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decommissioning and closure is also considered. Finally, flows from the site runoff and diversion channels are also discussed as a potential stressor to sediment quality (Table 7.8-3).

The physical and chemical sources and processes leading up to the final composition of the released tailings effluent at Galore Creek are not discussed in this section, because they are considered in detail in Sections 7.5 and 7.6 (Water Quantity and Water Quality) and in the water quality model for the impoundment (Appendix 7-D). This includes metal leaching and acid rock drainage (ML/ARD) from various mine components (*i.e.* open pits, tailings and waste rock storage facilities, on site chemical spills, overburden pits and ore stockpiles) and leaching of blasting residues (ammonia salts).

Sewage from the mine camp produced during construction and operations phases will be treated for solids separation, and sewage effluent will be deposited within a tile field situated at least 100 m away from nearby waterbodies. Associated phosphorus and nitrogen compounds from sewage will travel slowly through groundwater movement only, travelling downslope into the waste rock or tailings facilities. Effluent discharge from the tailings pond will be managed in terms of nutrient concentration to avoid impacts to water quality downstream. Therefore, this will minimize effects on sediment quality.

Tailings effluent collected from the north end of the tailings pond will be pumped out into a spillway which will connect to the diversion channel and discharge into Galore Creek below the tailings and seepage dams (Figure 7.8-2). The seepage dam will collect seepage from the tailings dam and this will be pumped back into the tailings facility. The diversion channel will collect non-contact water from 74% of the Galore Watershed, and provide dilution to the tailings effluent. Additional downstream dilution will be provided by small tributaries feeding directly into lower Galore Creek as well as from a hanging valley which represents 8% of total Galore Creek Watershed area which discharges into Galore Creek 0.5 km upstream from the Scud River.

The characteristics of the diversion channel water used in the water quality modelling were based on baseline water quality conditions. Although the potential for ML/ARD to occur along the diversion channel is not yet known, this will be studied during construction. A synthetic durable liner will be placed along the base of the diversion channel (and along the sides as required) to minimize erosion and seepage and to mitigate the risk of ML/ARD. The diversion channel will be breached during closure, to reconnect original tributary flows to Galore Creek. There are no significant effects to sediment quality associated with the diversion channel (Table 7.8-3).

Controlled Discharge

Effluent from the tailings pond will be comprised of water (containing various chemicals and metals) as well as unsettled tailings fines. In order to assess potential changes to sediment quality caused by effluent discharge from the tailings facility, several effects pathways were assessed. These include direct loading of particulate-bound metals, as well as precipitation or adsorption of metals from the water column into streambed sediment.

During the 22 years of operations, effluent discharge will be scheduled from May to early October, avoiding low flow periods over the winter. It will be paced with the hydrograph (*e.g.* higher

**Table 7.8-3
Effect Assessment of Discharges of the Galore Creek Project on Sediment Quality**

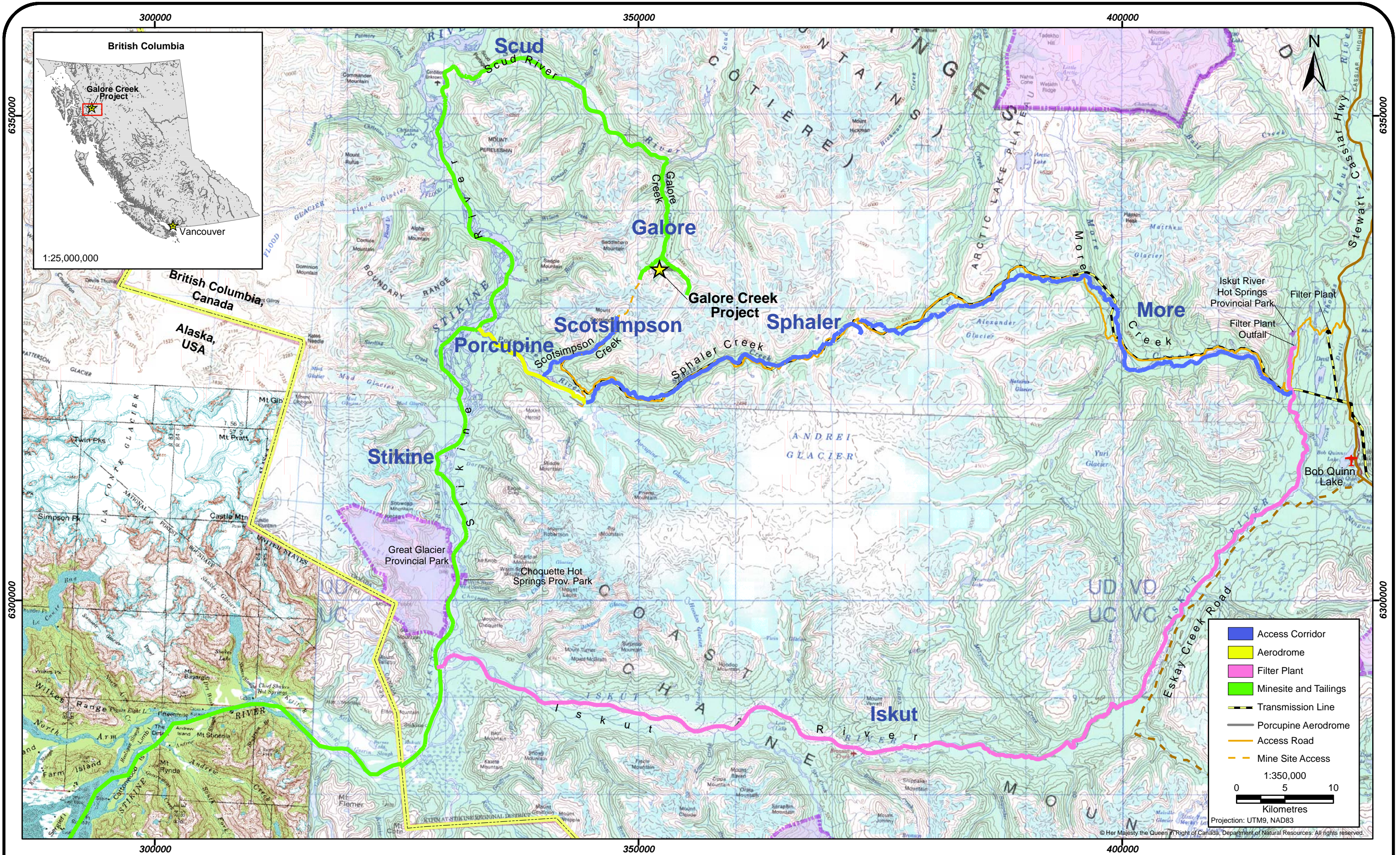
Mine Component description of mine component	Summary of Effect description of effect	Descriptor Criteria for Pre Mitigation Effects								Proposed Mitigation description of proposed mitigation	Summary of Residual Adverse Effects description of residual adverse effect	Potential for Residual Adverse Effect to be Significant Negligible Considerable
		Timing (start) Construction Phase Operation Phase Decommissioning and Closure Phase Post Closure Phase	Direction Positive Neutral Adverse	Duration Short Term Medium Term Long Term Far Future	Magnitude Negligible Low Moderate High	Geographic Extent Local Landscape Regional Transboundary	Resilience Reversible Short-term Reversible Long-term Irreversible	Frequency One time Periodic Continuous	Probability of Occurrence Nil Low Moderate Unknown High			
Controlled Discharge												
Galore Creek Valley (A, B, C, E, F)	Effluent discharge results in degradation of SQ through particulate loading of metals and water-sediment interactions	Operation	Adverse	Long Term	Negligible	Landscape	Reversible Long-term	Periodic	Moderate	Restricted periods of effluent discharge (May to October); Restrict TSS to 15 mg/L; monitor receiving environment (adaptive management)	None	Negligible
Site runoff, diversion and sediment control (D)	ML/ARD and particulates in diversion waters result in degradation of SQ through metal input by particulates	Operation	Adverse	Long Term	Low	Landscape	Reversible Long-term	Continuous	Unknown	Lining bottom of Diversion Channel to reduce leaching	Minor localized degradation of SQ	Negligible
Construction camps, Operations camps (G, H)	Sewage waste - Nutrient and organic loading to sediment in receiving environment	Construction	Adverse	Long Term	Negligible	Local	Reversible Short-term	Periodic	Low	Sewage treatment well away from waterbodies. Any groundwater transport of Galore sewage effluent would be captured in tailings pond.	None	Negligible
Filter Plant Outfall (N)	Degradation of SQ downstream of diffuser by metal loading	Operation	Adverse	Long Term	Low	Local	Reversible Long-term	Continuous	Moderate	Water treatment plant coupled with a diffuser in Iskut River	None	Negligible
Accidental Discharge												
Construction and Operations Camps, Aerodrome, Heliport (G, H, P, Q)	Localized fuel spill enters waterbody directly or through groundwater, degrading local SQ	Construction	Adverse	Long Term	Low	Local	Reversible Short-term	Periodic	Moderate	Spill Contingency and Emergency Response Plan (SCERP)	Minor localized degradation of SQ	Negligible
Aerodrome along Porcupine River and its access road (P)	Spilled deicing fluid could degrade SQ through groundwater transport to waterbody.	Operation	Adverse	Medium Term	Low	Landscape	Reversible Short-term	Periodic	Moderate	SCERP	Minor localized degradation of SQ	Negligible
Mill tailings and waste rock storage facilities including containment dam and haul roads (C)	Tailings dam breach would release tailings effluent and particulates downstream, degrading SQ due to TSS and metal loading	Operation	Adverse	Far Future	High	Regional	Irreversible	One time	Nil/Low	Use Best Management Practice, impermeable membranes for stability, regular structural monitoring	None	Negligible
Galore Creek Valley (A, B, C, E, F)	Tailings dam overflow during avalanche or storm could release effluent and particulates, degrading SQ due to TSS and metal loading	Operation	Adverse	Long Term	Moderate	Landscape	Reversible Long-term	One time	Low	Use irregular contour to reduce wave transmission, built to contain 1-in-100 year event	Rare increase in loadings to sediment, reducing SQ locally and temporarily.	Negligible
Process plant, concentrate slurry and diesel pipelines, facilities at Bob Quinn (B, L, M)	Ruptured concentrate pipeline releasing slurry would result in particulates and metal loadings to wetlands and rivers along road route, degrading SQ.	Operation	Adverse	Medium Term	Low/Moderate	Local/Landscape	Reversible Short-term	One time	Low	Use of thick pipes, buried to protect against avalanche, monitoring, emergency shut-down system. Waste Management & Spills Contingency Plans.	Rare localized degradation of SQ; spill would be managed based on SCERP.	Negligible
Process plant, buried ore concentrate slurry and diesel pipelines, facilities at Bob Quinn (B, L, M)	Ruptured diesel pipeline would release fuel to waterways, degrading SQ.	Operation	Adverse	Medium Term	Low/Moderate	Local/Landscape	Reversible Short-term	One time	Low	Use of thick pipes, buried to protect against avalanche, monitoring, emergency shut-down system. Waste Management & Spills Contingency Plans.	Rare localized degradation of SQ; spill would be managed based on SCERP.	Negligible
Access Road (J)	ML/ARD from stockpiled waste rock flowing into waterbodies degrading SQ	Construction	Adverse	Medium Term	Negligible - Moderate	Local	Reversible Long-term	Periodic	Unknown	Proper management and disposal of PAG waste rock.	None	Negligible
Access Road (J)	ML/ARD drainage originating from cut rock walls along access corridor degrading SQ	Operation	Adverse	Long Term	Negligible - Moderate	Local	Reversible Long-term	Periodic	Unknown	WQ monitoring; for ML/ARD areas, use diversion of water above exposed cut rock, and limestone-lined ditches.	None	Negligible
Facilities at Bob Quinn, Explosives manufacturing and storage plant (I, M)	Spill of chemicals or concentrate at mine or filter plant, degrading SQ of local waterbody	Operation	Adverse	Medium Term	Low	Local	Reversible Short-term	Periodic	Low	Spill Contingency and Emergency Response Plan (SCERP); clean-up of spill removing contaminated sediment from aquatic habitat.	None	Negligible
Truck transport of concentrate along Highway 37 to Stewart (O)	Truck accident could result in concentrate spill on highway, transport to waterways would cause locally degraded SQ	Operation	Adverse	Short Term	Low	Local	Reversible Short-term	One time	Low	Spill Contingency and Emergency Response Plan (SCERP); clean-up of spill removing contaminated sediment from aquatic habitat.	None	Negligible

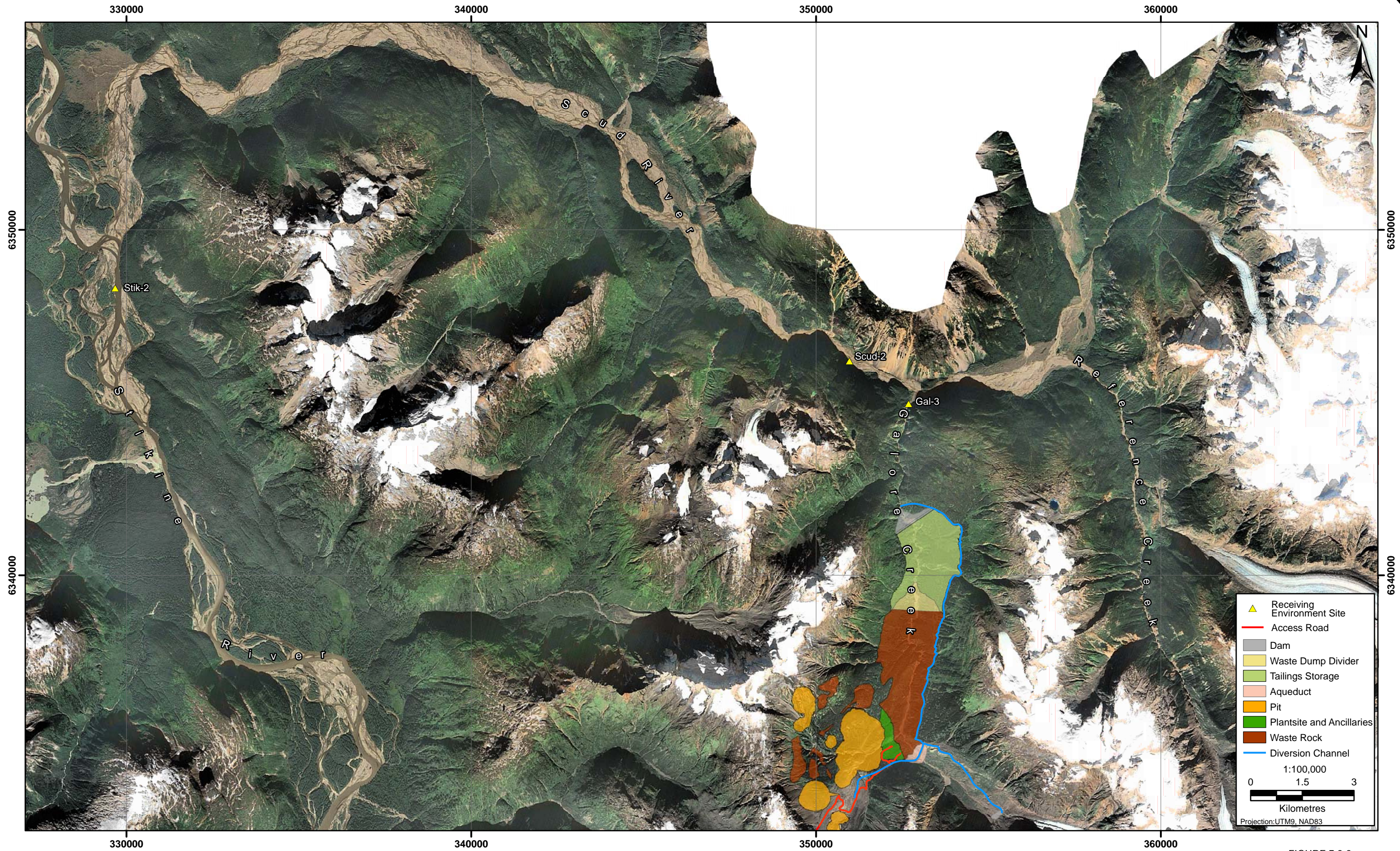
SQ = Sediment Quality; TSS = Total Suspended Solids

**Table 7.8-4
Effect Assessment of Siltation of the Galore Creek Project on Sediment Quality**

		Descriptor Criteria for Pre Mitigation Effects										
Mine Component description of mine component	Summary of Effect description of effect	Timing (start)	Direction	Duration	Magnitude	Geographic Extent	Resilience	Frequency	Probability of Occurrence	Proposed Mitigation description of proposed mitigation	Summary of Residual Adverse Effects description of residual adverse effect	Potential for Residual Adverse Effect to be Significant Negligible Considerable
		Construction Phase Operation Phase Decommissioning and Closure Phase Post Closure Phase	Positive Neutral Adverse	Short Term Medium Term Long Term Far Future	Negligible Low Moderate High	Local Landscape Regional Transboundary	Reversible Short-term Reversible Long-term Irreversible	One time Periodic Continuous	Nil Low Moderate Unknown High			
Galore Creek Valley, construction camps, access road, concentrate ore slurry and diesel pipeline, filter plant outfall (A, B, C, E, F, G, H, J, L, N)	Construction activities causing increased TSS loading into waterbodies, degrading SQ.	Construction	Adverse	Short Term	Low	Landscape	Reversible Short-term	Periodic	Moderate	Erosion control measures, Best Management Practice, sediment control ponds, dam	None	Negligible
Galore Creek Valley, operations camps, access road, concentrate ore slurry and diesel pipeline, filter plant outfall (A, B, C, E, F, G, H, J, L, N)	Construction and operational activities causing increased TSS loading into waterbodies along access road, degrading SQ.	Operation	Adverse	Long Term	Low	Landscape	Reversible Short-term	Continuous	Moderate	Silt curtains, erosion control measures, Best Management Practice, sediment control ponds, dam	None	Negligible
Site runoff, diversion and sediment control (D)	Pulse of sediment during opening of diversion channel, degrading SQ in lower Galore Creek.	Construction	Adverse	Short Term	Moderate	Landscape	Reversible Short-term	Periodic	Moderate	Line base of channel with membrane	None	Negligible
Site runoff, diversion and sediment control, access road (D, J)	Landslide within Galore Creek Valley or along access road increases TSS loads and altered substrate sizes in waterbodies, degrading SQ.	Operation	Adverse	Long Term	Moderate	Landscape	Reversible Long-term	One time	Low	Best Management Practice, revegetate slopes, water management, reclaim at closure	None	Negligible
Access Road, facilities at Bob Quinn, aerodrome, heliport (J, M, P, Q)	Construction and operational activities causing increased TSS loading into waterbodies along access road, degrading SQ.	Operation	Adverse	Long Term	Low	Landscape	Reversible Short-term	Periodic	Moderate	Best Management Practice	None	Negligible

SQ = Sediment Quality





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discharge during peak flows) which will maximize dilution and maintain concentrations of variables within the range of natural variability. Minimizing increases in metal concentrations in the receiving environment reduces the likelihood of metal transfer from water to sediment through precipitation. A discharge schedule has been designed so that there will be adequate dilution of effluent with the diversion channel flows. In addition, the tailings impoundment will act as a settling pond so that total suspended solids (TSS) in the effluent can conform to federal permit (*i.e.* MMER) levels.

Following closure, the diversion channel will be breached such that all surface flows above the dam will flow into the tailings pond. The surface layer of tailings pond water will be allowed to run freely into the spillway and into lower Galore Creek on a year-round basis. This is dependent on flow rates available for dilution as well as water quality of the tailings pond at closure. Discharge or water use management may be required, and if these measures were unsatisfactory then treatment may be used, based on the environmental effects assessment program results.

Discharged Particulate Effects to Sediment Quality

To assess effects related to fine tailings particles being introduced downstream in Galore Creek during discharge, loadings of total suspended solids (TSS) and three representative metals were calculated for two scenarios: “Baseline” and “Mine Scenario”. Based on the relative loading (kg/yr) of tailings particles during “Mine Scenario” to that of “Baseline” TSS for Galore Creek, and considering the proportional loading of Galore TSS and tailings to the Scud and Stikine systems, predicted changes in sediment loadings were calculated for each site. In the model, annual flow rates were used based on all baseline data (for “Baseline”) or all years of modelled data during operations (for “Mine Scenario”).

The first step involved comparing metal concentrations from natural TSS to those from tailings particles, to determine which metals were higher in tailings and could possibly be expected to pose a problem to sediment quality. Chemical analyses of TSS collected in lower Galore Creek (Gal-3 baseline) and from tailings from rock geochemistry pilot studies indicated that several metals will have high ratios of concentrations from tailings compared to natural suspended solids of lower Galore Creek (Table 7.8-5). This includes strontium, silver and copper, and to a lesser degree barium, selenium, uranium and lead. Based on these ratios, three metals were selected for loading calculations including copper (since Galore Creek is a copper mine and copper had a high ratio), strontium (since it had the highest ratio of all metals) and zinc (to show loadings for a metal with low ratio; zinc is also of potential concern to water quality). However, these high ratios do not necessarily imply that loadings will increase in future, because TSS loadings from the tailings pond will be managed so that concentrations do not exceed 15 mg/L based on MMER permit limits. For most metals, this decreased TSS loading will offset the increased metal concentrations in tailings relative to natural suspended sediments, as shown below (Table 7.8-5).

Total loadings were calculated for both scenarios for the lower Galore Creek (Gal-3), Scud River (Scud-2, a few kilometers downstream of the Galore confluence) and Stikine River (Stik-2), without allowing for any loss between sites due to deposition or chemical reactions. This is a realistic assumption based on the fast flows of Galore Creek and Scud River, the fact that sand is

transported in these waterbodies (observed in water TSS), and the predicted size fractions (very small) of the tailings particles to be included in discharged effluent.

**Table 7.8-5
Ratio of Total Metal Concentrations in Tailings Particulates versus
Lower Galore Creek (Gal-3) Suspended Solids**

Metal	<u>Concentration in Tailings</u> <u>Concentration in Natural TSS</u>
Strontium	18
Silver	13
Copper	10
Barium	8
Uranium	6
Selenium	4
Lead	3
Aluminum, Cadmium, Chromium, Cobalt, Manganese, Molybdenum, Nickel, Thallium, Tin, Zinc	0 to 2

It is possible that some quantities may be deposited in localized areas (interstitial spaces, side channels and low velocity areas) of the Galore and Scud which would reduce some of the calculated loadings. For simplicity and conservatism, it was assumed that all TSS loadings would travel successively downstream from site to site.

This is a realistic assumption based on the fast flows of Galore Creek and Scud River, the fact that sand is transported in these waterbodies, and the predicted size fractions (very small) of the tailings particles to be included in discharged effluent. It is possible that some quantities may be deposited in localized areas (interstitial spaces, side channels and low velocity areas) of the Galore and Scud which would reduce some of the calculated loadings. For simplicity and conservatism, it was assumed that all TSS loadings would travel successively downstream from site to site.

Calculation of “Baseline” scenario loadings involved baseline flow rates at each site and concentrations of natural TSS along with metal concentrations in TSS particles ([mg metal/kg TSS]). For each of the three sites, monthly baseline flow rates and TSS concentrations were used to calculate a weighted annual baseline TSS concentration. This was multiplied by the annual flow to determine an annual TSS load. For a given metal, the annual TSS load then was multiplied by the metal concentration in that TSS. Since these TSS metal analyses used Near-Total digestion with strong acids, thereby extracting more metals from the TSS than in natural conditions, metal concentrations are conservative.

For the first site, the annual flow in lower Galore (Gal-3) was termed Q_{sum} , and represents all outflow from Galore Creek Valley. Therefore, the following equations were used:

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- Gal-3 Annual TSS Load (kg/yr) = $[TSS]_{GAL3} * (Q_{sum})$.
- Gal-3 Annual Metal Load (kg/yr) = $[TSS]_{GAL3} * (Q_{sum}) * [metal\ in\ TSS]_{GAL3}$

Annual TSS and metal loadings were also calculated for Scud-2 and Stik-2. For each site, baseline TSS concentrations, TSS metal concentrations (mg/kg) and flow rates were used to calculate annual TSS and metal loads.

For “Mine Scenario” assessment of loadings, the sum of TSS and metal loadings to Gal-3 from all upstream sources was calculated. Note that Q_{sum} (baseline Galore Creek flow) therefore equals the sum of future flows in all mine components including the diversion channel (Q_1), tailings pond (Q_2) along with water retained within the tailings pond (Q_{TP}). Flow rates were based on the average flow rate over the life of the mine (*i.e.* 22 years). For the diversion channel contribution of TSS, the same annual flow rate and TSS concentration was used as for baseline conditions. This is assuming that TSS in non-contact water will not be affected by the project. The other source of TSS in “Mine Scenario” is from the tailings pond, which used effluent TSS concentrations and flow rates from water quality modelling (Appendix 7-D). Metal concentrations within the $< 13\ \mu m$ size fraction of tailings solids, which make up 23% of tailings by weight, were also used in calculations for the tailings pond contributions. This assumes that only the smallest size fractions of particles ($< 13\ \mu m$) will not settle within the tailings pond, and will be collected with surface pond water for discharge. It was also assumed in calculations that solids from the effluent would be purely tailings and not contain any natural TSS, although TSS would be deposited to the pond by surface runoff. This added another level of conservatism to the assessment since tailings had higher concentrations of many metals compared to the baseline TSS.

For the “Mine Scenario” conditions at Gal-3, the following equations were used:

- Gal-3 Annual TSS Load (kg/yr) = $[TSS]_{GAL3} * (Q_1) + [TSS]_{tail\ pond} * (Q_2)$
- Gal-3 Annual Metal Load (kg/yr) = $[TSS]_{GAL3} * (Q_1) * [metal\ in\ TSS]_{GAL3}$
+ $[TSS]_{tail\ pond} * (Q_2) * [metal\ in\ tailings]_{GAL3}$

Annual TSS and metal loadings were also calculated for Scud-2 and Stik-2. For each site, the difference in loadings between “Mine Scenario” and “Baseline” for Gal-3 was added to the “Baseline” loading for Scud-2 or Stik-2 to get their respective “Mine Scenario” loading. This assumes that the only change from “Baseline” to “Mine Scenario” occurs in Galore Creek.

Loadings for each variable were then compared between scenarios by dividing the “Mine Scenario” loading by the “Baseline” loading, for all variables at each of the three sites (Table 7.8-6).

Results indicate that total loadings of TSS will decrease in lower Galore Creek by 37%, resulting in a 6% decrease downstream in the Scud River and a 0.7% decrease in the Stikine River (Table 7.8-6). The latter value reveals the relatively minor effect the tailings effluent is projected to have on the sediment metal loadings in the Stikine River.

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Loadings of zinc and copper were predicted to decrease by 34% and 16% respectively at the lower Galore site. Strontium showed a slight increase (4%) at the Galore site compared to 2% and 0.2% increases at Scud and Stikine sites, respectively.

**Table 7.8-6
Calculated Annual Particulate Loadings of
Suspended Solids and Associated Metals for Baseline and
Mine Scenarios at Galore, Scud and Stikine Sites**

Site	Variable	Baseline Load (kg/yr)	Mine Scenario Load (kg/yr)	% Change from Background
Gal-3	TSS	67,647,871	42,863,653	-37%
	Copper	20,497	17,232	-16%
	Strontium	10,113	10,515	4%
	Zinc	12,177	8,027	-34%
Scud-2	TSS	384,099,320	359,315,103	-6%
	Copper	38,986	35,721	-8%
	Strontium	26,464	26,866	2%
	Zinc	56,463	52,313	-7%
Stik-2	TSS	3,314,353,816	3,289,569,598	-0.7%
	Copper	244,268	241,003	-1.3%
	Strontium	235,651	236,052	0.2%
	Zinc	772,244	768,095	-0.5%

These values are well within expected ranges of natural variability in sediment loadings, which vary in relation to changes in available exposed rock as the source of particles, as well as weathering and seasonal fluctuation in precipitation and surface flows (freshet). Therefore, most metal loadings will actually decrease based on mine development, due to the permitted decrease in TSS loadings based on MMER. Strontium and perhaps silver will show only slight increases in annual loadings at Gal-3, but no significant changes in loadings in Scud and Stikine are anticipated based on particulate transport from Galore Creek.

Annual monitoring of sediment, water and aquatic biota (including fish and benthos) will provide information regarding the degree to which metal transport is augmented in the three watersheds, and monitoring within the Stikine River will also be continued to allow detection of any changes to sediment quality.

Analysis of the particle size distribution of the tailings effluent showed that 23% of tailing particles were <13 µm (clay and very small silt sizes), indicating that this fraction would remain in the water column for significant distances (Van Rijn, 1985). Tailings particles will be transported down Galore Creek, travelling further downstream in the Scud and into the Stikine River, based on the energetic mixing observed in Galore Creek and Scud River throughout the high flow period. These fine tails are similar in size to clay and the smaller silt fractions of natural suspended sediments of the region. Static environments are required to settle particles of

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this size fraction, and a portion of the tailings may be temporarily trapped within interstitial areas in the gravel and sand, depending on particle size, water dynamics and sediment bed movement (Carling, 1983). Deposition in side channels may also occur in Galore Creek, on the Scud and Stikine rivers to a limited extent. During freshet, larger particles (sand and silt) as well as some clays were observed within the Stikine River water column, based on water sampling through the summer months. This indicates the low settling rates of particles in the Stikine River under baseline conditions. Similarly, fine tailings particles are not expected to settle in Galore or Scud rivers, but most likely in the Stikine River and estuary. The sediment loadings of particulates and metals from tailings effluent to the Stikine River will be negligible. This is based on further dilution of upper Stikine TSS with inputs from Porcupine and Iskut watersheds as well as the numerous tributaries flowing into the Stikine downstream of Stik-2, and in consideration of the already high metal concentrations in sediment of the Stikine River.

Potential Metal Loading from Water Column to Sediment

The results of water quality modeling (Appendix 7-D) of all inputs and output from the tailings pond were used to predict changes to water quality in the receiving environment downstream of the tailings dam (see Section 7.6).

During operations, water quality of lower Galore Creek is projected to contain similar or slightly elevated concentrations of total metals, slightly higher concentrations of some dissolved metals, and lower TSS concentrations compared to baseline values, with a pH similar to or slightly higher than the natural range observed (7.8 to 8.2 in Galore and Scud rivers).

Therefore, the potential for water chemistry to affect sediment quality was considered based on three pathways: total metals transfer to sediment, dissolved metals binding to sediment, and dissolved metals precipitating or forming colloids and settling into sediment.

For total metal concentrations in lower Galore Creek, calculated Hazard Quotients (HQ; ratio of future concentration to baseline concentration, based on worst case leachate scenario) were low for all variables (see Section 7.6). The HQ values in the Scud River were much lower than those of Galore due to dilution effects. This indicates that total metal concentrations in Galore and Scud waters are not predicted to significantly change due to mining, therefore no effects to sediment quality are related to this component of effluent discharge, based on mass balance.

Although dissolved metal concentrations are increasing slightly for some metals, the lack of significant sediment substrates in Galore Creek, related to the high flow rates, coupled with the scarcity of clays or organic matter which binds metals suggests that this will not be a pathway for metal loading to sediment. Therefore sediment quality should not be impacted by binding of dissolved metals to sediment.

To investigate the possibility of dissolved metals precipitating from water into sediment and degrading sediment quality, the chemical speciation model MINTEQ (Allison *et al.*, 1991) was used along with best professional judgment scenario from the water quality model (Appendix 7-D). MINTEQ used dissolved metal concentrations from the output of the water quality model. A total of 22 years of modelled monthly concentrations was available for both Gal-3 and Scud-2. Water quality data were converted from mg/L to mmol/L. Data for the month with the highest

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monthly average metal concentrations data (May) were selected for assessment of precipitation likelihood. As pH was not available from the model output, two scenarios (pH 7 and 9) representing a range of water pH values extending beyond natural predicted minimum and maximum pH values were used in the model.

As input, MINTEQ requires dissolved concentrations together with thermodynamic data for all chemical reactions that may possibly occur between the chemical constituents present in the water. MINTEQ then calculates, for each constituent, its equilibrium distribution over all the chemical species in which the particular constituent may be present, over all possible phases.

Results indicate that almost no metals will form precipitates in Galore Creek or Scud River, indicating that no effects to sediment quality are predicted based on metal transfer from water to sediment through precipitation. Compounds that will precipitate include hydroxides and oxides of iron and aluminium, as well as small amounts of BaSO₄ and PbMoO₄, the latter only precipitating at pH 7 and only at Galore Creek. Dilution occurring in the Scud River prevents these solids from forming. As iron and aluminium are ubiquitous in the regional sediment, any precipitation from water will represent an insignificant contribution to total sediment loads for these metals. At pH 9, a number of additional solids are predicted to form. These are mostly CaCO₃ and MnCO₃ compounds, as well as a Zn-Al carbonate compound. The MnCO₃ and Zn-Al carbonate compounds are predicted to be saturated in the Galore but not in the Scud, therefore these will not impact sediment quality.

Colloidal iron and aluminium hydroxides and oxides can adsorb metals in the water column. This pathway was not modelled due to lack of available data and the complexity of the chemical reactions involved. However, this pathway of metal removal from the water column is not expected to impact sediment quality because metal adsorption to hydroxides and oxides occurs naturally, and loadings related to adsorption are not expected to change in the future. The loadings will not change as adsorber and adsorbable metal concentrations are not predicted to significantly increase, based on the modelled concentrations of dissolved aluminium and iron relative to baseline (see Section 7.6).

Due to their small size and the fast flowing nature of Galore Creek and the Scud River, metal-enriched colloidal material will not settle out in these waters. It is more likely that these colloidal materials will be transported into the Stikine River. Colloids already diluted to this point would probably still not settle out, being transported down the Stikine River to the Pacific Ocean which represents dilution by another order of magnitude. Therefore, sediment quality is not predicted to change based on effluent discharge (Table 7.8-3).

During closure phase, the diversion channel will be breached. Therefore all flows downstream to lower Galore Creek will originate directly from the top of the tailings pond. The free flow of surface waters from the tailings pond to the downstream environment will be contingent on water quality which will be assessed by the Environmental Monitor on site. The tailings will be submerged by 8 m of water in order to minimize disturbance to the fine tailings particles. No new tailings or discharges will be deposited within the tailings facility following closure, therefore settling of particles out of solution should occur to a large extent. The rate of settling and resuspension will be monitored during operations.

Accidental Discharge

No accidental events were predicted to cause significant changes to sediment quality. Accidents included events of varying magnitudes and levels of probability. The Spill Contingency and Emergency Response Plan (SCERP) describes management procedures to handle spills. Training of emergency response staff in regards to Workplace Hazardous Materials Information System (WHMIS) and SCERP will allow for effective and rapid responses to chemical spills (e.g. fuel, de-icing fluid, process chemicals, ore concentrate) within the mine site. The ore processing plant and the explosives manufacturing and storage plant are situated well away from waterbodies, to minimize the risk of chemicals entering aquatic environments and to facilitate containment. Surface runoff from these facilities as well as from the access road within Galore Creek Valley (including tunnel) are all diverted into the tailings pond.

