7.5 Surface Water and Sediment Quality

This section examines potential project effects on surface water and sediment quality. Existing conditions in the project area are characterized and effects of project activities are predicted. Effects predictions are based on site water management plans and effluent treatment systems described in Section 2.9: Site Water Management, and projections of drainage and effluent quality, from ongoing testing and assessment of ARD and metals leaching from ore, development rock (Section 2.4: Rock Characterization) and tailings (Section 2.8: Tailing Facility). Information on predicted project effects on stream flows (Section 7.4: Surface Water Hydrology) and groundwater flows and quality (Section 7.6: Groundwater) are integrated into the assessment of effects on surface water and sediment quality. The findings of this section provide the basis for assessment of potential project effects on aquatic biota in Sections 7.7: Periphyton and Benthos and 7.8: Fish Resources. This section describes project effects under routine construction and operating conditions. Potential effects of project-related accidents and malfunctions on surface water and sediment quality are discussed in Section 8: Accidents and Malfunctions.

7.5.1 Scope of Assessment

Surface water and sediment quality are identified as VECCs because they are sensitive to project effects and because they provide a vital link in sustaining healthy aquatic ecosystems. Assessment of project effects on water and sediment quality provides an indication of potential effects on aquatic organisms at the population and community levels. Many aquatic organisms have known tolerances and responses to metals, nutrients and sediment typically associated with mining operations. Potential project effects on water and sediment quality can result from:

- introduction of sediments (total suspended solids, TSS) to receiving waters due to runoff from disturbed areas during mine facility and access road construction
- changes to the Go Creek flow regime and water and sediment quality, related to clean water diversions and site water management (drainage collection, settling ponds)
- discharge of treated effluent, containing metals, nutrients and sediment, and sewage to Go Creek
- seepage of contaminated groundwater from the tailings facility to Go Creek
- discharge of tailings pond supernatant to Go Creek following mine decommissioning
- seepage of potentially contaminated groundwater to Wolverine Creek following mine backfill at decommissioning and closure

Direct and indirect effects of water and sediment quality on aquatic life have been well recognized for over a century (Wetzel 2001). Currently, the Canadian Council of Ministers of the Environment (CCME) maintains and updates a list of scientifically derived water and sediment quality guidelines for protection of various users, including aquatic life (CCME 2004). Both periphyton and benthic invertebrates are used as indicators of water quality because of their recognized sensitivity to changes in nutrients, sediment (TSS) and metal levels. Water quality and biological community sampling are typically linked in government-developed biomonitoring programs in Canada (Environment Canada 2002) and the United States (Barbour et al. 1999).

Discharge of mine effluent to the receiving environment has potential for direct adverse effects on aquatic ecosystems, through toxicity of metals, nutrient enrichment (elevated nitrate or ammonia from blasting residues), increased sulphate levels, changes in pH, and release of suspended sediments. Environmental effects of mine effluent discharge have been well documented, and include excessive growth of periphyton resulting from nitrate or ammonia discharges, reduced abundance of periphyton and benthic invertebrates in areas close to discharge points, elimination of sensitive species, changes in community structure and deformities of periphyton induced by metals (Aquamin 1996). Changes in periphyton and benthos productivity can have an effect on fish assemblages (abundance, size, bioaccumulation of metals in tissue), which can then affect birds and wildlife that consume fish.

Metal Mining Effluent Regulations (MMER), under the *Fisheries Act*, and associated Environmental Effects Monitoring (EEM) programs, came into effect in 2002 and require three-year cycles of effluent and receiving environment monitoring. Environment Canada administers MMER. Mine permits and MMER describe effluent quality criteria. The regulation and the EEM guidance document (Environment Canada 2002) define statistically and ecologically supported procedures for assessing the effects of effluent discharge on the receiving environment. These include weekly, monthly or quarterly effluent monitoring, water monitoring in the receiving environment, acute and chronic effluent toxicity testing, benthic invertebrate and fish community studies, and assessment of supporting environmental parameters (e.g., habitat quality, nutrient levels).

Project components that have the potential to influence surface water and sediment quality are described briefly below. Further information on site water management facilities and design is provided in Section 2.9: Site Water Management.

Discharge of treated site drainage – Surface drainage in the vicinity of the underground mine portal and industrial complex will be collected in drainage ditches, directed to the surface sumps and pumped to the process water balance. Accordingly, site drainage will pass through the water treatment plant prior to discharge to Go Creek. The main area of surface disturbance in the Go Creek basin will be the borrow area. Drainage from the borrow area will be collected in ditches and pumped to the tailing pond. As noted above, tailings pond water will be incorporated in the process water balance circulation and any discharges will be treated in the water treatment plant prior to discharge to Go Creek.

Clean water diversions from upper Go Creek affecting flows – A diversion ditch will be built in upper Go Creek to divert clean water and slope runoff away from the tailings facility and into Go Creek. During construction, water will be diverted to the tailings pond from May to mid-July (freshet), which will reduce flows in upper Go Creek during that one season; however, flows will remain higher than summer low flows. There will be no significant changes in Go Creek flows related to mine operations during the operational phase or any reduction in dilution capacity for project related wastes. The only project effect on water quality in upper Go Creek near the camp will be discharge of effluent from the package sewage treatment plant at the camp. Discharge will meet CCME drinking water standards, and is unlikely to exceed SS-WQO once diluted in Go Creek (Section 7.4: Surface Water Hydrology).

Water treatment plant discharge to Go Creek - All mine and ore processing water will be circulated within the overall process water balance and water management system. Any excess water from this system will be treated before discharge to surface waters in Go Creek. Effluent quality has been projected based on mine water data collected to date and MMER requirements. Receiving water quality in Go Creek has been predicted based on proposed rates of effluent discharge and receiving water flows and quality.

Treatment plant effluent will meet or exceed MMER effluent quality criteria prior to discharge (Section 2.9). Effluent will be discharged to Go Creek approximately 100 m downstream of the Hawkowl Creek confluence. Treated effluent will be discharged mainly from May through October, when there is sufficient dilution capacity in Go Creek to ensure receiving water quality meets site-specific water quality objectives (SS-WQO) in lower Go Creek (Section 2.9). The SS-WQO will be developed in conjunction with regulatory agencies, and will be based on CCME guidelines for protection of aquatic life. The SS-WQO will take into consideration ambient water chemistry, e.g., cadmium levels in Go Creek, which exceed CCME guideline several times during the summer. Separate SS-WQO will likely be developed for Wolverine Creek, given that baseline levels of cadmium, selenium and zinc have exceeded CCME guidelines in all samples analyzed.

All metal and ammonia levels in Go Creek will meet SS-WQO at a designated water quality compliance site (W12) in lower Go Creek, 7 km downstream of the discharge. There is a two-fold increase in flows between the discharge point and W12, resulting from slope runoff and groundwater infiltration. Further dilution is provided by flows from Pup Creek, a Go Creek tributary downstream of W12, and by Money Creek.

Arsenic, copper, lead, nickel and zinc levels will meet SS-WQO immediately downstream of the treated effluent discharge point during the May through October discharge period. For ammonia, cadmium and selenium, further dilution in Go Creek will be required to meet the SS-WQO at W12.

Nitrate and ammonia are residues of explosives and are typically contained in waste rock storage area drainage, the tailings pond and sewage. Nitrate levels in effluent (Section 2.9) will be below the CCME guideline for protection of aquatic life (13 mg/L), which protects against toxicity but does not reflect nutrient enrichment or eutrophication. The potential for nutrient enrichment downstream of the discharge will be assessed, given that some enrichment of nutrients and stimulation of algal growth can provide benefits to an oligotrophic system but that over-enrichment can lead to excessive algal growth.

Discharge of potentially contaminated groundwater seepage from the tailings pond to Go Creek - Seepage from the tailings facility during operations will be intercepted by a seepage pond immediately down slope of the facility, pumped back to the tailings facility and process water balance and treated prior to discharge (Section 2.8: Tailings Facility).

Discharge from the tailings facility after mine closure - At the end of operations, the tailings facility will remain in place, with a water cover to prevent leaching of metals from the tailings related to acid rock generation (Section 2.8: Tailings Facility). Supernatant will be monitored and treated for at least five years, during which time most metals are predicted to be reduced to levels lower than SS-WQO (except for cadmium and selenium, which will take up to nine years). Flow rates from the pond spillway are expected to be less than 2.5% of summer flows.

Discharge of potentially contaminated groundwater from the backfilled underground mine to Wolverine Creek - At the end of operations, mine dewatering will cease and the groundwater table will rise to saturate the backfilled underground mine workings. As groundwater starts to move through the backfilled mine area, some residual products of ARD and metal leaching may be mobilized in the groundwater and ultimately discharge to Wolverine Creek and possibly Little Wolverine Lake (Section 7.6: Groundwater). Use of alkaline materials in paste backfill will reduce the potential for metals leaching.

A list of water and sediment quality VECCs has been defined for the project environmental assessment based on the EA Report Guidelines (Yukon Zinc Council Office 2005), the Biophysical Workplan submitted to regulators by YZC (Yukon Zinc Corp. 2005), a review of baseline information, review of a preliminary VECC list by the project Technical Committee (August 23, 2005) and consultation with Benoit Godin (Environment Canada), Sandra Orban (Fisheries and Oceans Canada) and Randy Lamb (Yukon Department of Environment). The selected VECCs and rationale for their selection are described in Table 7.5-1.

7.5.1.1 Temporal Boundaries

The temporal boundaries applicable to water and sediment quality include the period of record for collection of baseline data and all phases of the project (construction, operation, decommissioning and closure). The potential for introduction of silt and sediment to area streams will be present in all phases, but greatest during construction. The potential for introduction of metals or nitrogen to area streams will be present in all phases, but greatest during operation. Decommissioning will include a period to stabilize the quality of tailings pond discharge for ultimate closure. Monitoring will be conducted following reclamation of the tailings facility to check the quality of tailing pond water and seepage, provide treatment if required, prior to discharge to Go Creek and ensure effective long term management of ARD and metal leaching by underwater tailings storage. The assessment of the closure phase assumes stabilization of water quality conditions in the reclaimed tailings facility at closure. It is anticipated that this will be possible, based on monitoring during the operations and decommissioning phase, and adaptive management to ensure effective long-term management of potential project effects from tailings and groundwater.

