7.8 Fish Resources

This section describes the fish resources of the project area and potential project and cumulative effects on fish. The assessment of effects on fish is based on the assessment of project effects on water and sediment quality (Section 7.5) and periphyton and benthos (Section 7.7); the description of methods for constructing the access road and related stream crossings (Section 2.11: Transportation); and commitments to environmental protection during construction and operation as outlined in Section 9.2: Environmental Protection Plan. The potential social and cultural implications of project effects on fish resources are discussed in Section 7.11: Land Use and Tenure (effects on non-traditional fishing activities) and in Section 7.12: First Nations and Traditional Use.

This section discusses the effects of routine project construction and operations on fish resources. Potential effects of accidents and malfunctions are discussed in Section 8: Accidents and Malfunctions.

7.8.1 Scope of Assessment

Issues and Selection of Valued Ecosystem and Cultural Components

Project activities have the potential to affect a number of fish bearing and non-fish bearing streams that flow into Wolverine Lake, Finlayson River or Frances Lake within the upper Liard watershed. Fish species that have been documented in some of the sub-basins affected by project development include bull trout (*Salvelinus confluentus*), lake trout (*S. namaycush*), arctic grayling (*Thymallus arcticus*), burbot (*Lota lota*), northern pike (*Esox lucius*) and slimy sculpin (*Cottus cognatus*).

Of these species, bull trout have been designated as a "sensitive" species in the Yukon by the General Status of Species in Canada (National General Status Working Group 2004). Sensitive indicates that a "species is not believed to be at risk of immediate extirpation or extinction but may require special attention or protection to prevent them from becoming at risk". None of the species known or suspected to occur in the upper Liard drainage are listed as a species at risk under the federal *Species at Risk Act* (Environment Canada 2005).

As bull trout are relatively widespread throughout the upper Liard drainage (e.g., Gartner Lee, 2004, 2005) and have been designated as sensitive, bull trout have been identified as a sentinel species for this assessment. By protecting the habitat requirements necessary to sustain this species, the habitat quality and quantity of other fishes and, the fish populations themselves will also be protected.

For the purposes of this assessment, "fish" refers to all life stages of resident species known or suspected to occur within the project area. Fish habitat refers to spawning, egg incubation, rearing, overwintering areas and migratory corridors used by fish or other organisms that fish depend upon directly or indirectly in order to carry out their life processes. Habitat includes instream physical habitat (as characterized by channel gradient, width, residual pool depth, etc.), riparian habitats (that is stream bank vegetation that provides shade, cover and organic input to instream habitat), invertebrate food production, and stream water quality (dissolved oxygen, temperature, pH, turbidity, etc.). Protection of fish, fish habitats and the management of fisheries resources, are regulated by the federal *Fisheries Act;* therefore, the environmental effects of the project on freshwater fish and fish habitat are considered.

Project activities that have the potential to affect fish and fish habitat include the following:

- changes in stream flows from mine dewatering, diversions and effluent discharge affecting physical habitat capability in Wolverine and Go Creeks
- habitat disturbance during construction of access road stream crossings
- changes in water quality in Go or Wolverine Creek due to effluent discharge or contaminated groundwater seepage, with potential direct toxic effects on fish, effects on benthic community that provide food for fish, and/or potential metal accumulation in fish tissue
- erosion and runoff from disturbed areas at the minesite and along the access road with potential for sedimentation of instream habitat or stress to fish from elevated suspended solids in water

The VECCs selected for assessment of effects on fish resources and the rationales for their selection are summarized in Table 7.8-1. Fish habitat is defined in terms of observed fish presence or physical habitat that is suitable or accessible for use by fish, in particular bull trout (a sensitive indicator species). Mitigation for bull trout habitat will provide effective protection for all species. Project effects on metals accumulation in fish, in particular selenium, while difficult to predict are of growing concern in relation to mining developments. Therefore, metal levels in fish tissue is identified as a VECC for this assessment and for the purpose of baseline characterization for future monitoring.

Table 7.8-1 Fish Resource VECCs, Selection Rationale and Baseline Data Sources

VECC	Rationale for Selection	Linkage to EA Report Guidelines or Other Regulatory Drivers	Baseline Data for EA
Fish habitat	• Potential project effects on physical habitat due to facility and road construction and maintenance (loss/alteration of instream and riparian habitat, siltation, barriers to fish passage) • Potential effects on productive capacity of fish habitat due to changes in water quality and associated toxic effects or effects on benthic organisms (fish food) • Habitat provides effective proxy for assessing effects on fish	• Information requested in EA Report Guidelines and Biophysical Assessment Work Plan • Protection regulated by *Fisheries Act* • Bull trout in Yukon are listed as sensitive by the National General Status of Species Working Group	• 1996 field data • 2004 field data • 2005 field data
Metals in fish tissue	• Bioaccumulation of metals (e.g., Se provides a link between project impacts and effects of fish and wildlife • Species such as bull trout and arctic grayling can provide human food sources	• Information requested in EA Report Guidelines and Biophysical Assessment Work Plan	• 1996 field data • 2005 field data

Temporal Boundaries

The temporal boundaries applicable to fish and fish habitat include all phases of the project – construction, operation, decommissioning and closure. The potential direct effects on instream habitat are greatest during access road construction, in particular construction of stream crossings. The potential for introduction of silt and sediment to fish habitat will be present in all phases, but greatest during construction. The potential for introduction of metals or nitrogen to area streams will be present in all phases, but greatest during operation. The assessment of the closure phase assumes stabilization of water quality and associated effects on benthic organisms and fish at closure. It is anticipated that this will be possible, based on operations phase monitoring and adaptive management to ensure effective long-term management of potential project effects from tailings and groundwater.

Study Area

The local and regional study areas for the assessment of effects on fish resources are the same as those used for the water and sediment quality assessment (Figure 7.5-1). The local study area (LSA) includes all streams and associated waterbodies that may be influenced by construction or operation of the mine and access road. This includes streams in the Money and Wolverine watersheds, and several headwater streams that will be crossed by the access road between the mine and the Robert Campbell Highway:

- Go Creek, which traverses the mine site area, will receive permitted discharges of treated effluent and will also be affected by diversions, tailing facility, camp and borrow area facilities and activities. Go creek tributaries Hawkowl and Pup Creeks will also be affected by access road construction.
- Money Creek, a 1 km section downstream from Go Creek confluence, which might be influenced by project effects on Go Creek.
- Wolverine Creek, which drains the mine portal area and eastern slope of the mine property and enters Little Wolverine Lake.
- Streams affected by the proposed access route (Chip, Bunker, Light, Pitch creeks and others).

The proposed road alignment has been located in high elevation, headwater areas wherever possible, to avoid potential or identified fish-bearing streams. Several of these streams are ephemeral and were observed to be dry during August and October surveys in 1996 and 1997 (Gartner Lee 2004).

In addition to the instream areas noted, the LSA for assessment of fish habitat includes adjacent Riparian Management Areas (RMA). For the purpose of this assessment the RMA is defined as those plant assemblages located from 20 m to 100 m from top-of-bank, based on channel width (W_b) and fish presence (stream class: S1-S6) as defined by the *Forest and Range Practices Act* (2002; FRPA; formerly the *Forest Practices Code Act* [FPC]); *Riparian Management Area Guidebook;* FPC 1995). For example, a fish-bearing stream with a channel width of 5-20 m (S2) would have an RMA of 70 m (Table 7.8-2). These definitions and the classification system are consistent with those used during the 2005 baseline data collection program. Methods for the 2005 program followed the *Reconnaissance* (1:20,000) *Fish and Fish Habitat Inventory: Standards and Procedures* developed by the BC Resource Inventory Committee (RIC) 2001. The BC classification system was adopted, given that a comparable system for riparian vegetation management does not exist for the Yukon Territory. The BC classification system is also a generally accepted procedure for fish and fish habitat assessments in the Pacific and Yukon Region of DFO.

Table 7.8-2 Riparian Management Areas (RMAs) for Fish-Bearing and Non Fish-Bearing Watercourses (adapted from FPC 1995)

Channel Width (W_b; m)	Stream Class	Riparian Reserve Zone (RRZ; m)	Riparian Management Zone (RMZ; m)	Riparian Management Area (RMA; m)
Fish-bearing				
20 - 100	S1	50	20	70
5 - 20	S2	30	20	50
1.5 – 5.0	S3	20	20	40
<1.5	S4	0	30	30
Non fish-bearing				
>3.0	S5	0	30	30
<3.0	S6	0	20	20

The regional study area (RSA) includes water bodies and watersheds beyond the LSA that reflect the general region to be considered for cumulative effects and that provide suitable reference areas for sampling:

- Money Creek, upstream and downstream of the Go Creek confluence
- Wolverine and Little Wolverine Lakes and Nougha Creek, which drains Wolverine Lake
- extended reaches of larger streams that are crossed by or receive drainage from tributaries crossed by the access road

7.8.2 Baseline Conditions

7.8.2.1 Methods

Previous Studies

Copies of reports of historic studies are summarized in the Fish Resources Baseline Data Report for the Wolverine Project (Appendix 7.8-1). Previous fish and fish habitat studies conducted within the RSA confirmed the presence of seven species in total, with bull trout, Arctic grayling and slimy sculpin in Go Creek and slimy sculpin, bull trout, Arctic grayling, northern pike and burbot in Money Creek (Westmin Resources Ltd. 1996; White Mountain Environmental Consulting 1997) as shown in Table 7.8-3. Lake trout were confirmed in Wolverine and Little Wolverine Lakes (Gartner Lee Ltd. 2005). No fish were found in Hawkowl and upper Go Creeks (upstream from Hawkowl Creek confluence) during 1996 – 1997 studies (Gartner Lee Ltd. 2005).

Results from those studies have been summarized by Gartner Lee in the Wolverine Project Description Report (2004) and in Fisheries Study of Proposed Road Access Alignments, Wolverine Property (2005).

Table 7.8-3 Common and Scientific Names of Fish Species in the Project Area

Family	Common Name	Scientific Name
Salmonidae	arctic grayling	*Thymallus arcticus*
Salmonidae	bull trout	*Salvelinus confluentus*
Salmonidae	lake trout	*Salvelinus namaycush*
Gadidae	burbot	*Lota lota*
Catostomidae	longnose sucker	*Catostomus catostomus*
Esocidae	northern pike	*Esox lucius*
Cottidae	slimy sculpin	*Cottus cognatus*

Metal levels in fish tissue were determined in 1996, with data presented in Appendix 7.8-3. Ten composite samples of slimy sculpin (three to seven fish per sample), four samples of arctic grayling (both flesh and liver) and six samples of lake trout (back flesh, stomach flesh, liver) were taken for heavy metal contaminant analysis. The slimy sculpin were taken from two tributaries to Little Wolverine Lake, three tributaries to Wolverine Lake, the outlet of Wolverine Lake, and three sites on Money Creek. The arctic grayling were taken from the inlet and outlet of Wolverine Lake (two fish from each site). Zinc showed the greatest tissue accumulation and was highest in liver tissues and sculpins. Selenium was next highest in accumulation and was high in liver tissues but not sculpins. Arsenic levels were higher in sculpins that other tissue. Lake trout had lower cadmium levels in muscle tissues and higher levels in livers compared to other fish.