Construction materials and practices used for the tailings containment dam, including an impermeable membrane and impervious clay till central core built with safety factors to account for earthquakes, as well as monitoring will be conducted to minimize the risk of structural problems. Seepage and leakage will be avoided through proper engineering and regular monitoring of the dam. A seepage dam and underwater wells will contain and collect any groundwater seepage which may accumulate, and this will be pumped into the tailings facility. Therefore, major leaks or seepage events are considered improbable in this assessment, and are not related to effects to sediment quality.

In the case of a dam breach at the tailings facility, large volumes of TSS and metal-enriched effluent would be released downstream in Galore Creek and Scud River. This would result in significant degradation of sediment quality. This effect could be expected to extend quite far down the Scud River, and, depending on particulate settling rates and season, could impact sediment quality of the Stikine River. Effects would be more serious and longer lasting in Galore Creek and Scud River than in the Stikine River. However, an event such as this is classified as catastrophic and beyond any best engineering practices for earth-filled hydroelectric reservoirs (see also Section 5.9).

With the progression of global warming, glacial melt in the upper Galore Creek Valley will be expected to increase over the next hundred years, contributing significant amounts of meltwater which will flow into either the tailings facility or the diversion channel for release to Galore Creek. These increased volumes, as well as periods of high precipitation and avalanche events within the valley, could result in a tailings overspill event, leading to unscheduled discharges into the lower Galore Valley. An overspill event could result in increased metal loadings to Galore Creek and the Scud River. The geographic extent of significant degradation to sediment quality would probably be confined to the upper portions of the Scud River, but this would be proportional to spilled volume and the time of year in which the accident occurred. To mitigate the risk of an overspill event, sufficient freeboard of the dam will always be maintained to avoid effluent overspilling the dam which could erode the backside of the dam as well as result in unauthorized discharge to the receiving environment. The likelihood of such occurrences is judged to be of very low probability, since the dam height will be based on containment of a 1-in-100 storm event. Therefore, the risk of impact from a tailings effluent overspill is considered negligible (Table 7.8-3).

In summary, discharges from the mine area are predicted to have little or no impact to sediment quality in Galore and Scud watersheds, due to reduced loadings of most metals based on permitted discharge of TSS, and the low potential for transfer and accumulation of metals in sediment from dissolved metals in the water column. No effects to sediment quality are predicted in the Stikine River and its estuary, related to the lack of increased metal loadings from the project area. The Aquatic Effects Monitoring Plan includes sediment quality sampling in Galore Creek and Scud River, and will be applied using adaptive management to respond to any future monitoring requirements or changes to sediment quality in receiving environments.

7.8.2.3 Filter Plant and Access Corridor

Potential impacts to sediment quality are associated with the discharge of filter plant concentrate effluent, as well as accidents related to spills of fuel, ore concentrate, or filter plant chemicals (surfactants, flocculants, acids). The potential for ML/ARD drainage from cut rock along the access corridor is also discussed.

Discharge of effluent created from dewatering of ore concentrate at the Iskut filter plant will occur year-round at a location on the Iskut River upstream of the More Creek confluence. This area provides fast flows. A diffuser will be installed for discharge at depth within the river. Predicted water quality concentrations from a diffuser mixing model were developed for both low flow and average flow conditions (see Water Quality Section 7.6). Dilution of filter plant effluent will result in HQ values for total and dissolved metals ranging from below 1 (decrease in concentration in future) to 1.4 (slight increase in water concentrations based on model) at just 7 m distance downstream of the diffuser. The exception was total copper under low flow which showed an HQ of 3.1, although this increased copper level was still an order of magnitude lower than natural copper levels under peak flows. Therefore, potential effects to sediment quality would only be expected in the first 7 m downstream of the diffuser. Metal loadings to sediment will be very minor considering the only slight increased water concentrations of metals and the naturally high metal concentrations already present in Iskut River sediment (see Appendices 6-D and 6-E). The use of sand cartridge and activated charcoal filters will aid in minimizing the release of particulates and organics to the Iskut River, therefore loading of particulate-bound metals will be minimized, thereby maintaining current sediment quality. As metal concentrations of effluent will not be dramatically higher than background values and pH will be in the same range, water-sediment interactions such as precipitation are thought to be negligible, and binding substrates including clays (<2%) and organic matter (<3.0 mg/L) are scarce in the Iskut which has a streambed mainly of cobble and gravel. This indicates that the release of total and dissolved metals is probably not associated with a pathway to the sediment compartment, and that sediment quality would not be impacted in this manner.

At the filter plant, concentrate recovery will be maximized for both environmental and economic reasons, and pH-adjusted effluent will cause little to no effect to the sediment quality of the receiving environment. Concentrate will be loaded onto trucks using a silo and conveyor system, supplemented with loader vehicles for high volume shipments, based within an A-frame building with cement base. Concentrate, which will be covered and transported by truck to Stewart, and any road accidents, are considered within the SCERP and Waste Management Plans. No significant effects to sediment quality are associated with concentrate delivery by truck.

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Sewage from camps at the filter plant and More Creek heliport will be treated for solids separation and sewage effluent will be deposited within a tile field situated 100 m away from nearby waterbodies. Associated phosphorus and nitrogen compounds from sewage will travel slowly through groundwater movement only, and if they reach waterbodies their concentrations will be attenuated. Therefore no impact to sediment quality is predicted from camp sewage management.

Accidental discharges associated with a pipeline rupture along the access corridor involve the release of either diesel or concentrate to the environment, with the possibility of transport into waterways leading to degradation of sediment quality in wetlands or streams. To mitigate this risk, the pipelines will be buried and run parallel next to the roadway (to minimize disturbance to habitat and facilitate access during monitoring and emergencies), and will be buried deeper in zones rated to have high risk of avalanche or landslides. Exposed pipelines will be supported and insulated against freezing at all major crossings. Effects related to pipeline accidents will be minimized through the use of emergency shutdown systems along the diesel pipeline, as well as the use of pressure sensors set up along the concentrate pipeline which will detect leaks. An emergency containment sump tank at the low point at the mouth of Sphaler Creek on the Porcupine River will be set up designed to capture drained concentrate slurry in the case of a rupture along Sphaler Creek and Scotsimpson Creek.

In the event of a diesel pipeline rupture, significant amounts of fuel may be released into the environment, and, if this occurred near a waterbody, significant degradation of sediment quality will occur, particularly in wetland or lakes which have minimal flows and significantly more sediment to absorb contaminants than local streams. Spills associated with streams may also degrade sediment quality, depending on where the rupture occurred.

The rupture of the concentrate pipeline along the Sphaler-Porcupine section of the access corridor will result in only minimal release of concentrate to the environment. This is because the pipeline will drain downhill to the sump system at Porcupine. A concentrate pipeline rupture in the More Creek watershed will result in a similar effect, with concentrate being drained downhill to the Filter Plant.

Any fuel or ore concentrate spill will be assessed and clean-up will be conducted to either contain or remove contaminated materials and reduce or eliminate impacts to local sediment quality. The low likelihood of a pipeline rupture and the low magnitude of effect indicate that no significant adverse effects to sediment quality are predicted for this issue (Table 7.8-3).

The use of road salts as dust suppressants along the access road could lead to increased ionic concentrations in nearby waterbodies. However, these would be dissolved constituents, transported downstream and having no impact on sediment quality.

Impacts to sediment quality related to discharges at the More Creek heliport are limited to spills of either fuel or de-icing fluid. The use of an impermeable apron for fueling, and the application of the SPERC to manage any spills will minimize this pathway to the sediment of More Creek and local lakes and wetlands.

7.8.2.4 Aerodrome Facility

Potential impacts to sediment quality associated with discharges from the Porcupine Aerodrome include sewage effluent discharge as well as spills of fuel or de-icing fluid to the surrounding ground.

The camp at Porcupine Aerodrome will have a sewage treatment facility to remove solids and manage fluid discharges at a safe distance from waterways. No impacts to sediment quality would be associated with sewage effluent.

The local terrain is made up mainly of gravel and sand, therefore has high porosity. A chemical spill would more easily travel in groundwater through this matrix than in areas with higher silt or clay content. Chemicals can move several kilometres in the hyporheic (interstitial zone under a stream where groundwater and surface water mix) and groundwater zones of large rivers (Hancock, 2002). Therefore there is a potential for groundwater transport of chemicals into the Porcupine River or the downstream channel west of the airstrip. To manage this risk, the containment of de-icing fluids for recycling or disposal is part of the Mine Plan, and fuel stations will be built to contain spills in localized areas. Therefore, no significant impact to sediment quality is related to accidental chemical discharges at the aerodrome facility.

7.8.3 Siltation

7.8.3.1 Introduction

Siltation could result in physical or chemical effects to sediment quality, depending on the nature of introduced particles. Sources of siltation in waterbodies include:

- construction activities within the mine area affecting Galore Creek and downstream areas;
- construction of the tunnel, aerodrome, heliport, and access corridor (including transmission line and pipelines) affecting nearby streams and wetlands;
- traffic along all roads raising dust and leading to soil compaction and erosion along roadways;
- fugitive dust from blasting leading to aerial deposition of particulates to waterbodies; and
- landslides washing away slopes into adjacent waterbodies along road route or within Galore Creek Valley.

7.8.3.2 Mine Area, Scud and Stikine Rivers

During construction of the mine infrastructure including open mine pits, site runoff and diversion channels, roads, camp sites, temporary and permanent tailings dams and coffer dams, there is a potential of increased TSS loading to lower Galore Creek due to terrain disturbance and erosion. This is partially dependent on precipitation events relating to increases in erosion and transport of soil into waterbodies.

In order to control siltation to lower Galore Creek, best management practices will be used, including erosion control measures for roadways, silt curtains and sediment control ponds. The Erosion Control and Sediment Management Plan will ensure that sediment inputs to waterbodies are controlled to avoid altering the sediment quality. The temporary dam built upstream of the permanent dam location will serve to contain waters from upstream and allow pumped release of settled water downstream of the dam into Galore Creek. It is expected that there will be significant TSS loads in silt settling ponds, due to the relatively high proportion of clays in the rock of Galore Valley. Depending on rates of settling for particles, retention of water within settling ponds may be extended until water is clear enough for discharge. Blasting will result in aerial deposition of particulates to nearby streams, but local surface waters will be diverted to settling ponds or the tailings facility in order to reduce TSS to permit limits. Several progressions of diversion channel systems and associated roads are required during the mine life, each requiring sediment ponds to manage water TSS concentrations prior to discharge. The base of the diversion channel will be lined with a synthetic membrane and armoured with rock to mitigate erosion of the channel which could lead to siltation effects downstream.

During construction, some increases in TSS concentrations to lower Galore Creek may occur, depending on the efficacy of sediment settling ponds and precipitation rates which propagate siltation. However, these values will remain within the range of baseline conditions, and will not result in significant effects to sediment quality (Table 7.8-4). TSS levels within the Galore Creek Project are relatively high (from 50 to 550 mg/L at Gal-3). Environmental Monitors will be on site during construction to ensure that water quality of discharge waters meets acceptable criteria.

No significant changes to sediment quality in Galore or Scud rivers are anticipated from siltation during operations. This is because TSS will actually be reduced (to a maximum of 15 mg/L based on MMER) relative to background TSS concentrations which can exceed 500 mg/L during freshet.

7.8.3.3 Filter Plant and Access Corridor

The construction of the access road from Highway 37 to the mine site, including the More Creek heliport and the access tunnel, will be conducted based on best management practices which include erosion/sediment control plans. Deposition of soil into any of the nearby wetlands and lakes as well as the streams along the access corridor will be avoided through the use of appropriate water management measures, proper engineering design of roadways and crossings, and ongoing road monitoring. The majority of the transmission line right-of-way will retain original vegetation cover and construction access will be via the access corridor or helicopter, minimizing disturbance. Similarly, the diesel and concentrate pipelines will be installed underground together on the edge of the roadway. In areas of geotechnical risk (*i.e.* areas of landslide, debris flow or avalanche) the pipelines will be buried deeper. At most stream crossings, the pipelines will be buried using horizontal drilling, although they will be exposed on bridges at a few crossings where drilling is not appropriate. Road monitoring and maintenance will be conducted regularly to assure stability and mitigate any developing issues relating to erosion from road runoff, particularly in more steeply graded areas. Slopes will be seeded for revegetation to improve water retention and terrain stability. In the event of a landslide, significant effects to local waterways downstream will occur, including increases in TSS and potential blocking and rerouting of waterways, leading to altered water levels in existing

waterbodies or flooding of terrestrial habitats. However, regular monitoring of roadways and stream crossings will mitigate the risk of landslides. Therefore, activities associated with the construction of the access road, pipelines and transmission line will not have significant adverse effects on sediment quality (Table 7.8-4).

During construction and operation, haul road traffic will be a regular source of airborne dust to local waterbodies along the access corridor. To mitigate effects, the road will be built away from wetlands and ponds to minimize dust inputs, traffic speeds will be enforced, and water and road salts will be used as dust suppressants during dry summer periods. The implementation of diesel fuel and ore concentrate pipelines in the Mine Plan results in a significant reduction in vehicle traffic along the access road. No significant effects to sediment quality are associated with siltation from traffic.

7.8.3.4 Aerodrome Facility

During construction of the aerodrome, minor inputs of silt to the Porcupine River are expected. These will be minimized based on the location of the airstrip, and sediment/erosion control measures. The substrate of the floodplain area where the airstrip is situated is composed of gravel, cobble and sand, and natural TSS concentrations are fairly high in the Porcupine River, so no significant impacts will occur (Table 7.8-4). Construction of the airstrip access road and bridge across the river will involve some disturbance of localized areas in order to place pilings. Silt curtains will act to minimize the siltation of the downstream environment. Air and ground traffic will contribute to dust being blown into waterbodies downwind, but effects to sediment quality will be negligible.

7.8.4 Significance of Residual Adverse Effects

No significant adverse residual effects to sediment quality were associated with project activities or components. Potentially serious adverse effects relating to catastrophic failures involving the tailings dam (breach or overspill events), pipeline ruptures, or filter plant accidents were all assigned a very low probability of occurrence. Best management practices and monitoring of structures and water quality of discharges by trained personnel will mitigate potential impacts.

The occurrence of landslides has a higher probability of occurrence and associated risks will be managed by proper road design, monitoring and routing. This includes adequate water management and slope stabilization measures which will reduce the potential for catastrophic erosion events. A landslide would be limited in geographic extent to a localized area and therefore impacts to regional sediment quality would not be significant.

Regarding scheduled activities, the discharge of tailings effluent and filter plant effluent are both judged to have negligible potential for impacts to downstream sediment quality, based on best available scientific data on predicted water quality of effluents. Finally, construction activities will require the monitoring and management of surface waters to safeguard against any increased loadings of TSS to the downstream environment. Natural background TSS levels are fairly high (up to 500 mg/L in lower Galore during freshet). Therefore, no residual adverse effects to sediment quality are related to scheduled discharges or construction activities of the Galore Creek Project.

7.9 Aquatic Resources Effects Assessment

7.9.1 Introduction

Aquatic Resources were assessed as a VEC in order to ensure that periphyton and aquatic invertebrates are protected from effects related to the development of the project. For this report, Aquatic Resources includes primary and secondary producers in streams, rivers, lakes and wetlands. However, the majority of the assessment involves streams rather than wetlands and lakes, because most predictable mine discharges and potential effects are connected only to stream and river habitat. Within streams the focus was directed on secondary producers (benthic invertebrates, or ‘benthos’) because primary producers, which are composed mainly of periphyton in streams, were very sparse and not visible in most streams. Macrophytes were absent or sparse from most streams and rivers.

Degradation of water and sediment quality (Sections 7.6 and 7.7), including alteration in levels of nutrients and organics, can all cause effects to primary and secondary producers, as well as to higher trophic levels. Additionally, effects to aquatic resources may themselves be reflected at higher levels of biological organization such as birds, amphibians and fish, which depend directly or indirectly on algae and benthos to survive. Other roles served by aquatic resources include nutrient and organic matter cycling, photosynthesis, and providing shelter to various organisms.

There is overlap between the Aquatic Resources VEC and some components of the Fish and Fish Habitat VECs (Section 7.10), because fish habitat includes aquatic invertebrates and plant life used for food and shelter. However, assessment of effects to aquatic resources is conducted in greater detail in this chapter.

The following sections describe the effects assessment components related to issues affecting aquatic resources, as well as the spatial boundaries and methodology used in this assessment.

7.9.1.1 Effects Assessment Components

The aquatic resources of streams, rivers, wetlands and lakes may experience various effects related to the development of the project. Project issues were addressed in the Section 6.8 of the Terms of Reference (TOR) and include:

- productive capacity of aquatic systems during all project phases
- all creeks and rivers that may experience changes to fisheries resources, including, but not limited to the Galore Creek Valley, and streams associated with the road access and slurry pipeline corridor and the filter plant site
- habitat loss or alteration, including aquatic vegetation and sensitive areas such as spawning grounds, nursery areas, winter refuges and migration corridors
- any rare and/or sensitive species and habitat and COSEWIC/SARA-listed species
- changes to the thermal regime of the aquatic environment
- mortality

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- aquatic organisms and habitat
- all creeks and rivers and associated food webs and water use potential that may be affected by changes in water chemistry (suspended solids, nutrients, major ions, metals) due to runoff or discharges from the project
- mitigation and/or compensation requirements (based on DFO's policy for the Management of Fish Habitat and the related principle of no net loss of the productive capacity of fish habitat)
- physical and chemical changes to sediment quality.

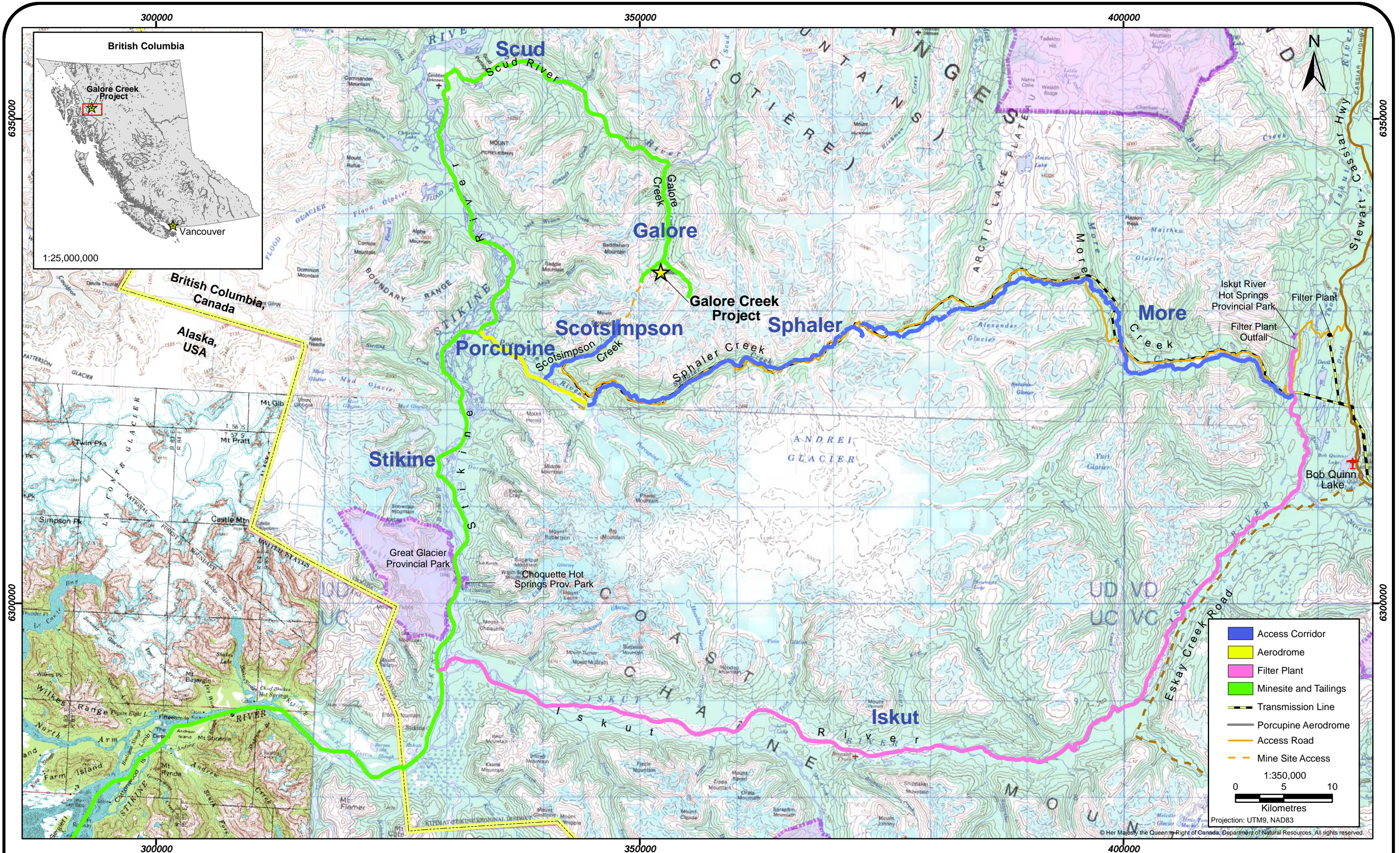
Due to the overlap of many of these issues, they were discussed within three main categories: habitat loss and alteration (Section 7.9.2), direct mortality and sublethal effects (Section 7.9.3), and altered productive capacity (Section 7.9.4). By nature, any issues related to the first two categories were also related to a potential reduction in productive capacity.

Effects related to these issues may vary depending on the phase of mine development and activity of concern. The various physical or chemical stressors introduced to the aquatic habitats may be related to different effects and recoveries for the various groups of organisms present in each system. This is related to biological factors such as interspecific differences in sensitivity to various stressors, life histories, rates of adaptation, as well as stressor factors such as chemical fate (movement to water or sediment), timing (exposure of critical life stages), duration and magnitude of exposure.

7.9.1.2 Spatial Boundaries

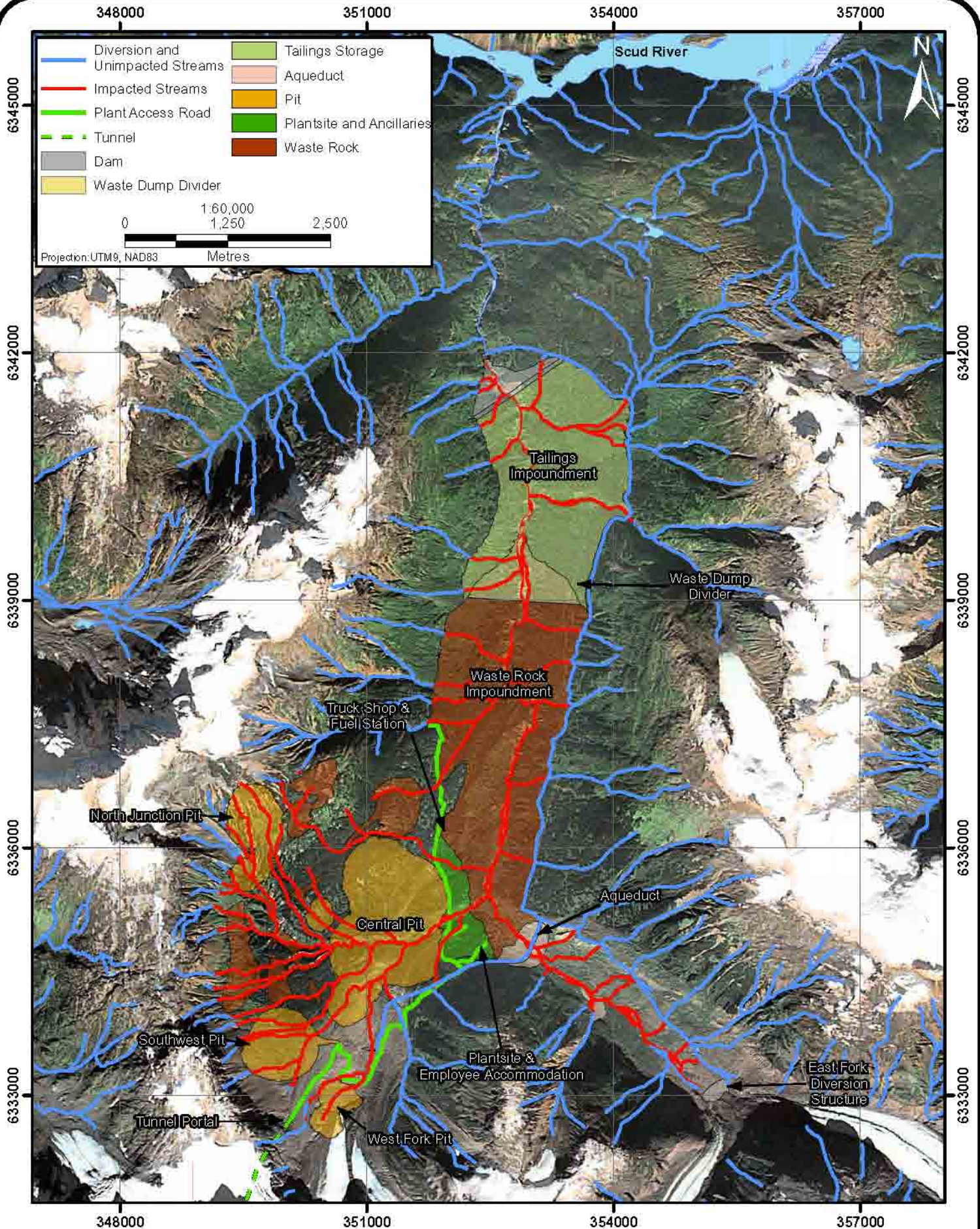
For the assessment of aquatic resources, eight watersheds were included within the regional assessment area (Figure 7.9-1). These include Galore, More, Sphaler, and Scotsimpson creeks and Scud, Iskut, Porcupine and Stikine rivers. Mine components were grouped together where appropriate to discuss collective effects to aquatic resources. Four groups were selected including:

- *Mine Area, Scud and Stikine Rivers* – This includes all mine components within the Galore Creek Valley (open pit mines, processing plant, mine camp, explosives storage and manufacturing facility, site runoff, diversion and sediment control, mill tailings and waste rock storage facilities, tailings containment and seepage dams, haul roads, tunnel, ore and topsoil storage, overburden and borrow pits; Figure 7.9-2). All contact waters will be directed to the tailings impoundment and all non-contact water will flow into the diversion channel. Therefore, effects from all of the above mine components were related to either tailings or diversion channel discharges to the lower Galore Creek below the tailings dam, and habitat loss due to mine component footprints. The area associated with potential effects from these components includes Galore Creek as well as the Scud and Stikine rivers.
- *Access Corridor* – This includes the access road, diesel and ore concentrate pipelines, construction camps and transmission line right-of-way. The area associated with these components includes Scotsimpson, Sphaler and More creeks, as well as portions of the



Aquatic Resources Effect Assessment Boundaries for the Galore Creek Project

FIGURE 7.9-1



Aquatic Habitat Alteration in the Galore Creek Mine Area

FIGURE 7.9-2

Porcupine and Iskut rivers. Local wetlands and lakes within these watersheds were also included in the assessment.

- *Filter Plant* – This includes the filter plant facility and camp, ore concentrate stockpile, truck load out facility, effluent pipeline and diffuser in the Iskut River. The area assessed under this component group included the Iskut River downstream of the proposed discharge, streams in close proximity to the filter plant site, and waterbodies along Highway 37 where the ore concentrate will be trucked to Stewart.
- *Aerodrome Facility* – This includes the Porcupine aerodrome and camp, as well as the aerodrome access road and bridge connecting the aerodrome to the access road. The potential effects from these components are associated with the Porcupine River and floodplain as well as wetlands and lakes within the Porcupine Watershed.

For each watershed, the spatial extent of the assessment included the major streams and rivers and their side channels, as well as floodplains exposed during low flow periods. For watersheds along the access road, stream crossings were also included, as well as nearby wetlands and lakes. The terrestrial components of the watersheds were considered only in the case of spills onto land and how this could result in effects to aquatic systems through surface and groundwater movement.

7.9.1.3 Methodology

Effects were assessed in relation to each of the three major issues (habitat loss and alteration, mortality and sublethal effects, and reduced productive capacity) for all mine components using effect tables based on three steps of assessment (Tables 7.9-1 to 7.9-5). Definitions for descriptor criteria used in the effect matrices are provided in Table 7.9-6. These are the same as those described in the introduction of Chapter 7 (Section 7.1), with the exceptions of magnitude, geographic extent, duration of effect, and reversibility which are highlighted in the table.

The first step in the assessment involved screening all mine components which may cause an effect to aquatic resources based on several issues (Table 7.9-1). Once the links between component and issue were identified, issues were scoped in terms of the defined categorical criteria and presented separately (Tables 7.9-3 to 7.9-5). Because any change to habitat or any lethal or sublethal effects to organisms could translate to altered productive capacity, the tables for the latter contain all of the potential issues shown in the first two tables. For discussion purposes, the section assessing productive capacity quickly summarized effects described previously for habitat or mortality and sublethality, followed by a discussion linking these effects to the productive capacity of the biological community. For those issues having a considerable potential for significant effects, residual effect analysis was conducted to rate significance to aquatic resources (Table 7.9-2). This was conducted in terms of productive capacity only, since this encompassed all potential effects to organisms and to habitat.

**Table 7.9-1
Potential Issues to Aquatic Resources from Mine Development Components**

Mine Component (from Project Scope Outlined in TOR)	Habitat Loss / Alteration		Direct Mortality	Sublethal Effects	Altered Productive Capacity
	Streams/ Rivers	Wetlands/ Lakes			
A Open pit mine located in Galore Creek Valley	X		X		X
B Process plant located in Galore Creek Valley	X				X
C Mill tailings and waste rock storage facilities including containment dam and haul roads	X		X	X	X
D Site runoff, diversion and sediment control	X		X		X
E Ore and marginal ore storage	X		X		X
F Mine borrow pits and overburden and topsoil storage	X		X		X
G Construction camps, including ancillary facilities	X		X	X	X
H Operations camp, including ancillary facilities	X		X	X	X
I Explosives manufacturing and storage plant					
J Access road from Highway 37 to mine site, including borrow pits and staging areas	X	X	X	X	X
K Transmission line from Highway 37 to mine site					
L Buried ore concentrate slurry and diesel pipelines	X	X	X	X	X
M Filter plant, ore concentrate stockpile, truck loadout facility (Bob Quinn)			X	X	X
N Filter plant outfall	X		X	X	X
O Transportation of concentrate from the filter plant along Highway 37 to Stewart			X	X	X
P Aerodrome along Porcupine River and its access road			X	X	X
Q Heliport in More Creek Valley near Round Lake			X	X	X

Table 7.9-2
Assessment of the Significance of Residual Adverse Effects to Aquatic Resources

Issue	Description of Residual Adverse Effect	Descriptor Criteria for Residual Adverse Effects			Significance of Residual Adverse Effect
		Magnitude	Geographic Extent	Duration	
Construction and operation of open pits, ore and overburden stockpiles, topsoil storage (A, E, F)	Habitat loss and mortality under footprints of various mine components resulting in reduced productivity	Low	Landscape	Far future	Not significant
Diversion Channel construction removes lower portions of all tributaries it crosses (D)	Habitat loss from diversion of water from lower reaches of tributary creeks	Low	Landscape	Long term	Not significant
Tailings Effluent Discharge to Galore Creek (C)	Effluent discharge (increased dissolved metals) causing toxic responses in aquatic biota, reduced productivity	Low	Landscape	Long term	Not significant
Slope failure (landslide) along access road leading to stream or wetland/lake habitat alteration (J)	Habitat loss and alteration, mortality to organisms, reduced productivity	Low-Moderate	Landscape	Long Term	Not significant
Filter Plant effluent discharge into Iskut River; toxicity (dissolved metals, ions) resulting in reduced productivity	Localized mortality and sublethal effects to biota immediately downstream of diffuser discharge zone.	Low	Local	Long term	Not significant