7.5.1.2 Study Area

The local and regional study areas are shown in Figure 7.5-1. The local study area (LSA) includes all streams and associated waterbodies that may be influenced by mine site activities or use of the access road. This includes streams in the Money, Wolverine and Light Creek watersheds, and several tributaries that will be crossed by the access road between the mine and the Robert Campbell Highway. Specifically the LSA includes:

- the Go Creek watershed, which will be affected by diversions, tailings pond, airstrip, borrow area and campsite development and will receive permitted discharges of treatment plant effluent; and tributaries of Go Creek (Hawkowl and Pup Creeks), which will be affected access road crossings
- Money Creek, a 1 km section downstream of the Go Creek confluence
- Wolverine Creek, which drains the mine portal area and eastern slope of the mine property and enters Little Wolverine Lake
- stream reaches crossed by the proposed access road (Chip, Bunker, Pitch and Putt Creeks and others within the Money and Light Creek watersheds) defined as up to 100 m upstream and 200 m downstream of the proposed road corridor

Figure 7.5-1 Water Quality, Sediment, Benthic Organisms and Fish – Local and Regional Study Areas (Vol. 2)

Table 7.5-1 Receiving Water Quality and Sediment VECCs

VECC	Rationale for Selection	Linkage to EA Report Guidelines or Other Regulatory Drivers	Baseline Data for EA
Water Quality: total suspended solids (TSS)	• Potential for project effects due to ground disturbance, construction, and associated erosion and sedimentation, and dust and particulates in runoff from mine facilities (stockpiles, waste areas)	• Information requested in EA Report Guidelines and Preliminary Workplan • CCME or other guidelines for protection of aquatic life • Will be required for MMER	• 1995-97 data • 2000-01 data • 2005 data
Water quality: pH, conductivity and alkalinity	• Potential for project effects due to ARD affecting treatment plant effluent discharges to Go Creek and groundwater discharge to Wolverine Creek. Characterizes sensitivity of receiving waters to project-related discharges. Changes in receiving water quality potentially affect aquatic resources, including fish	• Information requested in EA Report Guidelines and Preliminary Workplan • CCME or other guidelines for protection of aquatic life • Will be required for MMER	• 1995-97 data • 2000-01 data • 2005 data
Water quality: sulphate concentrations	• Potential for project effects due to ARD affecting treatment plant effluent discharges to Go Creek and groundwater discharges to Go and Wolverine Creeks • Indicator of mine related changes in water quality due to ARD	• Information requested in EA Report Guidelines and Preliminary Workplan • CCME or other guidelines for protection of aquatic life • Will be required for MMER.	• 1995-97 data • 2000-01 data • 2005 data
Water quality: metals concentrations (*e.g.* Cd, Se, Zn)	• Potential for project effects due to ARD and metal leaching affecting treatment plant effluent discharges to Go Creek and groundwater discharges to Wolverine Creek • Potential for bioaccumulation and toxic effects on aquatic resources and fish	• Information requested in EA Report Guidelines and Preliminary Workplan • CCME or other guidelines for protection of aquatic life • Will be required for MMER	• 1995-97 data • 2000-01 data • 2005 data
Water quality: concentrations of nitrogen compounds (NO_3 & NH_4)	• Potential for project effects due to blasting residue and sewage effluent discharges in the Go Creek drainage • Potential effects on primary productivity and associated effects on aquatic ecology. Potential toxicity to aquatic life in high concentrations	• Information requested in EA Report Guidelines and Preliminary Workplan • Will be required for MMER	• 1995-97 data • 2000-01 data • 2005 data •
Sediment quality: metals concentrations	• Potential for project effects due to treatment plant effluent discharges to Go Creek • Effects on sediment quality provide an indicator of potential effects on benthic communities and related effects on fish food	• Information requested in EA Report Guidelines and Preliminary Workplan • Will be required for MMER	• 1995-96 data • 2005 data

The proposed road alignment has been located in high elevation, headwater areas wherever possible, to avoid potential or identified fish-bearing streams. Several of these streams were observed to be dry during August and October surveys, and may be ephemeral (see Section 7.8: Fish Resources).

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

- Money Creek, from the Go Creek confluence to Frances Lake and tributaries of Money Creek downstream of the access road crossings
- Wolverine and Little Wolverine Lakes and Nougha Creek, which drains Wolverine Lake
- Light Creek and tributaries of Light Creek downstream of the access road crossings

7.5.2 Baseline Conditions

7.5.2.1 Methods

Existing information from previous studies conducted for the project are summarized in the Wolverine Project Description Report prepared by Gartner Lee (2004) and described in historic water sampling programs (Westmin 1996, 1997; Expatriate Resources 2001). Historic information has been augmented with the 2005 monitoring program, which will continue through 2006, to provide an annual baseline. Water and sediment data are compared to CCME guidelines for protection of aquatic life (CCME, 2004), shown in Table 7.5-2.

Table 7.5-2 CCME Guidelines for Protection of Freshwater Aquatic Life

Metal (total)	In Water (mg/L)	In Sediment (µg/kg)	
		ISQG[1]	PEL[2]
Aluminum	0.100		
Arsenic	0.005		
Cadmium	0.000017 (hardness = 1-60 mg/L CaCO3) 0.00008 (hardness = 60-120 mg/L CaCO3)	600	3500
Chromium	0.0089		
Copper	0.002 (hardness = 0-120 mg/L CaCO3)	35,700	197,000
Iron	0.30		
Lead	0.001 (hardness = 1-60 mg/L CaCO3) 0.002 (hardness = 60-120 mg/L CaCO3)	35,000	91,300
Mercury		170	486
Molybdenum	0.073		
Nickel	0.025 (hardness = 1-60 mg/L CaCO3) 0.065 (hardness = 60-120 mg/L CaCO3)		
Selenium	0.001		
Silver	0.0001		
Zinc	0.030	123,000	315,000

Notes: 1. ISQG = interim sediment quality guideline
2. PEL = probable effects level

Water Sampling Methods

Historic Water Sampling Programs (1995 to 2001)

Water sampling programs were conducted in the project area by Westmin Resources in 1995, 1996 and 1997 (Westmin 1996, 1997) and by Expatriate Resources in 2000 and 2001 (Expatriate 2001). The number of stations and frequency of sampling varied during the two programs, according to the scope and focus of the project envisioned at the time. Early studies included surveys of Wolverine, Little Wolverine and Little Jimmy Lakes, as well as of several streams. Sampling sites were established at 53 locations throughout the Money and Wolverine drainages, as shown in Figure 7.5-2, Figure, 7.5-3 and Table 7.5-3. The sampling schedule is shown in Table 7.5-4 (see Volume 2).

The programs are summarized as follows:

- 1995 – 22 stations in October
- 1996 – 11-29 stations in March, May, June, July, August and November, with extensive sampling in late July and late August
- 1997 – 12-29 stations in March, May, June, July, August and September, with extensive sampling in May, July and September
- 2000 –14 stations during June
- 2001 – 6-10 stations in January and July

Temperature, pH, conductivity and dissolved oxygen were measured *in situ* at all locations. Water samples were collected for analysis of metals (total and dissolved), alkalinity, nutrients (ammonia, nitrate, nitrite), total dissolved solids, total suspended solids, turbidity, anions (sulphate, chloride, fluoride) and, occasionally, cyanide.

Samples were analyzed by Quanta Trace Laboratories (Burnaby BC) in 1995 and ALS (Vancouver BC) in subsequent years. The 2000 and 2001 programs included field duplicates, travel blanks and filtration blanks. Results of historic water sampling programs are presented in Appendices 7.5-1 (analytical data) and 7.5-2 (*in situ* measurements) and discussed below in relation to the 2005 data.

Figure 7.5-2 Water and Sediment Sampling Sites 1995 to 2005 (Vol. 2)

Figure 7.5-3 Sampling Sites in Mine Footprint Area 1995 to 2005 (Vol. 2)

2005 Water Sampling Program

The 2005 workplan was prepared based on an assessment of historic data and EA Report Guidelines. The study design was developed to ensure adequate characterization of the receiving environments around the proposed mine site (Go Creek and tributaries, Wolverine Creek) and downstream (Money Creek upstream and downstream of Go confluence), areas along the proposed access road and potential reference areas.

Sites shown in Table 7.5-4 have been sampled monthly since May 2005 and analyzed as described in Table 7.5-5. As in previous years, the Quality Assurance/Quality Control (QA/QC) program included field and laboratory duplicates, travel blanks and field filtration blanks. Results are presented in Appendices 7.5-1 and 7.5-2 for May, June, July and August 2005 and discussed below in combination with the earlier data. Data collected between September and November will be reported separately in an addendum report, to be submitted in early 2006, along with sediment, periphyton, benthic invertebrate data that were provided following the submission date for this report.

Table 7.5-3 Current and Historic Water Quality Monitoring Sites, Yukon Zinc 1995 to 2005

Site Description	Site #	Site Description	Site #
Nougha Cr. 100 m downstream of Wolverine L.	W1	Go Creek upstream of airstrip	W31
Wolf Cr. 50 m upstream of mouth	W2	Little Wolverine Creek upstream of portal	W32
Wolverine Lake mid-transect opposite W-2	W3	Groundwater spring near ore body	W33
Viking Cr. 50 m upstream of mouth	W4	Money Creek below Robert Campbell Highway	W40
Wolverine Lake mid-transect opposite W-4	W5	pond near waste rock pad	W41
Jasper Cr. 30 m upstream of mouth	W6	seep/spring above waste rock pad	W42
Wolverine Lake mid-transect opposite W-6	W7	Go Creek opposite heli-fuel area	W43
Campbell Cr. 30 m upstream of mouth	W8	ephemeral creek at Tailings Road	W44
Wolverine Cr. 50 m u/s beaver dam at mouth	W9	creek at south end of Tailings Area	W45
Little Wolverine Lake mid-transect opposite W-9	W10	15 m upstream of Culvert at airstrip	W46
Money Cr. 60 m upstream of Go Cr.	W11	creek downstream of waste rock pad	W47
Go Cr. 20 m upstream of Pup Cr.	W12	tributary of Light Creek – d/s of proposed road	W51
Pup Cr. 20 m upstream of mouth	W13	Light Creek - 500 m u/s of W51 (below wetland)	W51A
Money Cr. 100 m downstream of Go Cr.	W14	Bunker Creek (upper watershed)	W61
Hawkowl Cr. 30 m upstream of Go Cr.	W15	Bunker Cr. tributary, 200 to 400 m u/s of Bunker	W62
Go Cr. 15 m upstream of Hawkowl Cr.	W16	Chip Creek road crossing (upper watershed)	W69
Headwaters of Go Cr. (left tributary)	W17	Pitch Creek (Sept. 2005)	W71
Headwaters of Go Cr. (right tributary)	W18	Light Creek (Sept. 2005)	W72
Upper Hawkowl Cr.	W19	Bunker Creek at proposed crossing (Sept. 2005)	W73
Burn Cr. 20 m upstream of mouth	W20	Chip Creek (Sept. 2005)	W74
Nougha Cr. 30 m u/s Robert Campbell Highway	W21	Little Jimmy Lake tributary (Sept 2005 benthos)	W75
Money Cr. 50 m u/s Robert Campbell Highway	W22	underground water	UG
Money Cr. upstream of Dollar Cr.	W23	Wolverine Cr near mill site	
East Cr.	W24	Little Jimmy Lake	M-1
Inflow to Little Wolverine Lake	W25	Little Wolverine Lake (same as W-10)	L-1
Wind Creek	W26	Wolverine Lake (1 mile north of island)	P-1
Dollar Creek	W27	Wolverine Lake (1/2 way between W2 & W4)	P-2
unnamed creek at Robert Campbell Highway	W28	Wolverine Lake (0.5 miles south of W5)	P-3
Wind Lake (centre or along shore)	W29	Wolverine Lake (1 mile north of W7)	P-4

Table 7.5-4 Water Quality Monitoring Sites and Dates, Yukon Zinc Study Area, 1995 to 2005 (Vol. 2)

Parameters, analytical methods and detection limits are summarized in Table 7.5-5.