2005 Survey Methods

Fish and Fish Habitat

Fish and fish habitat surveys were conducted at 27 sites associated with access road stream crossing sites and mine development areas between August 3 and 7, 2005 (Figure 7.8-1; Table 7.8-4). Six sites on Go Creek, one on Hawkowl and two on Wolverine Creek were surveyed in relation to mine developments and ten other sites were surveyed in relation to access road stream crossings. Substantial sampling and habitat classification effort was completed throughout Bunker Creek mainstem, primarily upstream from the proposed access road crossing near previously identified potential stream crossing sites to confirm fish presence/absence. Fish and fish habitat sampling was also completed in Light Creek (near Robert Campbell Highway) and Money, Go, Pup, Hawkowl, Chip and Wolverine Creeks.

An additional ten access road watercourse crossing sites (inaccessible first and second order tributaries) were assessed through aerial reconnaissance and determined to have negligible fish habitat value, based on fish absence at larger watercourses in the immediate vicinity and observed habitat fragmentation (multiple beaver dams) located between the tributary and larger mainstem habitats (Appendix 7.8-1).

Figure 7.8-1 Fish and Fish Habitat Sample Site Locations and Fish Distribution Limits (1996, 1997 and 2005) (Vol. 2)

Table 7.8-4 Watershed-specific Fish and Fish Habitat Survey Locations, 2005

Major Drainage	Stream	Number of Sample Sites		Access Road Stream Crossings (September 2005 Alignment)
		Ground Survey	Aerial Survey	
Finlayson River	Light Ck.	5	4	8
Money Creek	Bunker Ck.	7	2	1
	Chip Ck.	1	4	7
	Go Ck.	6		1[1]
	Money Ck.	2		Nil
	Pup Ck.	1		1
	Hawkowl Ck.	3		2
Wolverine Creek	Wolverine Ck.[2]	2		Nil[2]
	Total:	27	10	19

Notes: 1. Flows and water quality in Go Creek will be affected by treatment plant effluent discharge and a diversion from upper Go Creek to the tailings facility
2. Flows and water quality in Wolverine Creek will be affected by mine dewatering during operations and potential discharge of contaminated groundwater during closure

Following the 2005 fish survey, sections of the road right-of-way (ROW) were realigned, based on geotechnical considerations. As a result, the new alignment will include a total of 19 stream crossings (Figure 7.8-1)

Field data collected and analyzed during this assessment generally followed Resource Inventory Standards Committee (RISC; formerly Resources Inventory Committee [RIC]) methodologies described in Reconnaissance (1:20 000) Fish and Fish Habitat Inventory: Standards and Procedures (v.2, RIC 2001) and FPC Guidebooks Fish-Stream Identification Guidebook (FPC 1998) and Riparian Management Area Guidebook (FPC 1995).

Fish habitat data collected at each site, includes:

- fish cover
- channel morphology
- substrate composition
- basic water quality parameters (temperature, pH, conductivity)
- stream stage
- riparian vegetation
- channel characteristics (i.e., width, residual pool depth, bank, and gradient, etc.)

Dissolved oxygen was not measured as all tributaries crossed by the project road and facilities comprise relatively cold, moderate to high velocity (> 1.0 m/s) steep headwaters (or steep entire stream length) and typically maintain dissolved oxygen levels at or near saturation. The area of aquatic habitat assessed at each site ranged from approximately 50 m to 400 m upstream and downstream from the geo-referenced site location (UTM coordinates), depending on channel width, probability of fish presence and habitat quality. Site-specific habitat data collection and fish sampling effort were sufficient to accurately characterize representative habitat conditions and fish use for that reach. Stream reach classification was not completed during the 2005 survey.

Fish species presence was determined through electrofishing and/or baited minnow trap effort (24 h sets x 2 traps/site) as described in *Fish Collection Methods and Standards Version 4* (RIC 1997). All bull trout, lake trout and arctic grayling captured were enumerated by species, measured (± 1 mm; fork length) and released unharmed at point of capture. Slimy sculpin samples were measured (total length), weighed and sacrificed for tissue analyses.

Based on review of historic fisheries information collected throughout the RSA and species presence and channel width data collected during the 2005 survey, streams potentially affected by the project were classified to RISC standards (Table 7.8-2). All site-specific fish capture and habitat data for the 2005 survey are presented in Appendix 7.8-1.

Fish Tissue Analysis

Slimy sculpin (whole fish metals analyses) were collected from three sites (W11, W12 and W14) during the August and September 2005 field programs. Tissue analyses will characterize naturally occurring background (pre-mine development) metal accumulations in resident sculpin tissue. Metals analyzed and detection limits for tissue analysis are shown in Table 7.8-5. As Site W11 is located in Money Creek upstream from Go Creek confluence, baseline metals accumulations in resident sculpins from that site will represent control values for comparison with EEM future data from sites potentially influenced by mine site discharge (e.g., W12 and W14).

Table 7.8-5 Metals and Detection Limits for Sculpin (*Cottus cognatus*) Tissue Analyses, 2005

Total Metals by ICPMS	DL[1]	Total Metals by ICPMS	DL	Total Metals by ICPMS	DL
Total Aluminum (Al)	10	Total Iron (Fe)	10	Total Sodium (Na)	10
Total Antimony (Sb)	0.01	Total Lead (Pb)	0.01	Total Strontium (Sr)	0.01
Total Arsenic (As)	0.02	Total Magnesium (Mg)	10	Total Thallium (Tl)	0.005
Total Barium (Ba)	0.01	Total Manganese (Mn)	0.02	Total Tin (Sn)	0.01
Total Beryllium (Be)	0.01	Total Mercury (Hg)	0.005	Total Titanium (Ti)	0.1
Total Bismuth (Bi)	0.01	Total Molybdenum (Mo)	0.01	Total Vanadium (V)	0.2
Total Cadmium (Cd)	0.005	Total Nickel (Ni)	0.08	Total Zinc (Zn)	0.1
Total Calcium (Ca)	10	Total Phosphorus (P)	1	Total Zirconium (Zr)	0.05
Total Chromium (Cr)	0.1	Total Potassium (K)	10		
Total Cobalt (Co)	0.03	Total Selenium (Se)	0.05		
Total Copper (Cu)	0.05	Total Silver (Ag)	0.005		

Notes: 1. DL: detection limits mg/kg wet weight

Latex gloves were used when handling fish and care was taken to prevent the samples from contacting any metal. Slimy sculpins samples were weighed (±0.1g), measured (total length; mm) and placed in Ziploc bags. Samples were stored frozen until shipped to the laboratory (Maxxam, Burnaby BC) for analysis. All other fish captured were released, unharmed at point of capture, immediately following meristic data collection.

7.8.2.2 Results

Fish and Fish Habitat

Overall habitat quality within the crossings was ranked poor to excellent based on habitat complexity (deep pools, spawning substrates, fish cover, etc.), flow velocity and connectivity to known fish-bearing water (Table 7.8-6). Seven of the 27 sites assessed provide excellent bull trout and/or arctic grayling spawning, rearing and/or overwintering habitat. Six sites provide moderate fish habitat values based on presence of at least one habitat attribute essential to a specific life stage requirement (i.e., spawning gravel). Fourteen sites provide negligible fish habitat value but contribute flows to downstream fish-bearing habitats. The 10 sites assessed through aerial reconnaissance support negligible or very low fish habitat value based on lack of connectivity to fish bearing waters (sub-surface flows, multiple beaver dams), trickle discharges (lack of deep pools) and probability of freeze up or minimal flow during most of the year.

Photographs of all sites surveyed in 2005 are contained in Appendix 7.8-4.

Light Creek

Several tributaries of Light Creek are crossed by the access road route and Light Creek itself is crossed by the route, upstream from the confluence with Pitch Creek. A perched culvert located at the Robert Campbell Highway crossing is a barrier to fish migration upstream from the Finlayson River. Light Creek in the vicinity of the access road is comprised of multiple beaver dams, ponds and wetland areas. Fish habitat is fragmented and isolated, at least during the late summer low flow period. In most cases, potential spawning habitats for bull trout and arctic grayling are isolated from rearing habitats (overstream cover, deep pools, low velocity flows, organic substrates).

Juvenile arctic grayling were captured from one site in the Light Creek drainage (Light Creek site 4) at a location previously documented to support that species (Gartner Lee 2005). Light Creek Site 4 provides a diversity of habitat types (spawning, rearing, overwintering, fluvial and wetland) required to sustain fish year round. Fish habitat values at other sites within the Light Creek drainage vary from poor to excellent. Numerous first order tributaries on the west side of Light Creek were assessed by ground or aerial reconnaissance at the proposed road crossing sites during the 2005 and previous studies (Gartner Lee 2005). They are considered non fish-bearing with negligible fish value. Tributaries on the east side of Light Creek were not surveyed but originate from very steep headwater sources. They are also likely non fish-bearing, with the possible exception of the lower elevation reaches near Light Creek mainstem.

Despite the lack of fish captures at Light Creek sites 1 to 3 and habitat fragmentation, the presence of arctic grayling at Light Creek Site 4 and apparent absence of permanent impasses (i.e., falls), Light Creek sites 1 – 3 are inferred to be fish-bearing.