**Table 7.9-3
Effect Assessment of Habitat Loss and Alteration on Aquatic Resources**

Mine Component	Summary of Effect	Timing (Start of Effect)	Direction	Duration	Magnitude	Geographic Extent	Resilience	Frequency	Probability of Occurrence	Proposed Mitigation description of proposed mitigation	Summary of Residual Adverse Effects description of residual adverse effect	Potential for Residual Adverse Effect to be Significant
		Construction Operation Decom/ Closure Post Closure	Positive Neutral Adverse	Short term Medium term Long term Far future	Negligible Low Moderate High	Local Landscape Regional Transboundary	Resilient short-term Resilient long-term Not Resilient	One time Periodic Continuous	Low Moderate Unknown High			Negligible Considerable
1 Galore Creek Valley (A, B, C, D, E, F)	Habitat loss under footprints of pits and associated infrastructure	Construction	Adverse	Far Future	Moderate	Landscape	Not Resilient	One time	High	Minimization of lost drainage area through diversion of surface flows around mine components.	Permanent removal of one third of stream habitat in Galore Creek watershed; some area changed to lake-type habitat	Considerable
2 Galore Creek Valley; Construction and operations camps (A, B, C, F, G, H)	Siltation from construction leading to increased TSS; altered Galore Creek habitat	Construction	Adverse	Medium Term	Low	Landscape	Resilient short-term	Periodic	High	Erosion and sediment management plan, including sediment ponds, silt curtains, temporary dam, monitoring.	Slightly increased loadings of TSS to Galore Creek possible, minimal effect based on high TSS background. No effect to Scud River habitat.	Negligible
3 Galore Creek Valley (A, B, C, E, F)	Reduced organic loading due to lost upstream inputs into tailings dam; altered downstream habitat	Construction	Adverse	Far Future	Low	Landscape	Not Resilient	Continuous	Moderate	Diversion channels minimize lost drainage area during operations, and drainage below dam will continue to provide organic inputs to lower Galore Creek.	Minor reductions in organic loadings to lower Galore Creek, potentially reducing food and habitat.	Negligible
4 Galore Creek Valley (A, B, C, D)	Reduced upstream source of benthic drift to lower Galore Creek due to tailings dam	Construction	Adverse	Far Future	Negligible-Low	Landscape	Not Resilient	Continuous	Moderate	Remaining drainage will provide sufficient drift colonizers to downstream Galore Creek.	Negligible effect on benthic populations as upstream travel and remaining available drainage will supply sufficient colonizers.	Negligible
5 Mill tailings and waste rock storage facility; site runoff, diversion and sediment control (C, D)	Decreased winter flow volumes in Galore Creek resulting in reduced water levels and aquatic habitat	Construction	Adverse	Long Term	Low	Landscape	Resilient short-term	Periodic	Moderate	Monitor and manage flows in diversion channel in winter to maintain required minimum flows	Minimal reduction in water levels during low flow period.	Negligible
6 Mill tailings and waste rock storage facility; site runoff, diversion and sediment control (C, D)	Increased flow volumes during discharge period in Galore Creek resulting in increased water levels, flooding, scouring.	Construction	Adverse	Long Term	Negligible	Landscape	Resilient short-term	Periodic	Moderate	Water management plan to reduce variation in water flows from baseline (pacing flows with natural hydrograph)	Potential for increased variation in water levels in summer; limited to Galore Creek area, occasional events only therefore no habitat effect.	Negligible
7 Site runoff, diversion and sediment control (D)	Silt loading during construction alters Galore Creek habitat, reduces visibility and increasing scour	Construction	Adverse	Short Term	Low	Landscape	Resilient short-term	Periodic	Moderate	Erosion and sediment management plan, including sediment ponds, silt curtains, temporary dam, monitoring.	Short-term increase in turbidity in lower Galore Creek during each stream diversion, no residual effect	Negligible
8 Site runoff, diversion and sediment control (D)	Habitat loss from diversion of water from lower reaches of tributary creeks into Diversion Channel	Construction	Adverse	Long Term	Low	Landscape	Resilient long-term	Continuous	High	Streams will be reconnected to Galore Creek during mine closure.	Stream reaches downslope of diversion channels are lost habitat, but represents only small portion of total habitat in Galore watershed.	Considerable
9 Access road, concentrate ore slurry and diesel pipeline (J, L)	Construction removing habitat at crossings, TSS altering habitat during construction of ditches and tunnels	Construction	Adverse	Medium Term	Low	Local	Resilient short-term	Periodic	Moderate	Silt curtains, rip-rap, slope support, revegetation, best management practices, avoid waterbodies	Minor loss of habitat and inputs of TSS at crossings, negligible alteration of habitat in localized area.	Negligible
10 Access road, concentrate ore slurry and diesel pipeline (J, L)	Construction removing riparian habitat at wetland in lower More Creek, reducing organic inputs to habitat	Construction	Adverse	Long Term	Moderate	Local	Not Resilient	Continuous	High	Road avoids waterbodies, and sufficient riparian habitat unaffected to support local wetlands.	Minor loss of organic inputs during flooding events, altered water flows, negligible effect on local wetlands.	Negligible
11 Construction and Operations Camps (G, H)	Siltation from water runoff during construction leading to altered habitat quality.	Construction	Adverse	Short Term	Low	Local	Resilient short-term	Periodic	Moderate	Roadway monitoring for erosion control, slope engineering, ditches and culvert design to manage water	Minor inputs of TSS to streams, negligible alteration of habitat in localized area.	Negligible
12 Transmission Line (K)	Reduction of riparian vegetation input to streams along right-of-way; habitat alteration	Construction	Adverse	Long Term	Negligible	Local	Resilient long-term	Continuous	Moderate	Maintain shrub / pole-saplings along banks, limit clearing to overheight trees only	None	Negligible
13 Facilities at Bob Quinn (M)	Habitat alteration due to siltation of nearby streams during construction and from erosion	Construction	Adverse	Medium Term	Low	Landscape	Resilient short-term	Continuous	Moderate	Silt curtain, best management practices, isolation from waterbodies	None	Negligible

TSS = Total Suspended Solids, SCERP = Spill Containment and Emergency Response Plan

(continued)

**Table 7.9-3
Effect Assessment of Habitat Loss and Alteration on Aquatic Resources (completed)**

Mine Component	Summary of Effect	Timing (Start of Effect)	Direction	Duration	Magnitude	Geographic Extent	Resilience	Frequency	Probability of Occurrence	Proposed Mitigation description of proposed mitigation	Summary of Residual Adverse Effects description of residual adverse effect	Potential for Residual Adverse Effect to be Significant	
		Construction Operation Decom/ Closure Post Closure	Positive Neutral Adverse	Short term Medium term Long term Far future	Negligible Low Moderate High	Local Landscape Regional Transboundary	Resilient short-term Resilient long-term Not Resilient	One time Periodic Continuous	Low Moderate Unknown High			Negligible Considerable	
14	Filter plant outfall (N)	Siltation of Iskut River from in-stream construction of diffuser	Construction	Adverse	Short Term	Negligible-Low	Local	Resilient short-term	One time	High	Silt curtain, diversion of construction zone to minimize siltation downstream; timing of construction	Minor short-term siltation, minor temporary disturbance of habitat	Negligible
15	Open pit mine, process plant, ore and marginal ore storage, mine overburden pits and topsoil storage, operation camp (A, B, E, F, H)	Increased TSS to Galore Creek from erosion, alter downstream habitat	Operations	Adverse	Long Term	Low	Landscape	Resilient short-term	Periodic	Moderate	Erosion and sediment management plan, including sediment ponds, settling in tailings pond, water quality monitoring.	No increased loadings of TSS to receiving environment	Negligible
16	Site runoff, diversion and sediment control (D)	Discharge of diversion channel from spillway into Galore Creek leading to erosion of stream bed and increased siltation	Operations	Adverse	Far Future	Negligible	Landscape	Resilient long-term	Continuous	Low	Armour (rock) and line bottom of diversion channel to reduce erosion. Build protective structures at base of channel to dissipate flows and minimize scouring of Galore Creek bed	TSS discharges will be similar to background; no effect to downstream productivity	Negligible
17	Operations camps, access road (H, J)	Siltation to streams, wetlands and lakes from road operations	Operations	Adverse	Long Term	Low	Local	Resilient short-term	Periodic	Moderate	Erosion and sediment management plan, silt barriers, dust suppressants along roads	None	Negligible
18	Aerodrome, heliport (P, Q)	Siltation from ground and air traffic (soil compaction increasing runoff, dust)	Operations	Adverse	Long Term	Low	Local	Resilient short-term	Periodic	High	Dust suppressants, isolation from waterbodies	None	Negligible
19	Site runoff, diversion and sediment control; access road (D, J)	Slope failure (landslide) due to erosion and slope instability; stream blockage	Operations	Adverse	Long Term	Moderate	Landscape	Resilient long-term	One time	Low	Slope engineering, culvert design, road monitoring, best management practices	Low potential for landslide event causing significant habitat alteration	Considerable
20	Site runoff, diversion and sediment control (D)	Reduced organic loading due to lost upstream inputs when diversion channel breached and diverted into tailings dam; altered downstream habitat	Closure	Adverse	Far Future	Low	Landscape	Not Resilient	One time	Moderate	Downstream pristine sources of organic material will continue to provide woody inputs to lower Galore Creek.	Decreased organic loadings to lower Galore, reducing food and shelter substrates for benthic invertebrates and algae.	Considerable
21	Site runoff, diversion and sediment control (D)	Habitat loss on colonized diversion channels upon closure	Closure	Adverse	Far Future	Low	Landscape	Not Resilient	One time	High	Original tributaries re-opened to flow into revegetated Waste Rock area and into Galore Creek.	Minimal loss of habitat, replaced with new habitat in reclaimed waste rock area.	Negligible

TSS = Total Suspended Solids, SCERP = Spill Containment and Emergency Response Plan

**Table 7.9-4
Effect Assessment of Mortality and Sublethal Toxicity on Aquatic Resources**

Mine Component	Summary of Effect	Timing (Start of Effect)	Direction	Duration	Magnitude	Geographic Extent	Resilience	Frequency	Probability of Occurrence	Proposed Mitigation description of proposed mitigation	Summary of Residual Adverse Effects description of residual adverse effect	Potential for Residual Adverse Effect to be Significant Negligible Considerable
		Construction Operation Decom/ Closure Post Closure	Positive Neutral Adverse	Short term Medium term Long term Far future	Negligible Low Moderate High	Local Landscape Regional Transboundary	Resilient short-term Resilient long-term Not Resilient	One time Periodic Continuous	Low Moderate Unknown High			
1 Construction camp, access road (G,J)	Groundwater seepage of sewage effluents (nitrates) into waterbodies along access road causing toxicity	Construction	Adverse	Medium Term	Low	Landscape	Resilient short-term	Continuous	Low	Sewage treatment; isolation from waterbodies; removal of solids and ground filtering effluent.	None	Negligible
2 Construction and Operations Camps (G,H)	Sewage effluent nitrates seeping into tailings pond through groundwater, released to Galore Creek resulting in toxicity	Construction	Adverse	Long Term	Low	Landscape	Resilient short-term	Continuous	Low	Sewage treatment; isolation from waterbodies; removal of solids and ground filtering effluent; wells collect groundwater below dam and pump to tailings pond.	None	Negligible
3 Construction and Operations Camps (G,H)	Removal/ mortality of organisms, and siltation causing mortality during construction	Construction	Adverse	Short Term	Low	Local	Resilient short-term	Periodic	Moderate	Roadway monitoring for erosion control, slope engineering, ditches and culvert design to manage water.	Minor inputs of TSS to streams, negligible mortality and minor disturbance to biota.	Negligible
4 Construction and Operations Camps, Aerodrome, Heliport (G,H,P,Q)	Localized fuel spill enters waterbody, toxicity to organisms	Construction	Adverse	Medium Term	Low	Landscape	Resilient short-term	Periodic	Moderate	SCERP, fueling zones located well away from waterbodies, in contained areas.	Potential for minor releases to localized areas, affecting only small number of individuals.	Negligible
5 Explosives manufacturing and storage plant (I)	Chronic leaks and spills of ANFO runoff to tailings pond, release to Galore Creek: toxicity	Construction	Adverse	Long Term	Low	Local	Resilient short-term	Periodic	Low	SCERP, isolation from waterbodies, diversion of surface runoff to tailings pond (managed discharge).	None	Negligible
6 Access Road (J)	ML/ARD from stockpiled waste rock flowing into waterbodies; toxicity to organisms	Construction	Adverse	Medium Term	Negligible-Low	Landscape	Resilient short-term	Periodic	Unknown	Proper management and disposal of PAG waste rock.	Minor localized reductions in productivity, depending on waste rock containment.	Negligible
7 Access road, concentrate ore slurry and diesel pipeline (J,L)	Siltation to streams at crossings during construction of ditches and tunnels causing mortality	Construction	Adverse	Short Term	Low	Local	Resilient short-term	Continuous	Moderate	Minimize area of impact. Recolonization of area will occur.	Minor mortalities during construction, no adverse effect to community.	Negligible
8 Galore Creek Valley (A,B,C,E,F)	Effluent discharge (increased dissolved metals and nitrite) causing lethal and sublethal toxicity	Operations	Adverse	Long Term	Low	Landscape	Resilient long-term	Periodic	High	Water quality monitoring, settling particulates in tailings pond, pace discharge with hydrograph and time with high flows.	Some toxicity to sensitive taxa resulting in some mortality in Galore Creek, much less potential for effects in Scud River	Considerable
9 Mill tailings and waste rock storage facility (C)	Tailing dam breach releasing tailings and effluent downstream to Galore Creek, resulting in toxicity	Operations	Adverse	Far Future	High	Transboundary	Not Resilient	One time	Nil-Low	Use best management practices, impermeable membrane and till core, safety factors for earthquakes, regular monitoring.	Tailings dam management and design results in extremely low risk of tailings breach.	Negligible
10 Mill tailings and waste rock storage facility (C)	Tailings dam overflow releasing additional effluent & TSS downstream, results in toxicity	Operations	Adverse	Medium Term	Low - Moderate	Landscape	Resilient short-term	One time	Low	Dam built high enough to contain 1 in 100 yr storm event	Tailings dam management and design results in very low risk of overflow event.	Negligible
11 Mill tailings and waste rock storage facility (C)	Seepage under tailings dam enters lower Galore Creek, causing toxicity and reduced productivity	Operations	Adverse	Medium Term	Negligible-Low	Landscape	Resilient short-term	Periodic	Low	Seepage blocked by secondary dam, and collected in wells and pumped back to tailings pond.	None	Negligible
12 Site runoff, diversion and sediment control (D)	ML/ARD within diversion channel leading to metal transport to lower Galore Creek, toxicity to organisms	Operations	Adverse	Long Term	Low-Moderate	Landscape	Resilient long-term	Continuous	Unknown	Armour bottom of diversion channel to reduce erosion and metal leaching; line bottom with synthetic membrane to prevent leaching.	ML/ARD potential to be assessed.	Negligible
13 Access Road (J)	ML/ARD drainage originating from cut rock walls along access corridor causing toxic effects to biota	Operation	Adverse	Long Term	Low-Moderate	Local	Resilient long-term	Periodic	Unknown	WQ monitoring; for ML/ARD areas, use diversion of water above exposed cut rock, and limestone-lined ditches.	Minimal impacts to biota, depending on treatment of high risk sites.	Negligible
14 Access Road (J)	Dust suppressant (salts) runoff to waterbodies, causing toxicity	Operation	Adverse	Long Term	Low-Moderate	Local	Resilient short-term	Periodic	Moderate	WQ monitoring downslope of road, and water management with ditches and culverts.	Minimal impacts to biota, localized potential only.	Negligible

TSS = Total Suspended Solids, SCERP = Spill Containment and Emergency Response Plan

(continued)

**Table 7.9-4
Effect Assessment of Mortality and Sublethal Toxicity on Aquatic Resources (completed)**

Mine Component	Summary of Effect	Timing (Start of Effect)	Direction	Duration	Magnitude	Geographic Extent	Resilience	Frequency	Probability of Occurrence	Proposed Mitigation description of proposed mitigation	Summary of Residual Adverse Effects description of residual adverse effect	Potential for Residual Adverse Effect to be Significant Negligible Considerable
		Construction Operation Decom/ Closure Post Closure	Positive Neutral Adverse	Short term Medium term Long term Far future	Negligible Low Moderate High	Local Landscape Regional Transboundary	Resilient short-term Resilient long-term Not Resilient	One time Periodic Continuous	Low Moderate Unknown High			
15 Concentrate ore slurry and diesel pipeline (L)	Rupture of diesel pipeline, release to waterbodies; toxicity to organisms	Operations	Adverse	Medium Term	High	Landscape	Resilient short-term	One time	Low	Proper pipeline engineering, emergency shut-off system, SCERP, burying deeper in geohazard zones.	Low risk of diesel spill to environment. Spill would be detected and cleaned up, therefore any effects would be temporary	Negligible
16 Concentrate ore slurry and diesel pipeline (L)	Rupture of concentrate pipeline, release to waterbodies; toxicity to organisms	Operations	Adverse	Medium Term	Medium	Landscape	Resilient short-term	One time	Low	Proper pipeline engineering, emergency pressure sensors to detect leaks, emergency drain tank at Porcupine, SCERP, burying deeper in geohazard zones.	Low risk of concentrate slurry spill to environment. Spill would be detected and cleaned up, therefore any effects would be temporary	Negligible
17 Facilities at Bob Quinn (M)	On-site spill of process chemicals or concentrate leachate from concentrate stockpile runoff to waterbodies (toxicity)	Operations	Adverse	Medium Term	Low	Local	Resilient short-term	Periodic	Low	SCERP, concentrate stored covered in building, cement flooring for containment.	None	Negligible
18 Facilities at Bob Quinn, truck transport of concentrate along Highway 37 to Stewart (M,O)	Accidental spill of concentrate near filter plant or en route to Stewart: toxicity to organisms.	Operations	Adverse	Short Term	Low	Local	Resilient short-term	One time	Low	Enforced speed limits, traffic safety, SCERP.	None	Negligible
19 Filter plant outfall (N)	Filter Plant effluent discharge into Iskut River; increased dissolved metals causing toxicity	Operations	Adverse	Long Term	Low	Local	Resilient short-term	Continuous	High	Filtering and treating effluent to meet permit levels, diffuser allows rapid mixing and dilution.	Effects limited to small mixing area immediately below diffuser. No effect to Iskut River productivity.	Negligible
20 Aerodrome, heliport (P,Q)	Spilled deicing fluids entering waterbodies, toxicity to organisms	Operations	Adverse	Long Term	Low	Local	Resilient long-term	Periodic	Low	Containment of de-icing fluid, recycling or disposal, isolation from waterbodies.	Minimal risk of exposure to aquatic organisms, no effect on productivity	Negligible
21 Site runoff, diversion and sediment control (D)	Re-opening of closed Galore tributaries along diversion channel causing disturbance in tailings pond, toxicity to organisms downstream	Closure	Adverse	Short Term	Moderate	Landscape	Resilient short-term	Periodic	Low	Cover tails with rock armor to minimize disturbance when diversion channel water re-enters tailings pond.	Minimal pulse of elevated tailings in water column; no effect to biota	Negligible

TSS = Total Suspended Solids, SCERP = Spill Containment and Emergency Response Plan

**Table 7.9-5
Effect Assessment of Reduced Productive Capacity on Aquatic Resources**

Mine Component	Summary of Effect	Timing (Start of Effect)	Direction	Duration	Magnitude	Geographic Extent	Resilience	Frequency	Probability of Occurrence	Proposed Mitigation description of proposed mitigation	Summary of Residual Adverse Effects description of residual adverse effect	Potential for Residual Adverse Effect to be Significant Negligible Considerable
		Construction Operation Decom/ Closure Post Closure	Positive Neutral Adverse	Short term Medium term Long term Far future	Negligible Low Moderate High	Local Landscape Regional Transboundary	Resilient short-term Resilient long-term Not Resilient	One time Periodic Continuous	Low Moderate Unknown High			
1 Galore Creek Valley; Construction and operations camps (A, B, C, F, G, H)	Silt loading during construction alters Galore Cr. habitat, reduces visibility (altered behaviour including drift and feeding and avoidance), smothering; reducing productivity	Construction	Adverse	Medium Term	Low	Landscape	Resilient short-term	Periodic	High	Erosion and sediment management plan, including sediment ponds, silt curtains, temporary dam, monitoring.	Slightly increased loadings of TSS possible in Galore Creek, no effect to productive capacity due to monitoring and effluent control. No effect to Scud River.	Negligible
2 Galore Creek Valley (A, B, C, E, F)	Habitat loss and mortality under mine footprints resulting in reduced productivity	Construction	Adverse	Far Future	Low	Landscape	Not Resilient	Continuous	High	Minimization of lost drainage area through diversion of surface flows around mine components.	Permanent removal of habitat, reducing productivity of upper Galore Creek habitat	Considerable
3 Galore Creek Valley (A, B, C, E, F)	Reduced organic loading due to lost upstream inputs into tailings dam, resulting in reduced productivity	Construction	Adverse	Far Future	Negligible - Low	Landscape	Not Resilient	Continuous	Moderate	Diversion channels minimize lost drainage area during operations, and drainage below dam will continue to provide organic inputs to lower Galore Creek.	Minor reductions in organic loadings to lower Galore Creek, potentially reducing food and habitat to benthos, reducing productivity.	Considerable
4 Galore Creek Valley, access road, slurry and diesel pipelines (A, C, D, J, L)	Aerial deposition (blasting and other dust sources) into waterbodies, increasing turbidity and reducing productivity	Construction	Adverse	Long Term	Negligible - Low	Landscape	Resilient short-term	Continuous	High	Water quality monitoring, dust suppressants and containment in facilities	Minimal dust loadings to lower Galore Creek, and streams and wetlands along access road	Negligible
5 Site runoff, diversion and sediment control (D)	Silt loading during construction alters Galore Cr. habitat, reduces visibility (altered behaviour including drift and feeding and avoidance), smothering; reducing productivity	Construction	Adverse	Short Term	Moderate	Landscape	Resilient short-term	Periodic	Moderate	Erosion and sediment management plan, including sediment ponds, silt curtains, temporary dam, monitoring.	Short-term increase in turbidity in lower Galore Creek during each stream diversion, no effect to productive capacity.	Negligible
6 Mill tailings and waste rock storage facility; site runoff, diversion and sediment control (C, D)	Decreased winter flow volumes in Galore Creek resulting in reduced water levels and aquatic habitat	Construction	Adverse	Long Term	Low	Landscape	Resilient short-term	Periodic	Moderate	Monitor and manage flows in diversion channel in winter to maintain required minimum flows	Minimal reduction in water levels during low flow period.	Negligible
7 Mill tailings and waste rock storage facility; site runoff, diversion and sediment control (C, D)	Increased flow volumes during discharge period in Galore Creek resulting in increased water levels, flooding, scouring.	Construction	Adverse	Long Term	Negligible	Landscape	Resilient short-term	Periodic	Moderate	Water management plan to reduce variation in water flows from baseline (pacing flows with natural hydrograph)	Potential for increased variation in water levels in summer; local biota adapted to this environment, no effect to productivity.	Negligible
8 Site runoff, diversion and sediment control (D)	Habitat loss from diversion of water from lower reaches of tributary creeks; reduced productivity	Construction	Adverse	Long Term	Low	Landscape	Resilient long-term	Continuous	High	Streams will be reconnected to Galore Creek during mine closure.	Stream reaches downslope of diversion channels are lost habitat, but represents only small portion of productive habitat in Galore watershed.	Considerable
9 Construction and operations camps, access road (G, H, J)	Sewage effluent nitrates seeping into local waterbodies causing toxicity and reduced productivity	Construction	Adverse	Long Term	Low	Landscape	Resilient short-term	Continuous	Low	Sewage treatment; removal of solids and ground filtering effluent; wells collect groundwater below dam and pump to tailings pond	Minimal potential for nitrate transport in groundwater to cause effects.	Negligible
10 Construction camp, access road, concentrate ore slurry and diesel pipeline (G, J, L)	Degraded habitat along access road from siltation during construction resulting in reduced productive capacity	Construction	Adverse	Short Term	Low	Local	Resilient short-term	Periodic	Moderate	Erosion and Sediment Management Plan, silt barriers, rip-rap, proper culvert design	Minor pulses of TSS at stream crossings, some loss of habitat, minor effect on productive capacity of waterbodies.	Negligible
11 Access road, concentrate ore slurry and diesel pipeline (J, L)	Construction removing riparian habitat at wetland in lower More Creek, reducing organic inputs to habitat	Construction	Adverse	Long Term	Moderate	Local	Resilient long-term	Continuous	High	Road avoids waterbodies, and sufficient riparian habitat unaffected to support local wetlands.	Minor loss of organic inputs during flooding events, altered water flows, negligible effect on local productivity	Negligible

TSS = Total Suspended Solids, SCERP = Spill Containment and Emergency Response Plan

(continued)

**Table 7.9-5
Effect Assessment of Reduced Productive Capacity on Aquatic Resources (continued)**

Mine Component	Summary of Effect	Timing (Start of Effect)	Direction	Duration	Magnitude	Geographic Extent	Resilience	Frequency	Probability of Occurrence	Proposed Mitigation description of proposed mitigation	Summary of Residual Adverse Effects description of residual adverse effect	Potential for Residual Adverse Effect to be Significant Negligible Considerable
		Construction Operation Decom/ Closure Post Closure	Positive Neutral Adverse	Short term Medium term Long term Far future	Negligible Low Moderate High	Local Landscape Regional Transboundary	Resilient short-term Resilient long-term Not Resilient	One time Periodic Continuous	Low Moderate Unknown High			
12 Access Road (J)	ML/ARD from stockpiled waste rock flowing into waterbodies; toxicity reducing productivity	Construction	Adverse	Medium Term	Negligible-Low	Landscape	Resilient short-term	Periodic	Unknown	Proper management and disposal of PAG waste rock.	Minor localized reductions in productivity, depending on waste rock containment.	Negligible
13 Construction and operations camps, aerodrome, heliport (G, H, P, Q)	Localized fuel spill enters waterbody resulting in toxicity, reducing productive capacity	Construction	Adverse	Medium Term	Low	Landscape	Resilient short-term	Periodic	Moderate	SCERP, fueling zones located well away from waterbodies, in contained areas.	Low potential for minor effects from spills to localized areas	Negligible
14 Explosives manufacturing and storage plant (I)	Chronic leaks or spills of ANFO running into surface waters, causing eutrophication or toxicity in Galore Creek, affecting productive capacity	Construction	Adverse	Long Term	Low	Local	Resilient short-term	Periodic	Low	SCERP, isolation from waterbodies, diversion of surface runoff to tailings pond (managed discharge).	None	Negligible
15 Transmission line (K)	Reduction of riparian vegetation along powerline right-of-way, reducing allochthonous inputs to streams, reducing productivity.	Construction	Adverse	Long Term	Negligible	Local	Resilient long-term	Continuous	High	Maintain shrub / pole-saplings along banks, limit clearing to overheight trees only	None	Negligible
16 Facilities at Bob Quinn (M)	Sedimentation from site runoff entering streams, degrading habitat and reducing productivity	Construction	Adverse	Medium Term	Low	Landscape	Resilient short-term	Continuous	Moderate	Silt curtain, best management practices, isolation from waterbodies.	None	Negligible
17 Filter plant outfall (N)	Sedimentation from in-stream construction of diffuser in Iskut River, degrading habitat and reducing productivity	Construction	Adverse	Short Term	Negligible-Low	Local	Resilient short-term	One time	High	Silt curtain, diversion of construction zone to minimize siltation downstream; timing of construction	Minor short-term siltation, minor temporary reduction in habitat productivity at site of disturbance	Negligible
18 Galore Creek Valley (A, B, C, E, F)	Effluent discharge (increased dissolved metal concentrations) could cause lethal or sublethal effects to aquatic organisms, reducing productivity.	Operations	Adverse	Long Term	Low	Landscape	Resilient long-term	Periodic	High	Water quality monitoring, settling particulates in tailings pond, pace discharge with hydrograph and time with high flows	Some toxicity to sensitive organisms or taxa resulting in slight decreases in productivity.	Considerable
19 Open pit mine, process plant, ore and marginal ore storage, mine overburden pits and topsoil storage, operation camp (A, B, E, F, H)	Erosion during operations - Silt altering habitat, smothering organisms reducing productivity	Operations	Adverse	Long Term	Negligible	Local	Resilient short-term	Periodic	Moderate	Erosion and sediment management plan, including sediment ponds, settling in tailings pond, water quality monitoring.	No increased loadings of TSS to receiving environment based on effluent discharge limits, no effect on downstream productivity.	Negligible
20 Mill tailings and waste rock storage facility (C)	Tailing dam breach releasing effluent downstream to Galore Creek, resulting in toxicity and reduced productivity	Operations	Adverse	Far Future	High	Transboundary	Not Resilient	One time	Nil-Low	Use best management practices, impermeable membrane and till core, safety factors for earthquakes, regular monitoring	Tailings dam management and design results in extremely low risk of tailings breach.	Negligible
21 Mill tailings and waste rock storage facility (C)	Tailings dam overspill releasing additional effluent & TSS downstream, toxicity resulting in reduced productivity	Operations	Adverse	Medium Term	Low - Moderate	Landscape	Resilient short-term	One time	Low	Dam built high enough to contain 1 in 100 yr storm event, with irregular contours to reduce waves	Tailings dam management and design results in very low risk of overspill event.	Negligible
22 Mill tailings and waste rock storage facility (C)	Seepage under tailings dam enters lower Galore Creek, causing toxicity and reduced productivity	Operations	Adverse	Medium Term	Negligible-Low	Landscape	Resilient short-term	Periodic	Low	Seepage blocked by secondary dam, and collected in wells and pumped back to tailings pond	None	Negligible
23 Site runoff, diversion and sediment control (D)	Discharge of diversion channel from spillway into Galore Creek leading to habitat alteration, siltation, and reduced productivity	Operations	Adverse	Far Future	Low	Landscape	Resilient long-term	Continuous	Low	Armour (rock) and line bottom of diversion channel, with settling ponds, to reduce erosion and scouring of stream bed	Discharges will be similar to background; protective structures will dissipate channel flow as it enters Galore Creek. No effect to downstream productivity	Negligible

**Table 7.9-5
Effect Assessment of Reduced Productive Capacity on Aquatic Resources (continued)**

Mine Component	Summary of Effect	Timing (Start of Effect)	Direction	Duration	Magnitude	Geographic Extent	Resilience	Frequency	Probability of Occurrence	Proposed Mitigation description of proposed mitigation	Summary of Residual Adverse Effects description of residual adverse effect	Potential for Residual Adverse Effect to be Significant Negligible Considerable
		Construction Operation Decom/ Closure Post Closure	Positive Neutral Adverse	Short term Medium term Long term Far future	Negligible Low Moderate High	Local Landscape Regional Transboundary	Resilient short-term Resilient long-term Not Resilient	One time Periodic Continuous	Low Moderate Unknown High			
24 Site runoff, diversion and sediment control (D)	ML/ARD within diversion channel leading to metal transport to lower Galore Creek, toxicity to organisms and reduced productivity	Operations	Adverse	Long term	Low - Moderate	Landscape	Resilient long-term	Continuous	Unknown	Armour bottom of diversion channel to reduce erosion and metal leaching; line bottom with synthetic membrane to prevent leaching	ML/ARD potential to be assessed.	Negligible
25 Operations camps, access road (H, J)	Sedimentation degrading habitat in streams, wetlands and lakes during road operations, reducing productive capacity	Operations	Adverse	Long Term	Low	Local	Resilient short-term	Periodic	Moderate	Erosion and sediment management plan, silt barriers, rip rap, dust suppressants along roads	None	Negligible
26 Access Road (J)	ML/ARD drainage originating from cut rock walls along access corridor causing toxicity, reducing productivity	Operation	Adverse	Long Term	Negligible - Moderate	Local	Resilient long-term	Periodic	Unknown	WQ monitoring; for ML/ARD areas, use diversion of water above exposed cut rock, and limestone-lined ditches.	Minimal impacts to biota, depending on treatment of high risk sites.	Negligible
27 Access Road (J)	Dust suppressant (salts) runoff to waterbodies, causing toxicity and reducing productivity	Operation	Adverse	Long Term	Low-Moderate	Local	Resilient short-term	Periodic	Moderate	WQ monitoring downslope of road, and water management with ditches and culverts. Reduce usage if necessary.	Minimal impacts to biota, localized potential only.	Negligible
28 Site runoff, diversion and sediment control; access road (D, J)	Slope failure (landslide) leading to stream or wetland/lake habitat alteration, reducing productive capacity	Operations	Adverse	Long Term	Moderate	Landscape	Resilient long-term	One time	Low	Slope engineering, culvert design, road monitoring, best management practices	Low potential for landslide event causing significant habitat alteration and some reduced productivity.	Considerable
29 Concentrate ore slurry and diesel pipeline (L)	Rupture of diesel pipeline, groundwater flow to waterbodies resulting in toxicity and reduced productivity	Operations	Adverse	Medium Term	Moderate	Landscape	Resilient short-term	One time	Low	Proper pipeline engineering, emergency shut-off system, SCERP, burying deeper in geohazard zones	Low risk of diesel spill to environment. Spill would be detected and cleaned up, therefore any effects would be temporary	Negligible
30 Concentrate ore slurry and diesel pipeline (L)	Rupture of concentrate pipeline, groundwater flow to waterbodies resulting in toxicity and reduced productivity	Operations	Adverse	Medium Term	Moderate	Landscape	Resilient short-term	One time	Low	Proper pipeline engineering, emergency pressure sensors to detect leaks, emergency drain tank at Porcupine, SCERP, burying deeper in geohazard zones	Low risk of concentrate slurry spill to environment. Spill would be detected and cleaned up, therefore any effects would be temporary	Negligible
31 Facilities at Bob Quinn (M)	Spill of process chemicals or leachate from concentrate stockpile, toxicity leading to reduced productivity	Operations	Adverse	Medium Term	Low	Local	Resilient short-term	Periodic	Low	SCERP, concentrate stored covered in building, cement flooring for containment.	None	Negligible
32 Facilities at Bob Quinn, truck transport of concentrate along Highway 37 to Stewart (M, O)	Spill of concentrate near filter plant or en route to Stewart, toxicity leading to reduced productivity	Operations	Adverse	Long Term	Low	Local	Resilient short-term	One time	Low	Enforced speed limits, traffic safety, SCERP	None	Negligible
33 Filter plant outfall (N)	Filter Plant effluent discharge into Iskut River; toxicity (dissolved metals, ions) resulting in reduced productivity	Operations	Adverse	Long Term	Low	Local	Resilient short-term	Continuous	High	Filtering and treating effluent to meet permit levels, diffuser allows rapid mixing and dilution	Effects limited to small mixing area immediately below diffuser. No effect to Iskut River productivity.	Negligible
34 Aerodrome, heliport (P, Q)	Spilled de-icing fluids entering waterbodies, causing toxicity and reducing productivity	Operations	Adverse	Medium Term	Low	Local	Resilient long-term	Periodic	Low	Containment of de-icing fluid, recycling or disposal, isolation from waterbodies	Minimal risk of exposure to aquatic organisms, no effect on productivity	Negligible
35 Aerodrome, heliport (P, Q)	Aerial deposition of silt from ground and air traffic entering waterways, reducing productivity.	Operations	Adverse	Long Term	Low	Landscape	Resilient short-term	Periodic	High	Dust suppressants, isolation from waterbodies	None	Negligible
36 Galore Creek Valley (A, B, C, D)	Reduced upstream source of benthic drift to lower Galore Creek due to tailings dam	Closure	Adverse	Far Future	Negligible-Low	Landscape	Not Resilient	One time	Moderate	Remaining drainage will provide sufficient drift colonizers to downstream Galore Creek.	Minor reduction in drift to lower Galore Creek.	Negligible

**Table 7.9-5
Effect Assessment of Reduced Productive Capacity on Aquatic Resources (completed)**

Mine Component	Summary of Effect	Timing (Start of Effect)	Direction	Duration	Magnitude	Geographic Extent	Resilience	Frequency	Probability of Occurrence	Proposed Mitigation description of proposed mitigation	Summary of Residual Adverse Effects description of residual adverse effect	Potential for Residual Adverse Effect to be
		Construction Operation Decom/ Closure Post Closure	Positive Neutral Adverse	Short term Medium term Long term Far future	Negligible Low Moderate High	Local Landscape Regional Transboundary	Resilient short-term Resilient long-term Not Resilient	One time Periodic Continuous	Low Moderate Unknown High			Negligible Significant Considerable
37 Site runoff, diversion and sediment control (D)	Reduced organic loading due to lost upstream inputs when diversion channel breached and diverted into tailings dam; altered downstream habitat	Closure	Adverse	Far Future	Low	Landscape	Not Resilient	Continuous	High	Downstream pristine sources of organic material will continue to provide woody inputs to lower Galore Creek.	Decreased organic loadings to lower Galore, reducing food and shelter substrates for benthic invertebrates and algae.	Considerable
38 Site runoff, diversion and sediment control (D)	Habitat loss on colonized diversion channels upon closure; reduced productivity	Closure	Adverse	Far Future	Low	Landscape	Not Resilient	One time	High	Original tributaries re-opened to flow into revegetated Waste Rock area and into Galore Creek.	Minimal loss of habitat, replaced with new habitat in reclaimed waste rock area.	Negligible
39 Site runoff, diversion and sediment control (D)	Disturbance of tailings in pond due to breaching of diversion channel: toxicity leading to reduced productivity	Closure	Adverse	Short Term	Low	Landscape	Resilient short-term	Periodic	Low	Cover exposed tails with rock armor to minimize disturbance prior to allowing diversion channel water to re-enter tailings pond.	Minimal pulse of elevated tailings in water column; minimal effect in lower Galore Creek	Negligible

TSS = Total Suspended Solids, SCERP = Spill Containment and Emergency Response Plan

**Table 7.9-6
Impact Assessment Descriptor Criteria Definitions for Aquatic Resources**

Timing (Start Time of Effect)	Direction	Duration **	Magnitude**	Geographic Extent**	Resilience**	Frequency	Probability of Occurrence
<p>Construction Phase: effect is initiated during pre-construction and/or construction phases</p> <p>Operation Phase: effect is initiated during mine operation phase</p> <p>Decommissioning and Closure Phase: effect is initiated in mine decommissioning or closure phases</p> <p>Post Closure Phase: effect is initiated post-closure</p>	<p>Positive: effect creates conditions that are better for VEC relative to baseline conditions</p> <p>Neutral: effect creates conditions for VEC that are neither better or worse for VEC relative to baseline conditions</p> <p>Adverse: effect creates conditions that are less desirable for VEC relative to baseline conditions</p>	<p>Short Term: effects persist < 1 month</p> <p>Medium Term: effect persists for 1 month to 2 years</p> <p>Long Term: effect persists from 2 years to life of mine (<i>i.e.</i> , 20 years)</p> <p>Far Future: effect persists beyond the life of the mine (<i>i.e.</i> , > 20 years)</p>	<p>Negligible: no detectable effect on aquatic populations compared to baseline conditions</p> <p>Low: affects a localized population, within variation observed in baseline conditions</p> <p>Moderate: affects a portion of a population, effect may produce rapid and unpredictable change, and may temporarily exceed normal range of variability</p> <p>High: affects entire population; significant effect beyond the range of natural variation</p>	<p>Local: effect is limited to site of disturbance (<i>e.g.</i> localized sections of watershed)</p> <p>Landscape: effect is limited to less than two full watersheds</p> <p>Regional: effect is limited to the Cassiar Iskut-Stikine LRMP boundary (<i>e.g.</i> , two full watersheds)</p> <p>Transboundary: effect extends beyond the boundaries of the Cassiar Iskut-Stikine LRMP boundary (<i>e.g.</i> , Alaska)</p>	<p>Reversible Short-term: effect can be reversed within the life of the project, or within one generation of the VEC</p> <p>Reversible Long-term: effect can be reversed in more than one generation or beyond the life of the mine</p> <p>Irreversible: effect can not be reversed</p>	<p>One time: effect is confined to one discrete period in time during the life of the Project and potentially beyond the life span of the Project</p> <p>Periodic: effect occurs intermittently but repeatedly over the life span of the Project and potentially beyond the life span of the Project</p> <p>Continuous: effect occurs constantly during the life of the Project and potentially beyond the life span of the Project</p>	<p>Nil: an effect has no probability of occurring</p> <p>Low: an effect is unlikely but could occur</p> <p>Moderate: an effect is likely but may not occur</p> <p>Unknown: the likelihood of occurrence of an effect can not be predicted</p> <p>High: an effect will definitely occur</p>

** Definition for this descriptor criterion is modified from original definition provided in Introduction to Chapter 7.

7.9.2 Habitat Loss and Alteration

7.9.2.1 Introduction

This issue is affected by any events that lead to the loss or alteration of the physical habitat, resulting in adverse conditions for resident periphyton and benthos. This could be related to physical changes such as increased siltation changing the watercourse so that a side channel dries up, or altered flow patterns changing water levels in a habitat. Although chemical contamination is a form of habitat alteration, it is considered separately as a cause of direct mortality or sublethal effects (Section 7.9.3). Altered nutrient loadings are also considered separately as a potential cause of altered productive capacity (Section 7.9.4). Since aquatic resources are a biological component of fish habitat, they are protected under the federal *Fisheries Act*, which prohibits the harmful alteration, disruption, or destruction of habitat used either directly or indirectly by fish for any part of their life cycle (Fisheries and Oceans Canada, 1985).