Table 7.5-5 Water Quality Parameters and Detection Limits

Parameter		Detection limit (mg/L)	Analytical Method
Aluminum, total and dissolved	Al	0.001 to 0.2	ICP / ICP MS
Antimony, total and dissolved	Sb	0.00005 to 0.02	ICP / ICP MS
Arsenic, total and dissolved	As	0.00005 to 0.02	ICP / ICP MS
Barium, total and dissolved	Ba	0.00005 to 0.02	ICP / ICP MS
Beryllium, total and dissolved	Be	0.0005 to 0.005	ICP / ICP MS
Bismuth, total and dissolved	Bi	0.0005 to 0. 2	ICP / ICP MS
Boron, total and dissolved	B	0.001 to 0.01	ICP / ICP MS
Cadmium, total and dissolved	Cd	0.000017 to 0.01	ICP / ICP MS
Calcium, total and dissolved	Ca	0.05 to 0.1	ICP / ICP MS
Chromium, total and dissolved	Cr	0.0001 to 0.1	ICP / ICP MS
Cobalt, total and dissolved	Co	0.0001to 0.01	ICP / ICP MS
Copper, total and dissolved	Cu	0.0001 to 0.01	ICP / ICP MS
Iron, total and dissolved	Fe	0.01 to 0.03	ICP / ICP MS
Lead, total and dissolved	Pb	0.00005 to 0.05	ICP / ICP MS
Lithium, total and dissolved	Li	0.0005 to 0.01	ICP / ICP MS
Magnesium, total and dissolved	Mg	0.05 to 0.1	ICP / ICP MS
Manganese, total and dissolved	Mn	0.00005 to 0.005	ICP / ICP MS
Mercury (total) , total and dissolved	Hg	0.00002 to 0.00005	Cold Oxidation (CVAAS)
Molybdenum, total and dissolved	Mo	0.00002 to 0.03	ICP / ICP MS
Nickel, total and dissolved	Ni	0.0001 to 0.05	ICP / ICP MS
Phosphorus, total and dissolved	P	0.05 to 0.3	ICP / ICP MS
Potassium, total and dissolved	K	0.2 to 2	ICP / ICP MS
Selenium, total and dissolved	Se	0.0005 to 0.2	ICP / ICP MS
Silicon, total and dissolved	Si	0.001 to 0.05	ICP / ICP MS
Silver, total and dissolved	Ag	0.00001 to 0.01	ICP / ICP MS
Sodium, total and dissolved	Na	2	ICP / ICP MS
Strontium, total and dissolved	Sr	0.0001 to 0.005	ICP / ICP MS
Thallium, total and dissolved	Tl	0.00005 to 0.2	ICP / ICP MS
Tin, total and dissolved	Sn	0.0001 to 0.03	ICP / ICP MS
Titanium, total and dissolved	Ti	0.01	ICP / ICP MS
Vanadium, total and dissolved	V	0.0002 to 0.03	ICP / ICP MS
Zinc, total and dissolved	Zn	0.001 to 0.005	ICP / ICP MS
Total alkalinity	$CaCO_3$	1	Titration to pH=4.5
Ammonia	N	0.005 to 0.02	Colorimetry
Nitrate	N	0.005	Ion Exchange Chromatography
Nitrite	N	0.001	Colorimetry
Nitrite + nitrate	N	0.005	Ion Exchange Chromatography
Sulphate	SO_4	0.03 to 1	Ion Exchange Chromatography
Total dissolved solids	TDS	1 to 5	Filtration/Gravimetric
Total suspended solids	TSS	1 to 5	Filtration/Gravimetric
Turbidity		0.1 to 1.0 (NTU)	Nephelometric
Conductivity		1.0 to 2.0 (µS)	Conductivity cell
pH (Relative Units)		0.01 (RelU)	Potentiometric
Cyanide (total)	CN	0.005	Distillation/UV Detection
Fluoride	F	0.02 to 0.5	Colorimetry
Chloride	Cl	0.5	Colorimetry

Quality Assurance / Quality Control

QA/QC included collection of duplicate and triplicate samples, travel blanks, filter blanks, and comparison of total and dissolved metals concentrations. Results are provided in Appendix 7.5-3.

Duplicate samples provide a check on collection and processing methods and potential for variability at sites. There was good agreement between field duplicates, with 25 reports of differences greater than 20% from a total of 352 comparisons. Of the 25 reports, 10 were associated with values close to the detection limit (where the difference is of less significance). Notable differences included eight for parameters representative of particulate matter (turbidity, total aluminum, iron, manganese, zinc), where some variability may be expected, one for dissolved ortho-phosphate, one for dissolved organic carbon, one for antimony and four for dissolved metals (aluminum, copper iron, magnesium). There was also good agreement between laboratory duplicates (10% of samples submitted in 2005), with all parameters meeting laboratory quality objectives.

Triplicate samples were collected at nine sites in June 2000 to provide an indication of short-term variability. Variability was assessed in terms of standard deviation of the mean. On average, standard deviation was within 10% of the mean, indicating low short-term variability, and was highest for silver (59% and 68% of the mean for total and dissolved, respectively, with values close to the detection limit).

Travel blanks (de-ionized water that travels from laboratory to field and back, unopened) are submitted to provide a measure of potential sample contamination during shipping and handling. The nine travel blanks analyzed during baseline studies had 11 reports of trace levels of metals out of 321 measurements. Six reports were associated with one sample collected July 15, 1997 (for aluminum, barium, copper, manganese, strontium, and calcium), suggesting an isolated contamination incident related to the original laboratory sample or an event during transport. Metal levels were not high enough to suggest reduced quality of other analytical results for those dates.

Filter blanks (de-ionized water filtered in the field following the method used to prepare dissolved metals samples) were submitted to detect errors introduced through filtering. Of the ten filter blanks analyzed, metals were measurable in 30 of the 311 analyses, indicating generally high quality field techniques. Of these 30 records, 16 represented values close to detection limits and 14 were more notable, including 11 associated with two samples, suggesting isolated methodological or analytical issues (14 June and 2 July 1997 - barium, boron, copper, lead, manganese, strontium, tin and zinc). Other detectable metals included calcium (May 1996, July 1996) and iron (August 1996).

Comparison of total and dissolved metals concentrations also evaluates error associated with metals introduced during the filtering process, which would result in higher concentrations measured in the dissolved fraction. Of 10,771 analyses done between 1995 and 2001, 1333 showed higher levels of dissolved than total metal (12% of analyses).

Water quality data collected for the baseline study are of good quality. This is especially important considering the large numbers of samples collected, broad geographic area and changes in sampling protocols and personnel over time. Duplicates were replicable and there was little variation introduced through the sampling method or short-term natural variability. Travel and filter blanks analyzed for June and July 1997 show possible contamination, and may be due a contaminated batch of de-ionized water provided by the lab, or poor handling technique by field staff at that time.

Sediment Collection Methods

Stream sediments were sampled in October 1995, July 1996 and June/July 2001 using two different approaches. The baseline was expanded in 2005 to provide more representative data and meet requirements of the EA Report Guidelines. Data from the 2005 survey will be provided in an addendum report, to be submitted in early 2006. Sites are listed in Table 7.5-9 and shown in Figure 7.5-2.

The 1995 program (19 sites) results did not specify habitat type or collection methods. Stream sediment was passed through a 100 mesh (0.15 mm) screen and the fine portion analyzed for total metals by Quanta Trace Laboratories (Burnaby, BC).

The 1996 program (24 stream sites) included collection of sediment from an exposed area of the bank (in areas of fine grain size), using a teflon trowel. Lake sediment samples (six sites) were collected from deep areas of Wolverine (four sites), Little Wolverine (one site) and Little Jimmy (one site) lakes using an Eckman dredge. All samples were sieved to create two particle size fractions (<0.070 mm and 0.070 to 2 mm), and then analyzed for total metals and dissolved organic carbon. Chemex Laboratories (Vancouver BC) analyzed the samples. These results reflect conditions along stream banks rather than in instream habitat, so their utility is limited to comparative purposes.

The 2001 program (five stream sites, one site in Little Wolverine Lake) involved collection of five replicate samples from each site, with samples sieved and the <0.230 mm fraction analyzed for metals. Collection methods were the same as for 1996. Samples were analyzed by ALS Laboratory (Vancouver BC). Sites sampled in 2001 were located in receiving waters around the proposed mine site and were intended to serve as potential monitoring sites in the future.

The 2005 program (23 stream sites) followed recommendations of the EA Report Guidelines, with samples collected from riffle areas using a 2.5 cm diameter PVC tube to extract fine sediment from below the cobble and boulder substrate. This method was recommended by Environment Canada for consistency with recent Yukon programs. Samples were sieved in the laboratory and the <0.063 mm fraction analyzed for total metals. This method was followed in order to obtain representative data for riffle habitat.

Table 7.5-6 Summary of Sediment Chemistry Sampling Program

Site	1995	1996	2001	2005
W1 Nougha Cr. 100 m downstream of Wolverine Lake	X	X		X
W2 Wolf Cr. 50 m upstream of mouth	X	X		
W4 Viking Creek 50 m upstream of mouth	X	X		
W6 Jasper Cr. 30 m upstream of mouth	X	X		
W8 Campbell Cr. 30 m upstream of mouth	X	X		X
W9 Wolverine Cr. 50 m upstream of beaver dam at mouth	X	X	X	X
W11 Money Cr. 60 m upstream of Go Cr.	X	X		X
W12 Go Cr. 20 m upstream of Pup Cr.	X	X	X	X
W13 Pup Cr. 20 m upstream of mouth	X	X		X
W14 Money Cr. 100 m downstream of Go Cr.	X	X		X
W15 Hawkowl Cr. 30 m upstream of Go Cr.	X	X		X
W16 Go Cr. 15 m upstream of Hawkowl Cr.	X	X	X	X
W17 Headwaters of Go Cr. (left tributary)	X	X		
W18 Headwaters of Go Cr. (right tributary)	X	X		X
W19 Upper Hawkowl Cr.	X	X		X
W20 Burn Cr. 20 m upstream of mouth	X	X		
W21 Nougha Cr. 30 m upstream of Robert Campbell Highway	X	X		X
W22 Money Cr. 50 m upstream of Robert Campbell Highway	X	X		X
W23 Money Cr. upstream of Dollar Cr.		X		X
W24 East Cr.		X		
W25 Inflow to Little Wolverine Lake		X		
W26 Wind Creek		X		
W27 Dollar Creek		X		
W28 unnamed creek at Robert Campbell Highway		X		
W30 Go Creek downstream of airstrip			X	
W31 Go Creek upstream of airstrip				X
W32 Wolverine Creek upstream of portal area			X	
W40 Money Creek downstream of highway				X
W71 Pitch Creek				X
W72 Light Creek				X
W73 Bunker Creek				X
W74 Chip Creek				X
W75 Inlet creek on west side of Little Jimmy Lake				X
M-1 Little Jimmy Lake		X		
L-1 Little Wolverine Lake		X	X	
P-1 Wolverine Lake (1 mile north of island)		X		
P-2 Wolverine Lake (1/2 way between W2 & W4)		X		
P-3 Wolverine Lake (0.5 miles south of W5)		X		
P-4 Wolverine Lake (1 mile north of W7)		X		

7.5.2.2 Results

Water Quality

Baseline results are described using all available data from 1995 to 2005, and are discussed for waterbodies in the LSA, then for those in the RSA. Results for Go Creek and tributaries (Sites W15, W16 and W12), Wolverine Creek (W9) and Money Creek (W11) are summarized in Figures 7.5-4 to 7.5-6 to show the annual range of metal levels in stream reaches potentially affected by mine construction and operation.

Go Creek and Tributaries

Go Creek, a 12 km long tributary of Money Creek, is the main system that will be affected by project activities It flows through the YZC lease area, drains areas where mine facilities will be established, and will receive permitted discharges from the water treatment facility. Seven sites have been monitored in Go Creek and its tributaries:

- W18, Go Creek, right tributary in headwater
- W31, Go Creek, upstream of airstrip
- W16, Go Creek, upstream of Hawkowl Creek
- W12, Go Creek, upstream of Money Creek confluence
- W15, Hawkowl Creek (tributary in the upper Go watershed), upstream of Go Creek
- W19, Hawkowl Creek, in the headwaters
- W13, Pup Creek (tributary in the lower Go watershed), near the Go confluence

Water quality is of particular interest in the area around the effluent discharge in Go Creek (downstream of W16 and W15) and at W12, the designated point of compliance with SS-WQO, approximately 7 km downstream of the discharge. These areas will be important in evaluating potential effects of effluent discharge on water quality and aquatic resources when the mine is operational.

Water chemistry is summarized in Table 7.5-6 for the seven sites sampled in Go Creek and tributaries from 1995 to 2005. General parameters show consistent trends among the sites, and indicate that streams are slightly alkaline in pH, low to moderate in hardness, low in sulphate (less than 16 mg/L) and generally low in nutrients.