Table 7.8-6 Selected Habitat Characteristics, Fish Species Captures and Stream Classification, 2005

Site	Channel Width (W_b m)	Gradient (%)	Dominant Cover	Dominant Substrate	Fish Species	Class	Habitat Quality Comments
Light Ck 1	2.00	0.5	U	Fines	NFC (GR)	(S3)	Poor spawning substrates for GR/BT; moderate rearing and overwintering (deep water) if not frozen
Light Ck 2	3.13	0.5	OV	Fines	NFC (GR)	(S3)	Poor GR/BT spawning habitat due to lack of gravel substrates; good rearing and overwintering
Light Ck 3	1.52	4	OV	Fines	NFC (GR)	(S3)	Poor GR/BT spawning due to lack of substrate; moderate rearing; poor overwintering - few deep pools, probably freezes solid
Light Ck 4	2.43	0.5	DP	Gravel	GR	S3	Excellent spawning substrates for GR/BT; Deep water available for rearing and potential overwintering; Limited cover provided by undercut banks; main creek flows into wetland; moderate overwintering - may freeze in winter
4	0.62	1.5	OV	Fines	NFC	S6	Poor; Small meandering creek flows subsurface/wetland further upstream; no fish value at site or upstream towards road crossing
Bunker Ck 1	8.08	2	LWD	Gravel	NFC (GR, BT)	(S2)	Excellent GR/BT spawning and overwintering; deep pools, lwd, excellent fish cover; limited only by fast flows throughout most of reach (>1m/s)
Bunker Ck 2	3.85	2	U	Cobble	NFC (GR, BT)	(S3)	Poor; Swift current limits spawning capability for GR and BT
Bunker Ck 3	25.00	1	DP	Fines	NFC (GR, BT)	(S1)	Excellent; rearing in pond for GR and BT; too shallow for overwintering (<2m) and no spawning substrates
Bunker Ck 4	3.85	1.5	OV	Cobble	NFC (GR, BT)	(S3)	Excellent; GR/BT spawning substrate; excellent rearing and overwintering
Bunker Ck 5	2.95	1	DP	Fines	NFC (GR, BT)	(S3)	Moderate; negligible GR and BT spawning habitat (no gravels); excellent rearing and overwintering
Bunker Ck 6	4.80	1.5	U	Fines	NFC (GR, BT)	(S3)	Excellent; rearing for GR and BT; limited substrates and deep pools limit spawning and overwintering capabilities
5	1.15	3	OV	Fines	NFC	S6	Poor; Very steep gradient (>20%); low habitat quality; fast flows with very limited (negligible) rearing and spawning habitat for BT and GR
13	2.22	5	B	Cobble	NFC	S6	Poor; Very steep gradient (>25%) d/s from site; top of watershed in alpine zone
W14	17.17	1.5	B	Cobble	GR, CCG	S2	Excellent; Limited spawning gravels for GR and BT, excellent rearing, good overwintering

Table 7.8-6 Selected Habitat Characteristics, Fish Species Captures and Stream Classification, 2005 (cont'd)

Site	Channel Width (W_b m)	Gradient (%)	Dominant		Fish Species	Class	Habitat Quality Comments
			Cover	Substrate			
W11	14.00	1.5	DP	Cobble	GR, CCG	S2	Excellent; Excellent BT and GR habitat for all life stages, moderate abundance of spawning gravels may limit production
W13	1.84	2	U	Gravel	NFC (GR, BT)	(S3)	Moderate; Good adult BT and GR spawning gravels; limited use by all stages due to swift current; good overwintering and rearing along undercut banks
W12	4.15	3	OV	Cobble	GR, CCG	S2	Moderate; All stages of habitat quality limited by swift flows; potentially good rearing and spawning flows for GR and BT
Go Ck. 1	3.84	3	B	Cobble	GR, BT	S2	Moderate; Very swift current limits rearing, spawning and overwintering; limited spawning substrates; all rearing habitat occurs in eddies behind boulders and LWD
Go Ck. 2	5.63	3	B	Cobble	NFC (BT)	(S2)	Moderate; Swift current limits spawning capability for GR and BT
Go Ck. 3	4.18	2	OV	Cobble	NFC (BT)	(S3)	Poor; Swift flow limits BT and GR capabilities; excellent spawning gravels; marginal overwintering habitat - lack of deep pools
W16	3.35	3.5	OV	Cobble	NFC	S5	Poor; negligible BT and GR spawning habitat due to limited substrates; Poor overwintering due to few deep pools; swift flows limit habitat capabilities for all life stages
W15	2.90	5	OV	Boulders	NFC	S6	Poor; Swift flows limit BT and GR habitat in all life stages
W22	1.58	11	OV	Cobble	NFC	S6	Poor; Swift flows limit BT and GR habitat in all life stages; large bed material provide poor spawning substrates for GR/BT; poor overwintering due to few deep pools
W23	2.25	8.5	B	Boulders	NFC	S6	Poor; Swift flows limit bull trout and grayling habitat in all life stages; large pools available for overwintering
W24	1.40	2	OV	Cobble	NFC	S6	Poor spawning substrates for GR/BT; Swift flows reduce production potential
W9	0.30	2	OV	Gravel	LT	S4	Moderate; Excellent BT, LT and GR spawning; poor overwintering - probably freezes solid, deep pools (<0.5m)
14	0.63	3	OV	Fines	NFC	S6	Poor; Channel runs subsurface ~50m d/s and u/s from site; Poor spawning substrates for GR/BT; very small channel with limited pools provide poor to marginal rearing and overwintering habitat; channel probably freezes over winter; no fish access from Wolverine Lake - gradient too steep

Definitions: B - boulder; BT - bull trout; C - cobble; CCG - slimy sculpin; DP – deep pool; G - gravel; GR - arctic grayling; LT - lake trout; LWD- large woody debris; NFC - no fish captured; OV - overstream vegetation; U - undercut banks

Notes: Brackets indicate potential seasonal fish occurrence; stream classifications presented in Table7.8-2

Bunker Creek

Bunker Creek is crossed by the access road route and is of particular interest because of sections of high quality fish habitat. Considerable fish sampling effort was expended throughout Bunker watershed (six mainstem sites and one tributary site); however, no fish were captured. A previous study reported bull trout presence downstream from the proposed road crossing, approximately 1 km downstream from Bunker Creek Site 1, but not upstream from this site (Gartner Lee 2005).

A large, active beaver dam (estimated height: 3 m) located immediately upstream (200 m) from Bunker Creek Site 1 extends from valley wall to valley wall and likely prevents upstream fish passage to upper watershed reaches at least on a seasonal basis. Cascade-pool (boulder) channel morphology and high velocity water flows occur between Bunker Creek Site 1 and Site 2 and may also limit fish migration up into the upper watershed. As well, numerous beaver dams fragment fish habitat in the upper watershed between Bunker Creek sites 2 and 6.

Bunker Creek Site 4 provides excellent fish habitat value with a diversity of cover and substrate types (deep pools, undercut banks and overstream vegetation, cobbles and gravels). The remaining sites in upper Bunker Creek (sites 3, 5 and 6) also provide moderate to excellent habitat attributes, but generally lack one or more attributes required to sustain all life stages (i.e., dominance of fine substrates). Despite areas of difficult access and lack of fish captures, upper Bunker Creek watershed could support isolated and/or very low density fish populations at various times of the year (i.e., after spring freshet period) and is therefore inferred to be fish-bearing.

Chip Creek is a tributary to Bunker Creek. Several tributaries to Chip are crossed by the access route. Sites 10–13, located in upper Chip Creek watershed, are separated from Bunker Creek mainstem by steep (>20% gradient) reaches and provide negligible fish habitat value.

Money Creek

Money Creek provides high quality rearing, spawning and overwintering fish habitat and supports bull trout, arctic grayling, burbot, slimy sculpin and northern pike (Gartner Lee 2004). The 2005 investigation confirmed the presence of slimy sculpin and arctic grayling at sites upstream and downstream of the Go Creek confluence. Money Creek is classed as S2 (Table 7.8-3) based on fish presence and channel width (Wb: 14 – 17 m).

Go Creek

Six sites in Go Creek were sampled for fish presence and habitat quality. Upper Go Creek is crossed by an existing access road and the reach immediately below Hawkowl Creek will receive effluent discharge from the water treatment plant (Section 7.5) As a result of sustained high water velocity across the wetted width, lack of boulders, large woody debris (LWD) or habitat complexity required for rearing, Go Creek watershed generally offers very little useable habitat for any arctic grayling or bull trout life stages. Although no permanent barriers to fish passage were observed on Go Creek between the Money and Hawkowl Creek confluences, juvenile bull trout were captured upstream from several seasonal barriers (extensive beaver dam, log weir) and/or points of difficult access.

All fish captures occurred downstream from Go Creek Site 2 (Figure 7.8-1). The 2005 survey found the upstream limit to fish distribution in Go Creek to be 4.5 km upstream of the confluence with Money Creek, consistent with previous studies (Westmin 1997; Gartner Lee 2005). Although no fish have been captured in upper Go Creek (sites 2 through W24) and the quality of rearing habitat is poor, there is no permanent barrier to fish passage to the upper watershed; therefore upper Go is inferred to be fish-bearing.

Pup Creek

Pup Creek is a second order tributary to the lower Go Creek watershed. The access route will cross the headwaters. Similar to Go Creek, lack of habitat diversity and swift, bank to bank flow offer limited rearing or spawning opportunities. Undercut banks, however, do provide limited overwintering and rearing opportunity. No fish were captured from the one site sampled in the lower mainstem. Despite a poor to moderate habitat quality value and no fish captures, Pup Creek flows directly into the fish-bearing reach of Go Creek and, in the absence of a permanent fish barrier, is inferred fish-bearing.

Hawkowl Creek

Lower Hawkowl Creek is crossed by the proposed access route. Three sites were sampled in Hawkowl Creek during 2005. No fish were captured. Similar to Pup and Go Creeks, swift flow, moderately steep gradients (5–11%) and a general lack of quality habitat for all life stages of arctic grayling and bull trout preclude fish use. Although Hawkowl flows into the inferred fish-bearing reach of upper Go Creek, it remains extremely unlikely that this creek supports any fish at any time of year; therefore, it has been classified as non fish-bearing (S6) (Table 7.8-2).

Wolverine Creek

Wolverine Creek was sampled at Little Wolverine Lake confluence (W9) and at its headwaters (Site 9), immediately downstream from the mine portal. A single juvenile lake trout was captured from the downstream site where habitat is moderately good (good spawning, poor overwintering). An abandoned hydrology weir located immediately upstream from W9 presents a barrier to upstream fish passage. Habitat at the upper Wolverine Creek site (site 14) is negligible due to subsurface flows, lack of habitat diversity and impassable reach gradient between the lake and the upper watershed. Previous studies conducted in 1996-1997 (Gartner Lee 2004, 2005) did not confirm fish presence in lower Wolverine Creek.

Little Wolverine Lake

Little Wolverine Lake is a small (51 ha) lake at the headwaters of Wolverine Lake (Westmin 1996). Bathymetric soundings completed in 1996 indicated a maximum depth of 18 m. Fisheries investigations were conducted in Little Wolverine Lake in the summer of 1996 and 2001 using gillnetting (7 hours total), angling (25 min) and electrofishing (74 sec. in shoreline areas). Gillnetting employed sinking nets with multiple panels and a variety of mesh sizes at several locations (shown in Appenidx 7.8-2).

Lake trout and arctic graying were the predominant species caught in gillnets, with lake trout comprising 29% of the catch by number and 55% by weight and arctic grayling 66% by number and 37% by weight. Longnose suckers were also reported (5% of catch by number and 8% by weight). Length frequency data for arctic grayling for Little Wolverine and Wolverine Lakes are presented in Appendix 7.8-2.

Fall spawning surveys have recorded very few lake trout in Little Wolverine Lake. Those captured in 1996 were in a resting state and not ready to spawn that year. Lake trout in Little Wolverine Lake are likely part of the Wolverine Lake population. Combined length frequency calculations for lake trout taken in Little Wolverine and Wolverine Lakes are shown on Appendix 7.8-2.

Longnose suckers were not captured in gillnets but were reported in subsequent surveys, perhaps because they were spawning in creeks at the time of the gillnet survey (several ripe and exuding suckers were captured in Little Wolverine Lake). Juvenile burbot were found at the mouths of small tributaries entering Wolverine Lake, but no adults were recorded; hence it is assumed that a small population of adults lives in the lake.