Loss of aquatic habitat has both direct and indirect effects to aquatic organisms. Direct effects to aquatic resources include mortality and elimination of suitable area which aquatic life can colonize or where existing biota can continue to reside. Indirect effects include the reduction or elimination of the transfer of nutrients, organic matter, and organisms from lost upstream habitat to downstream habitat. A habitat that experiences significant changes in one or more of the above factors may have a reduced capacity to support biological communities. Depending on the quality and area of the habitat lost and the potential for reclamation or rehabilitation, this could represent a reduction in productive capacity and could represent a significant effect to the region (refer to Section 7.9.4 for discussion of indirect effects of habitat loss and alteration to downstream productive capacity).

Habitat loss related to this project is mainly from the planned footprints of mine components, the majority of which are within the Galore Creek Watershed (Table 7.9-3). Smaller footprint effects will occur at crossings of the Iskut and Porcupine rivers and More Creek due to pilings, rip-rap and closed culverts. Some riparian habitat within a wetland area of the lower More Creek Watershed will also be lost due to the access road footprint. Other habitat loss will be caused by increased siltation within waterbodies, although the probability of occurrence of these effects is low since it is contingent on efficacy of sediment control (which depends on the local range of particle sizes which must be settled out), precipitation (quite variable but high among years), accidents, and natural hazards such as landslides.

7.9.2.2 Mine Area, Scud and Stikine Rivers

Habitat loss and alteration within the mine area will occur due to construction of open pits and storage facilities over existing streams. Potential effects to lower Galore Creek include siltation, altered water levels and temperatures, and altered inputs of drifting benthos and organic matter.

Development of the Galore Creek Project will result in loss of aquatic habitat for periphyton and benthos within the Galore Creek Valley (Figure 7.9-2). The length of unimpacted and impacted stretches of streams were estimated based on simple two-dimensional map measurements (Table 7.9-7). Impacted and unimpacted drainage areas were quantified using a topographical map. Zones were classified as containing either contact water to be diverted into a mine

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component, or non-contact water to be diverted away from the mine site and into lower Galore Creek.

Almost all of the streams within the footprint of the mine site will be diverted to the tailings and waste rock facility, representing a loss of 27% of the drainage area within Galore Creek, or a loss of 36% based on stream length (Table 7.9-7). This includes tributaries on the western slopes of upper Galore Valley (covering 38 km²), as well as the west section of the West Fork of Galore Creek, due to development of open pits, diversion channels and mine infrastructure in the area. Successive construction of diversion channels along the eastern slopes of the Galore Creek Valley will remove the lower portions of intersected tributaries. The majority of the drainage area (86% by area) in Galore Creek is situated above the tailings dam. Of that, approximately 30% of the drainage area and 47% of stream length will be lost during construction. On a local scale, habitat loss for aquatic resources represents a considerable effect. However, this habitat is not unique to the region, therefore on a larger scale the effect from mine development will not be significant. Potential indirect effects of this habitat loss in lower Galore Creek include reduced loadings of organic matter from upstream riparian zones and reduced benthic drift downstream. These indirect effects are discussed in Section 7.9-4.

**Table 7.9-7
Stream Habitat Loss Due to Mine Footprints
in the Galore Creek Valley**

	Length (km)	Drainage Area (km²)
Total lost stream habitat	70	39
Total intact habitat upstream of dam	80	86
Total intact habitat downstream of dam	47	20
Total intact habitat in all of Galore Creek	127	106
TOTAL GALORE CREEK HABITAT	197	145
% of Upstream Habitat Lost	47%	31%
% of Galore Creek Habitat Lost	36%	27%
% of Galore Creek that is upstream of dam	76%	86%

Distances based on length measurements on map, no consideration of slopes used in calculations therefore overestimates stream lengths in flat areas (valley bottom) compared to steeper, untouched slopes. The % of actual habitat lost is therefore less than shown in table.

The habitat loss includes most habitat along the mainstem of Galore Creek above the dam, and a significant portion of its upper tributary habitat, particularly in the West Fork area. However, during closure, much of this area will be reclaimed as lake-type habitat where the open pits and tailings facilities are situated, and stream habitat in area of the reclaimed waste rock facility. Therefore, the long term effect on aquatic habitat in Upper Galore Creek Watershed is a change from stream to lake-type habitat, with some permanent loss of stream habitat.

Habitat alteration within the mine area will be caused by increased levels of siltation during construction of all mine site infrastructure including the open pits, mine roads, building

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foundations and storage areas. Depending on the efficacy of settling in ponds and the rate of development of the temporary dam downstream of the mine area, periodic release of waters with elevated total suspended solids (TSS) may occur. Increased siltation could result in habitat alteration in terms of altered siltation patterns and increased scouring within streams. During construction and operations, the erosion of roadways in this mountainous area as well as soil compaction by heavy vehicles will provide other sources of silt to contact waters flowing into the tailings pond. However, as background levels already exceed the effluent discharge limit for TSS (15 mg/L), any siltation increases will have little effect on the receiving environment during operations. If settling in the tailings facility is not sufficient and siltation is not controlled, other mitigative practices will be required to ensure discharge schedules and downstream water quality are maintained.

During construction of the site runoff diversion channel, temporary increases in turbidity are expected. As each tributary is connected to the diversion channel, this will release silt downstream to the receiving environment. However, quantities will be mitigated through best management practices and through implementation of the Erosion Control and Sediment Management Plan (Section 8.10). As turbidity fluctuates widely in this region, effects on downstream aquatic habitat will be negligible to low and limited to the lower Galore Creek. Also, to mitigate the potential for increased scour and erosion from the diversion channel flowing into Galore Creek, an energy dissipating structure will be designed. During operations, the diversion channel will contain natural flows, therefore no habitat alteration is related to this mine activity.

Discharge of the tailings effluent will not be permitted during low flow periods of November to April, and 30% of the Galore Creek Watershed above the tailings dam is captured and diverted into the tailings pond throughout the year. This necessitates that high volumes of effluent be discharged during the high flow period of June to September, matching the natural hydrograph, in order to release sufficient quantities on an annual basis to prevent overfilling of the tailings pond. The design for the tailings dam allows room for three extra months of storage before discharge would become necessary. The result of this discharge schedule is that Galore Creek will experience lower flows than normal during the winter low flow period, since only the diversion channel and lower tributaries will be flowing. This reduction in flow could lead to increased ice cover during winter months, as well as reduced wetted width. This would result in mortality to aquatic organisms in dried areas. Maintaining flow in the diversion channel will therefore be important in order to avoid effects to downstream habitat. Regular monitoring and clearing ice and debris from the diversion channel will ensure continuous flow in lower Galore Creek over the winter. The wetted width and area of downstream habitat are not expected to be significantly reduced, based on hydrologic and bathymetric studies of lower Galore Creek (see Section 7.5 Water Quantity).

At peak flows during freshet, total flows of Galore Creek would increase above natural levels due to higher volumes of tailings effluent discharge. The increased flows could lead to changes in river morphology including increased scouring of the channel, increased erosion of banks, homogenization of habitat, and deeper waters where shallow riffle habitat used to exist. However, these physical alterations to the stream habitat will not cause considerable effects on

periphyton or benthos communities, since these alterations will not greatly exceed baseline ranges.

Water temperatures in summer flows in lower Galore Creek are predicted to increase by a few degrees due to thermal stratification within the tailings pond. Discharge from the uppermost layer of the pond will have a peak daily temperature of 14 to 16°C, based on limnology studies in lakes of similar altitude assessed in upper More Creek in August 2005. This discharge will flow into lower Galore Creek and mix with water from the diversion channel (which averages 10°C in summer). The final temperature upon mixing is estimated to be 12 to 14°C, and will thus not be greatly increased from baseline conditions. Due to five-fold dilution, the Scud River will experience negligible increases in water temperature related to tailings effluent discharge. Therefore, no effects to aquatic biota are linked to altered water temperatures in Galore Creek or the Scud River.

During closure, the diversion channel will be breached and eastern tributaries will flow into Galore Creek through the reclaimed tailings and waste rock impoundment. Habitat within the diversion channel, colonized by periphyton and benthos post-construction, will be lost. Nutrient loading to lower Galore Creek should not be greatly affected by this major change in upstream hydrology and habitat structure, since nutrients dissolved in water will continue to flow out of the tailings impoundment. However, benthic drift and downstream loading of organic matter could be retained behind the dam, reducing downstream output. This is discussed under Productive Capacity in Section 7.9-4.

At closure, the tailings dam will be breached by a spillway to allow unimpeded year-round flow of the uppermost tailings pond water to the receiving environment. This avoids erosion of the tailings dam by localizing outflow at a specific stabilized area. Discharge will be dependent on water quality and may require treatment or other measures to ensure compliance with permit limits and to avoid effects to the downstream aquatic communities.

In the unlikely event of an effluent overspill or tailings dam breach, significant effects to downstream habitat may occur due to effluent and particulate release. However, an event such as this is classified as catastrophic and beyond any best engineering practices for earth-filled hydroelectric reservoirs (see also Section 5.9).

7.9.2.3 Access Corridor

Minor habitat loss and alteration will be caused by development of the 30 m wide right-of-way for the access route and both diesel and ore concentrate pipelines. This includes loss of habitat at the footprints of pilings, streambanks where rip-rap is used for stabilizing banks and minimizing erosion, as well as removal of riparian vegetation and coarse woody debris and siltation during construction of stream crossings. Road traffic may also cause minor alteration from aerial deposition of dust to waterways; mitigation will include speed limits and dust suppressants. Total area of in-stream habitat lost at fish bearing crossings is estimated to be approximately 327 m² (Section 7.10). Habitat will also be destroyed at 306 stream crossings where closed culverts will be installed (Appendix 5-I). This represents minor loss of habitat at each crossing based on the small fraction of impacted area compared to total stream lengths. Also, a total of

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0.9 ha of riparian habitat will be lost within a wetland area of lower More Creek, due to construction of the access road. This represents only 5% of this wetland area.

The total surface area lost due to development of the access corridor is quite small relative to the area covered by each stream, and negligible when observed on a regional level. However, habitat alteration due to siltation is expected briefly during construction, and localized erosion will occur along the road over the mine life. Roadway monitoring and repair will be important in mitigating and minimizing effects, but due to the steepness of the terrain covered, it is expected that some areas will experience erosional problems. Any unavoidable alteration, disruption or destruction of fish habitat will be compensated for through development of a Fish Habitat Compensation Plan in order to meet no net-loss criteria based on the *Fisheries Act* (Section 8.12.5).

Transmission line development will involve removing some riparian vegetation and trimming overheight trees, but this will result in negligible short term reductions in woody inputs and cover in streams. The transmission line right-of-way will be built along the access road, reducing disturbance to local waterbodies

The heliport at Upper West More Creek near Round Lake is not expected to involve any habitat loss or physical alteration since it will be located away from waterbodies. It may contribute small amounts of silt to localized streams through air-blown dust from air traffic. This will have a negligible effect on surrounding aquatic resources.

Road construction can be related to greatly increased occurrence of slope failures, especially in steep, coastal areas (Furniss *et al.*, 1991). This could result in stream blockages, changes to sedimentation patterns in rivers, and flooding events. To mitigate this risk, a geohazard assessment was completed in 2005. Appropriate protective measures (*e.g.* revegetation and reshaping of slopes, diversion ditches and culverts) and erosion control will be implemented along the access road to manage water and maintain slope stability. Thus, there is a low probability of significant effects on aquatic resources occurring along the access corridor due to landslides.

A rupture of either the ore concentrate or diesel pipeline could lead to effects to aquatic resources. In the case of a concentrate pipeline rupture, significant amounts of slurry could be released leading to altered physical habitat in nearby wetlands or streams. A response time of 2 to 15 minutes for concentrate spills is predicted, based on the capacity of the pressure sensor system. Chemical alteration of aquatic habitat by either concentrate or diesel is discussed in Section 7.9.3.2. To mitigate the risk of a rupture, pipelines will be buried underground to avoid damage from avalanches, rockfalls and landslides. In areas with a high risk of geohazard disturbance, pipelines will be buried at a greater depth. The pipelines are also insulated and physically supported when above ground at major stream and river crossings. The diesel pipeline will have several emergency shut-off valves built in at regular intervals along its length. The ore concentrate pipeline will have pressure sensors that will inform personnel immediately in the case of a rupture. A sump tank at Porcupine River at the low point between the tunnel and upper Sphaler watershed will be designed to contain all concentrate within the pipe in the case of a rupture in this portion of the pipeline. Therefore, the probability of an effect to aquatic

resources due to a pipeline rupture is quite low. In the unlikely event that one did occur, the Spill Contingency and Emergency Response Plan (SCERP) details protocols for the rapid assessment and clean-up of the spill to mitigate any effects to the environment.

7.9.2.4 Filter Plant

The filter plant, camp, and truck load-out facility will be constructed away from waterbodies and the Erosion Control and Sediment Management Plan will mitigate any potential effects due to siltation. Installation of the diffuser within the Iskut River will require site isolation for construction to proceed under dry conditions. Any silt-bearing water will be directed to settling ponds and/or released into terrestrial areas to filter particulates. A minor pulse of sediment loadings downstream of the diffuser will occur when the area is reopened to the river. Construction of the filter plant and pipeline would cause negligible sediment loadings to surrounding wetlands, lakes and streams, and therefore no effect to aquatic resources.

7.9.2.5 Aerodrome Facility

Construction of the airstrip access road and bridge across the Porcupine River will involve some habitat loss and alteration of localized areas in order to place pilings. Natural TSS concentrations are fairly high in the Porcupine River during the summer period when construction will occur, so no significant effects from siltation are expected to occur. Similarly, air and ground traffic will contribute to dust being blown into waterbodies downwind, but loadings to aquatic habitats will be relatively minimal. The Erosion Control and Sediment Management Plan will be put in place to minimize the siltation of the downstream environment.

7.9.3 Direct Mortality and Sublethal Effects

7.9.3.1 Introduction

Direct mortality of aquatic organisms may be caused by the destruction of habitat during construction activities within or near streams due to the removal of organisms in excavated substrates or by smothering of organisms with construction materials (*i.e.*, tailings dam). Mortality may also be caused by exposure to various contaminants related to planned and accidental discharges, including effluents, ML/ARD release and chemical spills.

Exposure to chemicals at concentrations below those associated with mortality can still cause sub-lethal effects which lead to reduced productive capacity on a population level. There are a number of potential sublethal effects which ultimately lead to either reduced growth or reproduction (*e.g.*, fecundity, egg survival), altered physiology (*e.g.*, metabolism, energy storage, oxygen consumption) or altered behaviour (*e.g.*, feeding rates, drift, predator avoidance). These sublethal effects can therefore result in effects at the community level.

Some mine components associated with potential lethal or sublethal effects to aquatic organisms include release of tailings effluent and diversion channel water to lower Galore Creek, discharge from the concentrate slurry filtration plant into the Iskut River, road runoff (suspended solids, dust suppressants, and released fuels), and spills from machinery or the diesel or concentrate slurry pipelines. These are all potential sources of stressors to aquatic systems in the project area (Table 7.9-4).

7.9.3.2 Mine Area, Scud and Stikine Rivers

Sources of stressors in the Galore Creek receiving environment include the regular discharge of tailings effluent as well as the diversion channel waters. Any chemical spills occurring within the mine footprint will be cleaned up following the SCERP, and any residual materials would be captured and diverted into the tailings pond. Seepage or leaks from the tailings pond will probably not be a source of contaminant stress in lower Galore Creek, since a network of underground wells will be used to collect seepage and groundwater that will be pumped back into the tailings pond.

The tailings effluent was one of five components judged to have considerable potential for residual adverse effects (Table 7.9-2). The tailings effluent contains a mixture of natural surface runoff from undisturbed (non-contact waters) as well as developed (contact) zones combined with tailings slurry. All contact waters of the mine site, including runoff from open pits, ore and marginal ore stockpiles, the tunnel portal, overburden pits and topsoil storage will be diverted into the tailings impoundment facility. Constituents in the tailings effluent have the potential to cause toxic effects downstream including lethal and sublethal responses in algae and benthos. Contaminant pathways to organisms include uptake of dissolved constituents as well as metal-bound particulates which may accumulate in sediment. Water-sediment interactions may occur, including precipitation or adsorption to sediment particles, or dissolution of particulate-bound metals back into the water column. Benthic organisms can therefore be exposed to contaminants in the water column as well as from consuming and living within sediment.

To assess potential effects of effluent, the change in chemical concentrations in water as well as total predicted loadings of chemicals to Galore, Scud and Stikine waters were calculated for both baseline and future operating conditions. Additionally, chemical behaviour modeling was conducted in order to predict the potential for metals to precipitate out of the water column, which could lead to accumulation in sediment. These results are all discussed in (Section 7.8.2.2).

Loading calculations indicate that particulate-associated metal loadings to Galore Creek and further downstream will decrease during mine operation, due to the low TSS discharge limit required under MMER (see Section 7.8.2.2). Therefore, metals accumulation in sediment will not increase and benthic organisms will not be affected.

Precipitation of metals from the water column was only predicted for relatively non-toxic iron and aluminium hydroxides and oxides, as well as minor amounts of BaSO₄ and PbMoO₄. The iron and aluminium compounds have the potential to bind other metals to form colloids. However, this does not present a potential effect to biota as colloid-bound metals would continue to be transported downstream to the Stikine River where they will represent insignificant loadings to this system. This assessment is based on the small mass of colloids and the high flows in Galore Creek and Scud River which prevent settling of lighter particles. Therefore, precipitation of metals of concern from tailings effluent will not occur in the receiving environment.

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A mass-balance water quality model was developed to characterize the chemistry of the tailings effluent based on rates of metal leaching/acid rock drainage (ML/ARD) from exposed rock including waste rock, open pits, and ore stockpiles (Appendix 7-D). The potential for exposed rock along the diversion channel to be a source of ML/ARD-derived metals to waters released to Galore Creek has yet to be determined. The model combined water from the diversion channel (baseline values of East Fork of Galore Creek) and effluent discharge based on predicted flows. Comparison of model values to baseline data provided Hazard Quotient (HQ) ratios indicating relative change due to effluent discharge. There was a degree of uncertainty associated with the final water quality in lower Galore Creek, due to uncertainty in ML/ARD rates, but model data did not predict extreme increases for any variables.

The water quality model predicted that total metal concentrations in lower Galore Creek will not increase as a result of effluent discharge (Water Quality Effects Assessment, Section 7.6). Also, the majority of particulates discharged from the tailings pond are predicted to be ultra-fine (<13 µm), indicating that most tailings particulates will be carried further downstream than Galore Creek, and will be diluted with natural TSS in the Scud and Stikine Rivers.

Sulphate was predicted to increase by more than two times in Galore Creek (up to 225 mg/L) but not in the Scud River, where it will remain below 60 mg/L (Water Quality Effects Assessment, Section 7.6). Sulphate toxicity is poorly understood, and the current provincial guideline of 100 mg/L may be overly cautious. A review of available literature indicated that sulphate toxicity is dependent on water hardness (moderate to high in Galore and regional rivers), and that several studies failed to account for this factor. The lowest concentration reported to cause acute toxicity was 446 mg/L (in mayflies), while the lowest concentration to produce species-specific chronic toxicity was higher at 775 mg/L, indicating problems with comparing between studies based on different conditions and treatments (Rescan, 2004). As predicted, concentrations in Galore Creek are well below both of these values, no effects to biota are expected. Within the Scud and Stikine rivers, effluent from Galore Creek would be diluted by a factor of 5 and 200, respectively; thus, if any sublethal effects occur, they will not extend beyond Galore Creek.

Dissolved concentrations of several metals including antimony, boron, cadmium, lead, manganese, nickel and zinc were predicted to increase by two to five times in lower Galore Creek. Several metals including cadmium, copper, nickel and zinc have been shown to be additive in toxicity to aquatic organisms, including freshwater fish, amphipods, marine fish, and copepods (Eisler, 1993; 1998). These increased metal concentrations could lead to possible sublethal effects in more sensitive taxa in Galore Creek. However, for many of these metals, the baseline concentrations were below the detection limits; therefore, a value of half the detection limit was used for the concentrations. Because of this, actual HQ values for these metals could be up to two times lower than those calculated in this assessment (*i.e.* HQs could be close to 1 in many cases). Also, the predicted metal concentrations are still considered to be very low, being less than an order of magnitude above detection limits. Risk assessment guidance indicates that there is a low risk of adverse effects to biota with HQs between 1 and 10 (US EPA, 1998). No dissolved metal concentrations approached any guidelines for total metal concentrations. These points all indicate that although some dissolved metal concentrations are predicted to increase slightly in lower Galore Creek, there is a low risk of adverse effects to biota.

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Dissolved metal concentrations further downstream in the Scud River were predicted to remain the same or only slightly increase due to the five-fold dilution of Galore Creek with Scud River. Waters of Galore Creek as well as the Scud and Stikine Rivers all have relatively similar pH, dissolved oxygen (D.O.), temperature, alkalinity and hardness. As these parameters play a major role in determining metal speciation, no drastic change in metal forms are expected as the effluent travels downstream through the receiving environment. This also supports the prediction of minimal to low magnitude effects to the biological communities of Galore Creek.

Nitrates may be introduced to the mine receiving environment from sewage and blasting residues. Sewage will be treated, with solids removed and effluent discharged into tile fields at least 100 m away from nearby waterbodies. Depending on groundwater transport and binding, the tailings pond may receive inputs of dissolved nitrogen and phosphorus-based compounds associated with the sewage effluents. A review of available studies on nitrate toxicity indicated effects on freshwater invertebrates and fish species at concentrations above 2 mg/L. All model and baseline nitrate concentrations are below 0.5 mg/L, indicating that blasting residue inputs to the tailings pond will not result in effects to aquatic life (Camargo *et al.*, 2005). Also, nitrates and phosphates would interact with other ions within the tailings pond, and would be diluted by many orders of magnitude prior to discharge to the receiving environment. Groundwater flows will be monitored below the dam using a network of wells, and water not meeting discharge criteria would be pumped back into the tailings facility. Therefore it is not expected that nitrates from sewage effluent or blasting will have any toxic effects to aquatic organisms in the receiving environment.

In the event of strong storm events causing an accidental overspill of the tailings dam, toxic effects could occur in the downstream environment depending on the volume of tailings water released and the time of year. Overspill events will only be possible during spring before discharge begins when storage volumes are highest. However, the freeboard of the dam will be maintained well above the surface of the pond, based on a 1-in-100 year storm event. Similarly, a breach in the tailings dam, considered highly unlikely, could cause catastrophic loss of aquatic life in Galore Creek as well as the Scud and possibly Stikine rivers. However, the tailings dam will be engineered to withstand earthquakes and extreme (1-in-10,000 year) storm events, will have an impervious clay till inner core as well as a bituminous geotextile liner, and will be monitored throughout construction and operations to ensure structural stability. Periodic inspections will also be conducted following mine closure, as required by the reclamation plan.

At closure, the tailings dam will be breached by a spillway to allow unimpeded year-round flow of the uppermost tailings pond water to the receiving environment via a spillway. Discharge will be dependent on water quality and may require treatment or other measures to ensure compliance with permit limits and to avoid effects on the downstream aquatic communities.

7.9.3.3 Access Corridor

Some direct mortality to aquatic resources will occur within the footprint of the access road at stream crossings (pilings, rip-rap) and along the road itself. However, the magnitude of effects to biota is quite small, based on the small area affected (see Habitat Loss and Alteration, Section 7.9.2). Construction and operation of the access corridor may be associated with siltation,

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chemical spills and ML/ARD, potentially resulting in lethal or sublethal effects to aquatic organisms in nearby rivers, wetlands or lakes.

Erosion along the road during construction and operations will likely cause temporary increases in turbidity in localized areas. This could lead to smothering of invertebrates including their eggs, decreased visibility which would reduce feeding efficiencies, and altered siltation patterns within streams. Recovery would be more rapid in fast flowing streams than wetlands or lakes. However, most wetlands and lakes are well away from the road route. In addition, More and Sphaler Creek and the Iskut River already have very high TSS concentrations, so siltation from the road is not expected to have a significant effect. Roadway monitoring, repair and sediment control will be important in mitigating and minimizing effects.

Construction along the road will generate large amounts of waste rock which could provide a source of ML/ARD to local waterbodies. To mitigate this risk, on-site testing will be conducted, along with visual observations by qualified experts. Potentially acid rock drainage-generating (PAG) rock will be managed or buried along the road using appropriate management measures. During operations, exposed cliff areas along the road with PAG rock will be managed with limestone-lined ditches and water diversions above the cliffs to reduce the potential for ML/ARD and mitigate risks to aquatic life.

Dust suppression using moisture-attracting salts (calcium chloride and magnesium chloride) could result in degraded water quality in streams downstream of access road crossings. Increased chloride concentrations from surface runoff from the road to nearby waterbodies could cause direct mortality or sublethal effects related to altered osmoregulatory and physiological processes in more sensitive life stages and species (Judd 1970; Hoffman *et al.*, 1981; Kapoor 1978). Effects would be strongly felt in lakes and wetlands that have long residence times compared to the regional streams (Blassius and Merritt, 2002). Water management and erosion control where the access road approaches or crosses a waterbody will minimize the potential for salt accumulation and toxicity to aquatic life. Water quality monitoring will also be conducted to avoid potential effects at some locations. However, wildlife mitigation measures suggest minimal use of calcium chloride (see Section 7.13)

Construction and staging camps along the access corridor will be relatively small (30 to 50 people), and sewage wastes will be handled such that solids are extracted and removed, while liquids are discharged to a tile field at least 100 m from the nearest waterbody. This activity should not lead to any significant effects to aquatic life, since only a portion of nutrients from sewage discharge will travel through groundwater (depending on soil chemistry and substrate sizes) to waterbodies, where they will be quickly diluted. Effects to wetlands and lakes would be more significant, hence discharge will be positioned to avoid exposure to these more sensitive areas.

Chemical spills (fuel, de-icer fluids) along the access corridor including the camps and the West More heliport may occur. Within the mine area, haul trucks will be refuelled at specified areas with concrete pads. Risks will be mitigated by locating fueling stations away from waterbodies, as well as implementation of the Spill Contingency and Emergency Response Plan.

Landslides can be caused by poorly engineered roads, especially in steep, coastal areas of high annual rainfall (Furniss *et al.*, 1991). A landslide along the access corridor or within the Galore Creek Valley could result in massive loadings of sediment to waterbodies, smothering benthos and affecting primary producers. This could also affect water clarity, where in extreme cases primary production would decline leading to effects at higher trophic levels. Other effects could include altered sedimentation patterns in rivers and flooding of habitat. However, there is a low probability of significant effects occurring along the access corridor related to landslides. Geohazard assessment was used to characterize the risk of avalanche or landslide events along the access corridor, and this was used in selecting the road route in order to avoid high-risk zones.

Similarly, there is a very low (<1%) probability of pipeline rupture during the operations phase, based on engineering design and geohazard studies. In the case of concentrate pipeline rupture, significant TSS and metal loading to the immediate environment could lead to toxic effects to biota in nearby wetlands or streams. The pipeline will operate at a flow rate of 1.5 m³/min, and because there are no emergency shutoff valves, emergency response would be based on pressure sensors detecting changes in flows. The degree of potential effect is dependent on where along the access corridor the rupture occurred. An emergency drain tank at the low point on the Porcupine River is designed to handle volumes from Scotsimpson to upper Sphaler. If the concentrate slurry reached a lake or wetland, it could cause significant mortality or sublethal effects to aquatic life directly or through trophic effects depending on species sensitivities to the metals introduced. The slurry will have a pH of 10 which also poses potential effects to many aquatic organisms accustomed to the more circum-neutral environments of the region (pH 7.5 to 8.5, with slightly lower values in some wetlands). These effects could be linked to effects on birds, fish and wildlife which depend on primary and secondary producers for food and habitat. Metal could be stored in organic sediment and act as a contaminant source to benthic organisms including invertebrates and fish. Spill of concentrate to a stream or river could also cause effects to aquatic life, but effects would be of lower magnitude and duration than those expected in wetlands, due to the flowing nature of streams. However, the likelihood of a spill reaching a waterbody is mitigated by the routing of the pipeline and access road away from these areas. Also, because the pipeline is mostly buried, a rupture underground would probably result in only a very localized spill.

Rupture of the diesel pipeline could also lead to toxic effects in aquatic organisms if fuel reached aquatic habitats either through surface or groundwater transport. Diesel fuel could cause significant mortality to aquatic life of streams and especially that residing in wetlands and lakes which are more static systems and therefore would contain the contaminants for a longer period. To mitigate risks to aquatic life, the pipeline will be buried deeper at higher risk zones, and emergency shut-off valves along the pipeline will control the volume of any spills. Therefore, there are no significant adverse effects associated with the diesel pipeline.

7.9.3.4 Filter Plant

The camp at the filter plant will be set up to treat sewage in the same manner as the camps at the mine area and along the access route. This activity should not lead to any effects to aquatic life. Regular water quality monitoring will be conducted.

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Chemical spills (fuel, de-icer fluids) at the filter plant may occur, but will be mitigated through the use of an impermeable fueling base with raised perimeter to contain spills, as well as the SCERP coupled with employee training. Any spills would be contained and collected for treatment offsite.

The construction of the diffuser for the filter plant effluent discharge to the Iskut River will cause some mortality to organisms within the development footprint. Also, this will introduce a short term increase in TSS levels to the immediate downstream environment, with minimal mortality or sublethal effects to aquatic life. Any effects on algal or benthic communities will be of low magnitude and of short duration.

Discharge of effluent created from dewatering of ore concentrate at the Iskut filter plant will occur year-round at a point on the Iskut River 6 km upstream of the More Creek confluence. This area provides fast flows and a high degree of mixing such that effluent will be diluted by a ratio of 130:1 only 7 m downstream of the diffuser. Total and dissolved metal concentrations are predicted to remain the same for many metals (HQ of 1 or less) or slightly increase with HQs up to 1.4. The exception was total copper (HQ = 3.1) during low flow, although this increased concentration was still an order of magnitude lower than peak baseline copper concentrations. Therefore, some localized mortality and sublethal effects are predicted in the 7 m stretch downstream of the diffuser due to metal uptake. Metal-sensitive taxa may be eliminated or reduced in this confined area, including increased avoidance through benthic drift. Effects would only occur during operations and no effects would extend beyond the More-Iskut confluence due to additional dilution from More Creek. The use of sand, cartridge and activated charcoal filters will aid in minimizing the release of particulates and organics to the Iskut River. Water-sediment interactions such as precipitation and adsorption are assumed to be negligible since pH is not predicted to change, and metal-binding substrates including clays and organic matter are scarce in the Iskut as in the Scud River. Also, the relatively small size of the mixing zone indicates that this should have no significant effect to the benthic communities of the Iskut River, which contains naturally high concentrations of many metals. Also, this area would likely be recolonized by more sensitive taxa during the post-closure phase, re-establishing a benthic community similar in diversity to that present during baseline conditions.

As concentrate recovery will be maximized for both environmental and economic reasons, the occurrence of concentrate spills will be minimized resulting in negligible effects to local waterbodies. Truck loading will be conducted using a silo and conveyor system, supplemented with loader vehicles for high volume shipments, based within an A-frame building with a cement base. Concentrate will be covered and transported by truck to Stewart, and road accidents are considered within the SCERP and Waste Management Plans.