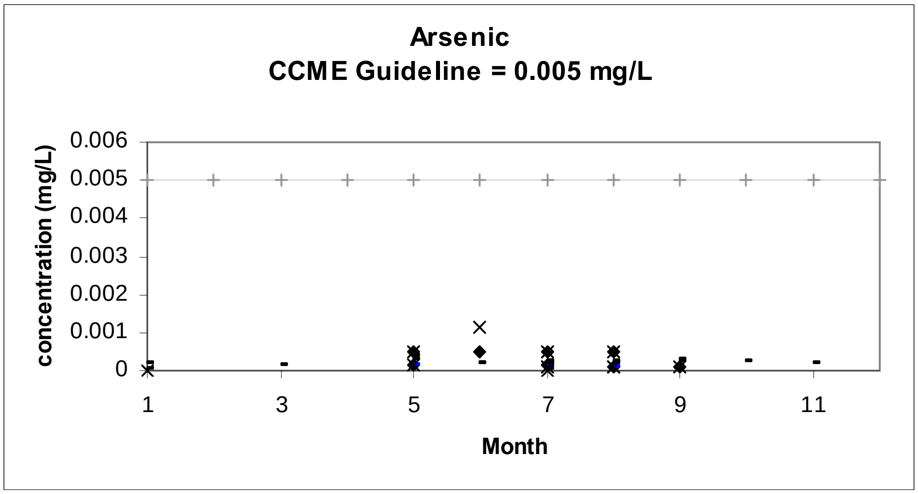
Annual trends in concentrations of total arsenic, cadmium, copper, lead, selenium and zinc are shown in Figure 7.5-4 for Sites W12, W15 and W16. Arsenic, lead, selenium and zinc levels are well below CCME guidelines in all samples. Copper slightly exceeds the guideline on one date. Cadmium levels exceed the guideline in all samples, in part due to high detection limits and difficulty achieving low detection limits. The 2005 cadmium analyses, which employ lower detection limits, indicate levels of 0.000025-0.000047 mg/L, which exceed the CCME guideline of 0.000017 mg/L.

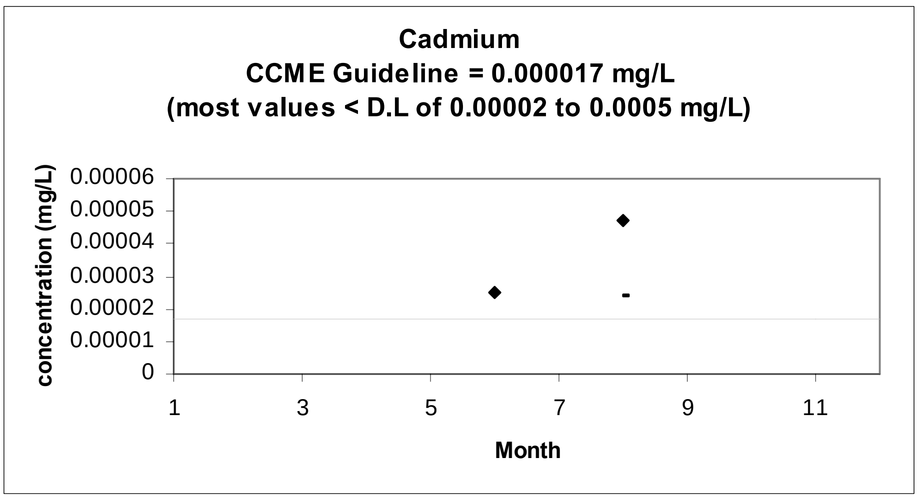
Table 7.5-7 Summary of Water Chemistry, Go Creek and Tributaries[1]

Parameter	Range		# of Times CCME Exceeded	Notes
	Minimum	Maximum		
Conductivity µmhos/cm	69	160	N/A	
PH	6.9	8.1	N/A	
Hardness mg $CaCO_3$/L	28	76	N/A	
Sulphate mg/L	3	11	N/A	
Nitrate mg/L	<0.005	0.173	N/A	
Ammonia mg/L	<0.005	<0.05	N/A	
Total Phosphorus mg/L	0.002	0.006	N/A	
Total Aluminum mg/L	0.0009	0.070	0	
Total Arsenic mg/L	0.00005	0.0004	0	Oct 1995 data excluded, <0.02 mg/L
Total Cadmium mg/L	<0.000017	0.00021	Measurable in 6 samples	Most values < detection (detection limit higher than guideline)
Total Chromium mg/L	0.0002	< 0.010	0	
Total Copper mg/L	0.001	0.006	8	Exceeds guideline on 4 dates, by up to 3 fold
Total Iron mg/L	0.01	1.31 mg/L	1	One date with high values, Hawkowl Creek
Total Lead mg/L	0.0001	<0.001	0	
Total Mercury mg/L	0.0005	<0.001	N/A	
Total Molybdenum mg/L	0.0002	0.03	0	
Total Nickel mg/L	0.003	0.02	0	
Total Selenium mg/L	0.0005	0.0012	1	Slightly exceeds guideline on 1 date
Total Silver mg/L	0.00001	0.0001	0	
Total Zinc mg/L	0.001	0.013	0	

Notes: 1. 7 sites; n=91 samples; 1995 to 2005
N/A = not applicable

Legend	W12	–
	W15	×
	W16	♦





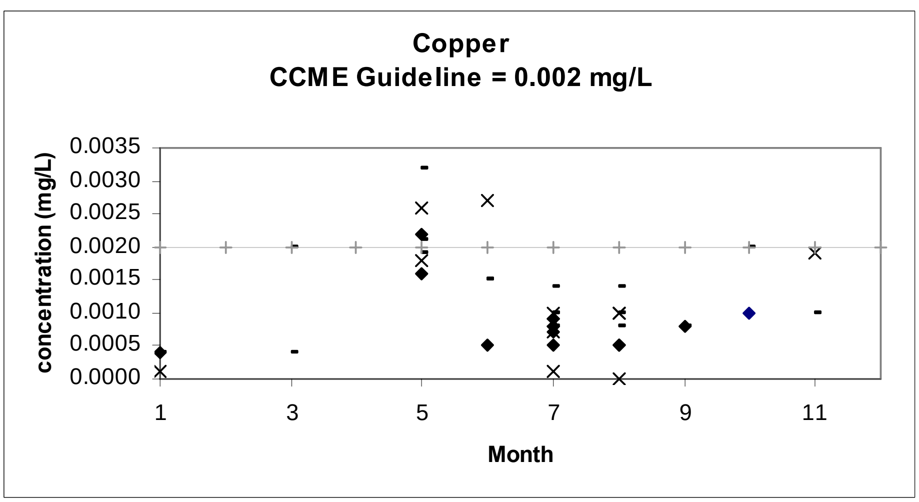


Figure 7.5-4a Go and Hawkowl Creeks — Total Metal Concentrations, 1995-2005

Legend	W12	–
	W15	×
	W16	♦

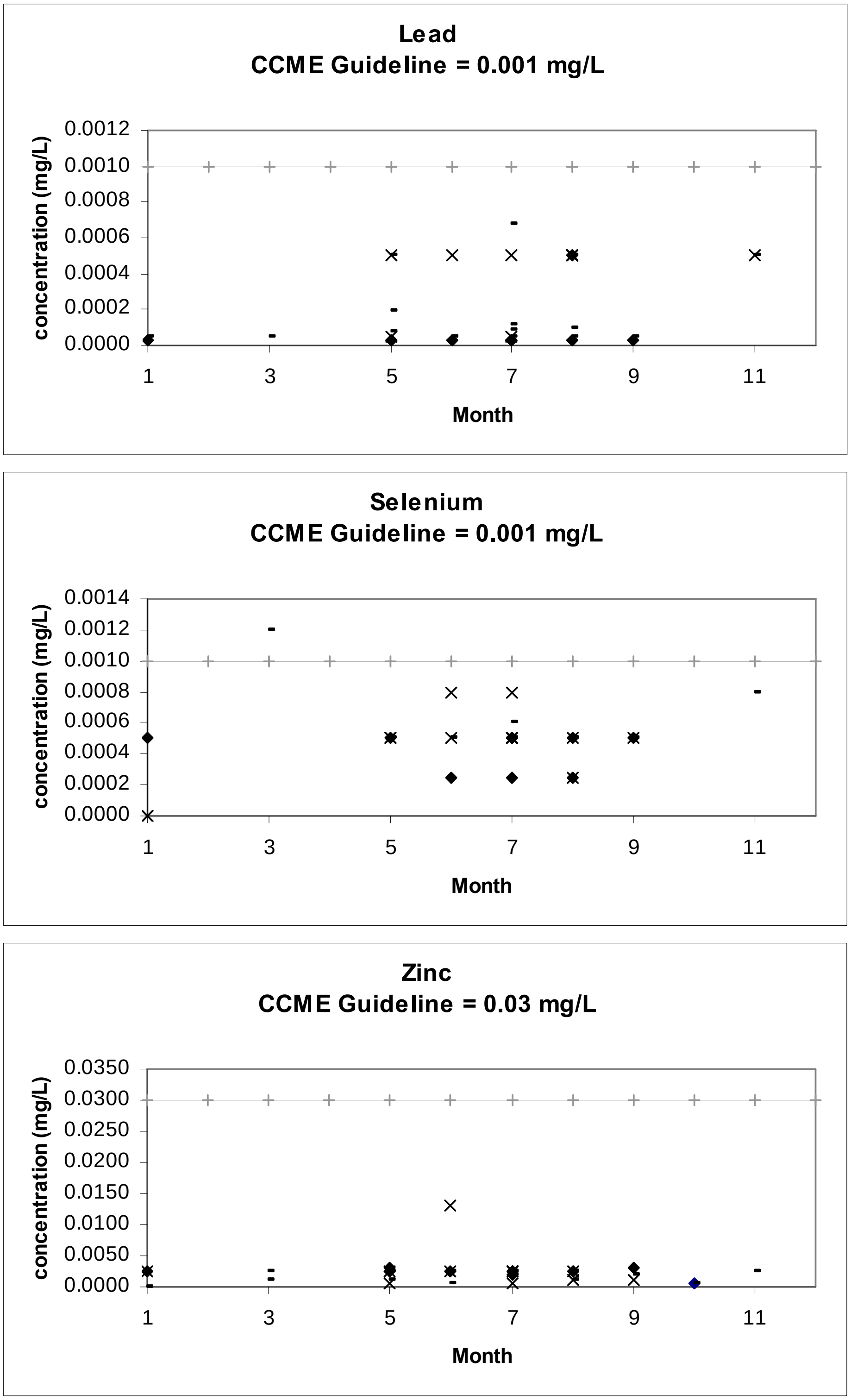


Figure 7.5-4b Go and Hawkowl Creeks — Total Metal Concentrations, 1995-2005

Total concentrations for aluminum, lead, nickel, selenium, silver and zinc are within CCME guidelines. Metals that exceed the guidelines include:

- cadmium, detected in six samples (0.000022 to 0.00021 mg/L) but not detectable in most samples, with detection limit of 0.0005 mg/L in 1995 and 1996, 0.00005 mg/L from 1997 to 2001, and 0.000017 mg/L in 2005, compared to a CCME guideline of 0.000017 mg/L
- copper, above guideline on four occasions / eight samples (maximum of 0.006 mg/L compared to a guideline of 0.002 mg/L)
- iron, at Hawkowl Creek on one occasion (maximum of 1.31 mg/L compared to a guideline of 0.3 mg/L)
- selenium, at Site W12 on one occasion (maximum of 0.0012 mg/L compared to a guideline of 0.001 mg/L)

The detection limit used for the 1995 arsenic analyses (0.02 mg/L) is higher than the CCME guideline (0.005 mg/L). This date is omitted from analyses for all sites, given that all subsequent values are all below the CCME guidelines.

Nutrient levels in Go Creek and tributaries tend to be low during the open water season, as indicated by 2005 data, the year in which the most complete dataset is available:

- ammonia levels are consistently below the detection limit of 0.02 mg/L
- nitrate levels tend to be highest in May and June (0.0058 to 0.0143 mg/L) and decrease to below detection limits in July and August (0.005 mg/L) at most sites in the Go watershed, with the exception of W15 (Hawkowl Creek) and W16 (upper Go Creek), which maintain nitrate levels of 0.01 to 0.04 mg/L in July and August
- total dissolved phosphate is measurable (0.002 to 0.0068 mg/L) in July and August

These nutrient concentrations suggest that Go Creek may be nitrogen limited during July and August. N:P ratios (total inorganic nitrogen: total inorganic phosphorus) provide a very rough estimate of nutrient ratios, and range from approximately 1:1 (W12, W13) to 3:1 to 6:1 (W15 and W16) during July and August.