Wolverine Lake

Wolverine Lake is a large lake (782 ha) with many tributaries and is connected to Little Wolverine and Wind Lakes by short channels (Westmin 1996). The lake is at least 75 m deep, as indicated in thermal profiles obtained in 1996 (Section 7.5). At the lake outlet, there is a smaller pool, separated from the main lake by a glacial esker, with distinct hydrological and chemical properties. Formal and informal observations indicate that the smaller lakes provide important fish habitat and likely play a significant role in the productivity of Wolverine Lake. Fisheries studies in Wolverine Lake have included 24.5 hours of gill net sampling at 25 locations around Wolverine Lake (Figure 7.8-1) in June 1996. Non-destructive, sinking nets with multiple panels with a variety of mesh sizes were used.

Fish Tissue Analyses

Results of the slimy sculpin tissue analyses (2005) are provided in Appendix 7.8-3. Some inconsistencies have been noted between data collected in 1996 and 2005, suggesting that further analyses will be useful in establishing baseline conditions. Monitoring of selenium levels in slimy sculpin (whole fish) is currently recommended for assessment of mining effects, given that evidence of bioaccumulation has been noted in North America (Chapman 2004). The 1996 results for bull trout and arctic grayling tissue analyses are also presented in Appendix 7.8-3.

In 2005, three sites were sampled for fish tissue collection:

- Go Creek (W12) - in fish bearing reach, potentially affected by water treatment plant effluent during operation and decommissioning and long term tailings pond decant
- Money Creek (W11) – fish bearing reach, reference site upstream of potential influence of Go Creek
- Money Creek (W14) – fish bearing reach, downstream of potential influence of Go Creek

For 2005, levels of some metals appear to vary according to size of fish rather than location, given that the sample from Go Creek consisted of one 5 g fish and samples from Money Creek upstream and downstream of the Go confluence consisted of composites of three smaller fish, totaling 5 g per sample. The following results are based on the limited sampling conducted in 2005:

- copper levels are higher in the Go Creek (2.8 mg/kg dry weight) than the Money Creek samples (1.0-1.7 mg/kg)

- arsenic levels are higher in the Go Creek (2.2 mg/kg) than the Money Creek samples (<0.2 mg/kg)
- nickel levels are higher in the Go Creek (84.7 mg/kg) than the Money Creek samples (1.5 mg/kg)
- levels of several metals are similar in fish from all three sites: cadmium (0.07-0.12 mg/kg), lead (<0.1-0.3 mg/kg), selenium (1.3-2.0 mg/kg) and zinc (46.3-54.1 mg/kg)

The value of 84.7 mg/kg nickel for Go Creek appears to be an anomaly (perhaps indicative of contamination or analytical problems), given that levels in fish from Money Creek, as well as from 1996, are considerably lower.

Tissue samples collected in 1996 (Westmin 1996) indicated no substantial differences in metals levels in slimy sculpin from Money and Go Creeks, based on four and one sample, respectively (Appendix 7.8-3). Results for arsenic, copper, lead and selenium are similar in 1996 and 2005, but the following metals data differed from those of 2005:

- cadmium levels ranged from 0.19 to 0.42 mg/kg (higher than in 2005)
- nickel levels ranged from <0.2 to 0.6 mg/kg (lower than in 2005)
- zinc levels ranged from 102 to 141 mg/kg dry weight (higher than in 2005)

7.8.3 Effects Assessment Methodology

Potential effects of the project on fish resources during construction, operations, decommissioning, and closure are discussed in detail in the following sections. For each phase of the project, effects on fish resource VECCs were assessed as follows:

- Potential project interactions with fish and fish habitat are characterized and the locations of effects identified. This section describes potential project effects on physical habitat. Effects due to changes in water quality and benthic communities are assessed on the basis of effects findings in Sections 7.5: Surface Water and Sediment Quality and Section 7.7: Periphyton and Benthos, respectively.
- Magnitude of effect is considered based on the documented fish presence or fish bearing classification of affected reaches, as described in the baseline description.
- Identified mitigation measures and commitments in YZC’s Environmental Protection Plan (Section 9.2) are considered in terms of proven effectiveness to protect fish resources.
- Proposed follow-up and monitoring plans, with identified contingency measures to address unexpected effects are considered.
- Predicted residual effects (taking into consideration mitigation and contingency measures) are characterized.
- The potential for residual project effects to contribute to cumulative effects is assessed in terms of multiple project effects on fish resources, effects in combination with existing activities, and effects with foreseeable future activities or events.

Project and cumulative effects on the fish resource VECCs are characterized in accordance with the EA Report Guidelines using effects attributes defined in Table 7.8-7. The ecological and social contexts of effects are integrated in the attributes for effect magnitude and elaborated upon as appropriate in the text. The likelihood of occurrence of residual effects occurring as predicted is stated with a supporting rationale.

Table 7.8-7 Effect Attributes for Fish Resources

Attribute	Definition
Direction	
Positive	Condition of VECC is improving
Adverse	Condition of VECC is worsening or is not acceptable
Neutral	Condition of VECC is not changing in comparison to baseline conditions and trends
Magnitude	
Low	Effect occurs that might or might not be detectable but is within the range of natural variability, does not pose a serious risk to resident fish populations, and does not compromise economic or social/cultural values
Moderate	Clearly an effect but unlikely to pose a serious risk to resident fish populations or represent a management challenge from an ecological, economic or social/cultural standpoint
High	Effect is likely to pose a serious risk to resident fish populations and represents a management challenge from an ecological, economic or social/cultural standpoint
Geographic Extent	
Site-specific	Effect on VECC confined to a single small area within the Local Study Area (LSA)
Local	Effect on VECC confined to the Local Study Area (LSA)
Regional	Effect on VECC extends into the Regional Study Area (RSA)
Duration	
Short term	Effects on VECC are measurable for less than 1 year
Medium term	Effects on VECC are measurable for 1 to 5 years (average age of bull trout at maturity; Ford et al. 1995)
Long term	Effects on VECC are measurable after 5 years but do not extend more than 10 years after decommissioning and final reclamation
Far future	Effects on VECC are measurable more than 10 years after decommissioning and abandonment
Frequency (Short term duration effects that occur more than once)	
Low	One time event and does not pose a serious risk to the VECC or its economic or social/cultural values
Moderate	Occurs annually but is unlikely to pose a serious risk to the VECC or its economic or social/cultural values
High	Occurs more than once a year and is likely to pose a serious risk to the VECC or its economic or social/cultural values
Reversibility	
Reversible	Effect on VECC is reversible through natural processes or compensation
Irreversible	Effect on VECC will persist during and/or after the project is complete
Likelihood of Occurrence	
Unknown	Effect on VECC is not well understood and, based on potential risk to the VECC or its economic or social/cultural values, effects will be monitored and adaptive management measures taken, as appropriate
High	Effect on VECC is well understood and there is a high likelihood of effect on the VECC as predicted

Determination of Effects Significance for Fish Resources

The significance of residual project and cumulative effects are determined based on the defined effects attributes, as follows:

- A residual effect on fish habitat is considered significant if it results in harmful alteration, disruption or destruction of fish habitat (HADD) that cannot be mitigated or compensated for.
- A residual effect on fish tissue is considered significant if selenium levels are elevated above CCME or BC interim tissue guidelines.

Otherwise, effects will be rated as not significant.

7.8.4 Project Effects

This section provides an analysis of the environmental effects of key project activities on the fish resource VECCs by phase.

7.8.4.1 Construction

Construction phase activities with the potential to affect fish resources include the following:

- Site clearing and ground disturbance for construction of minesite facilities and the access road with adverse effects on riparian vegetation and habitat and potential erosion and sedimentation of instream habitat.
- Culvert installation at access road stream crossings, with potential mortality of fish and fish ova (eggs) in the stream bed and sedimentation of downstream habitat.
- Changes in stream flow due to mine dewatering, stream diversions and drainage collection and diversion with potential effects on instream habitat.
- Potential introduction of contaminants to fish habitat from fuel spills, concrete mixing.
- Potential increase in angling pressure from construction crews.

Further discussion of potential effects and management measures is provided below

Riparian Habitat Disturbance and Sedimentation

Mine site, ancillary facility and watercourse crossing preparation and construction-related activities will occur within or adjacent to inferred fish-bearing and non fish-bearing streams/reaches, i.e., within the Riparian Management Area (RMA). Site preparation work for these activities generally includes clearing, grubbing and grading of trees, brush and other riparian vegetation along the road and mine site facility areas. Graders, bulldozers, and in some cases, excavators will be used to strip and stockpile topsoil, surface organic material and upper mineral soils. Following removal of topsoil, grading will be conducted on slopes and irregular ground surfaces to provide a safe and clean work surface.

Riparian Habitat

Mine site development and access road construction (clearing and grubbing activities) will result in loss and / or alteration of riparian habitat structure (species, canopy height, etc.) through removal of mixed forest and shrub communities (i.e., area covered by road surface) beyond the life of the project (access road retention). Clearing and grubbing of vegetation within the RMA may directly affect the quality, integrity and function of riparian habitat. Loss of riparian vegetation (e.g., due to clearing for road construction) or alteration of the native species assemblage (e.g., change of vegetation type from forest to shrub) along the access road ROW can adversely affect the productive capacity of fish habitat through:

- reduction in stream bank integrity typically reinforced by riparian vegetation root systems
- reduction of shading, which may result in increased stream temperature
- increase in instantaneous event-related discharge rates, which can result in torrents and erosion
- increased sedimentation, habitat infilling, channel lateral movement and realignment
- reduction of effective overstream fish cover (predator avoidance and stream temperature regulation)
- reduction in allochthonous nutrient inputs to the stream originating from upstream insect and woody debris recruitment

The effect of riparian buffers on stream temperatures in clearcut watersheds is well documented (e.g., Levno and Rothacher 1967). Brown (1971) noted that on very small streams (i.e., S4-S6) adequate shade is provided by brush and shrub species and that the angular canopy density (the percentage of the sun's actual path between 10:00 and 14:00 hr, standard time, on the stream channel in mid to late summer) is a better predictor of buffer effectiveness than buffer width. As such, the use of shrubs and brush during mitigative riparian re-vegetation of road stream crossings will provide effective shading of smaller watercourse crossings.

Martin et al. (1985) and Davies and Nelson (1994) determined that riparian buffers (RMAs) less than 10 m (minimum width) may be detrimental to fish habitat through windfall and associated erosion and sedimentation (Salo and Cedarholm 1981). Beschta et al. (1987) documented angular canopy density as a function of buffer strip width, and concluded that 30 m or more generally provided the same level of shading as that of an old growth forest in western Oregon and northern California.

The ability of stream temperatures to return to normal as riparian vegetation grows is also well documented. Feller (1981) determined that summertime temperature increase associated with clearcutting lasted for seven years; however, Harr and Fredriksen (1988) found that increased stream temperature in a logged stream in Oregon had mostly disappeared within three years of harvesting.

