted in a way that is complimentary of baseline collections (redd counts, hoop netting for rainbow trout and spawner counts for kokanee, microsatellite DNA analysis, etc.) and will be augmented by other approaches as needed.

Adaptive management will focus on maintaining production of Davidson Creek salmonid populations and continued use of baseline spawning grounds. Options for population restoration and homing mitigation are presented in the unlikely event of spawner declines.

Population restoration options include transfers of adults or eggs of similar genotypes (e.g., rainbow trout captured in Turtle Creek and rainbow trout or kokanee captured in Creek 661) into middle Davidson Creek, where imprinting of the next generation to the modified “olfactory bouquet” will create a self-sustaining population. Tagging of suspected Davidson Creek spawners, migrating through lower Chedakuz Creek (e.g., early-run kokanee) could also provide insight on the fate of spawners originating from Davidson Creek.

The plan identifies a more likely consequence of homing disruption as the absence of rainbow trout spawners in the middle reaches immediately downstream of the Freshwater Reservoir, where the only source of water will be Tatelkuz Lake (i.e., in the face of decreasing imprinted olfactory concentrations). This would be determined using the same methods as outlined above. Declines of rainbow trout spawners will trigger homing mitigation efforts. These may include the transfer of eggs and or adults from lower Davidson Creek to spawning grounds upstream and/or the use of artificial imprinting techniques (identified in the plan) directed at juveniles spawned in the lower reaches. When the artificially imprinted fish are expected to return, the imprinting agent can be added to waters at the upstream extent of baseline spawning habitat to attract spawners further upstream.

Monitoring of flows will be required during all phases of mine life to validate habitat model predictions and to assess whether adverse effects may occur at post-closure. Before potential effects occur at post-closure, 35 years of physical and biological monitoring data will be available to determine if a biological effect is expected, and to determine any required action. As with the fish components of the AEMP, the fish habitat components will also follow sampling sites, sampling methodology, sampling frequency and sample sizes used for baseline studies so that the monitoring data and baseline data can be compared directly. Fish habitat components of the AEMP (**Section 13.3.9.2**) may include the following:

- Stream flows and water temperatures in Davidson Creek, Creek 661, lower Chedakuz Creek, and Creek 705, measured continuously at the same locations as in 2011, 2012 and 2013. Temperature data loggers will be attached to hydrology stations;
- Stream habitat quality (e.g., water depth and velocity, substrate composition, stream bank erosion, etc.) at sites in Davidson Creek, Creek 661, lower Chedakuz Creek, and Creek 705, measured once per year in the low-flow period of mid-summer;

- Stream periphyton and benthic macroinvertebrate (BMI) sampling at sites in Davidson Creek, Creek 661, lower Chedakuz Creek, and Creek 705, measured once per year in mid- August – the time of maximum density, biomass and taxonomic diversity;
- Vertical profiles of temperature, conductivity and dissolved oxygen measured from Tatelkuz Lake, Lake 01682LNRS, and Lake 01538UEUT on a quarterly basis (as part of current water quality sampling protocol);
- Water surface elevation of Tatelkuz Lake measured continuously;
- Littoral zone fish habitat quantity and quality in Tatelkuz Lake, measured at transects around the lake once per year in the low-flow period mid-summer. This survey may be conducted for an initial period of 3 years. Thereafter, frequency may be relaxed to every second year or fifth year or stopped; and
- Lake phytoplankton, zooplankton and BMI sampling in Tatelkuz Lake, Lake 01682LNRS, and Lake 01538UEUT, once per year in mid-August – the time of maximum density, biomass and taxonomic diversity.