Wolverine Creek

The headwaters of Wolverine Creek drain the western slope where mine facilities will be built. The stream flows subsurface in the mid-section, resurfaces in the lower reach and flows through a beaver dammed area before entering Little Wolverine Lake. The main sampling site is W9, upstream of the beaver dam, although W32 in the headwaters is sampled occasionally. The water management system will collect potentially contaminated surface drainage in the Wolverine Creek basin and direct it to the process water balance for treatment and ultimate discharge to Go Creek. At closure, groundwater in the backfilled underground mine workings may carry contaminants to surface waters. Monitoring at Site W9 will indicate the effectiveness of management systems in preventing metals from entering the Wolverine watershed.

Wolverine Creek has higher conductivity, pH, hardness, sulphate, aluminum, copper, nitrate and total phosphorus than Go Creek, along with considerably higher cadmium, selenium and zinc (Table 7.5-7), reflecting the highly mineralized area around the ore body. Most of the cadmium, selenium and zinc are in the dissolved fraction. Seasonal trends for select metals in Wolverine Creek are shown in Figure 7.5-5.

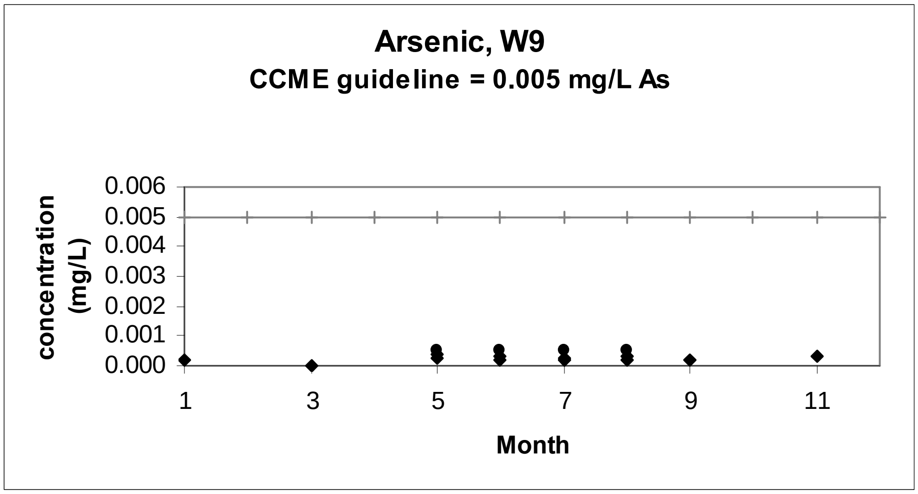
Several metals exceed the CCME guidelines in Wolverine Creek samples:

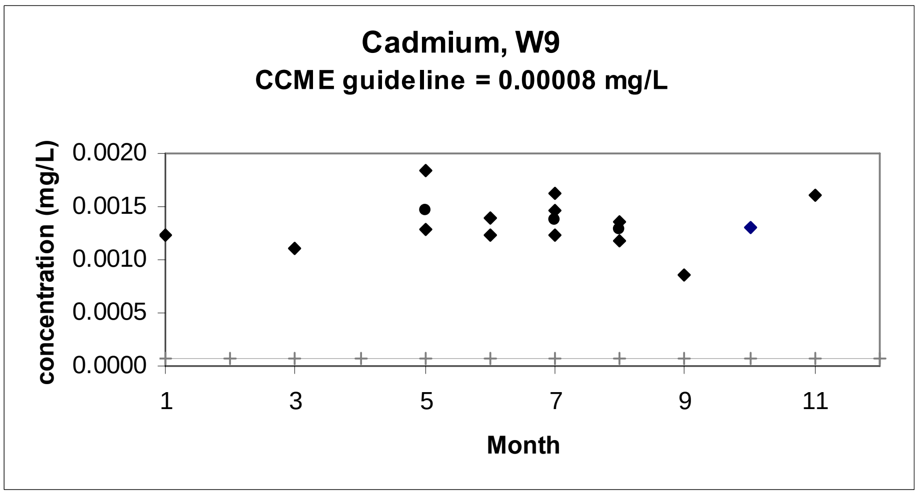
- cadmium in all samples, maximum 0.00184 mg/L (guideline of 0.00008 mg/L, based on hardness)
- copper in two samples, maximum value of 0.006 mg/L (guideline of 0.004 mg/L, based on hardness)
- selenium in all samples, maximum of 0.004 mg/L (guideline of 0.001 mg/L)
- zinc in all samples, maximum of 0.198 mg/L (guideline of 0.03 mg/L)

Table 7.5-8 Summary of Water Chemistry, Wolverine Creek[1]

Parameter	Range		# of Times CCME Exceeded	Notes
	Minimum	Maximum		
Conductivity μmhos/cm	221	271	N/A	
PH	7.4	8.3	N/A	
Hardness mg $CaCO_3$/L	8 to	143	N/A	
Sulphate mg/L	16	35	N/A	
Nitrate mg/L	0.046	0.300	N/A	
Ammonia mg/L	0.005	<0.05	N/A	
Total Phosphorus mg/L	0.009	0.012	N/A	
Total Aluminum mg/L	0.002	0.059	0	
Total Arsenic mg/L	0.00018	0.0038	0	Oct 1995 data excluded, <0.02 mg/L
Total Cadmium mg/L	0.00019	0.00184	17	All samples exceed guideline by 2 to 24 fold
Total Chromium mg/L	<0.0001	< 0.001	0	
Total Copper mg/L	0.0009	0.006	2	Up to 1.5 times higher than guideline
Total Iron mg/L	<0.003	0.29	0	
Total Lead mg/L	0.0001	<0.001	0	
Total Mercury mg/L	<0.00002	<0.0005	N/A	
Total Molybdenum mg/L	0.0009	<0.03	0	
Total Nickel mg/L	0.002	0.0064	0	
Total Selenium mg/L	0.0006	0.004	17	All samples exceed guideline 2 to 4 fold
Total Silver mg/L	0.00001	0.00005	0	
Total Zinc mg/L	0.055	0.198	17	All samples exceed guideline 1.6 to 6.6 fold

Notes: 1. one site; n=17 samples, 1995 to 2005
N/A = not applicable





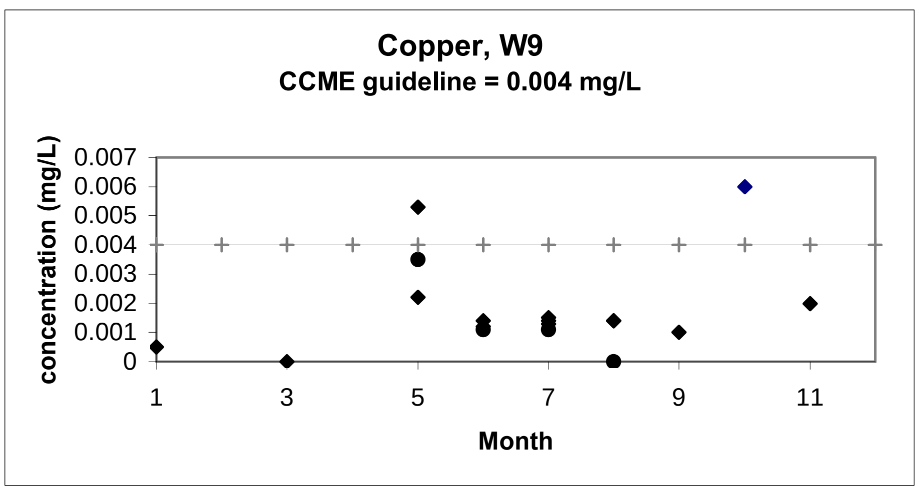


Figure 7.5-5a Wolverine Creek (Site W9) – Total Metal Concentrations, 1995-2005

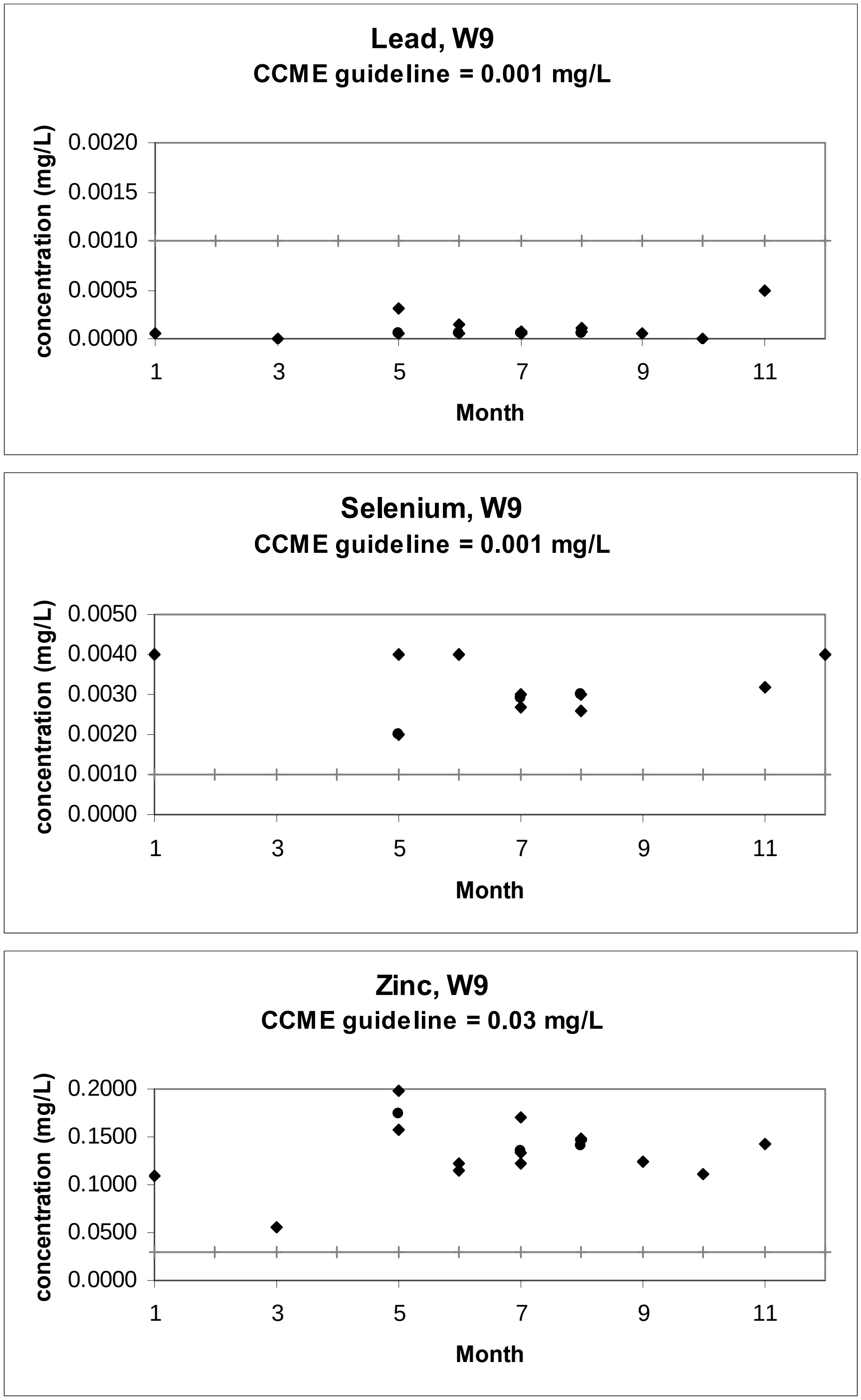


Figure 7.5-5b Wolverine Creek (Site W9) Metal Concentrations, 1995-2005

As noted for Go Creek, an arsenic value of <0.02 mg/L in October 1995 is unlikely to accurately exceed the guideline, based on subsequent analyses using lower detection limits.