The effects of clearcutting on stream temperature are also cumulative in a downstream direction. For example, water temperature of a cool stream flowing through a clearcut would increase continuously, although not a constant rate, in the downstream direction. McGurk (1989), however, determined that a stream that had been warmed in a clearcut cooled by 1.0-1.5° C as it flowed back into the trees within a distance of 130 m, and that for small streams, normal water temperature (riparian buffered) was recovered within 1.6 km downstream from a clearcut.

Finally, it should be noted that increased summer stream temperature can have a positive effect of fish in a cool climate. Thedinga et al. (1989) found more salmon fry in stream reaches that were logged to the banks than in unlogged reaches flowing through forests of Sitka spruce and western Hemlock in southeast Alaska.

Clearing in the RMA (20-70 m back from the stream bank) will be limited as much as possible to minimize effects on riparian vegetation. All project buildings and facilities will be located outside of the RMA. Where vegetation removal or ground disturbance is unavoidable in the RMA, areas will be revegetated as soon as possible with native plants, grasses, shrubs and trees. The Environmental Protection Plan (Section 9.2) will include specific measures for stream bank plantings to enhance bank stability and provide cover and to prevent erosion following disturbance. Protection measures will reference recognized best management practices such as Standards and Best Practices for Instream Works (MWLAP 2004). Vegetation control and management will include recommendations for shrub re-planting as well as scrub birch/willow planting and/or staking to restore the riparian vegetation and function at each road crossing.

Opportunities to mitigate riparian vegetation loss associated with access road development are limited but could include implementation of on-site re-vegetation programs of riparian areas within the LSA (i.e., areas previously affected by forest fires, highway construction) where replanting has not been completed. Many S5 and S6 class streams (non fish-bearing) crossed by the Robert Campbell Highway provide opportunity to implement this mitigative strategy.

At present the proposed road alignment will cross 19 non fish-bearing of which four are inferred fish bearing tributaries or reaches of Light, Bunker and Go Creeks. Although riparian vegetation communities may be altered during access road ROW clearing and grubbing activities, re-vegetation with indigenous shrub and brush species will minimize the environmental effects on stream channel integrity and function. Much of the access route is located in relatively steep reaches within the upper sub-basins of Light and Money Creeks that are non fish-bearing. Given that much of the minesite infrastructure and access road alignment occurs at or adjacent to the treeline, and given the questionable fish-bearing status (all crossings being either non fish-bearing or inferred fish-bearing status only), riparian vegetation loss or alteration will have minimal effect on fish resources.

The access road route is located within the Light Creek valley for approximately 2.5 km, prior to ascending to an elevated route across the uppermost reaches of steep first and second order tributaries. A single isolated population of arctic grayling was identified in Light Creek (site 4) downstream of the Light Creek crossing point. Effects of clearing for access road construction will be far future in duration, as it is intended that the road will remain at closure. A potential mitigative measure could be re-vegetation of non fish-bearing or inferred fish bearing reaches that currently lack streamside vegetation. Past experience on stream restoration projects has shown that these efforts can successfully mitigate the environmental effects of clearing. Over a relatively short period of time (two to three years) the vegetation will green-up and off-set potential project-specific (construction and operation) effects such that no net loss of riparian habitat occurs.

Given the relatively low value of fish habitat potentially affected by riparian vegetation clearing and opportunities for effective mitigation, project effects on riparian habitat are expected to be adverse, low magnitude, local in extent, long term in duration and reversible for the minesite area and far future in duration and functionally irreversible for the access road. The likelihood of effects as predicted is high based on observations of project effects and mitigation at many comparable developments.

Sedimentation of Instream Habitat

Increased sediment loads entering a watercourse or waterbody may adversely affect fish and fish habitat. High concentrations of sediment are detrimental to benthic organisms, fish ova (eggs) and alevin (young fish) survival and habitat productive capacity. *British Columbia Land Development Guidelines* (Chilibeck 1992) recommend that total suspended solids (TSS) concentrations should not increase by more than 25 mg/L above background levels of the receiving waters during normal, dry weather conditions and less than 75 mg/L above background levels during storm events.

The extent of these potential environmental effects depends on the concentration of suspended sediment, event duration, species and life stage of fish present within the increased TSS zone of influence, and sensitivity of the habitat type affected (spawning, overwintering, wetland, etc.). Exposure of fish and habitats to low levels of suspended sediments and seasonal freshet-related instantaneous increases occurs naturally. During increased TSS events, juvenile and adult fish most frequently avoid the zone of influence and return once TSS levels subside. However, high concentrations of suspended sediments over extended durations of exposure will reduce fish feeding success, (reduced prey capture and predator avoidance rates), reduce growth rates, damage gill membranes, decrease disease resistance, and/or impair ova development and embryonic development (hypoxia). Increased suspended sediments may also interfere with production of benthic invertebrates and other aquatic fish food organisms. Depending on the concentration and duration of exposure, stream discharge and fish life stage, as well as TSS particle hardness, size and angularity, behavioral, physiological and other sub-lethal and/or lethal effects may also occur.

Table 7.8-8 provides specific habitat and water quality requirements for the project sentinel fish species, bull trout. Bull trout have very specific habitat requirements and a narrow range (low tolerance) for variation in water quality, pool depth, cover attributes and flow rates. They require clean gravel spawning substrates, cool water temperatures and dissolved oxygen levels at or near saturation. Bull trout require deep pools for overwintering in combination with other fish cover attributes (boulders, cutbanks, LWD, etc.). They are extremely sensitive to increased turbidity as it affects foraging and predation, homing and migration, gill membrane function, osmoregulation, reproduction and growth, egg survival and quality of spawning habitat (Bash et al. 2001).

In the minesite area, the site water management plan will divert clean water flows around construction sites and collect drainage from disturbed areas for settlement of suspended solids in settling ponds prior to discharge (Section 2.9: Site Water Management). A comprehensive erosion and sediment control plant will be developed and implemented for all phases of the project. Key elements of the plan are listed in the Environmental Protection Plan (Section 9.2). Specific management measures for the RMA are also described. Best practices will be outlined along with conditions for application. Additional site-specific requirements will be included based on detailed design of facilities, access road and site water management plans.

Table 7.8-8 Bull Trout Habitat and Water Quality Requirements[1]

Species/Life-stage	Optimum Temperature Range	Optimum Oxygen Range	Preferred Substrates	Preferred Channel Morphology and Habitat Attributes
Incubation	2-4°C	>9.5 mg/L	0% fines (greatest [40%] survival)	Clean gravel substrates in pools and tailouts
Rearing and overwintering	<12°C	7.75 mg/L	Cobble and boulder	LWD, deep pools,
Adults/ spawning	<9°C	7.75 mg/L	Clean gravel with minimal fines (<6.35 mm)	Gravel tailouts within and downstream from pools

Notes: 1. Adapted from Ford et al. 1995

All work within the RMA (20-70 m depending on stream class) of a watercourse will only proceed under the appropriate territorial and federal (DFO) regulatory permits and approvals. Instream work in fish bearing watercourses will be undertaken during the approved fisheries work windows and will use identified mitigative procedures and structures.

Monitoring of total suspended solids in streams will be conducted during the construction phase in fish bearing streams, in accordance with permit requirements. If results are out of compliance with permit requirements, activities will cease and mitigative measures applied or enhanced as required to achieve compliance.

Given the relatively low value of fish habitat in stream reaches potentially affected by sedimentation during construction and opportunities for effective mitigation of potential effects, project effects of sedimentation on instream habitat during construction are expected to be adverse, low magnitude, local in extent, short term in duration and reversible, given the steep gradient and swift flows through most of the stream reaches affected. The likelihood of effects as predicted is high based on observations of project effects and mitigation at many comparable developments.

Culvert Installation

Culvert installation on the access road, if not mitigated, could affect critical instream fish habitats through alteration of water quality, pool depths or spawning substrate quality, elimination or re-distribution of instream fish cover attributes (LWD, boulders, cutbanks, etc.) and/or creation of partial or permanent migration barriers. Fish ova mortality could also result from introduction of sediment during the incubation period into critical spawning habitats (hypoxia) located adjacent to or downstream from road crossings.

Fish mortality could also result from direct physical contact with equipment, blasting activities in or near a watercourse, or entrainment in water pumps intakes used to isolate stream crossing sites (berm and pump).

Loss of containment and subsequent flooding of work areas during road watercourse crossings (culvert placement) could temporarily degrade water quality due to increased sedimentation and turbidity, or affect habitat quantity through deposition of debris and material into the stream.

All instream work will proceed only under the appropriate territorial and federal (DFO) regulatory permits and approvals. Instream work at known fish bearing watercourses will be undertaken during the approved fisheries work windows and will use identified mitigative procedures and structures for protection of fish and fish habitat as specified in the Environmental Protection Plan (Section 9.2).

Instream construction timing constraints are designed to protect fish species during sensitive life-stages (i.e., alevins, eggs). To avoid potential conflict with bull trout, lake trout and/or arctic grayling spawning timings, in-stream construction for all fish-bearing (known and inferred) watercourses will be scheduled during the period of least risk to fish and fish habitat (mid-late summer, low or no flow, or ice-in period(s)), unless specifically permitted by DFO and YTG authorities. Construction timing will consider incubating eggs and alevins for spring spawning arctic grayling and late summer/fall spawning Bull trout and fluvial lake trout. During those periods it is expected that most grayling and bull trout eggs will have hatched and most spawning will occur following construction. As no fish were captured and fish presence only inferred at all crossing locations, it is unlikely that access culvert placement will affect downstream fish and fish habitats during a constrained in-stream work window as described.

The extent of the effects on fish is predicted to be low due to the relatively large watershed areas located downstream from many stream crossings and the absence of fish at all crossings. Effects of culvert installation on sedimentation of downstream habitats are considered reversible due to generally steep stream channel gradients, lack of in-stream structures (e.g., LWD, boulders) that would tend to accumulate suspended sediments at road crossing sites, and the probability of sediment-laden water to be effectively transported and distributed downstream to discrete, low gradient locations (small accumulations) within the larger receiving waterbodies (i.e., Money Creek).

Accordingly effects of culvert installation on instream habitat during construction are expected to be adverse, low magnitude, local in extent, short term in duration and reversible. The likelihood of effects as predicted is high based on observations of project effects and mitigation effectiveness at many comparable developments.

Changes in Stream Flow

Project effects on surface flows during construction include the following:

- Diversion of flows from upper Go Creek to fill the tailing facility from May through mid-July of the construction year (200 m^3/hour during freshet). Effects on fish-bearing water is predicted to be not significant, as described in Section 7.4: Surface Water Hydrology.
- Potential effects of mine dewatering during pre-production mining on ground water discharge and surface flows in Wolverine Creek. Effects on surface flows will be most marked during summer and winter low flow conditions when the contributions from groundwater discharge are greatest. Base flow reductions of up to 50% may occur during summer and winter; however, the effects on surface flows will be less, given that much of the flows arise from snowmelt, precipitation and surface runoff (Section 7.4: Surface Water Hydrology).