7.9.3.5 Aerodrome Facility

Construction activities associated with the aerodrome could cause mortality to biota. Effects will be mitigated by controlling siltation to waterbodies using best management practices and by situating the airstrip away from waterbodies to reduce aerial deposition.

Chemical spills (fuel, de-icer fluids) at the Porcupine aerodrome could lead to more significant effects than spills occurring elsewhere. This is due to the porous nature of the ground substrate which is comprised of sand, gravel and cobble. A chemical spill would more easily travel in groundwater through this matrix than in areas with higher silt or clay content. Chemicals can move several kilometres in the hyporheic (interstitial zone under a stream where groundwater and surface water mix) and groundwater zones of large rivers (Hancock, 2002). Studies of major fuel spills have indicated that secondary production may suffer as far as 12 km downstream of the spill site, and effects may persist for longer than a year (Lytle and Peckarsky, 2001). Sub-lethal concentrations of chemical compounds used for de-icing aircraft have also been found in fish and invertebrates living downstream of major airports (Cancilla *et al.*, 2003). Uncontrolled spills could therefore have significant effects on aquatic life of the Porcupine River and wetlands of the valley following a significant chemical spill. This risk will be mitigated through the use of an impermeable fueling apron with raised perimeter to contain spills, as well as the SCERP.

7.9.4 Reduced Productive Capacity

Reduced productive capacity is the third major issue related to aquatic resources and originates from either of the first two issues described above, but can also arise in relation to indirect effects such as trophic effects (*e.g.*, reduced primary production leading to decline in food for benthos) and eutrophication. The productive capacity of fish habitat is defined as “the maximum natural capability of habitats to produce healthy fish, safe for human consumption, or to support or produce aquatic organisms upon which fish depend” (Fisheries and Oceans Canada, 1991). This aquatic resources assessment focuses on the latter portion of this definition, considering only primary and secondary production.

The productive capacity of aquatic habitats will decrease in certain areas due to project development, and will have the potential to do so in other areas (Table 7.9-5). Reductions in productive capacity will be related to habitat loss and alteration of habitat from lotic to lentic systems within the Galore Creek Valley under footprints of the various mine components including the open pit mines, waste rock and tailings storage facilities, roads and diversion channel. Effluent discharge could decrease productive capacity in lower Galore Creek to a moderate extent. Retention of organic material behind the tailings dam will reduce organic loadings downstream and potentially reduce productive capacity. Finally, there is a potential for slope failures to occur within the Galore Creek Valley or along the access corridor which could result in reduced productivity. However, none of these effects were rated as significant following final assessment, based on magnitude, extent and duration of potential effects (Table 7.9-2). Also, no trophic interactions or eutrophication effects were related to any of the project activities.

7.9.4.1 Mine Area, Scud and Stikine Rivers

Productive capacity will be reduced in the Galore Creek Valley, relating mainly to habitat loss above the tailings dam. Productivity may also be affected in habitat downstream of the dam due to effluent discharge, altered water levels, and the potential for siltation and reduced organic loadings from upstream.

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Habitat loss under the footprint of mine components including the open pits and diversion channels will occur in the upper Galore Creek Valley, as discussed above in Section 7.9-2. Habitat loss involves both direct and indirect effects. The direct effect of mortality and loss of space for organisms to live is proportional to the amount of habitat lost. During construction, loss of habitat from the open pits and other mine infrastructure in the West Fork of upper Galore Creek was calculated to be 26% of the drainage area within the entire Galore Creek Watershed. During closure, all drainage area (86%) above the dam will be diverted into the tailings pond. However, reclamation in the East Fork and within the waste rock facility will act to mitigate habitat loss. The main area of stream habitat that is significantly altered is under the tailings pond footprint. Therefore there will be a moderate loss or alteration of stream habitat (approximately 35%) in the Galore Creek watershed. The new lentic habitat formed by the filling of the open mine pits and the tailings impoundment is expected to have significantly different benthic communities (probably chironomid-dominated) compared to those found in streams under baseline conditions. Benthic community composition will be determined largely by the different habitat of streams and lakes which are preferred by different groups of organisms. Also, the sediment within the tailings facility will contain large volumes of tailings materials of high metal content. Benthic communities throughout the region are generally of relatively low abundance, related to the characteristics of the habitat. The communities of Galore Creek are generally typical of the region in terms of their taxonomic composition, diversity, and low productivity levels. Therefore, on a local scale, this represents a considerable change, but in terms of relative effect to the Cassiar Iskut-Stikine LRMP region, it will not affect productivity or biodiversity of algal or benthic communities.

Indirect effects of habitat loss and alteration will include minor reductions in downstream transport of organic debris and possibly benthic invertebrates (*i.e.*, drift), although the latter most likely do not travel the entire length of Galore Creek within a generation (Brittain and Eikeland, 1988). Organic matter will most likely settle at the bottom of the tailings pond, therefore organic matter loadings beyond the dam will likely decrease. It is however possible that the reclaimed lowland habitat of brush and trees over the waste rock facility may provide additional organic matter, and cycling of deposited woody debris within the tailings pond may eventually elevate dissolved organic matter. It is therefore difficult to predict the net change in organic matter loadings to lower Galore Creek to changing upstream habitat. In any case, the remaining 20 km² of downstream drainage should be sufficient to support the algal and benthic communities, although some minor reductions in productive capacity could occur. Nutrients would not be expected to decrease in concentration from this activity since they are dissolved and would continue to flow from the tailings facility downstream over the spillway in discharged effluent. In fact, nutrients may increase slightly due to inputs related to blasting residues. Sewage will be treated in isolation of waterbodies, therefore nutrient loading from sewage will be negligible and will depend on groundwater transport. Benthic drift likewise should be sufficient to support lower Galore Creek communities, based on organisms coming from the remaining 3 km lower stretch of Galore Creek as well as the hanging valley watershed tributary of lower Galore Creek. The baseline data did not indicate obvious patterns linking upstream and downstream communities; a few taxa were common to sites throughout Galore and many other watershed sites.

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During construction, digging of foundations and open pits will require extensive use of sedimentation ponds, containment dams and silt curtains to control silt loads in water prior to discharge to lower Galore Creek. To avoid erosion of the stream bed below the tailings dam spillway, a dissipation structure will be designed in Galore Creek. Siltation of upper Galore Creek could be significantly increased, so waters will be retained behind a temporary dam for settling. Depending on settling rates, increased silt loadings to lower Galore Creek could occur. Also, the development of the diversion channel will cause temporary and minor increases in turbidity downstream as each stream is connected to the main diversion channel. Sediment may settle into interstitial spaces in the substrate, smothering invertebrates and periphyton, eliminating available refuge areas, and lowering secondary production (Suren and Jowett, 2001). Because TSS concentrations reach up to 500 mg/L in lower Galore Creek during freshet, these organisms are accustomed to regular peaks in TSS and concentrations in released effluent will not approach these baseline values based on MMER requirements. This indicates that only temporary and minor adverse effects to local biota are expected. Some reduction in productive capacity may therefore occur in Galore Creek, but recovery of the benthic community would be relatively rapid, possibly within the same season. This is because of the high flow rates which would clear accumulated silt in the streams. Effects are predicted to be negligible in the Scud River due to a five times dilution factor, and no effects were predicted for the Stikine River. Implementation of the Erosion and Sediment Management Plan will ensure mitigation of siltation effects to biota.

During operations, erosion of roads and exposed areas could lead to increased siltation in Galore Creek. Sedimentation ponds and routine water quality monitoring of tailings effluent discharge will be used to maintain acceptable levels of TSS and mitigate any adverse effects.

The management of the tailings facility and discharges will result in altered water flows throughout the year. Water levels will increase relative to baseline during freshet months, potentially causing increased scouring, altered sedimentation patterns and reduced habitat heterogeneity (*e.g.*, lack of shallow riffle habitat during increased high freshet flows). During winter months, water levels are predicted to drop by approximately 5% (Water Quantity Section 7.5), an insignificant amount relative to yearly fluctuations. These changes in water levels are not expected to cause adverse effects to biological communities since water levels already fluctuate widely under natural conditions, causing periodic flooding and drying of aquatic habitat in lower Galore Creek. However, flow rates are predicted to drop significantly, and in the case of a blockage along the diversion channel, flows could drop to a point where ice formation increased in lower Galore Creek. Regular monitoring and clearing of the diversion channel will act to minimize the risk to downstream habitat. Effects on organisms will depend on the extent and duration of freezing of the creek. Effects to the Scud River would be negligible due to the five-fold increase in flow at this point.

The transformation of Galore Creek from a turbid glacial stream into a large tailings lake may lead to a temperature increase of up to 3 or 4°C in lower Galore Creek during summer months due to stratification in the tailings pond. However, the predicted temperature increase is not expected to adversely affect algal or benthic communities downstream. A temperature increase may actually increase productivity by promoting algal growth. Possible detrimental effects of

eutrophication leading to reduced dissolved oxygen concentrations in the tailings effluent are unlikely. This is because the effluent will be strongly mixed with non-contact waters upon release into the spillway and re-oxygenated in the turbulent waters of lower Galore Creek. Also, algal growth will most likely be limited by low phosphate concentrations, despite increased nitrogen from blasting residues. The water quality effect assessment (Section 7.6.4.1) demonstrated the potential for moderate effects on aquatic organisms due to ammonia and no effects related to other nutrients.

As discussed in Section 7.9.3, the release of tailings effluent and ML/ARD-derived metals from diversion channel waters into the Galore Creek Valley are predicted to have negligible to minor effects on the immediate downstream benthic community of Galore Creek, based on modelled concentrations of sulphate and metals in the water. As the existing benthic community is naturally adapted to high metal concentrations in both water and sediment, changes to productive capacity are expected to be low in magnitude. Effects would be limited to the more sensitive species, possibly reducing richness slightly. Adaptation of local benthic organisms could allow a return in productivity if not diversity during the operation phase.

There are little to no effects predicted to the Scud River, and no effects to the Stikine River or its estuary from activities within the Galore Creek Valley, both in terms of metal concentrations and metal loadings. Total metal concentrations in lower Galore Creek will be similar or reduced within the water column compared to baseline values. This is the product of increasing dissolved metal concentrations but decreasing TSS loadings in order to comply with MMER effluent discharge limits. Based on dilution and minor amounts of particulates settling out along the Scud River, no effect is predicted to occur 30 km downstream at the confluence of Scud and Stikine rivers.

Associated total metal loadings from both effluent and natural TSS particulates were shown to decrease or remain constant for Galore, Scud and Stikine sites during mine operation. Also, most effluent-derived particulates will be very fine and will be expected to travel downstream to the Stikine Estuary where precipitation may occur, at a dilution rate of over 400 times. Thus, no discernable increases in metal loadings to downstream riverine or estuarine water or sediment of the Stikine system are expected, and no effects to aquatic life are predicted.

In summary, the productive capacity in lower Galore Creek may be reduced due to shifts in community structure and decreases in the density of organisms caused by physical and chemical stressors as well as changes to available habitat. No significant effects on the productive capacity of aquatic life are predicted for the Scud and Stikine rivers.

7.9.4.2 Access Corridor

Potential reductions in productivity of waterbodies along the access corridor are associated with habitat loss, siltation during construction of the access road and pipelines, erosion along the road, rupture of a pipeline, ML/ARD from waste rock or from cliff areas along the road, aerial deposition of dust or chemical fuel spills into waterbodies near the West More heliport, sewage effluent from camps, and slope failures.

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As discussed in Section 7.9.2, siltation to waterbodies along the road route will be minimized, with only temporary pulses of TSS to streams during construction, and no lasting effect on water quality or aquatic resources. Habitat loss along fish-bearing crossings totals 327 m², representing a very insignificant area relative to the total area inhabited by aquatic biota in the hundreds of streams, rivers, lakes and wetlands along the access corridor. Additionally, there will be a total of 306 stream crossings where closed culverts will be installed (Appendix 5-I). This will cause only minor habitat loss to benthos and algae at each site. Productive capacity of the streams will not be impacted because of the small proportion of impacted area at each crossing. No lake habitat will be lost, and habitat loss within wetlands will be limited to 9,000 m² within one wetland area in lower More Creek, representing only 5% of this wetland. This is not expected to have any significant effects on the productivity of the wetland, and will relate to only minor decreases in organic detritus provided to the wetland during flooding of the area. Any habitat loss will be compensated for in order to comply with the policy of no net-loss of productive habitat as described in the *Fisheries Act* (see Fish Habitat Compensation Plan, Section 8.12.5).

Fuel spills will not affect aquatic biota as fueling stations will be built to contain any spills, and the West More heliport will be situated well away from local waterbodies. Similarly, dust deposition due to air traffic will not cause any adverse effects to biota as dust suppressants (water, salts) will be used and dust will not reach waterbodies. Camp sewage at the staging areas will be treated, and effluent will be disposed of in tile fields situated a minimum of 100 m away from waterbodies, therefore the risks of nitrate toxicity or nutrient enrichment of wetlands and lakes will be mitigated.

Unlikely sources of effects to productive capacity of streams, wetlands and lakes include either pipeline ruptures (diesel or concentrate) close to a waterbody, or landslide events due to erosion along the road. These events could significantly reduce productive capacity within the exposed waterbody, by increasing chemical toxicity (directly or indirectly through trophic effects) or physically altering habitat (*e.g.*, reduced water clarity, altered sediment substrate, reduced nutrient or organic inputs due to destruction of upstream riparian zone). The SCERP provides measures to mitigate and control effects related to chemical spills.

As discussed under Mortality and Sublethal Effects (Section 7.9.3), any waste rock or cut rock cliff areas along the access road which may cause ML/ARD issues will be managed appropriately to avoid effects to aquatic life. An on-site lab will be used to test waste rock samples, and any PAG rock will be shipped to the tailings facility for sub-aqueous disposal. Mitigation of PAG rock along cliffs will involve adding buffer (limestone) to collection ditches built at the cliff base, as well as the use of diversions above the cliff to minimize production of contact waters. Therefore, no significant effects to aquatic biota are related to ML/ARD generation along the access corridor.

Productive capacity of lakes and wetlands along the access corridor should remain unaffected by project activities. The road route was selected avoid unstable terrain and sensitive aquatic habitat including streams, wetlands and lakes. Therefore siltation effects during construction will be minimal. Silt curtains, rip-rap, and proper design of stream crossings will act to mitigate any effects to productive capacity of aquatic communities. Minor siltation of streams is expected

during road construction, but this would be temporary and not bear significance to overall productive capacity of the streams.

7.9.4.3 Filter Plant

Installation of the diffuser in the bed of the Iskut River will result in a temporary increase in turbidity. The construction will be conducted under dry conditions by isolating the area and managing silt-laden waters. This is not expected to have any significant effect on productive capacity, as organisms of the region are accustomed to naturally high TSS during the summer.

Discharge of filtered effluent from the concentrate dewatering process will be free of most TSS, and will contain slightly elevated metal concentrations. Dilution of filter plant effluent in the Iskut River will result in HQ values for total and dissolved metals ranging from below 1 (decrease in concentration in future) to 1.4 (slight increase in water concentration based on model) at just 7 m distance downstream of the diffuser. The exception was total copper under low flow which showed an HQ of 3.1, as discussed under Section 7.9.3.4. This increased copper level was still an order of magnitude lower than natural copper levels under peak flows. Therefore, potential mortality and sublethal effects to aquatic life would only be expected in the first 7 m downstream of the diffuser, prior to dilution. This could cause a localized reduction in productivity immediately downstream of the diffuser, related to reduced richness and abundance within the short mixing zone. More sensitive taxa could be replaced by metal tolerant species. Effects would only occur during operations and result in only minor toxicity to benthic organisms (density, diversity) depending on the sensitivity of the taxa present. Based on dilution rates, effects would be limited to the Iskut River between the diffuser and the More-Iskut confluence. Based on the small area affected, this will not have a significant effect on the productive capacity of the upper Iskut River. Following closure, recolonization of the mixing zone with benthos would be expected such that density and richness would be similar to other areas of the Iskut River.

At the filter plant, management of chemicals, concentrate, and siltation during construction will mitigate the effects of the plant on the surrounding lakes, wetlands and streams. De-watered concentrate will be stored in a solid A-frame structure with concrete base to prevent leaching of metals. Transfer of concentrate to trucks will be done using conveyor belts or loaders. As the concentrate is highly prized, economic and environmental incentives will act to minimize spills. In the unlikely event of an accident along the highway en route to Stewart, the concentrate is not expected to travel far from the immediate area, since it is predicted to be fairly dry and heavy. Any spill would be immediately assessed and contained based on the SCERP.

7.9.4.4 Aerodrome Facility

Construction of the aerodrome and road crossing on the Porcupine River will result in minimal siltation to the river, and negligible habitat loss under the bridge pilings which will be partially offset by providing habitat heterogeneity around the pilings.

During operations, flight traffic could result in aerial deposition of dust to waterbodies, potentially affecting biota. To mitigate this risk, the airstrip will be situated away from the Porcupine River and nearby wetlands, thereby reducing the potential for effects.

Chemical spills could result in decreased productive capacity in the downstream Porcupine River, due to the high porosity of the floodplain substrate which would promote rapid groundwater transport of chemicals. Various mitigation measures of the SCERP and the Mine Plan, including the isolation of the airstrip away from waterbodies, collection and recycling of used de-icing fluid, and use of a concrete apron for a fueling station will act to minimize the risk of fuel or de-icing fluid spills to the ground or waterways. No effects to aquatic biota are expected in relation to chemical spills at the aerodrome facility.

7.9.5 Significance of Residual Adverse Effects

No significant adverse residual effects to aquatic resources were associated with mine project activities or components (Table 7.9-2). Five adverse effects were identified:

- habitat loss and mortality within Galore Creek due to open mine pits and storage areas,
- habitat loss associated with the diversion of tributaries in upper Galore Creek,
- effluent discharge causing toxicity to biota in lower Galore Creek,
- slope failures along the access road causing mortality and habitat alteration.
- filter plant effluent discharge causing toxicity to biota in localized area downstream of diffuser in Iskut River.

Based on the magnitude, geographic extent and duration of potential effects, none of the above issues were predicted to have a significant adverse effect to aquatic resources (Table 7.9-3).

The loss and alteration of the majority of aquatic habitat to benthos and algae is the single largest effect predicted from this assessment. On a local scale (within the Galore Creek watershed), this effect will be significant, as a major reduction in productivity within the drainage area will occur. However, effects focused within the Galore Creek watershed were not deemed to have far-reaching effects in terms of regional productivity or biodiversity of benthos or algae. This is because the habitat within Galore Creek is not unique to the region, nor are the aquatic organisms that reside within it. Furthermore, the habitat is of typically low productivity as seen within the other study watersheds of the area. Effects within Galore Creek will not reduce productivity within the Scud River or elsewhere. Therefore, the loss of this habitat was not judged to be significant.

Regarding scheduled activities, the discharge of tailings effluent and filter plant effluent are both judged to have negligible potential for effects to downstream aquatic resources, based on best available scientific data on the predicted water quality of effluents. Any effects of tailings effluent to lower Galore Creek will not extend to the Scud River, largely due to the high dilution factor at the confluence of these waterbodies.

Construction activities will require the monitoring and management of surface waters to safeguard against any increased loadings of TSS to the downstream environment. Therefore, no residual adverse effects to sediment quality are related to scheduled discharges or construction activities of the Galore Creek Project.

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Discharge of treated filter plant effluent into the Iskut River using the diffuser will minimize the area of mixing, thereby minimizing the zone in which aquatic biota may experience toxic effects. Based on the small size of the effluent plume relative to the size and flow of the Iskut River, the effects will be low in magnitude and the extent of effects will be local (less than 200m below diffuser). No effects would extend beyond the Iskut-More confluence, therefore no effects to the Stikine River are related to filter plant effluent discharge.

Finally, the potential for landslides was assessed along the access road and within the Galore Creek Valley in 2005 by BGC. Associated risks will be managed by proper road design, road monitoring and by choosing a route that avoids high risk zones wherever possible. This includes adequate water management and slope stabilization measures which will reduce the potential for catastrophic erosion events. Slopes will be seeded to encourage revegetation which will increase stability and help absorb surface runoff, reducing erosion. Any landslide would be limited in geographic extent to a localized area and therefore effects to aquatic resources of the region were not judged to be significant.

7.10 Fish and Fish Habitat Effects Assessment

7.10.1 Introduction

Many fish species serve an important role in the ecological, economic and cultural health of British Columbia and neighbouring Alaska. Salmonid species in particular are captured for food and sport, supporting local economies and cultures, while other species may be used as indicators of environmental health and water quality. The Galore Creek Project has the potential to adversely affect local populations of several species of fish and their habitats, within what is currently a relatively pristine environment.

This chapter will assess the predicted potential impacts of the project on four fisheries VECs (Valued Ecosystem Components) and their habitats, and will determine if compensation will be required in order to achieve the least possible disruption of fish production. The fifth VEC assessed in this chapter is the Stikine River. The first sections of this chapter define spatial boundaries for the assessment, present the methodology used to assess effects on fisheries VECs, and present reviews of the life history and habitat requirements of each of the fisheries VECs. The following sections discuss the impacts of each mine component on the four main issues of concern for fish and fish habitat. Finally, the overall significance of residual adverse effects is discussed.

7.10.1.1 Effects Assessment Scope

The fisheries environmental effects assessment was designed to address the potential impacts of various mine components on fisheries VECs and their habitats. Project issues are identified in Section 6.8 of the Terms of Reference, and include:

- productive capacity of aquatic systems during all project phases;
- all creeks and rivers that may experience changes to fisheries resources, including, but not limited to the Galore Creek Valley, and streams associated with the road access and slurry pipeline corridor and the filter plant site;
- habitat loss or alteration, including aquatic vegetation and sensitive areas such as spawning grounds, nursery areas, winter refuges and migration corridors;
- any rare and/or sensitive species (including fish and amphibians) and habitat and COSEWIC/SARA-listed species;
- species of cultural, spiritual, or traditional use importance to First Nations (*e.g.* salmon);
- changes to the thermal regime of the aquatic environment;
- mortality (includes fishing);
- acoustic effects from blasting on fish and fish habitat in local aquatic systems along the access corridor;
- aquatic organisms and habitat;

- all creeks and rivers and associated food webs and water use potential that may be impacted by changes in water chemistry (suspended solids, nutrients, major ions, metals) due to runoff or discharges from the project;
- mitigation and/or compensation requirements (based on DFO's policy for the Management of Fish Habitat and the related principle of no net loss of the productive capacity of fish habitat); and
- physical and chemical changes to sediment quality.

Many of these issues overlap in terms of definition and scope. For the purposes of this report they were compiled into four categories for discussion: productive capacity of habitat (Section 7.10.2), habitat loss and alteration (Section 7.10.3), direct and indirect mortality (Section 7.10.4), and sublethal effects (Section 7.10.5).

7.10.1.2 Spatial Boundaries

The Galore Project Area in the context of fisheries assessment extends from Kadin Island near the mouth of the Stikine River in the south, to the Scud River, a tributary of the Stikine River, in the north, and from Highway 37 in the east to the Stikine River in the west. Streams, lakes, rivers, and wetlands were surveyed within these boundaries in 2004 and 2005 (Figure 7.10-1). The Stikine, Scud, Porcupine, Upper Iskut, More and Sphaler Creek watersheds were considered in this assessment. For the purposes of this report, the mine components (indicated by letters) were combined so that impacts that may affect more than one VEC in the same way and in the same area could be described. Six "component groups" are discussed in terms of potential impacts on fishery resources (Figure 7.10-2).

- Mine Area – includes the open pit mine (A), processing plant (B), ore storage (E), operations camp (H), explosives storage and manufacturing facility (I), and borrow pits and topsoil storage (F). The area encompassed by this component group includes the upper Galore Valley upstream of the junction of East and West Fork;
- Mill Tailings and Waste Rock Facility – includes the tailings dam, seepage dam, and impoundment area (C). This area includes the mainstem of Galore Creek from the lowermost seepage dam to the predicted upstream extent of the waste rock facility at mine closure.
- Site Runoff and Diversion Channel – includes the proposed diversion channel, which will run along the east side of the Galore Valley and discharge water into Galore Creek below the lowermost seepage dam (D).
- Access Corridor – includes the proposed road (J), powerline (K), pipelines (L), and construction camps (G). The areas assessed under this component group include the mainstems of the Iskut River, and More, Sphaler, and Scotsimpson Creeks, as well as all of the tributaries, wetlands, and lake crossings in close proximity to the access corridor.

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- Porcupine Aerodrome – includes the Porcupine airstrip and access road (P). The area assessed under this component group includes the mainstem of the Porcupine River, outwash lake, floodplain and associated wetlands.
- Filter Plant – includes the site of the filter plant (M), the effluent outfall on the Iskut River (N), and streams along the transportation corridor to Stewart (O). The area assessed under this component group includes the Iskut River downstream of the proposed discharge, streams in close proximity to the filter plant site, and waterbodies along Highway 37 where the ore concentrate will be trucked to Stewart.

7.10.1.3 Methodology

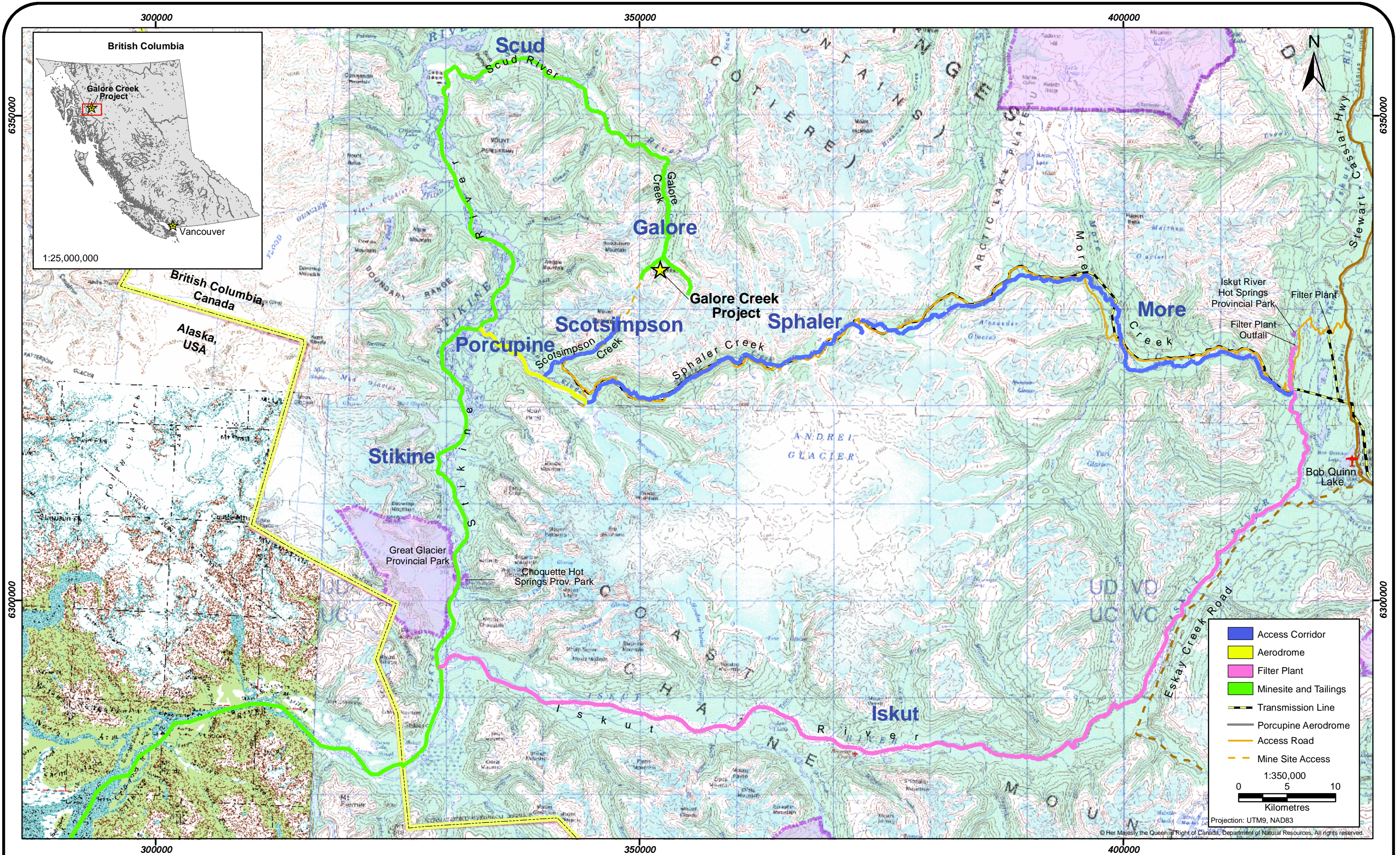
Process

The assessment of potential impacts of the Galore Creek Project on fisheries VECs was broken down into three main steps:

1. Effects screening: each mine component was assessed at a very general level to determine which mine components have the potential to affect fisheries VECs. The results of the screening are presented in Tables 7.10-1 to 7.10-5.
2. Issue scoping: for each fisheries VEC, issues arising from the construction, operation, or decommissioning of each mine component were assessed. Detailed results of the issues scoping are discussed in Section 7.10.2 to 7.10.5.
3. Residual Impact Analysis: Mine components with the potential to have a residual post-mitigation environmental effect were assessed to determine the significance of the lasting effect. Details of the residual impact analysis are discussed in Section 7.10.6 and presented in Table 7.10-8 of this report.

Definitions

The overall significance of a pre-mitigation impact was analysed by determining the magnitude, geographic extent, duration, and frequency of each effect along with the VECs ability to recover from the effect and probability of the effect occurring. Because many of the mine components could affect different fisheries VECs in several different ways, sub-components were addressed individually. For example, the open pit mine may result in sedimentation, tremor effects, and loss of habitat. Each of these “sub-components” has a different magnitude, duration, and/or geographic extent; thus, they were assessed separately. Table 7.10-6 presents definitions used for the issue scoping and residual impact analysis. Highlighted cells indicate that the definitions differ from other sections of Environmental Assessment.