Nutrient levels in Wolverine Creek tend to be low during the open water season, as indicated by 2005 data, the year with the most complete dataset:

- ammonia levels are consistently below the detection limit of 0.02 mg/L
- nitrate levels range from 0.057 to 0.079 mg/L
- total dissolved phosphate is measurable (0.0052 to 0.0065 mg/L) in July and August

These nutrient concentrations suggest that there are adequate nutrients available for algal growth during July and August, with neither nitrogen nor phosphorus apparently in limitation, given that N:P ratios are approximately 11:1.

Creeks along the Access Road

Streams crossed by the proposed access road were sampled in September 2005, after the general alignment had been determined, and will continue to be sampled. Results for Pitch (W71), Light (W72), Bunker (W73) and Chip (W74) Creeks will be provided in the addendum report, to be submitted in early 2006.

Money Creek

Go Creek drains into Money Creek, which flows into Frances Lake approximately 35 km downstream of the Go Creek confluence. Money Creek is in the LSA for a distance 1 km downstream of Go Creek and the RSA downstream to Frances Lake. Bull trout, arctic grayling and sculpin are present in Money Creek (Section 7.8: Fish Resources).

Four sites have been sampled regularly, with a fifth (W40, downstream of the Robert Campbell Highway) added in 2005:

- W23, upstream of Dollar Creek (and upstream of W11)
- W11, upstream of the Go Creek confluence
- W14, downstream of the Go Creek confluence
- W22, upstream of the Robert Campbell Highway crossing

General water chemistry and metal data are summarized in Table 7.5-8, with complete data provided in Appendices 7.5-1 and 7.5-2. Concentrations of general parameters and metals are similar in range to those reported for Go Creek. Hardness, sulphate, arsenic, cadmium and iron levels tend to be highest at Site W22, at the highway.

Seasonal trends for select metals in Money Creek (Site W11) are shown in Figure 7.5-6. Total metal concentrations for lead, nickel, selenium, silver and zinc are within CCME guidelines. The following metals exceed guidelines in some or all of the samples from all four sites on Money Creek:

- cadmium not detected in most samples, with detection limit of 0.0005 mg/L in 1995 and 1996, 0.00005 mg/L from 1997 to 2001, and 0.000017 mg/L in 2005, compared to guideline of 0.000017 mg/L; exceeds guideline at W22 in May and August 2005 (0.000054, 0.000066 mg/L) and W23 in August 2005 (0.000020 mg/L)

- copper (maximum of 0.004 mg/L compared to guideline of 0.002 mg/L) on three dates
- iron (maximum of 0.85 mg/L compared to guideline of 0.3 mg/L) four times

Table 7.5-9 Summary of Water Chemistry, Money Creek[1]

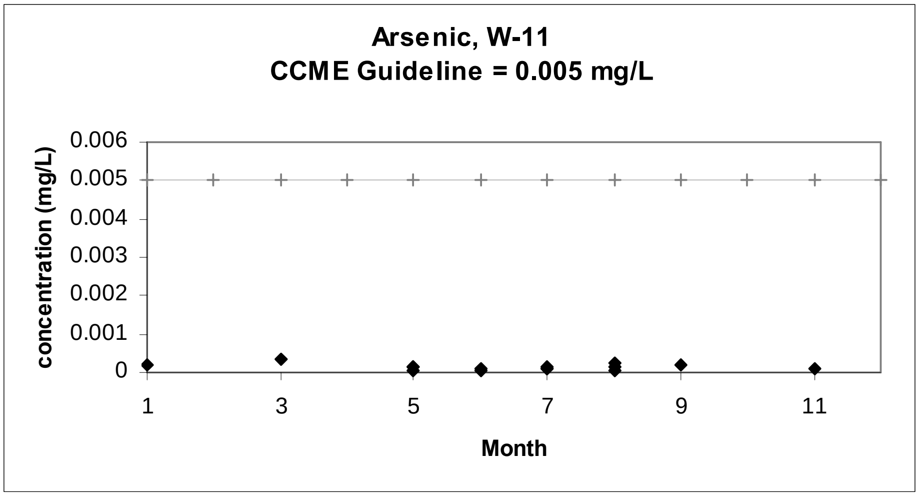
Parameter	Range		# of tImes CCME Exceeded	Notes
	Minimum	Maximum		
Conductivity µmhos/cm	65	138	N/A	
PH	7.0	8.2	N/A	
Hardness mg $CaCO_3$/L	21	72	N/A	
Sulphate mg/L	4	17	N/A	
Nitrate mg/L	0.005	.258	N/A	
Ammonia mg/L	0.005	<0.05	N/A	
Total Phosphorus mg/L	0.003	0.007	N/A	
Total Aluminum mg/L	0.01	0.123	1	
Total Arsenic mg/L	0.00005	0.00034	0	Oct 1995 data excluded, <0.02 mg/L
Total Cadmium mg/L	<0.000017	0.00066	Measurable in 3 samples	Most values < detection (detection limit higher than guideline)
Total Chromium mg/L	0.0002	< 0.01	0	
Total Copper mg/L	0.001	0.004	3	Exceeds guideline on 3 dates by up to 2-fold
Total Iron mg/L	<0.003	0.85	4	Tends to be high in March and May
Total Lead mg/L	0.0001	<0.001	0	
Total Mercury mg/L	<0.00002	<0.001	N/A	
Total Molybdenum mg/L	0.0002	<0.03	0	
Total Nickel mg/L	0.0016	<0.02	0	
Total Selenium mg/L	<0.0005	0.0011	0	
Total Silver mg/L	0.00001	<0.001	0	
Total Zinc mg/L	<0.001	0.008	0	

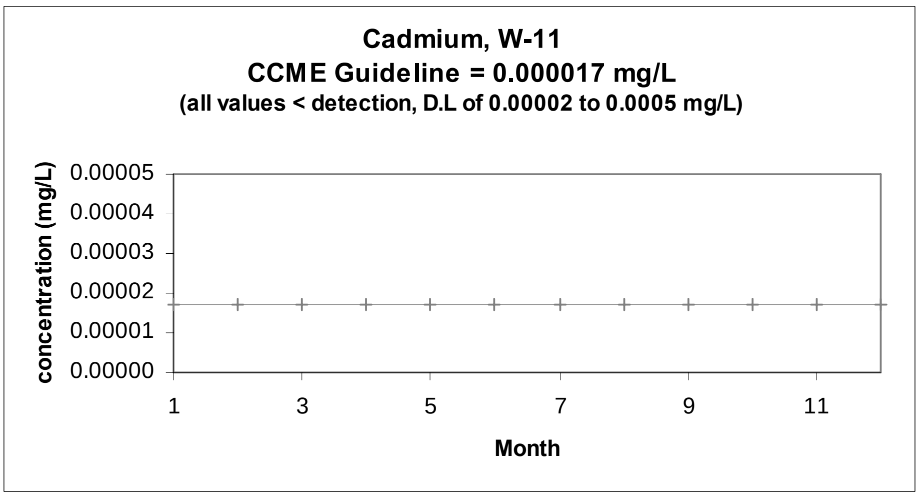
Notes: 1. four sites; n=86 samples, 1995 to 2005
N/A = not applicable

Nutrient levels in Money Creek are lower than those of Go Creek during the open water season, as indicated by 2005 data for Sites W11 and W14:

- ammonia levels are consistently below the detection limit of 0.02 mg/L
- nitrate decreases between May (0.0058 to 0.0076 mg/L) and July – August (below detection limit of 0.005 mg/L), and increases downstream of Go Creek confluence
- total dissolved phosphate ranges from less than detection (0.002 mg/L) to 0.0065 mg/L in July and August

These nutrient concentrations suggest that Money Creek, like Go Creek is nitrogen limited during July and August. N:P ratios are not provided because of the number of measurements below detection.





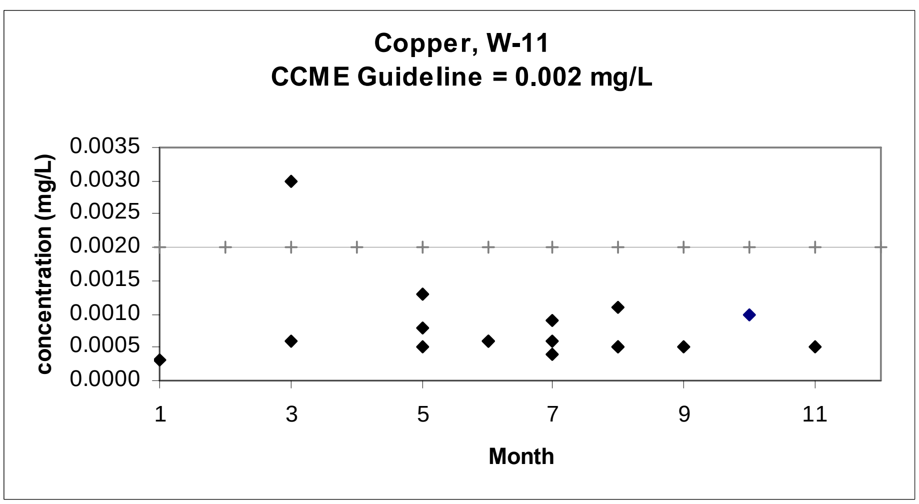


Figure 7.5-6a Money Creek (W-11) – Total Metal Concentrations, 1995-2005

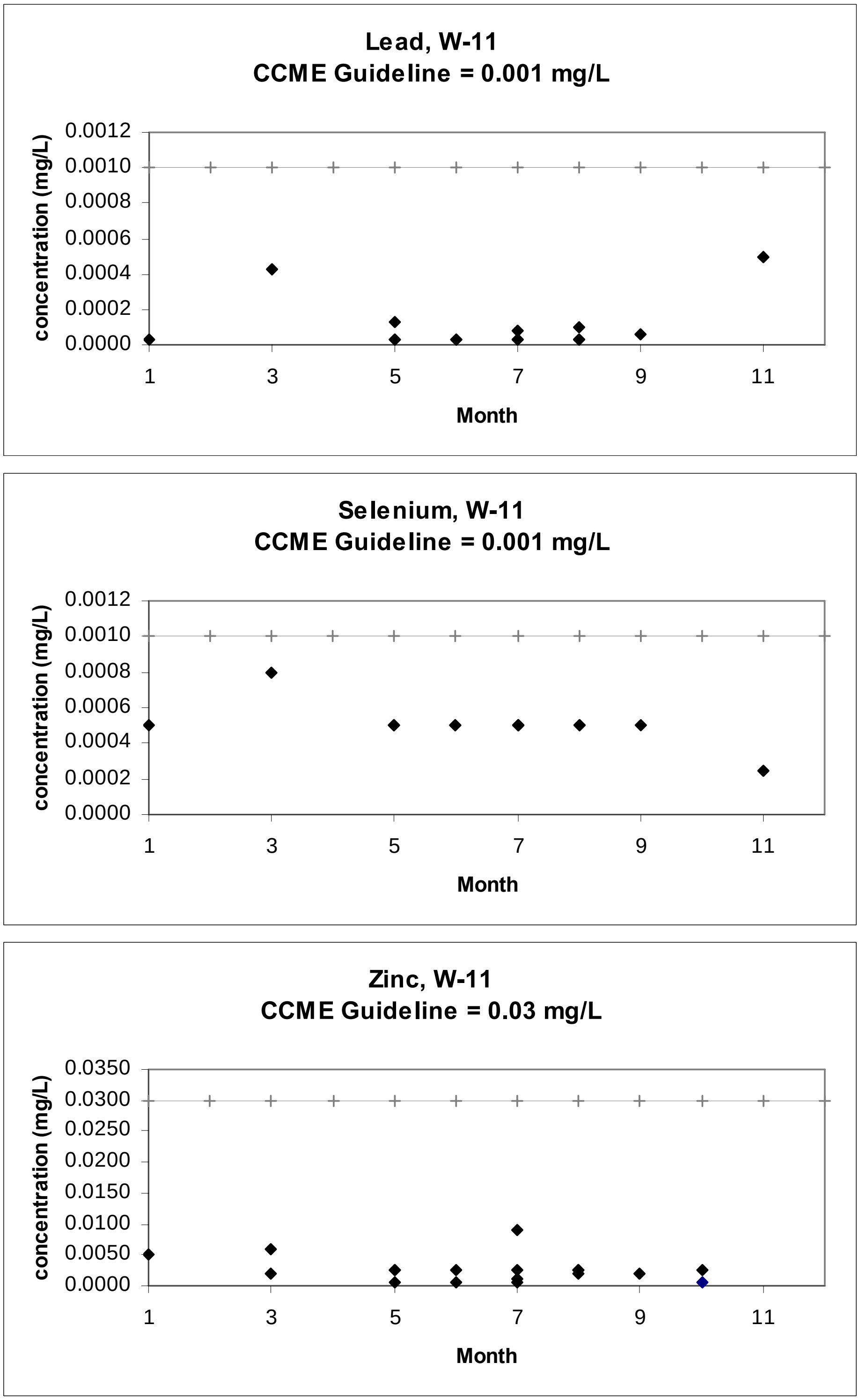


Figure 7.5-6b Money Creek (W-11) – Total Metal Concentrations, 1995-2005

Little Wolverine Lake

Little Wolverine Lake is within the RSA, and receives drainage from Wolverine Creek (mine portal area) and Campbell Creek (which is crossed by the road to the base camp on Wolverine Lake). The limnological survey conducted in July 1996 provides baseline water quality data (Appendix 7.5-4). Temperature and dissolved oxygen profiles taken from 0-9 m indicate a shallow thermocline between 2 and 8 m (temperature range of 5.5-13°C) during the summer.