  Although Wolverine Creek likely freezes solid during winter, the extended duration of freeze-up may affect late spring – early summer fish use in the lower, fish bearing reach. However, fish use and habitat is limited and restricted to the lowermost reach, so the effects of an extended ice-in period on fish (lake trout) productivity will likely be minimal. Effects of flow reduction will be monitored during operations. Stage discharge relationships will be refined (Section 7.4: Surface Water Hydrology) and the potential for effects on overwintering habitat (pools) will be clarified.

Accordingly, changes in stream flow due to mine dewatering and stream diversion will be adverse, low in magnitude site specific, long term in duration and reversible. The likelihood of this effect as predicted is high.

Runoff of Contaminants

A number of site construction activities will generate wastewater. Release of wastewaters such as concrete wash water or stormwater that has been in contact with uncured concrete directly into a stream may also result in degradation of water quality and subsequent fish kills. Residual hydrocarbons leaked from heavy equipment usage during construction activities or concentrations of lime in concrete wastewaters could exceed water quality guidelines for the protection of freshwater aquatic life (CCME 2004).

The concrete batch plant will be entirely self-contained with no disposal of wash water to surface waters (Section 2.10: Site Facilities and Infrastructure). Refueling procedures, equipment maintenance and inspection procedures will minimize the risk of spills that could make their way to surface waters (Section 92: Environmental Protection Plan). Accordingly effects of contaminant runoff affecting fish habitat are expected at worst to be low, site-specific, short term, and infrequent. The small volumes potentially involved and the self-renewing nature of streams would make any such effects reversible. The likelihood of this effect as predicted is high.

Angling Pressure

Construction personnel on site may increase fish mortality in the project area due to sports fishing. A policy to protect fish stocks will be incorporated into the project's environmental education and orientation program. All project personnel living on site will be apprised of potential pressures on fish stocks from fishing. Territorial fishing regulations will be reviewed, including requirements for licenses, use of single barbless hooks, bait bans and catch and release strategies.

Because of the low occurrence of fish in streams affected by the project, any effects would likely be confined to Wolverine Lake. Potential effects would be greatest during the one-year construction period when onsite personnel numbers will be highest, but would continue to a lesser extent throughout the life of the project. Effects are therefore expected to be adverse, low magnitude, regional, short term and irreversible. The likelihood that effects will occur as predicted is high.

7.8.4.2 Operations

During operations, some of the effects identified during construction will persist. The main incremental project effect on fish and fish habitat during operations will be changes in water quality in Go Creek due to water treatment plant effluent discharges, with related potential for toxic effects, effects on stream productivity and potential for metals accumulation in fish tissue.

Riparian Habitat Disturbance and Sedimentation

As noted above, riparian vegetation is an important component of the stream ecosystem as it provides shade, overstream fish cover, nutrients and woody debris and maintains channel bank integrity. Operational activities associated with maintenance of vegetation along the access road ROW, mine site, tailings facility, ancillary facilities and airstrip within a watercourse RMA (20-70 m) may reduce the functional value of the riparian vegetation. Re-vegetation of stream banks following construction in accordance with fish habitat protection measures (Section 9.2: Environmental Protection Plan) will reduce effects during operation. Vegetation management measures in RMAs (e.g., on the access road right-of-way) will sustain vegetation cover to enhance bank stability, provide cover and minimize erosion and sedimentation. Accordingly, effects during operation are expected to be adverse, low magnitude, local, long term (minesite) to far future (access road) and reversible. The likelihood of effects as predicted is high.

Treatment Plant Effluent and Runoff of Contaminants

As noted in Surface Water and Sediment Quality Section 7.5.5.2, all potentially contaminated site drainage and ore processing effluent will be directed to the process water balance and water treatment plant. The water treatment plant will discharge metal- or sediment-carrying effluent to a permitted discharge point in Go Creek downstream of the Hawkowl Creek confluence (i.e., downstream from Sites W15 and W16). Effluent will be discharged primarily between May and October of each year and will meet MMER criteria. Site-specific water quality objectives will be developed based on CCME guidelines for protection of aquatic life and baseline water quality. Objectives for most metals will be met immediately downstream of the discharge, but objectives for ammonia, selenium and cadmium will be met at W12, 7 km downstream of the discharge (cadmium objective will exceed the CCME guideline, given that baseline levels in Go Creek already exceed the CCME guideline at times during the summer). As a result, there will be a relatively small elevation of cadmium and selenium levels in fish-bearing water of Go Creek (Section 7.5), as the observed upper limit of fish distribution is 2 km upstream of W12.

Nitrate levels will meet CCME guidelines but will be elevated above baseline conditions (Section 7.5). An increase in nitrate levels in the receiving reaches of Go and subsequently Money Creek has the potential to proliferate various species of algae. An increase in algal growth on stream substrates may in turn stimulate fish food production (i.e., aquatic and terrestrial insect). As well, fish often use aquatic algae as instream cover.

The receiving environment and effluent will be subject to Environmental Effects Monitoring under MMER. In the event of recognized effects, adaptive management to enhance treatment will be developed in consultation with regulatory agencies. Potential for bioaccumulation of metals in the Go Creek system is considered low due to the fast flowing conditions throughout much of the creek, and few lentic conditions that seem to favour bioaccumulation of metals such as selenium (Section 7.5.5.2). Water and sediment quality will be monitored. If a trend of increasing metals levels is noted, monitoring of benthic invertebrate and/or fish tissue metals analysis will be initiated to determine if there is any bioaccumulation. Adaptive management measures will be developed in consultation with regulatory agencies, if required.

In summary, effects of water treatment plant effluent discharges to Go Creek on fish habitat and metals levels in tissue are expected to be adverse, low magnitude, local, long term and reversible. The likelihood of effects as predicted, in particular the potential extent of effects of nitrates on benthic communities and the likelihood of metals accumulation in fish tissue is unknown. Accordingly, monitoring will be conducted during operations to confirm predictions.

Changes in Stream Flow

Project effects on stream flows are assessed in Section 7.4: Surface Water Hydrology. Effects on fish and fish habitat are described below.

Wolverine Creek

Flow reductions in Wolverine Creek due to mine dewatering and decreased groundwater discharge to upper Wolverine Creek will continue as described for the construction phase (Section 7.4). Accordingly, effects of mine dewatering on fish habitat in Wolverine Creek are expected to be adverse, low magnitude, local in geographic extent, long term and reversible. The likelihood of effects as predicted is unknown; therefore follow up monitoring will be conducted, as a basis for adaptive management if required.

Go Creek

The addition of treated water from the permitted effluent discharge downstream of the Hawkowl Creek confluence will result in a net increase in summer low flows in Go Creek of approximately 36 m^3/h (Section 7.4). Accordingly, the effects of treated water additions on fish habitat capability in Go Creek are expected to be adverse, low magnitude, local in geographic extent, long term and reversible. The likelihood of effects as predicted is high.

Angling Pressure

Effects predicted for construction are expected to continue during operations. Angler education for operations personnel, use of barbless hooks, catch-and-release strategies and compliance with DFO and territorial regulations will reduce or eliminate project effects on the fisheries resources associated with potential increases in angler pressure. As such, projects effects associated with increased angling pressure by operations personnel are expected to be adverse, low magnitude, regional in geographic extent, long term and irreversible. The likelihood of effects as predicted is high.

7.8.4.3 Decommissioning

During decommissioning, most ancillary facilities and mine site infrastructure will be removed, the mine backfilled and the portal sealed. However, the access road, airstrip, water treatment plant and tailings facility will be retained at closure.

Riparian Habitat Disturbance and Sedimentation

The potential environmental effects of facility removal within a stream RMA (20-70 m setback area on either bank) during decommissioning will be similar to those for the construction phase and are related to riparian vegetation alteration and/or loss, alteration of in-stream habitat quality (gravel infilling, reduced benthic production) and/or potential mortality of fish ova due to sedimentation Mitigation measures identified for construction (sediment and erosion control plan, fish habitat protection plan, site water management plan, re-vegetation of cleared areas) will be implemented during decommissioning to eliminate or minimize potential effects. Accordingly, effects during decommissioning are expected to be adverse, low magnitude, local, medium term (minesite) to far future (access road) and reversible. The likelihood of effects as predicted is high.

Tailings Pond Decant to Go Creek

During at least the initial five years of the decommissioning phase, the water treatment plant will remain in operation to treat the tailing pond supernatant if required (Section 2.4: Taillings Disposal). The treatment plant and any remaining facilities will be removed once the tailings pond discharge has stabilized and meets site specific water quality objectives. The tailings pond will be reclaimed as a permanent pond in the Go Creek drainage with a spillway that will allow surface waters to passively decant and flow to Go Creek. The pond is designed to ensure deposited tailings remain underwater at all times. Discharge of tailings pond supernatant (at a rate of 8.3 m^3/hour) will be treated to reduce metal levels, and will contribute a small proportion of summer flows (up to 2.6%), so will have minimal effects on water quality of Go Creek (Section 7.5).

Groundwater Discharge to Wolverine Creek

As noted in Section 6: Groundwater, there is a possibility of elevated metals levels in groundwater discharge to Wolverine Creek and possibly Little Wolverine Lake as groundwater moves through the backfilled mine workings. Based on flow paths and rates for movement of groundwater from the backfilled mine to surface waters, no effects are anticipated during the decommissioning phase.

Change in Stream Flows

During decommissioning, mine water diversion from the Wolverine Creek basin to Go Creek will cease. Site water management facilities (diversions, drainage collection) will be decommissioned and natural drainage patterns restored in both drainages. Drainage in the tailings facility basin within the Go Creek basin will be treated and discharged to Go Creek. Flows in Go Creek will return to pre-project conditions immediately following decommissioning.

Low flows in Wolverine Creek will begin to increase 2.5 years after mine closure and will be completely restored by 16 years after mine closure (Section 7.6: Groundwater). Mean summer flow and peak flow in Wolverine Creek will not be significantly affected by the return to normal base flows. Accordingly, effects are expected to be adverse, low magnitude, site-specific, long term and reversible. The likelihood of this effect is unknown but will be clarified based on operations phase monitoring.

Angling Pressure

Effects predicted for mine construction and operations may continue during the decommissioning phase. Angler education for operations personnel, use of barbless hooks, catch-and-release strategies and compliance with DFO and territorial regulations will reduce or eliminate project effects on the RSA fisheries resources associated with potential increases in angler pressure. Accordingly, effects are expected to be adverse, low magnitude, regional in geographic extent, long term and irreversible. The likelihood of this effect is high.

7.8.4.4 Closure

Riparian Habitat Disturbance and Sedimentation

At closure, restoration of riparian habitat at all sites affected by the project will be complete and well established. Only the effects of the access road on stream crossings will remain. Accordingly, effects are expected to be adverse, low magnitude, local, far future and reversible, depending on the period the access road remains in use. The likelihood of effects as predicted is high.

Tailings Pond Decant to Go Creek

The tailings facility will be maintained and monitored as described in the mine closure plan (Section 3.4) to ensure metals are not released into Go Creek. Accordingly, no further effects on fish and fish habitat are expected at closure.