Fisheries Effect Assessment Boundaries for the Galore Creek Project

FIGURE 7.10-1

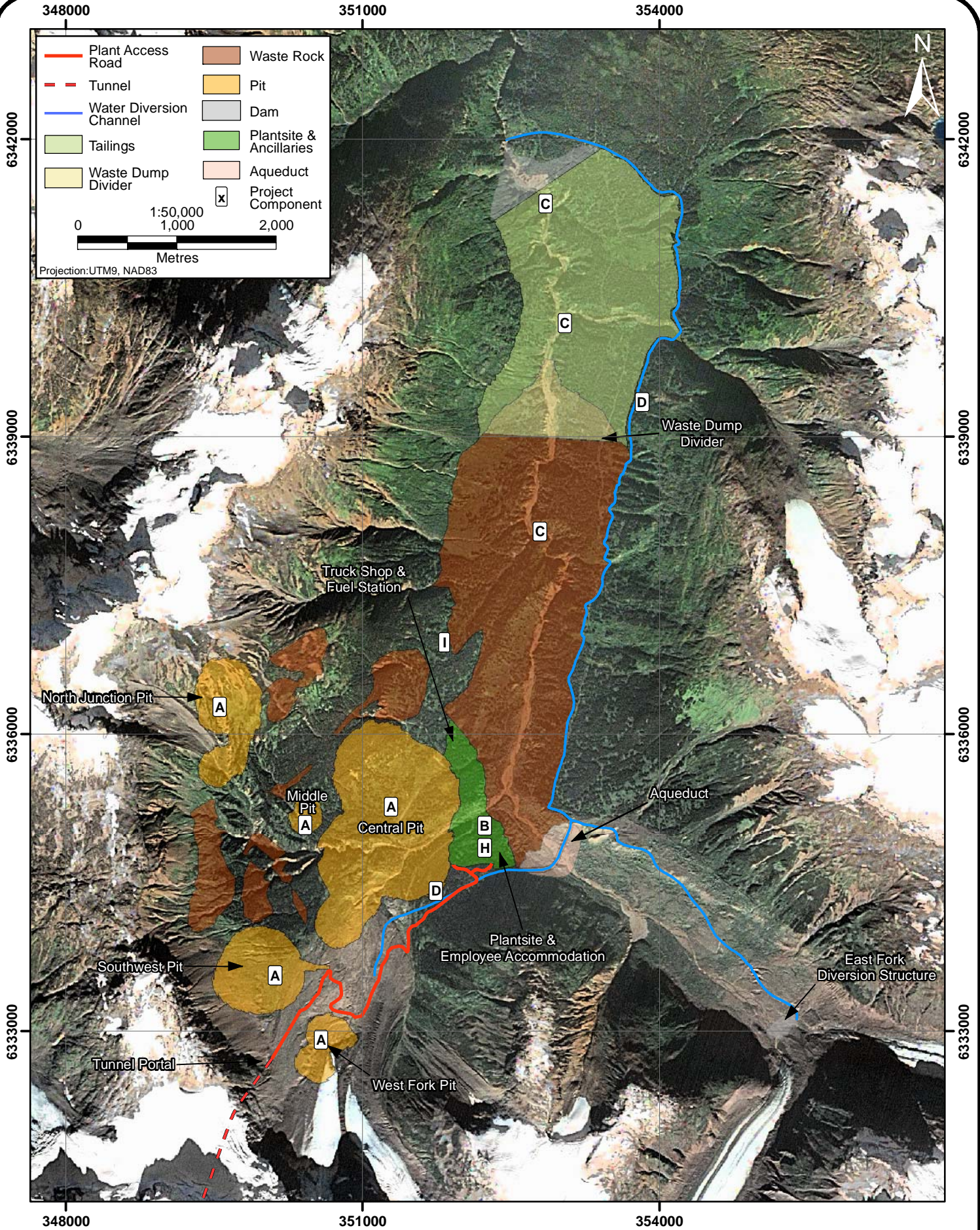


FIGURE 7.10-2

Location of Project Components

**Table 7.10-1
Potential Effects of Mine Components on Dolly Varden Char (*Salvelinus malma*)**

Mine Component (from Project Scope Outlined in TOR)	Productive Capacity of Aquatic Systems			Habitat Loss/Alteration		Mortality		Sublethal Effects		
	Streams/ Rivers	Wetlands	Lakes	Habitat	Habitat	Direct	Indirect	Tremor Effects from Blasting/Pile Driving	Habitat Avoidance	Fish Health Effects
				Loss	Degradation					
A Open pit mine located in Galore Creek Valley	X			X	X			X		
B Process plant located in Galore Creek Valley	X				X					
C Mill tailings and waste rock storage facilities including containment dam and haul roads	X			X	X	X	X	X	X	X
D Site runoff, diversion and sediment control	X			X	X		X		X	X
E Ore and marginal ore storage	X			X	X					
F Mine borrow pits and overburden and topsoil storage	X				X					
G Construction camps, including ancillary facilities	X				X					
H Operations camp, including ancillary facilities	X				X					
I Explosives manufacturing and storage plant	X									
J Access road from Highway 37 to mine site, including borrow pits and staging areas	X	X	X	X	X	X	X	X	X	
K Transmission line from Highway 37 to mine site	X				X					
L Buried ore concentrate slurry and diesel pipelines	X				X	X	X		X	X
M Filter plant, ore concentrate stockpile, truck loadout facility (Bob Quinn)	X				X					
N Filter plant outfall	X				X		X		X	X
O Transportation of concentrate from the filter plant along Highway 37 to Stewart	X	X	X		X		X		X	X
P Aerodrome along Porcupine River and its access road	X				X		X		X	X
Q Heliport in More Creek Valley near Round Lake	X				X					

**Table 7.10-2
Potential Effects of Mine Components on Bull Trout (*Salvelinus confluentus*)**

Mine Component (from Project Scope Outlined in TOR)	Productive Capacity of			Habitat Loss/Alteration		Mortality		Sublethal Effects		
	Aquatic Systems			Habitat	Habitat	Direct	Indirect	Tremor Effects from Blasting/Pile Driving	Habitat Avoidance	Fish Health Effects
	Streams/ Rivers	Wetlands	Lakes	Loss	Degradation					
A Open pit mine located in Galore Creek Valley	X			X	X	X				
B Process plant located in Galore Creek Valley	X				X					
C Mill tailings and waste rock storage facilities including containment dam and haul roads	X			X	X	X	X	X	X	X
D Site runoff, diversion and sediment control	X			X	X			X	X	X
E Ore and marginal ore storage	X			X	X					
F Mine borrow pits and overburden and topsoil storage	X				X					
G Construction camps, including ancillary facilities	X				X					
H Operations camp, including ancillary facilities	X				X					
I Explosives manufacturing and storage plant	X									
J Access road from Highway 37 to mine site, including borrow pits and staging areas	X	X	X	X	X	X	X	X	X	
K Transmission line from Highway 37 to mine site	X				X					
L Buried ore concentrate slurry and diesel pipelines	X				X		X	X	X	X
M Filter plant, ore concentrate stockpile, truck loadout facility (Bob Quinn)	X				X					
N Filter plant outfall	X				X			X	X	X
O Transportation of concentrate from the filter plant along Highway 37 to Stewart	X	X	X		X			X	X	X
P Aerodrome along Porcupine River and its access road	X				X		X	X	X	X
Q Heliport in More Creek Valley near Round Lake	X				X					

**Table 7.10-4
Potential Effects of Mine Components on Other Fish Species**

Mine Component (from Project Scope Outlined in TOR)	Productive Capacity of			Habitat Loss/Alteration		Mortality		Sublethal Effects		
	Aquatic Systems			Habitat	Habitat	Direct	Indirect	Tremor Effects from Blasting/Pile Driving	Habitat Avoidance	Fish Health Effects
	Streams/ Rivers	Wetlands	Lakes	Loss	Degradation					
A Open pit mine located in Galore Creek Valley	X			X	X	X				
B Process plant located in Galore Creek Valley	X				X					
C Mill tailings and waste rock storage facilities including containment dam and haul roads	X			X	X	X	X	X	X	X
D Site runoff, diversion and sediment control	X			X	X			X	X	X
E Ore and marginal ore storage	X			X	X					
F Mine borrow pits and overburden and topsoil storage	X				X					
G Construction camps, including ancillary facilities	X				X					
H Operations camp, including ancillary facilities	X				X					
I Explosives manufacturing and storage plant	X									
J Access road from Highway 37 to mine site, including borrow pits and staging areas	X	X	X	X	X	X	X	X	X	
K Transmission line from Highway 37 to mine site	X				X					
L Buried ore concentrate slurry and diesel pipelines	X				X		X	X	X	X
M Filter plant, ore concentrate stockpile, truck loadout facility (Bob Quinn)	X				X					
N Filter plant outfall	X				X			X	X	X
O Transportation of concentrate from the filter plant along Highway 37 to Stewart	X	X	X		X			X	X	X
P Aerodrome along Porcupine River and its access road	X				X		X	X	X	X
Q Heliport in More Creek Valley near Round Lake	X				X					

**Table 7.10-5
Potential Effects of Mine Components on the Stikine River**

Mine Component (from Project Scope Outlined in TOR)	Productive Capacity of			Habitat Loss/Alteration	
	Streams/ Rivers	Wetlands	Lakes	Habitat Loss	Habitat Degradation
A Open pit mine located in Galore Creek Valley					
B Process plant located in Galore Creek Valley					
C Mill tailings and waste rock storage facilities including containment dam and haul roads	X	X		X	X
D Site runoff, diversion and sediment control					
E Ore and marginal ore storage					
F Mine borrow pits and overburden and topsoil storage					
G Construction camps, including ancillary facilities					
H Operations camp, including ancillary facilities					
I Explosives manufacturing and storage plant					
J Access road from Highway 37 to mine site, including borrow pits and staging areas					
K Transmission line from Highway 37 to mine site					
L Buried ore concentrate slurry and diesel pipelines					
M Filter plant, ore concentrate stockpile, truck loadout facility (Bob Quinn)					
N Filter plant outfall					
O Transportation of concentrate from the filter plant along Highway 37 to Stewart					
P Aerodrome along Porcupine River and its access road					
Q Heliport in More Creek Valley near Round Lake					

**Table 7.10-6
Descriptor Definitions for the Fish and Fish Habitat Effects
Assessment**

Criteria	Descriptor Definitions			
Mine Phases	Construction Phase: Effect begins during pre-construction and/or construction phases	Operation Phase: Effect begins during mine operation phase	Decommissioning and Closure Phase: Effect begins in the mine decommissioning phase	Post Closure Phase: Effect begins after mine closure (e.g., ARD)
Duration of Impact	Short Term: Effect lasts < 1 month; exact duration defined in text	Medium Term: Effect lasts 1 month to 2 years	Long Term: Effect lasts 2 to 20 years (<i>i.e.</i> , approximate life of mine operations)	Far Future: Effect lasts more than 20 years
Geographic Extent	Local: Effect is limited to the immediate project footprint (<i>i.e.</i> , Mine Site, Aerodrome Facility, Filter Plant and Access Corridor)	Landscape: Effect is limited to the watershed boundaries (<i>i.e.</i> , 2 watersheds)	Regional: Effect is limited to the Cassiar Iskut-Stikine Land and Resource Management Plan (LRMP) boundary	Trans-Boundary: Effect extends beyond the boundary of the Cassiar-Stikine LRMP (<i>i.e.</i> , Alaska)
Direction	Positive: Effect creates conditions that are improved relative to baseline conditions	Neutral: Effect creates conditions that are neither better nor worse relative to baseline conditions	Adverse: Effect creates conditions that are less desirable relative to baseline conditions	
Magnitude	Negligible: No detectable change from baseline conditions	Low: Differs from the average value for baseline conditions, but within the range of natural variation and well below a guideline or threshold value	Moderate: Differs from the average value for baseline conditions, approaches the limits of natural variation, but below or equal to a guideline or threshold value	High: Predicted to differ from baseline conditions or a guideline or threshold value so that there will be a detectable change beyond the range of natural variation (<i>i.e.</i> , change of state from baseline conditions)
Frequency	One Time: Effect is confined to one discrete period in time during the life of the project and potentially beyond the life span of the project	Periodic: Effect occurs intermittently but repeatedly over the life span of the project and potentially beyond the life span of the project	Continuous: Effect occurs constantly during the life of the project and potentially beyond the life span of the project	
Resilience	Resilient Short-Term: VEC will recover within 1 generation	Resilient Long-Term: VEC will recover in >1 generation	Not Resilient: VEC cannot recover	
Probability of Impact Occurring	Nil: An effect has no probability of occurring	Low: An effect is unlikely but could occur	Moderate: An effect is likely but may not occur	High: An effect will occur

Note: Highlighted definitions are different than definitions for entire Environmental Assessment.

7.10.1.4 Valued Ecosystem Component Background

Introduction

As discussed in Section 4.11, the Valued Ecosystem Components (VECs) for fisheries in the Galore Creek Project area were identified as:

- Dolly Varden (*Salvelinus malma*), the most widespread fish species in the area and blue-listed in British Columbia;
- bull trout (*Salvelinus confluentus*), a closely related species that is blue-listed and globally threatened;
- Pacific salmon (*Oncorhynchus spp.*) species, especially sockeye and coho salmon, which occur in the Porcupine River;
- “other fish species”, including rainbow trout (*O. mykiss*), mountain whitefish (*Prosopium williamsoni*), longnose sucker (*Catostomus catostomus*) and threespine stickleback (*Gasterosteus aculeatus*); and
- the Stikine River, a culturally and economically valuable river supporting several populations of Pacific salmon as well as wildlife and human populations.

The following table provides a summary of the life history and habitat requirements of each of the VEC species, and provides background on the importance of the Stikine River. This information was used to conduct the Effects Assessment.

7.10.2 Productive Capacity of Habitat

7.10.2.1 Introduction

Fish habitat is protected under the federal *Fisheries Act*, which prohibits the harmful alteration, disruption, or destruction (HADD) of habitat that is used either directly or indirectly by fish for any part of their life cycle (Fisheries and Oceans Canada, 1985). Additional federal policies promote a net gain of fish habitat through the principle of “no net loss of productive capacity” (Fisheries and Oceans Canada, 1991). The productive capacity of fish habitat is defined as “the maximum natural capability of habitats to produce healthy fish, safe for human consumption, or to support or produce aquatic organisms upon which fish depend” (Fisheries and Oceans Canada, 1991). Productive capacity may be altered by physical or chemical changes to fish habitat, or by direct loss of fish habitat. Scoping of effects of mine components on the productive capacity of fish habitat is presented in Table 7.10-7.

7.10.2.2 Mine Area

General

Habitat in the upper Galore Valley where the open pit mine, processing facility, borrow pits, topsoil storage and ore stockpile will be located, could be classified as fish-habitat due to its ability to support the production of aquatic invertebrates that could be used as a food source further downstream in the system. However, the distance separating the mine area in upper Galore Creek from the fish-bearing reach at the mouth of the creek is so great that invertebrates produced near the mine site are not likely to drift far enough in a generation to influence fish food availability downstream. Many invertebrates drift actively, settling back to the substrate several meters downstream of their origin (Brittain and Eikeland, 1988). Rate of drift dispersal can exceed 100 m/d, and certain invertebrates, mainly species of baetid mayflies, may drift up to 10 km in a generation (Hemsworth and Brooker, 1979).

The mine area in which productive capacity will be altered is located 10 to 14 km upstream of the nearest fish-bearing reach of the streams. Thus, streams around the mine site are not considered to be fish habitat, and the loss of productivity resulting from sedimentation, habitat loss, and nitrate toxicity in those streams will not impact any fisheries VECs in Galore Creek or the Scud River.

There is a small potential for the deposition of nitrates and sulphates from dust in the air to affect fish and fish habitat in Galore Creek. Concentrations of these compounds are predicted to be between 20 and 2,000 times lower than baseline concentrations (see Section 7.6.2.3), thus, effects on the productive capacity of habitat will be negligible.

7.10.2.3 Mill Tailings and Waste Rock Facility

General

The proposed tailings management area will include a main dam and impoundment area in upper Galore Creek. Several authors have documented decreases in secondary productivity downstream of hydroelectric dams due to alterations in flow regime, sediment transport, and water temperature (Baxter, 1977; Rosenberg *et al.*, 1997). Dams block the export of coarse particulate organic matter (CPOM), and sediment to downstream areas while artificially warming stream water. Pulses of release water generally have a higher volume than normal flows and may cause bank erosion and bed scour downstream, while low flows are lower than normal and may cause mortality among stream invertebrates (an important food source for fish) and fish eggs when parts of the downstream river are dewatered (Baxter, 1977). Construction of the tailings impoundment will result in a loss of aquatic habitat in Galore Creek and its tributaries directly beneath and upstream of the structure as the stream is dammed and the reservoir filled. This may adversely affect the productive capacity of the downstream reaches by cutting off the export allochthonous materials from the upper Galore Valley; however, the effect will be limited by the construction of a diversion channel that will funnel water from almost 70% of the watershed back into Galore Creek below the dam. Construction of temporary containment dams, access roads and sediment control dams will also result in an increase in sediment production in Galore Creek. Temporary containment dams will aid in settling out sediment before water is released downstream, while much of the construction sedimentation will be controlled and limited via sediment control and erosion plans (Section 8.10).

During operation of the mine, tailings decant water will be discharged into Galore Creek each year during freshet. These discharges are expected to increase the concentrations of a selection of metals and nutrients in Galore Creek and the Scud River, and are therefore planned for high-flow periods when dilution from snow melt and rainwater will assist in mitigating the potential impacts of metal and nutrient toxicity.

Hazard quotients, which estimate the magnitude of proposed changes in water quality relative to baseline concentrations, have been calculated for metals, anions and nutrients in the tailings water (see Sections 7.6 and 7.9). Two contaminants, sulphate and molybdenum, had hazard quotients greater than 1. At the mouth of Galore Creek, sulphate is predicted to have the highest hazard quotient with average concentrations up to 2.4 times higher than baseline conditions.

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Little is known about the toxicity of sulphate to aquatic life (Rescan, 2004). Provincial guidelines of 100 mg SO₄²⁻/L may be overly cautious (see Section 7.9). A review of available literature found that the lowest concentration of sulphate reported to cause acute toxicity was 446 mg/L (in mayflies), while the lowest concentration to produce species-specific chronic toxicity was 775 mg/L, with water hardness affecting the overall toxicity of sulphate to aquatic organisms (Rescan, 2004). Modelling of predicted worst-case scenarios at the Galore Creek Project has predicted maximum sulphate concentrations of less than 250 mg/L at the mouth of Galore Creek; thus, sulphate toxicity is predicted to have minimal effects on the productive capacity of Galore Creek downstream of the dam.

Aquatic organisms are generally fairly resistant to the effects of molybdenum toxicity. Adverse effects on survival and growth of aquatic invertebrates have been shown at >60 mg/L and >1,000 mg/L, respectively (Eisler, 1989). Predicted concentrations during mine operations, at less than 0.02 mg/L, are considerably lower than these levels, and will not exceed CCME guidelines; therefore, no effects on productive capacity are expected as a result of molybdenum toxicity.

Other variables that are predicted to have high hazard quotients include fluoride, zinc, cadmium, selenium, ammonia, nitrate, and antimony; however, the hazard quotients for these variables are based on baseline concentrations that are very close to the detection limit. This introduces more uncertainty into the assessment since average baseline conditions that approach the detection limit likely include several instances of “non-detects” where concentrations during certain months were too low to be detected, and were therefore replaced with an arbitrary value of half of the detection limit. This has the effect of artificially lowering the baseline concentration and artificially inflating the hazard quotient.

While some metals are not predicted to have effects on their own, some metals have an additive, or synergistic, effect when combined in aqueous solution. Waterborne solutions of zinc-cadmium mixtures have been found to be additive in toxicity to aquatic organisms, including freshwater fish, amphipods, marine fish, and copepods (Eisler, 1993). Similarly, mixtures of copper and zinc are generally acknowledged to be more-than-additive in toxicity to a wide variety of aquatic organisms (Eisler, 1998). There is a slight probability that combinations of these metals, even though they are not predicted to have significant impacts on the productive capacity of aquatic habitat on their own, may combine to affect productivity downstream of the mine; however, these effects have not been modelled.

Residues from blasting near the dam may also result in increased nitrate concentrations downstream. Sublethal effects of nitrate toxicity have been observed in fish species at concentrations of 6.3 mg/L (McGurk, *et al.*, 2006). Early life stages of some invertebrates may experience increased mortality and decreased growth at very high concentrations (Camargo *et al.*, 2005). The effects of nitrate toxicity due to blasting will likely be negligible and short-term in nature, because blasting residues would end up in the tailings pond before being discharged.

During mine operation and decommissioning, the integrity of the tailings dam will be of importance. A tailings dam failure would result in a very large pulse of water travelling downstream. The force of the water may result in the destruction or alteration of habitat for

**Table 7.10-7
Effects Assessment of Productive Capacity of Fish Habitat**

VEC	Mine Component	Summary of Effect	Phase	Duration	Direction	Magnitude	Geographic Extent	Resilience	Frequency	Probability of Occurrence	Level of Confidence	Proposed Mitigation	Residual Adverse Effects (i.e. adverse effects remaining after mitigation)	Potential for Residual Adverse Effect to be Significant	
Bull Trout	A - Open pit mine located in Galore Creek Valley	Suspended sediments from in-stream construction entering Galore Creek	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	High	High	Sediment and erosion control plan, site isolation, settling pond and diversion	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible	
	B - Process plant located in Galore Creek Valley	Suspended sediments from in-stream construction entering Galore Creek	Construction	Medium term	Adverse	Negligible	Landscape	Resilient short-term	Periodic	High	High	Sediment and erosion control plan, site isolation, settling pond and diversion	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible	
	C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Direct habitat loss (food production) from construction of rock dam on Galore Creek	Construction	Far future	Adverse	Low	Local	Not Resilient	One time	High	High	Diversion channel will maintain nutrient and organic matter transport.	Permanent removal of habitat, with compensation elsewhere; however habitat is not high quality or necessary for fish	Negligible	
			Suspended sediments from in-stream construction entering Galore Creek	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	High	High	Sediment and erosion control plan, site isolation, settling pond and diversion	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	D - Site runoff, diversion and sediment control	Suspended sediments from in-stream construction entering Galore Creek	Construction	Medium term	Adverse	Moderate	Landscape	Resilient short-term	Periodic	Moderate	High	Sediment and erosion control plan, site isolation, settling pond and diversion	Increased turbidity in Galore Creek downstream of dam	Negligible	
	G - Construction camps, including ancillary facilities	Sewage entering surrounding rivers	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Continuous	Low	Moderate	Water treatment, sewage flow into tile field	Increased nutrients	Negligible	
			Suspended sediments from in-stream construction entering streams and rivers	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	High	High	Sediment and erosion control plan, site isolation, settling pond and diversion	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	H - Operations camp, including ancillary facilities	Suspended sediments from in-stream construction entering Galore Creek	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	High	High	Sediment and erosion control plan, site isolation, settling pond and diversion	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible	
	J - Access road from Highway 37 to mine site, including borrow pits and staging areas	Alteration of streambed with rip rap	Construction	Long term	Adverse	Low	Local	Resilient short-term	One time	High	High	Sediment/erosion control plan, habitat compensation	Alteration to substrate will exist for the life of the road, but will be of limited extent and impact	Negligible	
			Sedimentation from in-stream construction	Construction	Short term	Adverse	Low	Local	Resilient short-term	Periodic	Moderate	High	Sedimentation/erosion plans, hydroseeding	Some sedimentation likely, but high magnitude impacts would be limited in duration and extent	Negligible
			Alteration of habitat at bridge pilings	Construction	Far future	Adverse	Low	Local	Not Resilient	One time	High	High	Compensatory habitat creation, pillings may increase cover/shelter for fish	Permanent loss of habitat in piling footprint	Negligible
	L - Buried ore concentrate slurry and diesel pipelines	Sedimentation from ditch-digging, boring under streams	Construction	Medium term	Adverse	Low	Local	Resilient short-term	Periodic	Moderate	Moderate	Compact soil around pipe	Minor, if any, sedimentation in streams	Negligible	
	M - Filter plant, ore concentrate stockpile, truck load out facility (Bob Quinn)	Sedimentation from site runoff entering streams	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	Moderate	High	Sediment/erosion control plan; however, filter plant located well back from streams	Minor sedimentation in streams	Negligible	
	N - Filter plant effluent	Sedimentation from in-stream construction entering Iskut River	Construction	Short term	Adverse	Low	Local	Resilient short-term	One time	High	High	Sediment/erosion control plan	Minor sedimentation in the Iskut River during construction	Negligible	
	P - Airstrip along Porcupine River and its access road	Direct loss of habitat on Porcupine Floodplain (if floodplain is classified as habitat)	Construction	Far future	Adverse	Low	Landscape	Not Resilient	One time	Moderate	Low	Compensatory habitat creation, locate airstrip away from fish habitat	Loss of very low value food production habitat on floodplain (only flooded on rare occasions).	Negligible	
	Q - Heavy lift airstrip/heliport in More Valley near Round Lake	Soil compaction at site leading to sedimentation in surrounding streams	Construction	Long term	Adverse	Low	Local	Resilient short-term	Periodic	Low	Moderate	Sediment/erosion control plan	Minor, if any, sedimentation in streams	Negligible	
	I - Explosives manufacturing and storage plant	Explosives residues, leachate entering streams around construction sites	Construction	Long term	Adverse	Low	Local	Resilient short-term	Periodic	Low	Moderate	Explosives storage shed, contaminated water into tailings, non-corrosive silos, maintenance of bag houses, concrete apron	Possible low-level contamination of water in tailings facility	Negligible	
	A - Open pit mine located in Galore Creek Valley	Deposition of airborne dust and explosives residues into Galore Creek	Operations	Medium term	Adverse	Low	Local	Resilient short-term	Periodic	Low	Moderate	Concentrations will be much lower than baseline; therefore, none planned.	None	Negligible	
	C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Scheduled effluent discharge over the dam	Operations	Long term	Adverse	Low	Landscape	Resilient long-term	Periodic	High	High	Compensatory habitat creation, schedule discharge at high flows	Decrease in productive capacity of Galore Creek	Considerable	
		Unscheduled effluent release from dam	Operations	Medium term	Adverse	Moderate	Regional	Resilient short-term	One time	Low	High	Monitoring	Decrease in productive capacity of Galore Creek and Scud River	Negligible	
		Higher peak flow and lower low flow due to scheduled water release from dam	Operations	Long term	Adverse	Low	Landscape	Resilient short-term	Periodic	Moderate	Moderate	None	Increased peak flow, decreased low flow in Galore Creek may alter productive capacity of certain habitats	Negligible	
	D - Site runoff, diversion and sediment control	ML/ARD from diversion channel	Operations	Long term	Adverse	Low to Moderate	Landscape	Resilient long-term	Continuous	Unknown	Low	diversion of water back into tailings after mine closure, rock chemistry analysis	Potential for decrease productive capacity within and downstream of diversion channel	Negligible	
	E - Ore and marginal ore storage	Leachate from ore	Operations	Long-term	Adverse	Low	Local	Resilient long-term	Periodic	Moderate	Moderate	All runoff will enter tailings impoundment	Water will flow into waste rock facility and will not impact downstream reaches of Galore Creek	Negligible	
	F - Mine borrow pits, overburden and topsoil storage	ML/ARD from borrow pits, erosion from topsoil	Operations	Long term	Adverse	Low	Local	Resilient long-term	Periodic	Moderate	Moderate	All runoff will enter tailings impoundment	Water will flow into waste rock facility and will not impact downstream reaches of Galore Creek	Negligible	
	H - Operations camp, including ancillary facilities	Sewage entering surrounding rivers	Operations	Long term	Adverse	Low	Local	Resilient short-term	Continuous	Low	Moderate	Water treatment	Increased nutrients, eutrophication, decreased productive capacity	Negligible	
	J - Access road from Highway 37 to mine site, including borrow pits and staging areas	Slope failure due to concentration of water on slopes	Operations	Long term	Adverse	Moderate	Landscape	Resilient long-term	One time	Low	High	Slope engineering, culvert design	Long-term loss of habitat at site, with compensation elsewhere	Negligible	
		ML/ARD from highwalls, tunnel, and rock cuts	Operations	Long term	Adverse	Low to Moderate	Landscape	Resilient long-term	Periodic	Moderate	Low	Management plan, dewatering cliff faces, liming runoff, proper disposal of PAG	Slight potential for ML/ARD	Negligible	
		Sedimentation from road runoff	Operations	Long term	Adverse	Low	Local	Resilient short-term	Periodic	Moderate	Moderate	Sediment and erosion control plan	Minor sedimentation in streams	Negligible	
	L - Buried ore concentrate slurry and diesel pipelines	Rupture of diesel pipeline	Operations	Medium term	Adverse	Negligible	Landscape	Resilient short-term	One time	Low	High	Pipeline engineering, pressure sensors, spill management plan	Decreased productive capacity in streams along access corridor	Negligible	
		Rupture of slurry pipeline	Operations	Medium term	Adverse	Moderate	Landscape	Resilient short-term	One time	Low	High	Pipeline engineering, "backwash" tank at Porcupine, pressure sensors, spill management plan	Decreased productive capacity in streams along access corridor	Negligible	
	M - Filter plant, ore concentrate stockpile, truck load out facility (Bob Quinn)	Spills of concentrate/chemicals	Operations	Medium term	Adverse	Low	Local	Resilient short-term	Periodic	Low	Moderate	Spill management plan, immediate clean-up, storage away from streams	Decreased productivity in adjacent waterbodies	Negligible	
	N - Filter plant effluent	Discharge of contaminated water into Iskut River	Operations	Long-term	Adverse	Low	Local	Resilient short-term	Continuous	High	High	Water treatment facility	Potential increase in metals	Negligible	
O - Transportation of concentrate from the filter plant along Highway 37 to Stewart	Concentrate dust settling in fish habitat along route	Operations	Long-term	Adverse	Low	Local	Resilient short-term	Periodic	Low	High	Covers on ore trucks, solidifying agents	Potential increase in TSS	Negligible		
	Accidental spill of concentrate near fish habitat	Operations	Short term	Adverse	Moderate	Local	Resilient short-term	One time	Low	High	Speed limits, traffic safety	Contamination of fish habitat/tissues, decreased wq/sq, direct mortality of fish, decreased productive capacity of habitat	Negligible		
P - Airstrip along Porcupine River and its access road	Contamination from de-icing agents, fuel spills	Operations	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	Moderate	Moderate	Contained de-icing area, collection and recycling of deicing agents	Possible contamination of groundwater, hyporheic zone, side channels	Negligible		
C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Dam rupture	Operations/ Decommissioning	Far future	Adverse	High	Transboundary	Not Resilient	One time	Nil/Low	High	Overconstruction of tailings dam	Large scale contamination of all waterbodies downstream of dam, large scale mortality, habitat loss, productive capacity	Negligible		
C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Continuous effluent discharge over the dam	Decommissioning/ Closure	Far future	Adverse	Negligible to Low	Landscape	Resilient long-term	Continuous	High	High	Compensatory habitat creation, possible water treatment?	Decrease in productive capacity of Galore Creek sublethal effects on fish in both rivers	Negligible		
D - Site runoff, diversion and sediment control	Breaching diversion channel	Decommissioning/ Closure	Far future	Adverse	Low	Local	Not Resilient	One time	High	High	None	Loss of food production habitat in Galore Creek	Negligible		
J - Access road from Highway 37 to mine site, including borrow pits and staging areas	Sedimentation from bridge/crossing removal	Decommissioning/ Closure	Short term	Adverse	Low	Local	Resilient short-term	One time	Moderate	Moderate	Sediment and erosion control plan	Minor sedimentation in streams	Negligible		

(continued)

**Table 7.10-7
Effects Assessment of Productive Capacity of Fish Habitat (continued)**

VEC	Mine Component	Summary of Effect	Phase	Duration	Direction	Magnitude	Geographic Extent	Resilience	Frequency	Probability of Occurrence	Level of Confidence	Proposed Mitigation	Residual Adverse Effects (i.e. adverse effects remaining after mitigation)	Potential for Residual Adverse Effect to be Significant
Dolly Varden	A - Open pit mine located in Galore Creek Valley	Suspended sediments from in-stream construction entering Galore Creek	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	High	High	Sediment and erosion control plan, site isolation, settling pond and diversion	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	B - Process plant located in Galore Creek Valley	Suspended sediments from construction runoff entering Galore Creek	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	High	High	Sediment/erosion control plan, site isolation, settling pond and diversion	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Direct habitat loss (food production) from construction of rock dam on Galore Creek	Construction	Far future	Adverse	Low	Local	Not Resilient	One time	High	High	Site rehabilitation	Permanent removal of habitat; however habitat is not high quality or necessary for fish	Negligible
		Sedimentation from in-stream construction of containment dam entering Galore Creek	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	High	High	Erosion/sediment control plan, settling ponds, coffer dams	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	D - Site runoff, diversion and sediment control	Sedimentation from in-stream construction entering Galore Creek	Construction	Medium term	Adverse	Moderate	Landscape	Resilient short-term	Periodic	Moderate	Moderate	Erosion/sediment control plan	Increased turbidity in Galore Creek downstream of dam during channel activation	Negligible
	G - Construction camps, including ancillary facilities	Sewage entering surrounding rivers	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Continuous	Low	Moderate	Water treatment, sewage flow into tailings	Increased nutrients, eutrophication, decreased productive capacity	Negligible
		Soil compaction at site leading to sedimentation in surrounding streams	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	High	High	Erosion/sediment control plan	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	H - Operations camp, including ancillary facilities	Soil compaction at site leading to sedimentation in surrounding streams	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	High	High	Erosion/sediment control plan	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	J - Access road from Highway 37 to mine site, including borrow pits and staging areas	Alteration of streambed with rip rap	Construction	Long term	Adverse	Low	Local	Resilient short-term	One time	High	High	Sediment/erosion control plan, habitat compensation, best management practices, restoration of site post-closure	Alteration to substrate will exist for the life of the road, but will be of limited extent and impact	Negligible
		Sedimentation from in-stream construction	Construction	Short term	Adverse	Low	Local	Resilient short-term	Periodic	Moderate	High	Sedimentation/erosion plans, hydroseeding, best management practices	Some sedimentation likely, but high magnitude events would be limited in duration and extent	Negligible
		Loss of productive capacity in wetlands	Construction	Long term	Adverse	Moderate	Local	Resilient long-term	One time	Moderate	Moderate	Compensatory habitat creation, rehabilitation	Loss of food production habitat in wetland 3	Considerable
		Alteration of habitat at bridge pilings	Construction	Long term	Adverse	Low	Local	Resilient short-term	One time	High	High	Compensatory habitat creation, pilings may increase cover/shelter for fish	Loss of habitat in piling footprint, may be reclaimed following closure	Negligible
	L - Buried ore concentrate slurry and diesel pipelines	Sedimentation from ditch-digging, tunnel boring under streams	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	Moderate	Moderate	Compact soil around pipe, sediment and erosion control plans, best management practices	Minor sedimentation	Negligible
	M - Filter plant, ore concentrate stockpile, truck load out facility (Bob Quinn)	Sedimentation from site runoff entering streams	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	Moderate	High	Sediment/erosion control plan; however, filter plant located well back from streams	Minor, if any, sedimentation in streams	Negligible
	N - Filter plant effluent	Sedimentation from in-stream construction entering Iskut River	Construction	Short term	Adverse	Low	Local	Resilient short-term	One time	High	High	Sediment/erosion control plan, site isolation, best management practices	Minor sedimentation when flow is restored after construction	Negligible
P - Airstrip along Porcupine River and its access road	Direct loss of habitat on Porcupine Floodplain (if floodplain is classified as habitat)	Construction	Far future	Adverse	Low	Landscape	Not Resilient	One time	Moderate	Low	Compensatory habitat creation, locate airstrip away from fish habitat	Loss of very minor food production habitat (only useful to fish during very large flood events)	Negligible	
Q - Heavy lift airstrip/heliport in More Valley near Round Lake	Soil compaction at site leading to sedimentation in surrounding streams	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	Moderate	Moderate	Sediment/erosion control plan	Minor sedimentation to More Creek	Negligible	
I - Explosives manufacturing and storage plant	explosives residues, leachate entering streams around construction sites	Construction/ Operations	Long term	Adverse	Low	Local	Resilient long-term	Continuous	Low	Moderate	Explosives storage shed, contaminated water into tailings, non-corrosive silos, maintenance of bag houses, concrete apron	Possible contamination before tailings dam built	Negligible	
A - Open pit mine located in Galore Creek Valley	Deposition of airborne dust and explosives residues into Galore Creek	Operations	Medium term	Adverse	Low	Local	Resilient short-term	Periodic	Low	Moderate	Concentrations will be much lower than baseline; therefore, none planned.	None	Negligible	
C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Scheduled effluent discharge over the dam	Operations	Long term	Adverse	Moderate	Landscape	Resilient long-term	Periodic	High	High	Schedule discharge at high flows, monitoring	Decrease in productive capacity of Galore Creek and possibly Scud River, sublethal effects on fish in both rivers, possible mortality of fish in Galore Creek	Considerable	
	Higher peak flow and lower low flow due to scheduled water release from dam	Operations	Long term	Adverse	Low	Landscape	Resilient short-term	Periodic	Moderate	Moderate	None	Increased peak flow, decreased low flow in Galore Creek may alter productive capacity of certain habitats	Negligible	
	Unscheduled effluent release from dam	Operations	Medium term	Adverse	Moderate	Regional	Resilient short-term	One time	Low	High	Monitoring	Decrease in productive capacity of Galore Creek and Scud River	Negligible	
D - Site runoff, diversion and sediment control	MLARD from rock channel	Operations	Long term	Adverse	Low to High	Landscape	Resilient long-term	Continuous	Unknown	Low	diversion of water back into tailings after mine closure, treatment	Potential for decrease productive capacity within and downstream of diversion channel	Negligible	
E - Ore and marginal ore storage	Leachate from ore	Operations	Long term	Adverse	Low	Local	Resilient long-term	Periodic	Moderate	Moderate	All runoff will enter tailings impoundment	Water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible	
F - Mine borrow pits, overburden and topsoil storage	MLARD from borrow pits, erosion from topsoil	Operations	Long term	Adverse	Low	Local	Resilient long-term	Periodic	Moderate	Moderate	All runoff will enter tailings impoundment	Water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible	
H - Operations camp, including ancillary facilities	Sewage entering surrounding rivers	Operations	Long term	Adverse	Low	Local	Resilient short-term	Continuous	Low	Moderate	Water treatment, sewage flow into tailings	Increased nutrients, eutrophication, decreased productive capacity	Negligible	
J - Access road from Highway 37 to mine site, including borrow pits and staging areas	Sedimentation from road runoff	Operations	Long term	Adverse	Low	Local	Resilient short-term	Periodic	Moderate	Moderate	Sediment and erosion control plan	Minor sedimentation in streams	Negligible	
	Slope failure due to concentration of water on slopes	Operations	Long term	Adverse	Moderate	Landscape	Resilient long-term	One time	Low	High	Slope engineering, culvert design, habitat compensation	Potential long-term loss of habitat at site, with compensation elsewhere	Considerable	
	ML/ARD from highwalls, tunnel, and rock cuts	Operations	Long term	Adverse	Low to Moderate	Landscape	Resilient long-term	Periodic	Moderate	Low	Management plan, dewatering cliff faces, liming runoff, proper disposal of PAG	Slight potential for ML/ARD	Negligible	
L - Buried ore concentrate slurry and diesel pipelines	Rupture of diesel pipeline	Operations	Medium term	Adverse	Moderate	Landscape	Resilient short-term	One time	Low	High	Pipeline engineering, pressure sensors, spill management plan	Decreased productive capacity in affected waterbodies along access corridor	Negligible	
	Rupture of slurry pipeline	Operations	Medium term	Adverse	Moderate	Landscape	Resilient short-term	One time	Low	High	pipeline engineering, "backwash" tank at Porcupine, pressure sensors, spill management plan	Decreased productive capacity in affected waterbodies along access corridor	Negligible	
M - Filter plant, ore concentrate stockpile, truck load out facility (Bob Quinn)	Spills of concentrate	Operations	Medium term	Adverse	Low	Local	Resilient short-term	Periodic	Low	Moderate	Spill management plan, immediate clean-up, storage away from streams	Very low potential for stream contamination due to distance from waterbodies	Negligible	
N - Filter plant effluent	Discharge of contaminated water into Iskut River	Operations	Long term	Adverse	Low	Local	Resilient short-term	Continuous	High	High	Water treatment facility	Potential increase in metals	Negligible	
O - Transportation of concentrate from the filter plant along Highway 37 to Stewart	Concentrate dust settling in fish habitat along route	Operations	Long term	Adverse	Low	Local	Resilient short-term	Periodic	Low	High	Covers on ore trucks, solidifying agents	Potential increase in TSS	Negligible	
P - Airstrip along Porcupine River and its access road	Accidental spill of concentrate near fish habitat	Operations	Short term	Adverse	Moderate	Local	Resilient short-term	One time	Low	High	Speed limits, traffic safety	Decreased productive capacity in affected waterbodies	Negligible	
	Contamination from de-icing agents, fuel spills	Operations	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	Moderate	Moderate	Contained de-icing area, collection and recycling of deicing agents	Possible contamination of groundwater, hyporheic zone, side channels	Negligible	
C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Dam rupture	Operations/ Decommissioning	Far future	Adverse	High	Transboundary	Not Resilient	One time	Low	High	Overconstruction of tailings dam	Large scale contamination of all waterbodies downstream of dam, large scale mortality, habitat loss, productive capacity	Negligible	