Samples collected at 1 and 8 m indicate that Little Wolverine Lake water is soft, low in dissolved solids, with measurable levels of nutrients (0.2 mg/L ammonia, <0.005 mg/L nitrate, 0.016-0.043 mg/L phosphate) and chlorophyll *a* (0.77 mg/m^3 at 1 m; 1.19 mg/m^3 at 8 m), which is an indicator of phytoplankton biomass. Dissolved solids, phosphate and chlorophyll concentrations increase with depth, indicating light penetration is sufficient to sustain primary productivity at the bottom of the thermocline. Depth profiles for nutrients and chlorophyll are consistent with stratification and seasonal trends for algal growth (spring bloom followed by lower levels in surface waters during summer). Metal concentrations are below CCME guidelines for protection of aquatic life.

The outflow from Little Wolverine Lake to Wolverine Lake, sampled at 1, 5 and 12 m depths, has very soft water with low levels of dissolved solids and detectable levels of ammonia and phosphate. Concentrations of metals are below CCME guidelines. There is a slight decrease in pH, a sharp increase in manganese and an increase in alkalinity, total calcium, phosphate and chlorophyll levels with depth.

Wolverine Lake

Wolverine Lake is within the RSA and considered to contain important fish populations. The July 1996 limnological survey provides baseline water quality data (Appendix 7.5-4). Four sites were sampled, with water collected at three depths per site (1 m, mid-depth, deep) for chemical analysis. Temperature and depth profiles to 70 m indicate a thermocline at 5-20 m, with temperature ranging from 13-3.5°C.

Lake water is soft (54-61 mg/L $CaCO_3$), slightly basic (pH 7.1-7.7), low in dissolved solids, and clear (turbidity <0.4 NTU). Nutrient concentrations increase to maximum levels at depth. Surface waters contain low concentrations of ammonia (up to 0.006 mg/L) and phosphate (0.01 mg/L), with nitrate undetectable (<0.005 mg/L). Levels increase with depth, to 0.02 mg/L phosphate and 0.03-0.06 mg/L nitrate. Depth profiles for nutrients and chlorophyll are consistent with lake stratification and seasonal trends for algal growth (spring bloom followed by lower levels in surface waters during the summer). Metal concentrations are below the CCME guidelines, with selenium and zinc below their detection limits.

Primary productivity, measured as chlorophyll *a*, is lower than in Little Wolverine Lake and ranges from 0.4-0.76 mg/m^3. Concentrations are highest in and below the thermocline, indicating productivity at depth.

Nougha Creek

Nougha Creek has been sampled at the outlet of Wolverine Lake (W1) and the Robert Campbell Highway crossing (W21) since 1995. Both sites will be useful for regional long term monitoring. Water chemistry at W1 is similar in composition to that of Wolverine Lake, as would be expected given its proximity to the lake. Iron and cadmium concentrations are typically higher at W21 than at W1.

Nougha Creek water has moderate hardness (67-144 mg/L $CaCO_3$) and slightly basic pH (7.3-8.1). Nitrate levels range from near detection (0.005) to 0.121 mg/L, with a maximum in March. Phosphate levels range from 0.010-0.015 mg/L. Metal concentrations are below the CCME guidelines for protection of aquatic life, with the following exceptions:

- iron exceeds the guideline of 0.3 mg/L (four dates, up to 0.5 mg/L) at W21
- cadmium exceeds the guideline of 0.000017 mg/L on at least four dates (maximum of 0.00021 mg/L) at W21 (may be more frequent, but the high detection limit hinders the ability to make comparisons)
- copper exceeds the guideline of 0.002 mg/L (two dates, up to 0.003 mg/L) at W1 and W21

Sediment Results

Stream Sediment Quality

Analytical results are listed in Appendix 7.5-5 for all streams and summarized in Table 7.5-10 for Wolverine, Go and Money Creeks. Samples were collected from depositional areas at the edge of streams, so are not representative of erosional habitat. The report of the 2005 program (addendum report) will compare results for the two types of habitats.

For most samples, metal and dissolved organic carbon concentrations are higher in the <0.070 mm fraction than in the 0.070-2.0 mm fraction. Arsenic, cadmium, chromium, copper and zinc levels exceed CCME Interim Sediment Quality Guidelines (CCME, 2004) in most samples. Zinc and cadmium levels are highest in Wolverine Creek (W9), reflecting results for water. Copper levels are highest in W4 (Viking Creek), W15 and W19 (Hawkowl Creek) and W17 (Go Creek). Levels of zinc, cadmium, cobalt, and nickel are also high in W2 (Wolf Creek). Wolf, Wolverine and Viking Creeks drain the mineralized areas of the Wolverine and Fisher Zones. Go Creek has higher levels of chromium than Wolverine Creek, with levels exceeding interim sediment quality guidelines and the higher probable effect levels in some locations. Iron levels are highest at W17, W18 and W19 (tributaries in the upper Go Creek watershed), and also reflect trends for water. Arsenic, selenium, lead and silver levels are low or undetectable in all samples.

Metals concentrations appear consistent with sediment quality across the southeastern Yukon, ranging around the 50^{th} percentile of concentrations for the region, although zinc and cadmium concentrations in Wolverine Creek exceed the 95^{th} percentile and copper concentrations in the Go and Wolverine watersheds exceed the 95^{th} percentile.

Iron, cobalt, and chromium associate in sediment correlation analyses, possibly due to co-precipitation reactions (Appendix 7.5-5) Correlations are also noted between manganese and molybdenum and between molybdenum and dissolved organic carbon.

Lake Sediment Quality

Sediment was analyzed for metals levels in 1996 for Wolverine, Little Wolverine and Little Jimmy Lakes and again in 2001 for Little Wolverine Lake. Data are presented in Table 7.5-11. Metals concentrations, with the exception of lead, are higher in the 0.07-2 mm fraction than the <0.7 mm fraction. The reverse is noted for stream sediments.

Table 7.5-10 Sediment Chemistry Data for Wolverine, Go and Money Creeks[1]

Metal	Year	Fraction (mm)	Wolverine Creek W9	Money Creek W11	Go Creek W16	ISQG[1]
Cd mg/kg	1995	0.15	**14**	**0.8**	**7.1**	0.6
	1996	<0.070	**11.5**	<0.5	**3.5**	
		>0.070-2	**4.5**	<0.5	0.5	
	2001	<0.230	**22**		**6.25**	
Co mg/kg	1995	0.15	9.2	9	20.3	none
	1996	<0.070	14	13	28	
		>0.070-2	11	7	23	
	2001	<0.230	13		24.6	
Cr mg/kg	1995	0.15	23.8	29.2	**57.8**	37.3
	1996	<0.070	**98**	**108**	**172**	
		>0.070-2	**61**	**55**	**167**	
	2001	<0.230	**46.8**		**94.2**	
Cu mg/kg	1995	0.15	**67.1**	16.1	**54.7**	35.7
	1996	<0.070	**50**	17	**53**	
		>0.070-2	20	7	**36**	
	2001	<0.230	**114.4**		**81.4**	
Fe g/kg	1995	0.15	24.2	32.3	30.3	none
	1996	<0.070	40.1	43.3	56.1	
		>0.070-2	28.4	19.1	53.4	
	2001	<0.230	36.9		52.4	
Mn mg/kg	1995	0.15	973	3310	3070	none
	1996	<0.070	935	1695	1860	
		>0.070-2	740	600	1185	
	2001	<0.230	1596		7468	
Mo mg/kg	1995	0.15	3	<1	2	none
	1996	<0.070	4	3	1	
		>0.070-2	3	1	1	
	2001	<0.230	ND		ND	
Ni mg/kg	1995	0.15	72.1	41.9	46.6	none
	1996	<0.070	79	58	64	
		>0.070-2	37	25	48	
	2001	<0.230	106.2		56	
Pb mg/kg	1995	0.15	32	15	9	35
	1996	<0.070	35	30	8	
		>0.070-2	20	28	6	
	2001	<0.230	ND		ND	
Se mg/kg	1995	0.15	<2	<2	<2	none
	1996	<0.070				
		>0.070-2				
	2001	<0.230	ND		ND	
Zn mg/kg	1995	0.15	**2860**	**133**	249	123
	1996	<0.070	**2440**	**148**	**182**	
		>0.070-2	**892**	60	110	
	2001	<0.230	**4314**		**315.2**	

Notes: 1. ISQG = interim sediment quality guideline (CCME, 2004); numbers in bold indicate that ISQG is exceeded.

Copper, cadmium and zinc concentrations are highest in sediments of Little Wolverine Lake, intermediate in Wolverine Lake and lowest in Little Jimmy Lake. Metal levels are lowest in Little Jimmy Lake, with the exception of molybdenum.

Levels of zinc are over two times higher in Wolverine Creek than Little Wolverine Lake in both 1996 and 2001, as are levels of cadmium and copper in 2001. In general, however, cadmium, iron, manganese, molybdenum and zinc levels are higher in lake than stream sediment, as would be expected for lake depositional habitat. Concentrations of cobalt, copper, nickel and lead appear consistent with regional stream sediment values.

Cadmium, chromium, copper and zinc levels exceed the CCME Interim Sediment Quality Guidelines (CCME 1999) in Little Wolverine and Wolverine Lakes. Cadmium, chromium and zinc levels exceed the guidelines in Little Jimmy Lake, although to a lesser extent than in the other two lakes.

Correlation analysis (Appendix 7.5-5) indicates several potential relationships between metals in lake sediment:

- cadmium correlates well with zinc and copper and moderately with dissolved organic carbon and lead
- cobalt and chromium correlate well with copper and moderately with zinc
- copper correlates very strongly with zinc
- lead and zinc show a possible correlation to dissolved organic carbon
- molybdenum shows a consistent negative relationship with all other metals (strongest with cadmium, cobalt, copper, and zinc, perhaps due to differences in sediment composition on a watershed level or to possible replacement reactions between these metals at binding sites on sediment particles)

7.5.3 Effects Assessment Methodology

Project effects on water and sediment quality were assessed in accordance with the EA Report Guidelines using effects attributes defined in Table 7.5-12. Reversibility of effects is included in the attributes for effect duration. The ecological and social contexts of effects are integrated in the magnitude attributes.