Groundwater Discharge to Wolverine Creek

It will take a total of 13.5 years for the underground areas to fill with groundwater and for base flows to return to pre-mining conditions (Section 7.6: Groundwater), during which time, metal levels will equilibrate and may seep into Wolverine Creek and lead to elevated levels of some metals (likely cadmium, selenium, zinc), and probably Little Wolverine Lake, over an indefinite period of time. These metals already exceed CCME guidelines in the creek (Section 7.5). Although fish have been noted only at the mouth of Wolverine Creek, there is potential for effects on fish of Little Wolverine Lake and, perhaps on those in Wolverine Lake (given that fish will likely use habitat in both systems during their life cycle). The potential for metals leaching, described in Section 2.4: Rock Characterization, discusses mitigative effects of alkaline materials in paste backfill, which should help reduce the effects of elevated metals levels in Wolverine Creek, and discusses adaptive management strategies to be developed during the operational phase. The potential effects on Wolverine Creek fish and fish habitat are considered to be adverse, low magnitude, site specific, long-term or far future in duration, and reversible, with an unknown likelihood of occurrence. As a result, potential effects are rated as not significant, but conditions will be monitored.

Angling Pressure

The access road will continue to provide access to Wolverine Lake with the possibility of ongoing use for sports fishing. It is expected that the relatively remote location will limit use to levels that are lower than use by project personnel. Posted signage along the access road that describes catch-and-release strategies and compliance requirements with DFO and territorial regulations will reduce or eliminate project effects on the RSA fisheries resources associated with potential continued angler pressure. Accordingly, effects are expected to be adverse, low magnitude, regional in geographic extent, long term and irreversible. The likelihood of this effect is high.

7.8.4.5 Residual Project Effects and Significance

Site Preparation and Culvert Installation

Project effects on riparian habitat and sedimentation of instream habitat are long term in duration for minesite effects and far future in duration for the access road based on retention of the access road at closure. However, established standards for mitigation measures to minimize effects on fish and fish habitat (site water management, sediment and erosion control plans, fish habitat protection plans) as outlined in Section 9.2: Environmental Protectin Plan, are proven effective and accepted by regulators. Inspection during construction and operation and reporting to regulators will ensure compliance.

Only four of the affected reaches are inferred fish bearing. No fish use of the affected reaches has been documented to date. Egg mortality due to sedimentation and culvert installation is expected to be very low. At no time during the life of the project are effects expected to be greater than low magnitude and local in extent. In all cases effects are ultimately reversible. The likelihood of effects as predicted is high based on observations of effects and mitigation at many similar projects. DFO Whitehorse has indicated that in their opinion, a HADD is unlikely. Based on criteria in Section 7.8-3, effects of the project related vegetation clearing, erosion and sedimentation and direct effects of culvert installations are determined to be not significant.

Water Quality Effects on Fish Habitat and Fish Tissue

Go Creek

Water treatment plant discharges to Go Creek during operations and decommissioning will meet site specific water quality objectives in areas identified as fish-bearing. The exception is the lower 2 km of Go Creek upstream of W12, where cadmium and selenium levels may be slightly higher than the objectives. Nitrate levels will meet CCME guidelines but will be elevated above baseline conditions. An increase in nitrate levels in the receiving reaches of Go and subsequently Money Creek has the potential to proliferate various species of algae. An increase in algal growth on stream substrates may in turn stimulate fish food production (i.e., aquatic and terrestrial insect). As well, aquatic algae are often used as instream fish cover.

At closure, tailing pond decant discharges to Go Creek will meet the site specific objectives in areas identified as fish-bearing. There is no potential for a HADD that cannot be mitigated; therefore effects are determined to be not significant.

Water quality effects on Go Creek during operations and decommissioning have the potential to contribute to metals accumulation in fish tissue. Mitigating factors such as compliance with site specific objectives in fish bearing reaches, swift flowing conditions and probable dispersion of metals bearing sediments within the larger Money Creek basin indicate the risk of this occurrence is low. Monitoring will provide an early warning of metals trends in sediments and trigger follow-up tissue monitoring as required. Adaptive management to mange any observed effects will be developed and implemented in consultation with regulatory bodies. Accordingly the effect of the project on metals levels in fish tissue is determined to be not significant.

Wolverine Creek

As discharges of mine or waste waters into Wolverine Creek are not planned, project effects of water quality on fish habitat and fish tissue are not anticipated.

Flow Changes

Go Creek

Dewatering associated with mine operations will have a minimal effect on upper Go Creek flows. Diversion to fill the tailings facility will occur only during freshet and will not affect summer low. Flows and discharge of treated effluent will have a minimal net effect on surface flows, based on the small drainage area affected (4.8 km^2). As such, the effects of flow changes on fish habitat in Go Creek are determined to be not significant.

Wolverine Creek

Flow diversions and collection of mine site and groundwater in upper Wolverine Creek will affect the stream flow regime and fish habitat availability in the lower fish-bearing reach near the lake inlet. Effects of flow reduction will be monitored during operations. Stage discharge relationships will be refined (Section 7.4: Surface Water Hydrology) and the potential for effects on overwintering habitat (pools) will be clarified. Accordingly, effects of mine dewatering on fish habitat in Wolverine Creek are determined to be not significant.

7.8.5 Cumulative Effects and Significance

Residual project effects on fish, fish habitat and fish tissue metals levels are expected to be not significant. Residual low level effects include:

- effects on riparian vegetation and sedimentation of instream habitat
- potential reduction in habitat capability due to water quality effects and flow changes in reaches of Go and Wolverine Creeks
- potential metals accumulation in fish tissue
- potential increased mortality due to angling pressure

All of these effects are expected to be low magnitude and localized in extent. Because of this, it is not expected that multiple localized project impacts on fish habitat will result in a measurable cumulative effect on fish populations or habitat in the regional receiving drainages (Money, Light, Wolverine and Nougha Creeks and Little Wolverine and Wolverine Lakes).

Other activities within the RSA that may combine with project effects to influence fish resources include:

- increased traffic on the Robert Campbell Highway due to the project and reopening of the Cantung Mine, with potential for introduction of sediment and contaminated runoff (e.g., potential spills, accidents, road maintenance) to fish habitat in lower Money, Light and Nougha Creeks
- ongoing effects of vegetation management in RMAs at highway stream crossings
- increased sports fishing at other locations along the Robert Campbell Highway, Money and Nougha Creeks, Wolverine and Little Wolverine Lakes
- effects of other mining projects in the same drainages (there are currently no mining project under review that would incur cumulative effects on fish habitat in the RSA)

- increased risk of forest fire due to mining activity with potential for loss of riparian vegetation and sedimentation of instream habitat

Highway crossings associated with the project are well downstream of the project effects (e.g., Money Creek crossing approximately 35 km downstream). Effects on riparian habitat and sedimentation are separated in space and highly localized. Cumulative effects are expected to be low magnitude, site specific in the regional context and far future in duration. Effects of the Robert Campbell Highway on riparian habitat and sedimentation are functionally irreversible. The likelihood of effects as predicted is high. No HADD has been identified in the past or is anticipated in the future. Accordingly, these cumulative effects are determined to be not significant.

The effects of a contaminant introduction to fish habitat from the highway are variable depending on the amount and toxicity of the contaminant and habitat use of the effected reach at the time (potential concentrations of fish or ova). The magnitude of effects could range from low to high and a HADD could result. In any instance the contribution of the project to cumulative effects from this source would be low and not significant.

Increased angler effort associated with the Wolverine Project and various other development activities within the RSA may increase fish mortality through retention fisheries. Implementation of the angler education program described in Section 7.8.4.1 and signage postings along the access road or at the Robert Campbell Highway intersection encouraging the use of single barbless hooks, bait bans and catch and release strategies will reduce the contribution of the project to cumulative effects.

A forest fire could destroy riparian vegetation and alter water quality within the assessment area, resulting in environmental effects on fish resources, including fish mortality. Fire within the LSA (specifically along the access road) could occur during any phase of the project due to natural or anthropogenic activities. Factors influencing the severity and duration of environmental effects caused by a forest fire include time of year, weather conditions (wind, ground moisture, etc.) extent of fire damage and type of fire.

A fire during late summer or early fall could affect arctic grayling and bull trout migrations, and timing and success of spawning depending on duration, size and intensity. If the forest fire affects a large proportion of a watershed (i.e., lower Go Creek) and occurs during late fall, the magnitude of the environmental effect could be moderate to severe. Reversibility of physical environmental effects is high, but would occur over a long duration (five to ten years), particularly at high latitudes. Increased bedload transport and sedimentation would result in substrate aggradation in some reaches and downstream critical habitats infilling (spawning gravels and overwintering pools) and bank degradation in other reaches during subsequent spring freshets/snow melts until substantial re-vegetation occurs. Changes to groundwater patterns, base flows and instantaneous discharge rates in the stream may also be altered during this period due to changes in evaporation and infiltration rates. Although individual fish and ova mortality may occur as a result of a forest fire, the environmental effects on the population of resident and migratory fish are likely reversible as individuals from other reaches/sub-basins would eventually re-colonize the affected areas.

While project activities and increased traffic in the area could increase the risk of fire, the presence of people in the area can also support earlier detection and suppression. YZC has established procedures to prevent and respond to fire in the project area (Section 7.15.4: Forest Fire). All personnel and contractors will be provided with an orientation in these procedures and key personnel will demonstrate appropriate training to implement emergency response procedures. Project mitigation measures will minimize the risk of project related fires and support effective management of natural fires.

Nevertheless fires can and have occurred, as the charred remains of past fire(s) were observed during the 2005 fisheries assessment at the Money - Go Creek confluence. Associated effects on fish habitat could range in magnitude from low to high, local to regional in extent and could result in a HADD. The contribution of predicted project related effects on fish habitat to cumulative effects due to fire would be low and not significant.

7.8.6 Mitigation Measures

Mitigation measures for protection of fish and fish resources during all project phases are summarized in Table 7.8-9. The mitigation measures described in Table 7.8-9 utilize guidelines developed by the federal government (e.g., Freshwater Intake End-of-Pipe Fish Screen Guideline) and by the British Columbia government for the BC forest and land development industries. BC guidelines have been referenced here because similar, rigorous standards/guidelines and best management practices (e.g., culvert type and installation) have yet to be developed for the Yukon Territory. The Yukon Department of Energy, Mines and Resources references the BC Reconnaissance (1:20 000) Fish and Fish Habitat Inventory: Standards and Procedures (2001) for baseline data collection methods in Administrative Procedures for Environmental Assessment of Major Mining Projects in the Yukon, (September 2004). Accordingly, baseline studies completed in 2005 for YZC followed those standards. In the absence of comparable guideline for Yukon, it is assumed that mitigative techniques and best management practices developed for BC are acceptable for Yukon resource developments.