(continued)

**Table 7.10-7
Effects Assessment of Productive Capacity of Fish Habitat (continued)**

VEC	Mine Component	Summary of Effect	Phase	Duration	Direction	Magnitude	Geographic Extent	Resilience	Frequency	Probability of Occurrence	Level of Confidence	Proposed Mitigation	Residual Adverse Effects (i.e. adverse effects remaining after mitigation)	Potential for Residual Adverse Effect to be Significant
Dolly Varden	C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Continuous effluent discharge over the dam	Decommissioning/Closure	Far future	Adverse	High	Landscape	Resilient long-term	Continuous	High	High	Possible water treatment, long-term monitoring, requirement to meet effluent guidelines	Decrease in productive capacity of Galore Creek and possibly Scud River, sublethal effects on fish in both rivers, possible mortality of fish in Galore Creek	Negligible
	D - Site runoff, diversion and sediment control	Breaching diversion channel	Decommissioning/Closure	Far future	Adverse	Low	Local	Not Resilient	One time	High	High	Rehabilitation of tailings area	Loss of food production habitat in Galore Creek, reduction in allochthonous inputs and invertebrates to downstream stream sections	Negligible
	J - Access road from Highway 37 to mine site, including borrow pits and staging areas	Sedimentation from bridge/crossing removal	Decommissioning/Closure	Short term	Adverse	Low	Local	Resilient short-term	One time	Moderate	Moderate	Sediment and erosion control plan	Minor sedimentation in streams	Negligible
Other Fish Species	A - Open pit mine located in Galore Creek Valley	Suspended sediments from in-stream construction entering Galore Creek	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	High	High	Sediment and erosion control plan, site isolation, settling pond and diversion	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	B - Process plant located in Galore Creek Valley	Suspended sediments from construction runoff entering Galore Creek	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	High	High	Sediment/erosion control plan, site isolation, settling pond and diversion	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Direct habitat loss (food production) from construction of rock dam on Galore Creek	Construction	Far future	Adverse	Low	Local	Not Resilient	One time	High	High	Rehabilitation of tailings area	Permanent removal of habitat; however habitat is not high quality or necessary for fish	Negligible
		Sedimentation from in-stream construction of containment dam entering Galore Creek	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	High	High	Sediment and erosion control plan, site isolation, settling pond and diversion	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	D - Site runoff, diversion and sediment control	Sedimentation from in-stream construction entering Galore Creek	Construction	Medium term	Adverse	Moderate	Landscape	Resilient short-term	Periodic	Moderate	Moderate	Sediment and erosion control plan, site isolation, settling pond and diversion	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	G - Construction camps, including ancillary facilities	Sewage entering surrounding rivers	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Continuous	Low	Moderate	Water treatment	Increased nutrients, eutrophication, decreased productive capacity	Negligible
		Soil compaction at site leading to sedimentation in surrounding streams	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	High	High	Sediment and erosion control plan, site isolation, settling pond and diversion	Minor sedimentation of surrounding waterbodies	Negligible
	H - Operations camp, including ancillary facilities	Soil compaction at site leading to sedimentation in surrounding streams	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	High	High	Sediment and erosion control plan, site isolation, settling pond and diversion	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	J - Access road from Highway 37 to mine site, including borrow pits and staging areas	Alteration of streambed with rip rap	Construction	Long term	Adverse	Low	Local	Resilient short-term	One time	High	High	Sediment/erosion control plan, habitat compensation	Alteration to substrate will exist for the life of the road, but will be of limited extent and impact	Negligible
		Alteration of habitat at bridge pilings	Construction	Long term	Adverse	Low	Local	Resilient long-term	One time	High	High	Compensatory habitat creation, pilings may increase cover/shelter for fish	Loss of habitat in piling footprint	Negligible
		Sedimentation from in-stream construction	Construction	Short term	Adverse	Low	Local	Resilient short-term	Periodic	Moderate	High	Sedimentation/erosion plans, hydroseeding	Some sedimentation likely, but high magnitude impacts would be limited in duration and extent	Negligible
	L - Buried ore concentrate slurry and diesel pipelines	Sedimentation from ditch-digging, tunnel boring under streams	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	Moderate	Moderate	Compact soil around pipe, sediment and erosion control plans, best management practices	Minor sedimentation	Negligible
	M - Filter plant, ore concentrate stockpile, truck load out facility (Bob Quinn)	Sedimentation from site runoff entering streams	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	Moderate	Moderate	Sediment/erosion control plan, hydroseeding	Minor sedimentation in streams	Negligible
	N - Filter plant effluent	Sedimentation from in-stream construction entering Iskut River	Construction	Short term	Adverse	Low	Local	Resilient short-term	One time	High	High	Sediment/erosion control plan	Minor sedimentation in the Iskut River during construction	Negligible
	P - Airstrip along Porcupine River and its access road	Direct loss of habitat on Porcupine Floodplain (if floodplain is classified as habitat)	Construction	Far future	Adverse	Low	Landscape	Not Resilient	One time	Moderate	Low	Compensatory habitat creation, locate airstrip away from fish habitat	Loss of very minor food production habitat (only useful to fish during very large flood events)	Negligible
Q - Heavy lift airstrip/heliport in More Valley near Round Lake	Soil compaction at site leading to sedimentation in surrounding streams	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	Moderate	Moderate	Sediment/erosion control plan	Minor sedimentation in More Creek	Negligible	
I - Explosives manufacturing and storage plant	Explosives residues, leachate entering streams around construction sites	Construction/Operations	Long term	Adverse	Low	Local	Resilient long-term	Continuous	Low	Moderate	Explosives storage shed, contaminated water into tailings, non-corrosive silos, maintenance of bag houses, concrete apron	Possible contamination before tailings dam built	Negligible	
C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Scheduled effluent discharge over the dam	Operations	Long term	Adverse	Moderate	Landscape	Resilient long-term	Periodic	High	High	Schedule discharge at high flows, monitoring	Decrease in productive capacity of Galore Creek and possibly Scud River, sublethal effects on fish in both rivers, possible mortality of fish in Galore Creek	Negligible	
	Higher peak flow and lower low flow due to scheduled water release from dam	Operations	Long term	Adverse	Low	Landscape	Resilient short-term	Periodic	Moderate	Moderate	None	Increased peak flow, decreased low flow in Galore Creek may alter productive capacity of certain habitats	Negligible	
	Unscheduled effluent release from dam	Operations	Medium term	Adverse	Moderate	Regional	Resilient short-term	One time	Low	High	Monitoring	Decrease in productive capacity of Galore Creek and Scud River	Negligible	
D - Site runoff, diversion and sediment control	MLARD from rock channel	Operations	Long term	Adverse	Low to High	Landscape	Resilient long-term	Continuous	Unknown	Low	Diversion of water back into tailings after mine closure, rock chemistry	Potential for decrease productive capacity within and downstream of diversion channel	Negligible	
E - Ore and marginal ore storage	Leachate from ore	Operations	Long term	Adverse	Low	Local	Resilient long-term	Periodic	Moderate	Moderate	All runoff will enter tailings impoundment	Water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible	
F - Mine borrow pits, overburden and topsoil storage	MLARD from borrow pits, erosion from topsoil	Operations	Long term	Adverse	Low	Local	Resilient long-term	Periodic	Moderate	Moderate	All runoff will enter tailings impoundment	Water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible	
H - Operations camp, including ancillary facilities	Sewage entering surrounding rivers	Operations	Long term	Adverse	Low	Local	Resilient short-term	Continuous	Low	Moderate	Water treatment	Increased nutrients, eutrophication, decreased productive capacity	Negligible	
J - Access road from Highway 37 to mine site, including borrow pits and staging areas	Slope failure due to concentration of water on slopes	Operations	Long term	Adverse	Moderate	Landscape	Resilient long-term	One time	Low	High	Slope engineering, culvert design, habitat compensation	Potential long-term loss of habitat at site, with compensation elsewhere; however, little potential for slope failure near streams bearing this VEC	Negligible	
	ML/ARD from highwalls, tunnel, and rock cuts	Operations	Long term	Adverse	Low to Moderate	Landscape	Resilient long-term	Periodic	Moderate	Low	Management plan, dewatering cliff faces, liming runoff, proper disposal of PAG	Slight potential for ML/ARD	Negligible	
L - Buried ore concentrate slurry and diesel pipelines	Sedimentation from road runoff	Operations	Long term	Adverse	Low	Local	Resilient short-term	Periodic	Moderate	Moderate	Sediment and erosion control plan	Minor sedimentation in streams	Negligible	
	Rupture of diesel pipeline	Operations	Medium term	Adverse	Moderate	Landscape	Resilient short-term	One time	Low	High	Pipeline engineering, pressure sensors, spill management plan	Decreased productive capacity in affected waterbodies along access corridor	Negligible	
	Rupture of slurry pipeline	Operations	Medium term	Adverse	Moderate	Landscape	Resilient short-term	One time	Low	High	Pipeline engineering, pressure sensors, spill management plan	Decreased productive capacity in affected waterbodies along access corridor	Negligible	
M - Filter plant, ore concentrate stockpile, truck load out facility (Bob Quinn)	Spills of concentrate	Operations	Medium term	Adverse	Low	Local	Resilient short-term	Periodic	Low	Moderate	Spill management plan, immediate clean-up, storage away from streams	Possible contamination of surrounding waterbodies	Negligible	
N - Filter plant effluent	Discharge of contaminated water into Iskut River	Operations	Long-term	Adverse	Low	Local	Resilient short-term	Continuous	High	High	Water treatment facility	Potential increase in metals.	Negligible	
O - Transportation of concentrate from the filter plant along Highway 37 to Stewart	Concentrate dust settling in fish habitat along route	Operations	Long-term	Adverse	Low	Local	Resilient short-term	Periodic	Low	High	Covers on ore trucks, solidifying agents	Potential increase in TSS	Negligible	
	Accidental spill of concentrate near fish habitat	Operations	Short term	Adverse	Moderate	Local	Resilient short-term	One time	Low	High	Speed limits, traffic safety	Contamination of fish habitat/tissues, decreased wq/sq, direct mortality of fish, decreased productive capacity of habitat	Negligible	

(continued)

**Table 7.10-7
Effects Assessment of Productive Capacity of Fish Habitat (completed)**

VEC	Mine Component	Summary of Effect	Phase	Duration	Direction	Magnitude	Geographic Extent	Resilience	Frequency	Probability of Occurrence	Level of Confidence	Proposed Mitigation	Residual Adverse Effects (i.e. adverse effects remaining after mitigation)	Potential for Residual Adverse Effect to be Significant
Other Fish Species	P - Airstrip along Porcupine River and its access road	Contamination from de-icing agents, fuel spills	Operations	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	Moderate	Moderate	Contained de-icing area, collection and recycling of deicing agents	Possible contamination of groundwater, hyporheic zone, side channels	Negligible
	C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Dam rupture	Operations/ Decommissioning	Far future	Adverse	High	Transboundary	Not Resilient	One time	Low	High	Overconstruction of tailings dam	Large scale contamination of all waterbodies downstream of dam, large scale mortality, habitat loss, productive capacity	Negligible
	C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Continuous effluent discharge over the dam	Decommissioning/ Closure	Far future	Adverse	High	Landscape	Resilient long-term	Continuous	High	High	Long-term monitoring, possible water treatment	Decrease in productive capacity of Galore Creek and possibly Scud River, sublethal effects on fish in both rivers, possible mortality of fish in Galore Creek	Negligible
	D - Site runoff, diversion and sediment control	Loss of allochthonous matter and invertebrate inputs due to breaching of the diversion channel	Decommissioning/ Closure	Far future	Adverse	Low	Local	Not Resilient	One time	High	High	None	Loss of food production habitat in Galore Creek	Negligible
	J - Access road from Highway 37 to mine site, including borrow pits and staging areas	Sedimentation from bridge/crossing removal	Decommissioning/ Closure	Short term	Adverse	Low	Local	Resilient short-term	One time	Moderate	Moderate	Sediment and erosion control plan	Minor sedimentation in streams	Negligible
Pacific Salmon	C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Direct habitat loss (food production) from construction of rock dam on Galore Creek	Construction	Far future	Adverse	Low	Local	Not Resilient	One time	High	High	Rehabilitation of tailings area	Permanent removal of habitat, with compensation elsewhere; however habitat is not high quality or necessary for fish	Negligible
		Sedimentation from in-stream construction of containment dam entering Galore Creek	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	High	High	Erosion/sediment control plan	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	D - Site runoff, diversion and sediment control	Sedimentation from in-stream construction entering Galore Creek	Construction	Medium term	Adverse	Moderate	Landscape	Resilient short-term	Periodic	Moderate	Moderate	Sediment and erosion control plan, site isolation, settling pond and diversion	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	G - Construction camps, including ancillary facilities	Sewage entering surrounding rivers	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Continuous	Low	Moderate	Water treatment	Potential contaminated sites, soil compaction may lead to erosion	Negligible
		Soil compaction at site leading to sedimentation in surrounding streams	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	High	High	Sediment/erosion control plan	Minor sedimentation in streams	Negligible
	H - Operations camp, including ancillary facilities	Sedimentation from site entering Galore Creek	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	High	High	Sediment and erosion control plan, site isolation, settling pond and diversion	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	N - Filter plant effluent	Sedimentation from in-stream construction entering Iskut River	Construction	Medium term	Adverse	Low	Local	Resilient short-term	One time	High	High	Sediment/erosion control plan	Minor sedimentation	Negligible
	P - Airstrip along Porcupine River and its access road	Sedimentation from construction of airstrip	Construction	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	Moderate	Moderate	Sediment/erosion control plan	Increased sediment during storms	Negligible
	C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Scheduled effluent discharge over the dam	Operations	Long term	Adverse	Low	Landscape	Resilient long-term	Periodic	High	High	Schedule discharge at high flows	Decrease in productive capacity of Galore Creek and possibly Scud River, sublethal effects on fish in both rivers, possible mortality of fish in Galore Creek	Negligible
	H - Operations camp, including ancillary facilities	Sewage entering surrounding rivers	Operations	Long term	Adverse	Low	Local	Resilient short-term	Continuous	Low	Moderate	Water treatment, spill management plan	Habitat loss/alteration, contaminated water will enter tailings facility	Negligible
N - Filter plant effluent	Discharge of contaminated water into Iskut River	Operations	Long term	Adverse	Low	Local	Resilient short-term	Continuous	High	High	Water treatment facility	Potential increase in metals, but all release will be >30 km from salmon bearing reaches	Negligible	
Stikine River	O - Transportation of concentrate from the filter plant along Highway 37 to Stewart	Concentrate dust settling in fish habitat along route	Operations	Long term	Adverse	Low	Local	Resilient short-term	Periodic	Low	High	Covers on ore trucks, solidifying agents	Potential increase in TSS	Negligible
		Accidental spill of concentrate near fish habitat	Operations	Short term	Adverse	Moderate	Local	Resilient short-term	One time	Low	High	Speed limits, traffic safety	Contamination of fish habitat/tissues, decreased wq/sq, direct mortality of fish, decreased productive capacity of habitat	Negligible
	P - Airstrip along Porcupine River and its access road	Contamination from de-icing agents, fuel spills	Operations	Medium term	Adverse	Low	Landscape	Resilient short-term	Periodic	Moderate	Moderate	Contained de-icing area, collection and recycling of deicing agents	Contamination of fish habitat/tissues, decreased wq/sq, direct mortality of fish, decreased productive capacity of habitat	Negligible
	C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Dam rupture	Operations/ Decommissioning	Far future	Adverse	High	Transboundary	Not Resilient	One time	Low	High	Overconstruction of tailings dam	Large scale contamination of all waterbodies downstream of dam, large scale mortality, habitat loss, productive capacity; however, very low probability	Negligible
	C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Continuous effluent discharge over the dam	Decommissioning/ Closure	Far future	Adverse	High	Landscape	Resilient long-term	Continuous	High	High	Long-term monitoring, possible water treatment	Decrease in productive capacity of Galore Creek and possibly Scud River, sublethal effects on fish in both rivers, possible mortality of fish in Galore Creek	Negligible
	C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Dam rupture	Operations/ Decommissioning	Far future	Adverse	High	Transboundary	Not Resilient	One time	Low	High	Overconstruction of tailings dam	Large scale contamination of all waterbodies downstream of dam, large scale mortality, habitat loss, productive capacity	Negligible

**Table 7.10-8
Summary of Life History and Habitat Requirements of VEC Species**

Requirements	Species										
	Dolly Varden	Bull Trout	Pacific Salmon				Rainbow trout/ Steelhead	Mountain Whitefish	Longnose Sucker	Threespine Stickleback	
			Coho	Sockeye	Chinook	Pink	Chum				
Life History											
Life-History Strategy	A, R, AD	A, R, F, AD	A, R	A	A	A	A	A, R, F	R	R	R
Age at Maturity (years)	5 to 6	3 to 5	3 to 4 (A); 2 to 3 (R)	4 to 6	2 to 9 years	2	3 to 5	1 to 6	3 to 4	4 to 9	1
Spawning Dates	Aug to Nov	Aug to Oct	Oct to Mar	Aug to Nov	October to March	July to Oct	summer, fall	late winter, spring	Sept to Feb	Apr to May	May to July
Egg Incubation	4 to 5 months	4 to 5 months	35 to 50 days	80 to 140 days	35 to 159 days	4 to 5 months	1.5 to 4.5 months	28-40 days	-	2 weeks	7 days at 19°C
Hatching Dates	March to Apr	January to February	early spring	Dec to Jan	early spring	Dec to Feb	Dec to Feb	June to Aug	March to Apr	May to June	-
Emergence Dates	Apr to June	April to June	March to July	April to May	March to Jul	Apr to May	Apr to Early May	June to Sept	Apr to May	June	na
Freshwater Residence (years)	2 to 4	-	0 to 2	-	0 to ≥1	0	0	≤4	na	na	na
Migration Timing											
Age at First Migration (years)	3 to 5	1 to 4	0 to 2	0+ to 2	0 to 6	0+	0+	3 to 5	na	na	na
Downstream Migration	May to June	-	March to April	Apr to June	Feb to May	April to June	April to June	spring	na	na	na
Spawning Migration	July to Oct	May to Aug	October to March	July to Sept	Apr to Aug	June to Oct	June to Sept	summer and winter	na	na	na
Time Spent at Sea	-2 to 3 summers	-	~2 years	~2 to 3 years	~2 to 3 years	12 to 18 months	3 to 5	≤4 years	na	na	na
Habitat											
Spawning											
Habitat	S, R	R, S	R, S	R, S, L	R, S	S, R	S, R	S*, R, L	R, S, L	S, L	S, R
Substrate Preference	G	G, C	G	G	G	G	G, B, Be	G	G, C	G	S
Depth	≥0.2 m	0.15 to 0.84 m	shallow	-	deep	<0.50m	0.15 to 0.30 m	0.15 to 2.5 m	shallow	0.15 to 0.28 m	shallow
Current velocity	moderate	0.25 to 0.65 m/s	fast	-	~0.5 m/s	-	-	0.30 to 0.90 m/s	fast	30 to 40 cm/s	-
Temperature	~7.8°C	<9°C	-	~5°C	-	≤16°C	4 to 16°C	7 to 13°C	~3 to 5°C	~5°C	15°C
Rearing											
Habitat	S*, R	S, R	S, R	R, S, L	R, S	na	na	R, S, L	R, S, L	S, L	S, R
Substrate Preference	G	G, C, B	G	G	G	na	na	C, B	S, G	-	S
Temperature	4 to 18°C	≤18°C	0 to 25°C	12 to 14°C	3 to 15°C	na	na	≤20°C	-	-	4 to 20°C
Other											
Freshwater Feeding	FI, TI, F, M, A, Bi	FI, F	FI, TI, F	FI	FI, TI	FI	FI	FI, TI, F	FI, TI, F	FI	FI, TI
Predators	M, W, O, Bi	-	F, Bi, M	-	F, Bi	F	F, Bi, M	F, M, Bi	-	F, Bi, M	F, Bi
Conservation Status											
Provincial (British Columbia)	Blue-listed	Blue-listed	na	na	na	na	na	na	na	na	na
Federal (Canada)	na	Special concern	na	na	na	na	na	na	na	na	na

Note: Dashes indicate data not available

Life History Strategy: A = anadromous, R = resident (freshwater), F = fluvial, AD = adfluvial

Freshwater Residence: pertains only to anadromous populations

Habitat: R = river, S = stream (includes small tributaries), L = lake; * indicates preferred habitat type

Substrate Preference: S = sand, G = gravel, C = cobble, B = boulder, Be = Bedrock

Diet: FI = freshwater invertebrates, TI = terrestrial invertebrates, F = fish and fish eggs, M = small mammals, A = amphibians including frogs, Bi = birds

Predators: F = fish, M = mammals including bears, W = wolves, O = otters, Bi = birds

na = not applicable

kilometres downstream of the mine, possibly as far as the Stikine River. At the mouth of the Stikine River, the pulse of water would not be as much as a yearly flood; however, when added to an ongoing flood events (such as a 5-year event), the pulse would resemble a 1-in-50 year flood (see Chapter 13). Contaminated sediment from the tailings pond would settle in the Scud River and potentially cause mortality among primary and secondary producers. However, an event such as this is classified as catastrophic and beyond any best engineering practices for earth-filled hydroelectric reservoirs (see also Section 5.9).

Dolly Varden

Dolly Varden may experience effects from decreased productive capacity in Galore Creek, as they are the only documented species living in the stream. It is estimated that Dolly Varden have access to the lower 1.8 km of Galore Creek, but are prevented from migrating farther upstream by velocity barriers located in the Galore Canyon. Construction of the tailings facility, located approximately 3.2 km upstream from the confluence of Galore Creek and the Scud River, will largely block the downstream flow of allochthonous matter from the middle and upper reaches of Galore Creek. However, the diversion channel will maintain the flow of water, as well as a certain amount of allochthonous exports to the lower reaches of the stream, at least until the mine is decommissioned. Once the diversion channel is breached after mine closure, the remaining watershed area will likely contain sufficient natural production to support the small population of Dolly Varden living at the mouth of the stream.

No significant effects of reduced productive capacity are predicted for Dolly Varden living in the Scud River, which has many times the flow volume of Galore Creek.

Bull Trout

Bull trout have not been identified in Galore Creek; however, they have been captured in the Scud River downstream of Galore. It is possible that bull trout exist in limited numbers in Galore Creek but they have not yet been genetically identified, thus it is important to consider the effects of the mine on this species. Bull trout are differentiated from Dolly Varden mainly through genetics, as they are physically alike, with similar habitat and food requirements. If they are present in lower Galore Creek, then the impact on the productive capacity of their habitat would be similar to the impacts observed on Dolly Varden, and the residual effects of these impacts are predicted to be negligible.

Pacific Salmon

The reduction of productive capacity in Galore Creek is predicted to have no impact on Pacific salmon species. While coho and sockeye salmon have been observed and captured in the Scud River, most of them utilize habitat that is well downstream of the predicted areas of influence and are not likely to be affected.

Other Fish Species

Other fish species living in the Scud River in the vicinity of Galore Creek include slimy sculpins and mountain whitefish. These species have never been captured in Galore Creek, instead relying on the resources of the Scud River; thus, they would not be affected by the loss of productive habitat in Galore Creek.

Stikine River

The Stikine River is only expected to be impacted in the highly unlikely event of a tailings dam rupture (see Chapter 13). Tailings water and sediment would likely travel as far as the Stikine. This may have catastrophic effects on the productivity of the river, affecting not only fish species, but also wildlife and humans. Productive capacity would likely be altered for years as newly-exposed potentially acid-generating (PAG) rock begins to leach acid, and contaminated sediment settles onto the substrate of the river. In practice, the tailings dam will be constructed to last indefinitely and become a permanent feature of the landscape.

7.10.2.4 Site Runoff and Diversion Channel

General

The construction of a diversion channel will allow clean water surrounding the mine site and tailings facility to be funnelled directly to Galore Creek below the tailings dam. During construction, sedimentation could alter the productive capacity of habitat in Galore Creek. Sediment control and erosion plans will limit the severity of this effect, and a lack of depositional areas in Galore Creek could result in the sediment being carried all the way to the Scud River without affecting the stream substrate. Once in the Scud River, sediment would be deposited in slower moving water and potentially affect benthic invertebrates and, by association, the fish that feed on them. The extent of this effect is predicted to be minimal and patchy because the Scud River is a large and highly variable river that frequently shifts its course through the floodplain. Organisms living in this highly turbid environment are adapted to the variability in flow and sediment deposition (Robinson *et al.*, 2002); therefore, occasional incremental increases in sediment deposition arising from construction in Galore Creek will have little impact on productive capacity.

In many areas, the diversion channel will be blasted out of bedrock. This may result in the exposure of potentially acid-generating (PAG) rock. Acid rock drainage (ARD) can result in elevated levels of many metals that can impact the productive capacity of streams and rivers (*e.g.*, Gray, 1998). The effects of acid rock drainage from exposed PAG rock in the diversion channel may have the potential to affect productive capacity of Dolly Varden and bull trout habitat in Galore Creek; however, these effects have not yet been modelled. The option to line parts of the diversion channel to prevent exposure of PAG rock will be explored as needed.

Upon completion of mining activities in the Galore Creek Valley, the diversion channel will be removed, allowing tributaries to flow directly into the tailings facility. This will cut off the flow of allochthonous and autochthonous materials to downstream reaches of Galore Creek. These resources will flow into, and likely settle in the tailings and waste rock ponds. This will likely result in a decrease in the productive capacity of non-fish-bearing sections of Galore Creek. However, it is not predicted to have a significant impact on fish-bearing sections of the river for two reasons:

- the fish-bearing reach is far enough away from the affected reach that the remaining stream area will be sufficient to support fish populations; and

- an undisturbed tributary to Galore Creek downstream of the dam will continue to export allochthonous materials and invertebrates to the mainstem of the stream.

The presence of undisturbed tributaries downstream of dams has been shown to mitigate the impact of dams on stream invertebrate communities in arid climates (Vinson, 2001). In that case, the undisturbed tributary had intermittent flow, and was located in an arid, sparsely vegetated region of Utah, U.S.A. Furthermore, studies of streams in southeastern Alaska near the Galore Creek Project area have reported that small, non-fish-bearing headwater streams export significant amounts of invertebrates and detritus to fish-bearing streams, especially where the tributaries are dominated by riparian vegetation such as red alder (*Alnus rubra*) (Piccolo and Wipfli, 2002). The tributary of Galore Creek downstream of the dam is similar to the situation studied by Piccolo and Wipfli; therefore, the export of organic matter from this stream to Galore Creek will likely be sufficient to support the small downstream fish population.

7.10.2.5 Access Corridor and Pipelines

General

Salmonid food webs receive important energy subsidies from terrestrial inputs of invertebrates and nutrients falling into streams from riparian vegetation (Wipfli and Gregovich, 2002; Allan *et al.*, 2003). Clearing of riparian vegetation for road and bridge construction removes this valuable resource over short distances and can affect the productive capacity of stream habitat over moderate distances. However, removal of streamside vegetation may also increase the amount of solar radiation reaching the stream, influencing primary production and boosting the short-term productivity of the habitat. Studies of deforestation have shown that periphyton biomass increases with decreasing shade (Kiffney *et al.*, 2003), macroinvertebrate density increases (Carlson *et al.*, 1990), and Dolly Varden abundance increases (Keith *et al.*, 1998). Additional armouring of stream banks with rip-rap alters the substrate size and may affect composition of the invertebrate community over short distances. Replacement of streamside vegetation and additional habitat compensation can mitigate these effects.

During construction, incidental sedimentation will occur at road crossings (Furniss *et al.*, 1991). The effect of this impact may be temporarily elevated suspended sediment levels; however, it will not persist beyond the construction phase for each crossing. Sediment is unlikely to accumulate in most of the streams crossed due to the steep, turbulent nature of most of the streams along the access corridor. Limited sedimentation is also expected to occur from the road bed during operation; however, sediment and erosion control plans will minimize this effect on the productive capacity of streams and waterbodies.

Contamination of habitat leading to decreased productive capacity for VEC species may occur if the proposed slurry or fuel pipelines leak or burst near fish habitat. The most likely place for this to happen would be at any road crossings where the pipeline is not buried, but rather attached to the crossing structures. The pipeline will be directionally drilled under some road crossings; however, some pipeline crossings will be entrenched using a cut-and-cover methodology and others may have the pipeline affixed to the bridge above ground. This will require site isolation and sediment control techniques to prevent sedimentation in streams. Design specifications for the pipeline will ensure that where the pipeline is not buried under the stream, it remains

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insulated against freezing. In the event of a pipeline breakage, automatic switches would shut off the pumps driving the materials through the pipelines. Thus, the likelihood of a breach or breakage occurring is very low and the net effect, if it should occur, would not be significant.

Productive capacity of aquatic habitat may also be impacted by catastrophic slope failures, debris torrents, and avalanches associated with the proposed access corridor and its stream crossings. Road building has been associated with increased rates of slope failure and large-scale erosion, particularly in steep, coastal watersheds (Furniss *et al.*, 1991). Debris torrents in streams can affect productivity in streams for hundreds of years by scouring channels to bedrock, depositing fine sediment over downstream habitat, and blocking access to upstream habitat. The significance of this potential secondary effect could be very high. To mitigate this risk, a geohazard assessment was completed in 2005 (Section 5.12.1.7). Appropriate protective measures (*e.g.*, revegetation and reshaping of slopes, diversion ditches and culverts) and erosion control will be implemented along the access road to manage water and maintain slope stability. The likelihood of a major slope failure will therefore be low, so no compensation is planned.

Dolly Varden

Dolly Varden are the most abundant and widespread fish species along the proposed access corridor, and were the only species captured in the More Creek Watershed during the 2004 - 2005 field program. Thus, construction of the proposed road is more likely to affect this species than others that are less abundant. Dolly Varden tend to aggregate in pools with high in-stream cover and low overhead cover (Keith *et al.*, 1998); therefore, removal of some riparian vegetation may actually provide more habitat for this species, as long as sedimentation is controlled at each site. In addition to road crossings where productive habitat may be affected by sedimentation, slope failure, or substrate changes, wetland habitat downstream of the road may be impacted. Wetlands provide important rearing and overwintering habitat for Dolly Varden (Appendix 6-E). Sediment deposition in these areas may alter invertebrate density and result in a decrease in the ability of the wetland to support fish. Productive capacity may also be altered by the building of roads over wetland habitat which, although it stays dry for most of the year, may flood during high water, providing food and shelter to rearing fish.

Bull Trout

Bull trout are less abundant than Dolly Varden along the proposed access corridor, and have only been captured in the Iskut River (Appendices 6-D and 6-E). However, it is possible that they occur, but have not yet been identified in other drainages in the project area, including More Creek. Bull trout, like Dolly Varden, are sensitive to the effects of development on their habitat. Bull trout abundance has been negatively correlated with increased sediment levels (Watson and Hillman, 1997; Ripley *et al.*, 2005); thus, it will be important to maintain sediment and erosion control plans to protect bull trout habitat.

Pacific Salmon

Pacific salmon species are not found in any of the streams associated with the proposed access corridor, except the Porcupine River, where coho and sockeye salmon use the side-channels well below the bridge crossing site for spawning and rearing. Productive capacity of Pacific salmon habitat will not be effected.

Other Fish Species

Other fish species found in streams along the proposed access corridor include rainbow trout (in streams and rivers near Bob Quinn), longnose sucker (in wetlands and rivers near Bob Quinn), mountain whitefish (mainly in the Iskut River), and slimy sculpin (possibly in streams near the Iskut River). Productive capacity of fish habitat in these streams could be affected by sedimentation from road and pipeline construction and operation. Productive capacity could also be affected at four crossings where instream piers will be required. Habitat in the immediate footprint of the piers/pilings will be lost, and construction of the piers may create minor sedimentation. Sedimentation will be limited by proper site isolation and sediment control plans, and permanently displaced habitat will be compensated for in other areas (see Section 8.12.5). Piers may also trap material such as bedload and large woody debris (LWD), which can then create scour. Due to the limited geographic extent of such effects, decreases in productive capacity resulting from bridge piers are predicted to be negligible.

7.10.2.6 Porcupine Aerodrome

General

The proposed Porcupine Aerodrome will be constructed on the valley floor and old floodplain of the Porcupine River, and will likely include storage for fuel and de-icing substances. The old floodplain area is not flooded on a regular basis; however, major flood events (*e.g.*, one in 50 or 100 years floods) may temporarily inundate the area and create fish habitat. Streams and waterbodies on the wide floodplain support invertebrate populations that contribute to the productive capacity of the watershed.

Storage of contaminants such as fuel and de-icing substances will be of importance due to the porous nature of the floodplain. The hyporheic habitat of large rivers (*i.e.*, the region where surface flow interacts with groundwater in the riverbed) may extend laterally for several kilometres, and contribute nutrients and macroinvertebrates to the main channel (Hancock, 2002). Studies of major fuel spills have indicated that secondary production may suffer as far as 12 km downstream of the spill site, and may persist for longer than a year (Lytle and Peckarsky, 2001). Sub-lethal concentrations of chemical compounds used for de-icing aircraft have also been found in fish and invertebrates living downstream of major airports (Cancilla *et al.*, 2003). Major spills could make their way into active fish habitat relatively quickly via groundwater flows through the porous gravel substrate. Accidental discharge of these substances could potentially cause a decrease in the productive capacity of habitat for all fisheries VECs.