7.8.7 Monitoring and Follow-up

Follow-up Studies

Based on sufficient fish species assemblage data obtained during previous studies (e.g., Westmin 1996, 1997; Gartner Lee 2005) and the 2005 program, confirmation of fish distribution limits and generally low fish densities or absence, no further follow-up studies are recommended for the Fish Resource VECCs.

To confirm the accuracy of the effects predications on metals bioaccumulations in fish tissue, follow-up sampling consisting of annual, single season collection and metal analyses of fish samples will be initiated.

Table 7.8-9 Mitigation Measures for Effects on the Fish Resources

Potential Project Effect	Mitigation Measures
Effects of site clearing, grubbing, grading on loss/alteration of riparian vegetation and sedimentation of in-stream fish habitat	• Minimize removal of vegetation and soils disturbance and maximize retention within Riparian Management Areas (RMA: 20-70 m) of all streams potentially affected by the project • Locate buildings, portal, tailings ponds and facilities outside of Riparian Management Areas • Implement a sediment control plan (Section 9.2: Environmental Protection Plan) • Implement fish habitat protection plan (Section 9.2: Environmental Protection Plan) • Implement site water management plan (Section 2.9: Site Water Management) • Re-vegetate stream banks with native plants, grasses, shrubs and trees • Obtain required DFO and Yukon Authorizations for all in-stream and riparian works
Effects of culvert placement on fish and fish egg mortality and instream fish habitat	• Adhere to the *Forests and Range Protection Act, Stream Crossing Guidebook* (FRPA 2002) • Adhere to *Standards and Best Practices for Instream Works* (MWLAP 2004) • Complete crossing construction in the dry during the summer low flow period or in winter when streams are frozen solid (surface to substrate) at crossing sites during the period of least risk to fish and fish habitat • Isolate work area and salvage fish before commencing crossing work (a permit for fish salvage may be required from DFO) • Implement sediment and erosion control plan (Section 9: Environmental Management Plan) • Implement fish habitat protection plan (Section 9.2: Environmental Protection Plan) • Complete crossing construction in the dry during the summer low flow period or in winter when streams are frozen solid (surface to substrate) at crossing sites • Screen by-pass and water intake pumps as per *Freshwater Intake End-of-Pipe Fish Screen Guideline*s (as required) • Conduct blasting in accordance with *Guidelines for Use of Explosives in Canadian Fisheries Waters* • Restore streambed to pre-construction status and incorporate large woody debris and / or boulders into stream channel restoration • Maintain all culverts and bridges in good working order; replace dysfunctional culverts and /or bridges as required in association with sedimentation control measures application and fish salvage as required
Changes in stream flow due to mine dewatering, stream diversions and drainage collection and diversion with potential effects on instream habitat in Go Creek and Wolverine Creek	• Implement site water management plan (Section 2.9: Site Water Management)

Table 7.8-9 Mitigation Measures for Effects on the Fish Resources (cont'd)

Potential Project Effect	Mitigation Measures
Potential introduction of contaminants to fish habitat from fuel spills, concrete mixing	• Refer to mitigation measures for water quality (Section 7.5.8) • Discharge all wastewater in accordance with Yukon and Federal regulations and more than 100 m from fish habitat • Implement site water management plan (Section 2.9: Site Water Management) including water treatment to meet site specific water quality objectives at Site W12 in Go Creek and collection and treatment of site drainage • Implement a sediment control plan (EPP) • Adhere to protocols for refueling and equipment inspection and maintenance • Implement the mine closure plan, including saturation of tailings, treatment of decant during decommissioning and monitoring to ensure stabilization of water quality prior to closure • Maintain water cover of the disposed tailings as designed • Conduct regular/routine monitoring of tailings pond water quality and for potential leaks
Potential increase in angling pressure from project personnel	• Implement personnel environmental awareness training and environmental protection policy (Section 9: Environmental Management Plan) • All personnel will abide by applicable territorial fishing regulations • Posted signage along access road / North Campbell Highway intersection describing responsible angling techniques

Monitoring Programs

All construction activities will require inspection and monitoring of sediment input to receiving waters, to ensure that erosion and sediment control structures are appropriately installed, maintained and removed in accordance with regulatory requirements, the site water management plan, and commitments in the Environmental Protection Plan (Section 9.2). An on-site monitor (environmental inspector) will be present during all mine site and ancillary facilities development, access road construction at watercourse crossings and culvert and bridge installations to conduct monitoring and ensure compliance with all requirements.

DFO, Whitehorse (S. Orban, pers. comm.) has indicated that a project-related HADD is unlikely, and that a Letter of Advice will be the only requirement of DFO, along with approved EPP, sediment control, re-vegetation, mitigation and monitoring programs. As such, the project is expected to achieve DFO's no net loss principle (NNL; DFO 1986) and will maintain of the productive capacity of fish habitats. Post construction compliance monitoring will include routine inspection of watercourse crossings (culverts) and re-vegetation of RMAs during the first year of operation to ensure that erosion and sedimentation control measures and riparian re-vegetation programs are successful.

Water levels in Wolverine Creek will continue to be monitored to check impact predictions and ensure protection of fish habitat, as required.

Monitoring of project facilities, effluents and receiving water quality will occur as required by territorial and federal permits and regulations. If EEM suggests increasing metals levels in water and sediments, monitoring of fish tissue metals levels will be initiated to check for potential bioaccumulation. Based on monitoring results, requirements and approaches for adaptive management enhance management of project effects, will be developed and implemented in consultation with the relevant territorial and federal agencies.

Proposed monitoring programs for fish resources are summarized in Table 7.8-10 and will be implemented by the proponent.

Table 7.8-10 Monitoring Programs for the Fish Resource VECCs

Potential Project Effect	Program Objectives	General Methods	Reporting	Implementation
Alteration of in-stream habitat quality due to sedimentation from clearing, ground disturbance and culvert installation during construction	• To monitor effectiveness and BMPs for sediment control and fish habitat protection and ensure compliance with permit regulations	• Turbidity and TSS monitoring during construction as required by permit	• YTG and DFO as required	Proponent
Alteration of in-stream habitat quality due to culvert installation	• To confirm effectiveness of sediment control and fish habitat protection measures, and to address compliance issues immediately	• Post-construction evaluation of instream habitat in the vicinity of culvert installations (sedimentation, fish passage, bank erosion, culvert effectiveness) • Complete remedial action for any failed culvert, bank protection measures, etc.	• YTG and DFO as required	Proponent
Alteration / loss of riparian vegetation	• To confirm effectiveness of riparian re-vegetation program	• Annual inspection of planting survival and effectiveness over a three year period	• YTG and DFO as required	Proponent
Effects of reduced low flows in Wolverine Creek from mine water diversion	• Check effects predictions and implement adaptive management if necessary	• Refine stage discharge relationship in Wolverine Creek • Observe effects on overwintering habitat in Wolverine Creek.	• YTG and DFO as required	Proponent
Metals bioaccumulation in fish tissues	• Confirm effects predictions. • Initiate contingency plans to address unexpected effects, as required	• During EEM monitoring (Section 7.5: Surface Water and Sediment Quality) • Contingency to initiate fish tissue sampling & analysis • Collection of fish samples at identified monitoring sites, analysis for metals levels	• YTG as required • Reporting schedule according to MMER	Proponent

7.8.8 Summary of Effects

Project and cumulative effects on fish resources are summarized in Table 7.8-11.

Table 7.8-11 Summary of Effects on Fish Resources

Potential Effect	Level of Effect[1]						Effect Rating[2]	
	Direc-tion	Magni-tude	Extent	Duration/ Frequency	Reversibility	Like-lihood	Project Effect	Cumulative Effect
Construction								
Effects of site clearing, grubbing, grading on loss/alteration of riparian vegetation and sedimentation of in-stream fish habitat	Adverse	Low	Local	Long term for minesite Far future for access road	Reversible	High	Not significant	Not significant
Effects culvert placement on fish and fish egg mortality and sedimentation of instream fish habitat	Adverse	Low	Local	Short term Low frequency	Reversible for sedimentation Irreversible for mortality	High	Not significant	Not significant
Changes in stream flow due to mine dewatering, stream diversions and drainage collection and diversion with potential effects on instream habitat	Adverse	Low	Site-specific	Long term	Reversible	High	Not significant	Not significant
Potential introduction of contaminants to fish habitat from fuel spills, concrete mixing	Adverse	Low	Site-specific	Short term Low frequency	Reversible	High	Not significant	Not significant
Potential increase in angling pressure from construction crews	Adverse	Low	Regional	Short term	Irreversible	High	Not significant	Not significant
Operations								
Effects of vegetation management on the minesite and access road right-of-way on loss/alteration of riparian vegetation and sedimentation of in-stream fish habitat	Adverse	Low	Local	Long term for minesite Far future for access road	Reversible	High	Not significant	Not significant
Effects of treatment plant effluent discharges on fish habitat and fish tissue metals levels in Go Creek	Adverse	Low	Local	Long term	Reversible	Unknown	Not significant	Not significant
Changes in stream flow and habitat capability due to mine dewatering in Wolverine Creek and treatment plant effluent discharges in Go Creek	Adverse	Low	Local	Long term	Reversible	High for Go Creek Unknown for Wolverine Creek	Not significant	Not significant
Potential increase in angling pressure from project personnel	Adverse	Low	Regional	Long term	Irreversible	High	Not significant	Not significant

Table 7.8-11 Summary of Effects on Fish Resources (cont'd)

Potential Effect	Level of Effect[1]						Effect Rating[2]	
	Direc-tion	Magni-tude	Extent	Duration/ Frequency	Reversibility	Like-lihood	Project Effect	Cumulative Effect
Decommissioning								
Effects of mine infrastructure removal on riparian and in-stream fish habitat in Wolverine and Go Creek (sedimentation)	Adverse	Low	Local	Medium term for minesite Far future for access road	Reversible	High	Not significant	Not significant
Effects of tailings pond decant on in-stream fish habitat (water quality) and fish tissue metals levels in Go Creek	Adverse	Low	Local	Medium term	Reversible	Unknown	Not significant	Not significant
Changes in stream flow and habitat capability due to recovery of groundwater table in Wolverine Creek basin	Adverse	Low	Site specific	Long term	Reversible	Unknown	Not significant	Not significant
Potential increase in angling pressure from project personnel	Adverse	Low	Regional	Short term	Irreversible	High	Not significant	Not significant
Closure								
Effects on riparian habitat and sedimentation of instream habitat due to retention of the access road	Adverse	Low	Local	Far future	Reversible	High	Not significant	Not significant
Elevated metal levels in Wolverine Creek resulting from groundwater recharge of underground areas	Adverse	Low	Site-specific	Long term or Far future	Reversible	Unknown	Not significant	Not significant
Effects of tailings pond decant on in-stream fish habitat (water quality) and fish tissue metals levels in Go Creek	Adverse	Low	Local	Medium term	Reversible	Unknown	Not significant	Not significant
Potential increase in angling pressure from public access	Adverse	Low	Regional	Long term	Irreversible	High	Not significant	Not significant

Notes:
1 Based on criteria in Table 7.8-7
2 Based on criteria in Section 7.8.4