Dolly Varden

Dolly Varden are abundant throughout the Porcupine River floodplain, living in the mainstem of the river, in side-channels and sloughs, and in the many small tributaries arising from the valley walls. Spills of fuel or de-icing fluid could potentially affect the small streams arising from and flowing over the floodplain downstream of the airstrip. Productive capacity of these habitats may be altered by the surface or groundwater transport of contaminants to invertebrate communities; however, the likelihood of this occurring is very low. Fuel and other contaminants will be kept in tanks surrounded by lined berms designed to contain any spills. Spill kits and

management plans will limit the possibility that any uncontained spill will have a serious effect on the productive capacity of habitat for Dolly Varden.

Bull Trout

Pure bull trout have not been captured in the Porcupine River Watershed; however, first-generation bull trout/Dolly Varden hybrids have, implying that there may be bull trout present. Bull trout utilize the same habitat types as Dolly Varden and, like Dolly Varden, are at a low risk of being affected by any changes in productive capacity near the proposed aerodrome.

Pacific Salmon

Several species of Pacific salmon, especially coho and sockeye, are known to spawn in the Porcupine River and its tributaries. Coho and sockeye both spawn near the mouths of clear tributaries of the Porcupine and in the mainstem itself. One important spawning site, supporting several dozen spawners, has been observed near the northwest corner of the Porcupine floodplain (Appendix 6-E). Juvenile coho are known to rear in the many side channels and tributaries on the floodplain, while juvenile sockeye likely utilize wetland and beaver dam habitat close to the mainstem of the river (Appendices 6-D and 6-E). Juvenile chinook salmon are known to inhabit larger, more turbid tributaries of the Porcupine River east of the proposed airstrip. The Porcupine River Watershed may also support very limited numbers of pink and chum salmon; however, this has not been confirmed in the field.

Juvenile coho, because of their association with small, clear side-channels, are probably most at risk by any decreases in productive capacity associated with the proposed aerodrome. However, the probability of a significant impact on productive capacity occurring would be very low due to the proposed spill and sediment management plans.

Other Fish Species

The Porcupine River Watershed also supports smaller populations of mountain whitefish and slimy sculpin. Mountain whitefish were found primarily in the active mainstem channel of the river and would not likely be affected by any small changes in productivity associated with the proposed aerodrome (Appendix 6-E). Slimy sculpin are found in small numbers throughout the watershed (Appendices 6-D and 6-E). As with other species, they are not predicted to be impacted significantly by any localized alterations to productive capacity on the floodplain.

7.10.2.7 Filter Plant Effluent

Construction of the filter plant diffuser will require instream work to bury the pipe and construct the diffusers that will release treated water into the Iskut River. The productive capacity of habitat for Dolly Varden, bull trout, and other fish species could be affected by this instream work; however, proper site isolation and sediment control techniques will limit the effect and residual effects will be negligible.

Chemical contamination from the filter plant effluent may also affect productive capacity in the Iskut River immediately downstream of the effluent diffusers. The filter plant effluent is predicted to have higher than normal concentrations of copper (see Section 7.6). During annual low flow conditions, the hazard quotient (HQ) for copper is predicted to be greater than one

(meaning that concentrations will exceed baseline conditions) from the diffuser pipe effluent to the confluence of More Creek, 6 km downstream. The maximum predicted HQ during this time period is 3, indicating that copper concentrations will be 3 times higher than baseline conditions. This represents a low effect on water quality, and is not likely to have a significant impact on the productive capacity of the river. Substantial dilution will occur at the confluence of the Iskut River and More Creek, thus, productive capacity will not be affected beyond this point. During average annual flow conditions, effects on water quality are only expected for the 100 m stretch downstream of the diffuser. Thus, the effects of increased copper concentrations will be limited to a relatively small area. In addition, avoidance of high copper concentrations by fish is well documented, both in the field and in the laboratory (Atchison *et al.*, 1987), thus, fish can make use of extensive habitat in the upper Iskut River that will not be impacted by the filter plant. Therefore, because of the limited geographic extent of this effect and the ability of fish VECs to avoid the zone of impact, the residual impact on fish populations is predicted to be minimal.

7.10.3 Habitat Loss and Alteration

7.10.3.1 Introduction

Habitat loss and alteration refers to the removal or physical alteration of aspects of the environment that are used either directly or indirectly by fish. Under the *Fisheries Act*, chemical alteration of water/habitat quality by the introduction of deleterious substances to surface waters is also considered a HADD (Fisheries and Oceans Canada, 1985). However, chemical effects usually alter the productive capacity of habitat by impacting aquatic invertebrates or fish health directly; therefore, these effects are detailed under the “Productive Capacity of Fish Habitat” and “Sublethal Effects” sections of this section. Table 7.10-9 presents the issue scoping matrix for habitat loss and alteration.

7.10.3.2 Mine Area

The upper Galore Creek Watershed where the mine facilities will be located is not considered to be fish habitat (Section 7.10.2.2). No activities in this area are predicted to have an effect on fish habitat in downstream areas.

7.10.3.3 Mill Tailings and Waste Rock Facility

The dam associated with the tailings facility will result in a direct loss of habitat at the site upstream of the dam because of water impoundment and alterations to flow and habitat downstream. As with the mine site, the loss of habitat due to construction of the tailings dam is not predicted to have a significant effect on fisheries VECs due mainly to the continued transport of invertebrates and allochthonous material from small tributary streams to downstream areas via the diversion channel (see also Sections 7.10.2.4).

The construction and operation of the dam will also result in alterations to the discharge pattern in the stream. High flows during freshet will be even higher due to increased decants from the tailings management area, while low flows will be lower due to the impoundment of water during the winter. This could lead to alterations in downstream habitat such as erosion, changes in channel complexity, alterations to sedimentation patterns, increased scour and bank erosion,

**Table 7.10-9
Effects Assessment of Habitat Loss and Alteration of Fish Habitat**

VEC	Mine Component	Summary of Effect	Phase	Duration	Direction	Magnitude	Geographic Extent	Resilience	Frequency	Probability of Occurrence	Level of Confidence	Proposed Mitigation	Residual Adverse Effects (i.e. adverse effects remaining after mitigation)	Potential for Residual Adverse Effect to be Significant
Bull Trout	A - Open pit mine located in Galore Creek Valley	Suspended sediments from in-stream construction entering Galore Creek	Construction	Medium term	Adverse	Low	Local	Reversible long-term	Periodic	Moderate	High	Sediment and erosion control plan, site isolation, settling pond and diversion	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	B - Process plant located in Galore Creek Valley	Suspended sediments from construction runoff entering Galore Creek	Construction	Medium term	Adverse	Low	Local	Reversible long-term	Periodic	Moderate	High	Sediment/erosion control plan, site isolation, settling pond and diversion	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Direct habitat loss (food production) from construction of rock dam on Galore Creek	Construction	Far future	Adverse	Low	Local	Not reversible	One time	High	High	Compensatory habitat creation	Permanent removal of habitat; however habitat is not high quality or necessary for fish	Negligible
	D - Site runoff, diversion and sediment control	Sedimentation from in-stream construction of containment dam entering Galore Creek	Construction	Medium term	Adverse	Low	Local	Reversible long-term	Periodic	High	High	Erosion/sediment control plan	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
			Construction	Medium term	Adverse	Low	Landscape	Reversible long-term	Continuous	Moderate	High	Erosion/sediment control plan	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
			Construction	Medium term	Adverse	Low	Local	Reversible short-term	Periodic	Moderate	Moderate	Erosion/sediment control plan	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	G - Construction camps, including ancillary facilities	Soil compaction at site leading to sedimentation in surrounding streams	Construction	Medium term	Adverse	Low	Local	Reversible short-term	Periodic	Moderate	Moderate	Erosion/sediment control plan	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	H - Operations camp, including ancillary facilities	Soil compaction at site leading to sedimentation in surrounding streams	Construction	Medium term	Adverse	Low	Local	Reversible short-term	Periodic	Moderate	Moderate	Erosion/sediment control plan	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	J - Access road from Highway 37 to mine site, including borrow pits and staging areas	Alteration of streambed with rip rap	Construction	Long term	Adverse	Low	Local	Reversible short-term	Continuous	High	High	Sediment/erosion control plan, habitat compensation	Alteration to substrate will exist for the life of the road, but will be of limited extent and impact	Negligible
			Construction	Short term	Adverse	Moderate	Local	Reversible short-term	Periodic	Moderate	High	Compensatory habitat creation, sedimentation/erosion plans, hydroseeding	Some sedimentation likely, but high magnitude impacts would be limited in duration and extent	Negligible
			Construction	Far future	Adverse	Low	Local	Not reversible	One time	High	High	Compensatory habitat creation, pilings may increase cover/shelter for fish	Permanent loss of habitat in piling footprint	Negligible
	K - Transmission line from Highway 37 to mine site	Riparian vegetation alteration	Construction	Long term	Adverse	Low	Local	Reversible long-term	One time	Low	Moderate	Machine free zone, top only high trees	Minor alteration of riparian vegetation	Negligible
	L - Buried ore concentrate slurry and diesel pipelines	Sedimentation from ditch-digging, tunnel boring under streams	Construction	Medium term	Adverse	Low	Local	Reversible long-term	Continuous	Moderate	Moderate	Compact soil around pipe, sediment and erosion control plan	Minor sedimentation in streams	Negligible
	M - Filter plant, ore concentrate stockpile, truck load out facility (Bob Quinn)	Sedimentation from site runoff entering streams	Construction	Long term	Adverse	Low	Local	Reversible long-term	Periodic	Low	Moderate	Sediment/erosion control plan, compensatory habitat creation	Minor sedimentation in streams	Negligible
	N - Filter plant effluent	Sedimentation from in-stream construction entering Iskut River	Construction	Medium term	Adverse	Low	Local	Reversible short-term	Continuous	High	High	Sediment/erosion control plan	Minor sedimentation in streams	Negligible
	P - Airstrip along Porcupine River and its access road	Direct loss of habitat on Porcupine Floodplain (if floodplain is classified as habitat)	Construction	Far future	Adverse	Low	Landscape	Not reversible	One time	Moderate	Low	Locate airstrip away from fish habitat	Loss of very low value food production habitat on floodplain (only flooded on rare occasions).	Negligible
	Q - Heavy lift airstrip/heliport in More Valley near Round Lake	Soil compaction at site leading to sedimentation in surrounding streams	Construction	Long term	Adverse	Low	Local	Reversible short-term	Periodic	Low	Moderate	Sediment/erosion control plan	Minor, if any, sedimentation in streams	Negligible
	J - Access road from Highway 37 to mine site, including borrow pits and staging areas	Slope failure due to concentration of water on slopes	Operations	Long term	Adverse	Moderate	Landscape	Reversible long-term	One time	Low	High	Slope engineering, culvert design, habitat compensation	Long-term loss of habitat at site, with compensation elsewhere	Considerable
			Operations	Long term	Adverse	Low	Local	Reversible short-term	Periodic	Moderate	Moderate	Sediment and erosion control plan	Minor sedimentation in streams	Negligible
	L - Buried ore concentrate slurry and diesel pipelines	Rupture of pipeline	Operations	Short term	Adverse	Moderate	Landscape	Reversible long-term	One time	Low	High	Pipeline engineering, "backwash" tank at Porcupine River	Contamination of fish habitat/tissues, decreased wq/sq, direct mortality of fish, decreased productive capacity of habitat	Negligible
Operations			Long-term	Adverse	Low	Local	Reversible short-term	Periodic	Low	High	Covers on ore trucks, solidifying agent	Minor, if any, sedimentation in streams	Negligible	
O - Transportation of concentrate from the filter plant along Highway 37 to Stewart	Concentrate dust settling in fish habitat along route	Operations	Long-term	Adverse	Low	Local	Reversible short-term	Periodic	Low	High	Covers on ore trucks, solidifying agent	Minor, if any, sedimentation in streams	Negligible	
		Operations	Short term	Adverse	Moderate	Local	Reversible short-term	One time	Low	High	Speed limits, traffic safety	Contamination of fish habitat/tissues, decreased wq/sq, direct mortality of fish, decreased productive capacity of habitat	Negligible	
C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Dam rupture	Operations/ Decommissioning	Far future	Adverse	High	Transboundary	Not reversible	One time	Low	High	Overconstruction of dam	Large scale contamination of all waterbodies downstream of dam, large scale mortality, habitat loss, productive capacity	Negligible	
D - Site runoff, diversion and sediment control	Breaching diversion channel	Decommissioning/ Closure	Far future	Adverse	Low	Local	Not reversible	One time	High	High	None	Loss of food production habitat in Galore Creek	Negligible	
J - Access road from Highway 37 to mine site, including borrow pits and staging areas	Sedimentation from bridge/crossing removal	Decommissioning/ Closure	Short term	Adverse	Low	Local	Reversible short-term	One time	Moderate	Moderate	Sediment control plan	Minor sedimentation in streams	Negligible	
Dolly Varden	A - Open pit mine located in Galore Creek Valley	Construction of pits in stream habitat	Construction	Far future	Adverse	Low	Local	Not reversible	One time	High	High	None	Loss of food production habitat in Galore Creek	Negligible
	B - Process plant located in Galore Creek Valley	Suspended sediments from in-stream construction entering Galore Creek	Construction	Medium term	Adverse	Low	Local	Reversible long-term	Periodic	Moderate	High	Sediment and erosion control plan, site isolation, settling pond and diversion	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
			Construction	Medium term	Adverse	Low	Local	Reversible long-term	Periodic	Moderate	High	Sediment/erosion control plan, site isolation, settling pond and diversion	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
			Construction	Far future	Adverse	Low	Local	Not reversible	One time	High	High	Diversion channel will maintain transport of nutrients and organic matter	Permanent removal of habitat; however habitat is not high quality or necessary for fish	Negligible
	D - Site runoff, diversion and sediment control	Sedimentation from in-stream construction of containment dam entering Galore Creek	Construction	Medium term	Adverse	Low	Local	Reversible long-term	Periodic	High	High	Erosion/sediment control plan	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
			Construction	Medium term	Adverse	Moderate	Landscape	Reversible long-term	Continuous	Moderate	High	Erosion/sediment control plan	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	G - Construction camps, including ancillary facilities	Soil compaction at site leading to sedimentation in surrounding streams	Construction	Medium term	Adverse	Low	Local	Reversible short-term	Periodic	Moderate	Moderate	Erosion/sediment control plan	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	H - Operations camp, including ancillary facilities	Soil compaction at site leading to sedimentation in surrounding streams	Construction	Medium term	Adverse	Low	Local	Reversible short-term	Periodic	Moderate	Moderate	Erosion/sediment control plan	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	J - Access road from Highway 37 to mine site, including borrow pits and staging areas	Alteration of streambed with rip rap	Construction	Long term	Adverse	Low	Local	Reversible short-term	Continuous	High	High	Sediment/erosion control plan, habitat compensation	Alteration to substrate will exist for the life of the road, but will be of limited extent and impact	Negligible
			Construction	Short term	Adverse	Moderate	Local	Reversible short-term	Periodic	Moderate	High	Sedimentation/erosion plans, hydroseeding	Some sedimentation likely, but high magnitude impacts would be limited in duration and extent	Negligible
J - Access road from Highway 37 to mine site, including borrow pits and staging areas	Loss of habitat in wetlands along access corridor	Construction	Long term	Adverse	Moderate	Local	Reversible long-term	One time	Moderate	Moderate	Compensatory habitat creation, rehabilitation	Loss of food production habitat in wetland 3	Considerable	
		Construction	Far future	Adverse	Low	Local	Not reversible	One time	High	High	Compensatory habitat creation, pilings may increase cover/shelter for fish	Permanent loss of habitat in piling footprint	Negligible	
K - Transmission line from Highway 37 to mine site	Riparian vegetation alteration	Construction	Long term	Adverse	Low	Local	Reversible long-term	One time	Low	Moderate	Machine free zone, top only high trees	Minor alteration of riparian vegetation	Negligible	
L - Buried ore concentrate slurry and diesel pipelines	Sedimentation from ditch-digging, tunnel boring under streams	Construction	Medium term	Adverse	Low	Local	Reversible long-term	Continuous	Moderate	Moderate	Compact soil around pipe, sediment and erosion control plan	Minor, if any, sedimentation in streams	Negligible	

(continued)

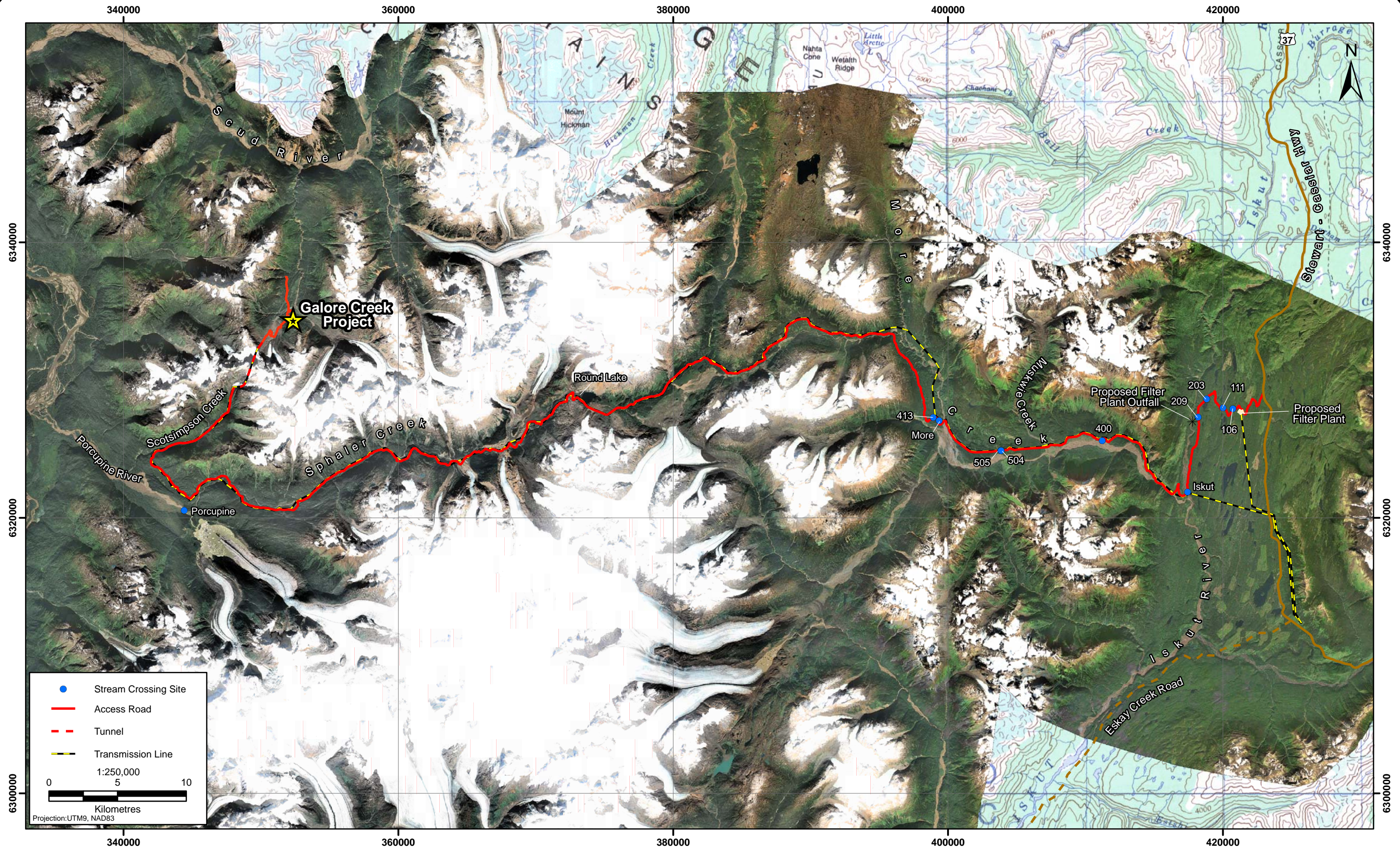
**Table 7.10-9
Effects Assessment of Habitat Loss and Alteration of Fish Habitat (continued)**

VEC	Mine Component	Summary of Effect	Phase	Duration	Direction	Magnitude	Geographic Extent	Resilience	Frequency	Probability of Occurrence	Level of Confidence	Proposed Mitigation	Residual Adverse Effects (i.e. adverse effects remaining after mitigation)	Potential for Residual Adverse Effect to be Significant
Dolly Varden	M - Filter plant, ore concentrate stockpile, truck load out facility (Bob Quinn)	Sedimentation from site runoff entering streams	Construction	Long term	Adverse	Low	Local	Reversible long-term	Periodic	Low	Moderate	Sediment/erosion control plan, compensatory habitat creation	Minor sedimentation in streams	Negligible
	N - Filter plant effluent	Sedimentation from in-stream construction entering Iskut River	Construction	Medium term	Adverse	Low	Local	Reversible short-term	Continuous	High	High	Sediment/erosion control plan	Minor sedimentation in streams	Negligible
	P - Airstrip along Porcupine River and its access road	Direct loss of habitat on Porcupine Floodplain (if floodplain is classified as habitat)	Construction	Far future	Adverse	Low	Landscape	Not reversible	One time	Moderate	Low	Locate airstrip away from fish habitat	Loss of very low value food production habitat on floodplain (only flooded on rare occasions).	Negligible
	Q - Heavy lift airstrip/heliport in More Valley near Round Lake	Soil compaction at site leading to sedimentation in surrounding streams	Construction	Long term	Adverse	Low	Local	Reversible short-term	Periodic	Low	Moderate	Sediment/erosion control plan	Minor, if any, sedimentation in streams	Negligible
	J - Access road from Highway 37 to mine site, including borrow pits and staging areas	Slope failure due to concentration of water on slopes	Operations	Long term	Adverse	High	Landscape	Reversible long-term	One time	Moderate	Moderate	Slope engineering, culvert design, habitat compensation	Long-term loss of habitat at site, with compensation elsewhere	Considerable
	L - Buried ore concentrate slurry and diesel pipelines	Sedimentation from road runoff	Operations	Long term	Adverse	Low	Local	Reversible short-term	Periodic	Moderate	Moderate	Sediment and erosion control plan	Minor sedimentation in streams	Negligible
		Rupture of pipeline	Operations	Short term	Adverse	Moderate	Landscape	Reversible long-term	One time	Low	High	Pipeline engineering, "backwash" tank at Porcupine River	Contamination of fish habitat/tissues, decreased wq/sq, direct mortality of fish, decreased productive capacity of habitat	Negligible
	O - Transportation of concentrate from the filter plant along Highway 37 to Stewart	Concentrate dust settling in fish habitat along route	Operations	Long-term	Adverse	Low	Local	Reversible short-term	Periodic	Low	High	Covers on ore trucks, solidifying agent	Minor, if any, sedimentation in streams	Negligible
		Accidental spill of concentrate near fish habitat	Operations	Short term	Adverse	Moderate	Local	Reversible short-term	One time	Low	High	Speed limits, traffic safety	Contamination of fish habitat/tissues, decreased wq/sq, direct mortality of fish, decreased productive capacity of habitat	Negligible
	D - Site runoff, diversion and sediment control	Breaching diversion channel	Decommissioning/ Closure	Far future	Adverse	Low	Local	Not reversible	One time	High	High	None	Loss of food production habitat in Galore Creek	Negligible
J - Access road from Highway 37 to mine site, including borrow pits and staging areas	Sedimentation from bridge/crossing removal	Decommissioning/ Closure	Short term	Adverse	Low	Local	Reversible short-term	One time	Moderate	Moderate	Sediment control plan	Minor sedimentation in streams	Negligible	
Other Fish Species	A - Open pit mine located in Galore Creek Valley	Suspended sediments from in-stream construction entering Galore Creek	Construction	Medium term	Adverse	Low	Local	Reversible long-term	Periodic	Moderate	High	Sediment and erosion control plan, site isolation, settling pond and diversion	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	B - Process plant located in Galore Creek Valley	Suspended sediments from construction runoff entering Galore Creek	Construction	Medium term	Adverse	Low	Local	Reversible long-term	Periodic	Moderate	High	Sediment/erosion control plan, site isolation, settling pond and diversion	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Direct habitat loss (food production) from construction of rock dam on Galore Creek	Construction	Far future	Adverse	Low	Local	Not reversible	One time	High	High	Compensatory habitat creation	Permanent removal of habitat; however habitat is not high quality or necessary for fish	Negligible
	D - Site runoff, diversion and sediment control	Sedimentation from in-stream construction of containment dam entering Galore Creek	Construction	Medium term	Adverse	Low	Local	Reversible long-term	Periodic	High	High	Erosion/sediment control plan	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
		Sedimentation from in-stream construction entering Galore Creek	Construction	Medium term	Adverse	Low	Landscape	Reversible long-term	Continuous	Moderate	High	Erosion/sediment control plan	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	G - Construction camps, including ancillary facilities	Soil compaction at site leading to sedimentation in surrounding streams	Construction	Medium term	Adverse	Low	Local	Reversible short-term	Periodic	Moderate	Moderate	Erosion/sediment control plan	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	H - Operations camp, including ancillary facilities	Soil compaction at site leading to sedimentation in surrounding streams	Construction	Medium term	Adverse	Low	Local	Reversible short-term	Periodic	Moderate	Moderate	Erosion/sediment control plan	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible
	J - Access road from Highway 37 to mine site, including borrow pits and staging areas	Alteration of streambed with rip rap	Construction	Long term	Adverse	Low	Local	Reversible short-term	Continuous	High	High	Sediment/erosion control plan, habitat compensation	Alteration to substrate will exist for the life of the road, but will be of limited extent and impact	Negligible
		Sedimentation from in-stream construction	Construction	Short term	Adverse	Moderate	Local	Reversible short-term	Periodic	Moderate	High	Compensatory habitat creation, sedimentation/erosion plans, hydroseeding	Some sedimentation likely, but high magnitude impacts would be limited in duration and extent	Negligible
		Alteration of habitat at bridge pilings	Construction	Far future	Adverse	Low	Local	Not reversible	One time	High	High	Compensatory habitat creation, pilings may increase cover/shelter for fish	Permanent loss of habitat in piling footprint	Negligible
	K - Transmission line from Highway 37 to mine site	Riparian vegetation alteration	Construction	Long term	Adverse	Low	Local	Reversible long-term	One time	Low	Moderate	Machine free zone, top only high trees	Minor alteration of riparian vegetation	Negligible
	L - Buried ore concentrate slurry and diesel pipelines	Sedimentation from ditch-digging, tunnel boring under streams	Construction	Medium term	Adverse	Low	Local	Reversible long-term	Continuous	Moderate	Moderate	Compact soil around pipe, sediment and erosion control plan	Minor, if any, sedimentation in streams	Negligible
	M - Filter plant, ore concentrate stockpile, truck load out facility (Bob Quinn)	Sedimentation from site runoff entering streams	Construction	Long term	Adverse	Low	Local	Reversible long-term	Periodic	Low	Moderate	Sediment/erosion control plan, compensatory habitat creation	Minor sedimentation in streams	Negligible
	N - Filter plant effluent	Sedimentation from in-stream construction entering Iskut River	Construction	Medium term	Adverse	Low	Local	Reversible short-term	Continuous	High	High	Sediment/erosion control plan	Minor sedimentation in streams	Negligible
	P - Airstrip along Porcupine River and its access road	Direct loss of habitat on Porcupine Floodplain (if floodplain is classified as habitat)	Construction	Far future	Adverse	Low	Landscape	Not reversible	One time	Moderate	Low	Locate airstrip away from fish habitat	Loss of very low value food production habitat on floodplain (only flooded on rare occasions).	Negligible
	Q - Heavy lift airstrip/heliport in More Valley near Round Lake	Soil compaction at site leading to sedimentation in surrounding streams	Construction	Long term	Adverse	Low	Local	Reversible short-term	Periodic	Low	Moderate	Sediment/erosion control plan	Minor, if any, sedimentation in streams	Negligible
	J - Access road from Highway 37 to mine site, including borrow pits and staging areas	Slope failure due to concentration of water on slopes	Operations	Long term	Adverse	Moderate	Landscape	Reversible long-term	One time	Low	High	Slope engineering, culvert design, habitat compensation	Long-term loss of habitat at site, with compensation elsewhere	Considerable
	L - Buried ore concentrate slurry and diesel pipelines	Sedimentation from road runoff	Operations	Long term	Adverse	Low	Local	Reversible short-term	Periodic	Moderate	Moderate	Sediment and erosion control plan	Minor sedimentation in streams	Negligible
Rupture of pipeline		Operations	Short term	Adverse	Moderate	Landscape	Reversible long-term	One time	Low	High	Pipeline engineering, "backwash" tank at Porcupine River	Contamination of fish habitat/tissues, decreased wq/sq, direct mortality of fish, decreased productive capacity of habitat	Negligible	
O - Transportation of concentrate from the filter plant along Highway 37 to Stewart	Concentrate dust settling in fish habitat along route	Operations	Long-term	Adverse	Low	Local	Reversible short-term	Periodic	Low	High	Covers on ore trucks, solidifying agent	Minor, if any, sedimentation in streams	Negligible	
	Accidental spill of concentrate near fish habitat	Operations	Short term	Adverse	Moderate	Local	Reversible short-term	One time	Low	High	speed limits, traffic safety, slurry will be dewatered, very heavy, so won't erode easily	Contamination of fish habitat/tissues, decreased wq/sq, direct mortality of fish, decreased productive capacity of habitat	Negligible	
C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Dam rupture	Operations/ Decommissioning	Far future	Adverse	High	Transboundary	Not reversible	One time	Low	High	Overconstruction of dam	Large scale contamination of all waterbodies downstream of dam, large scale mortality, habitat loss, productive capacity	Negligible	
D - Site runoff, diversion and sediment control	Breaching diversion channel	Decommissioning/ Closure	Far future	Adverse	Low	Local	Not reversible	One time	High	High	None	Loss of food production habitat in Galore Creek	Negligible	
J - Access road from Highway 37 to mine site, including borrow pits and staging areas	Sedimentation from bridge/crossing removal	Decommissioning/ Closure	Short term	Adverse	Low	Local	Reversible short-term	One time	Moderate	Moderate	Sediment control plan	Minor sedimentation in streams	Negligible	
Pacific Salmon	C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Direct habitat loss (food production) from construction of rock dam on Galore Creek	Construction	Far future	Adverse	Low	Landscape	Not reversible	One time	High	High	Diversion channel will maintain transport of nutrients and organic matter	Permanent removal of habitat; however habitat is not high quality or necessary for fish	Negligible
		Sedimentation from in-stream construction of containment dam entering Galore Creek	Construction	Medium term	Adverse	Low	Local	Reversible long-term	Periodic	High	High	Erosion/sediment control plan	Turbid water will flow into waste rock facility and will not impact downstream reaches of Galore	Negligible

(continued)

**Table 7.10-9
Effects Assessment of Habitat Loss and Alteration of Fish Habitat (completed)**

VEC	Mine Component	Summary of Effect	Phase	Duration	Direction	Magnitude	Geographic Extent	Resilience	Frequency	Probability of Occurrence	Level of Confidence	Proposed Mitigation	Residual Adverse Effects (i.e. adverse effects remaining after mitigation)	Potential for Residual Adverse Effect to be Significant
Pacific Salmon	G - Construction camps, including ancillary facilities	Soil compaction at site leading to sedimentation in surrounding streams	Construction	Long-term	Adverse	Low	Local	Reversible short-term	Periodic	Low	Moderate	Sediment/erosion control plan	Minor sedimentation in streams	Negligible
	N - Filter plant effluent	Sedimentation from in-stream construction entering Iskut River	Construction	Medium term	Adverse	Low	Local	Reversible short-term	Continuous	High	High	Sediment/erosion control plan	Minor sedimentation in streams	Negligible
	P - Airstrip along Porcupine River and its access road	Alteration of habitat at bridge pilings	Construction	Far future	Adverse	Low	Local	Not reversible	One time	High	High	Compensatory habitat creation, pilings may increase cover/shelter for fish	Permanent loss of habitat in piling footprint	Negligible
		Direct loss of habitat on Porcupine Floodplain (if floodplain is classified as habitat)	Construction	Far future	Adverse	Low	Landscape	Not reversible	One time	Moderate	Low	Locate airstrip away from fish habitat	Loss of very low value food production habitat on floodplain (only flooded on rare occasions).	Negligible
	H - Operations camp, including ancillary facilities	Sedimentation from site entering Galore Creek	Construction/ Operations	Long term	Adverse	Low	Local	Reversible long-term	Continuous	High	High	Water treatment, spill management plan	Habitat loss/alteration, turbid water will enter tailings facility	Negligible
	P - Airstrip along Porcupine River and its access road	Sedimentation, runoff of dust suppressants into Porcupine River	Construction/ Operations	Long term	Adverse	Low	Local	Reversible long-term	Periodic	Moderate	Moderate	Sediment/erosion control plan, best management practices for dust suppressants	Increased sediment during storms, potential increase in chloride concentration	Negligible
	H - Operations camp, including ancillary facilities	Sewage entering surrounding rivers	Operations	Long term	Adverse	Low	Local	Reversible short-term	Continuous	Moderate	High	Water treatment, spill management plan	Habitat loss/alteration, contaminated water will enter tailings facility	Negligible
	O - Transportation of concentrate from the filter plant along Highway 37 to Stewart	Concentrate dust settling in fish habitat along route	Operations	Medium term	Adverse	Negligible	Transboundary	Reversible short-term	Periodic	Low	High	Covers on ore trucks, solidifying agent	Minor, if any, sedimentation in streams	Negligible
		Accidental spill of concentrate near fish habitat	Operations	Short term	Adverse	Moderate	Transboundary	Reversible long-term	One time	Low	High	Speed limits, traffic safety	Contamination of fish habitat/tissues, decreased wq/sq, direct mortality of fish, decreased productive capacity of habitat	Negligible
	Stikine River	C - Mill tailings and waste rock storage facilities including containment dam and haul roads	Dam rupture	Operations/ Decommissioning	Far future	Adverse	High	Transboundary	Not reversible	One time	Low	High	Overconstruction of dam	Large scale contamination of all waterbodies downstream of dam, large scale mortality, habitat loss, productive capacity; however, very low probability
C - Mill tailings and waste rock storage facilities including containment dam and haul roads		Dam rupture	Operations/ Decommissioning	Far future	Adverse	High	Transboundary	Not reversible	One time	Low	High	Overconstruction of dam	Large scale contamination of all waterbodies downstream of dam, large scale mortality, habitat loss, productive capacity; however, very low probability	Negligible



- Stream Crossing Site
- Access Road
- - - Tunnel
- - - Transmission Line

1:250,000

0 5 10

Kilometres

Projection: UTM9, NAD83

Stream Crossing Sites where Fish Habitat Compensation will be Required