Determination of Effects Significance

A residual effect on water and sediment quality will be considered significant for the project or cumulatively, based on the attributes defined in Table 7.5-12, if it is:

- a moderate magnitude adverse effect of high likelihood and far long term in duration or irreversible
- a high magnitude adverse effect of high likelihood, except when it is only site-specific
- a high magnitude adverse effect of high likelihood that is site-specific and far future in duration or irreversible

Otherwise, effects are rated as not significant. In addition, as required by the EA Report Guidelines, the probability of occurrence of any significant adverse residual effects and the degree of confidence for each prediction are stated with supporting rationale.

Table 7.5-11 Sediment Chemistry Data for Little Wolverine, Little Jimmy and Wolverine Lakes, 1996 and 2001

Metal	Year	Fraction (mm)	Little Wolverine Lake (L-1)	Little Jimmy Lake (M-1)	Wolverine Lake					ISQG[1]
					P-1	P-2	P-3	P-4	Mid lake	
D.O.C. mg/kg	1996	<0.070	2350	1150	1800	387	1250	750		none
		>0.070<2	2850	Not sampled	1080	300	1050	625		
	2001	<0.23							<100	
Cd mg/kg	1996	<0.070	**9**	**2.5**	**4.5**	**3**	**4**	**4**		0.6
		>0.070<2	**10**	Not sampled	**5**	**3**	**6**	**6**		
	2001	<0.23							**5**	
Co mg/kg	1996	<0.070	15	5	11	12	13	14		none
		>0.070<2	14	Not sampled	14	10	16	17		
	2001	<0.23							2.8	
Cr mg/kg	1996	<0.070	**81**	**48**	**71**	**58**	**43**	**58**		37.3
		>0.070<2	**77**	Not sampled	**77**	**58**	**49**	**58**		
	2001	<0.23							9.8	
Cu mg/kg	1996	<0.070	**68**	23	**47**	**37**	**39**	**55**		35.7
		>0.070<2	**71**	Not sampled	**52**	31	**48**	**54**		
	2001	<0.23							17	
Fe (g/kg)	1996	<0.070	58.6	14.5	45.8	63.8	36.7	36.4		none
		>0.070<2	55.1	Not sampled	60.7	65.9	42.5	43.8		
	2001	<0.23							14.3	
Mn mg/kg	1996	<0.070	2050	580	2180	5330	6370	4980		none
		>0.070<2	1850	Not sampled	2680	6690	6780	5070		
	2001	<0.23							245	
Mo mg/kg	1996	<0.070	4	9	5	8	4	6		none
		>0.070<2	5	Not sampled	8	9	4	5		
	2001	<0.23							<4	
Ni mg/kg	1996	<0.070	52	28	78	47	52	66		none
		>0.070<2	54	Not sampled	97	45	68	78		
	2001	<0.23							15	
Pb mg/kg	1996	<0.070	25	18	20	18	20	16		35
		>0.070<2	22	Not sampled	17	17	22	16		
	2001	<0.23							<50	
Zn mg/kg	1996	<0.070	**860**		**446**	**342**	**382**	**438**		123
		>0.070<2	**982**	142	**554**	**292**	**496**	**556**		
	2001	<0.23		Not sampled					**462**	

Notes: ISQG = interim sediment quality guideline (CCME, 2004)
numbers in bold indicate that ISQG is exceeded

Table 7.5-12 Effect Attributes for Surface Water and Sediment

Attribute	Definition
Direction	
Positive	Condition of VECC is improving
Adverse	Condition of VECC is worsening or is not acceptable
Neutral	Condition of VECC is not changing in comparison to baseline conditions and trends
Magnitude	
Low	Effect on VECC can be quantified as no change in a variable from ambient conditions
Moderate	Effect on VECC can be quantified as a change in a variable from ambient conditions but change does not exceed threshold level (CCME water or sediment quality guideline)
High	Effect on VECC can be quantified as a change in a variable that exceeds threshold level (CCME water or interim sediment quality guideline)
Geographic Extent	
Site-Specific	Effect on VECC confined to a reach of a stream in the LSA (*e.g.* <500 m)
Local	Effect on VECC extends throughout the LSA
Regional	Effect on VECC extends into the RSA
Duration	
Short term	Effect on VECC is measurable for up to 1 year
Medium term	Effect on VECC is measurable for 1 to 5 years (average age of bull trout at maturity)
Long term	Effect on VECC measurable for longer than 5 years, but does not extend more than 10 years after decommissioning and final reclamation
Far future	Effect on VECC measurable >10 years after decommissioning and abandonment
Frequency (Short term duration effects that occur more than once)	
Low	Effect on VECC occurs infrequently (< 1day per month)
Moderate	Effect on VECC occurs frequently (seasonal or several days per month)
High	Effect on VECC occurs continuously
Reversibility	
Reversible	Effect on VECC will cease to exist during or after the project is complete
Irreversible	Effect on VECC will persist during and/or after the project is complete
Likelihood of Occurrence[20]	
Unknown	Effect on VECC is not well understood and based on potential risk to the VECC, effects will be monitored and adaptive management measures taken, as appropriate
High	Effect on VECC is well understood and there is a high likelihood of effect on the VECC as predicted

7.5.4 Project Effects

Potential project effects during construction, operations, decommissioning and closure are described by watershed in the following sections. Most project actions are expected to affect stream rather than lake water and sediments. Mitigation measures are summarized in Section 7.5.7. Mitigation measures to protect water and sediment quality will also protect other aquatic VECCs (benthic invertebrates, periphyton, fish and fish habitat).

[20] Characterizes the investigator's confidence that effect will occur as predicted, based on the status of scientific or statistical information, experience and/or professional judgment of the author.

7.5.4.1 Construction

Wolverine Creek

Facilities that will be constructed in the Wolverine Creek basin include the mine portal area and underground access, underground mine development, ore stockpiles, temporary waste rock storage area and the industrial complex.

Wolverine Creek is a short, high gradient stream, flowing subsurface in some areas, with fish resources concentrated at the mouth where it discharges to Little Wolverine Lake (Section 7.8: Fish Resources). As noted previously, Wolverine Creek has higher pH, major ion, nutrient and metals concentrations than streams in the Go and Money Creek watersheds, reflecting the mineralized area around the ore body. Baseline cadmium, selenium and zinc concentrations consistently exceed CCME guidelines for protection of aquatic life. Little Wolverine Lake and Wolverine Lake are considered to contain valuable fish resources (lake trout, bull trout, arctic grayling). Metal levels in lake sediment, measured in 1996 and 2001, are higher than CCME guidelines, again reflecting the mineralized watershed. Data for the depositional lake sediments will provide a good basis for monitoring effectiveness of the water management plan over time.

The Wolverine Creek basin has already been affected by access road construction, mine portal construction and pre-production mine development. Potential project effects on Wolverine Creek during construction include:

- ***Further pre-production mining with continuing groundwater interception and mine dewatering.*** Mine water will be pumped into the process water balance and ultimately treated and discharged to the Go Creek drainage (Section 2.9: Site Water Management). Reductions in groundwater discharge to Wolverine Creek are predicted to be on the order of minewater withdrawals, estimated at about 10 L/s (Section 7.6: Groundwater). Effects on surface flows will be most marked during low flow conditions when groundwater contributions are greatest. Base flows may be reduced by up to 50% during late summer and winter; however, mean summer flows and peak flows will not be significantly affected by the reduction in base flow, as these flows are primarily derived from snowmelt, rainfall runoff and shallow groundwater (Section 7.4: Surface Water Hydrology). Reduction in Wolverine Creek flows is not expected to have any deleterious effect on water quality as there will be no discharge of contaminated drainage. It is possible that some metal levels may be decreased in stream water as the contribution of groundwater to surface flows is decreased relative to surface runoff.
- ***Increased suspended sediment in runoff from construction sites for various facilities in the basin.*** Throughout the life of the project, where project activities involve ground disturbance with potential for erosion and stream sedimentation, YZC will implement their erosion and sediment control program (Section 9: Environmental Management Plans) to minimize the risk of introducing suspended sediments to surface waters. In addition, all site drainage in the minesite construction zone will be collected in drainage ditches, directed to surface sumps, and pumped to the process water balance (Section 2.9: Site Water Management), where it will be contained for treatment and/or used as process water. Drainage water will ultimately be discharged, via the treatment plant, to Go Creek. Prior to start up of the water treatment plant, existing and new ditches and sumps will be used and water settled, tested, treated with flocculants and coagulants as needed, then discharged. Accordingly, no effects on water quality in Wolverine Creek are anticipated.

Diversion of surface drainage from disturbed areas in the Wolverine Creek basin to the Go Creek water management system during construction may result in a small reduction of stream flows in Wolverine Creek (Section 7.4: Surface Water Hydrology).

- ***Runoff from temporary development rock storage area and ore stockpiles with potentially elevated nitrogen compounds, metals and suspended sediments.*** The foundations of the development rock storage and ore stockpile areas have been lined to collect waste rock drainage and direct it to the process water balance (Section 2.9: Site Water Management), with ultimate treatment and discharge to Go Creek. These temporary facilities will be decommissioned within the first two years of operation. As noted above, diversion of surface drainage from disturbed areas in the Wolverine Creek basin to the water management system may result in a small reduction of stream flows in Wolverine Creek.

Site management to collect mine water and potentially contaminated runoff in the construction zone is expected to minimize potential impacts on water quality in the Wolverine Creek basin. The main effect of construction in the Wolverine Creek basin is predicted be a decrease in flows due to mine dewatering and collection of surface drainage from the construction zone and diversion for ultimate discharge to the Go Creek basin (Section 7.4: Surface Water Hydrology). No effect on water or sediment quality outside of natural variability is expected. Therefore, project effects on water and sediment quality in Wolverine Creek during construction are predicted to be neutral or low magnitude and site-specific. Effects will continue through operations (see below) and so will be long term. Effects of reduced surface flows on water quality are expected to gradually decrease and return to pre-mining condition during closure, and so will be reversible.

Go Creek

Facilities to be constructed in the Go Creek basin include the tailings facility, discharge facility for treated effluent, camp facilities, airstrip, borrow area and access road to the Robert Campbell Highway. A camp road and airstrip have already been built. The airstrip will be extended during construction.

Go Creek is a 12 km long stream with areas of high gradient, riffle and beaver pond habitat. As noted previously, it is a somewhat soft-water system with low nutrient and metal levels most of the year. CCME guidelines for copper and iron are occasionally exceeded by a small amount, and are also be exceeded for cadmium, although the extent is difficult to confirm because detection limits are typically higher than guidelines. Fish have not been noted in upper Go Creek, where effluent will be discharged, but are present in the lower 2 km of Go Creek and in Money Creek. Potential project effects on Go Creek during construction include:

- ***Further pre-production mining with continuing groundwater interception and mine dewatering.*** The main effect of mine dewatering will be on Wolverine Creek, with much smaller potential reductions in groundwater discharge to Go Creek predicted (Section 7.4: Surface Water Hydrology). Accordingly, no effects on water quality due to decreased flows in Go Creek are anticipated.
- ***Upper Go Creek diversion.*** A diversion channel will be constructed to divert flows from upper Go Creek to the tailings facility. The channel will divert 200 m^3/hr during freshet (May through early July) of the construction year. Go Creek flows at W31

will remain above 350 m^3/hr during diversion (summer low flow level). Small effects on flow and no effects on dilution capacity in Go Creek are expected during construction.

- ***Tailings pond construction.*** Clean fill from the site will be used for construction of the tailings pond dam and clean fill and waste rock will be used for separation dykes within the pond. As a result, no metals or nitrogen from blast residues are expected to seep or be discharged into Go Creek during construction.
- ***Increased suspended sediment in runoff from construction sites in the basin.*** Site clearing, ground disturbance and stockpiling of topsoil will increase the risk of site erosion and increased suspended sediment loads in runoff. Clearing adjacent to the stream will be avoided to provide intact riparian buffer zones. The YZC erosion and sediment control program (Section 9: Environmental Management Plans) will be followed to minimize introduction of suspended sediments to surface waters. In addition, all site drainage in the construction zone will be collected by site water management facilities (Section 2.9: Site Water Management) and contained for treatment, prior to discharge to Go Creek. Accordingly, effects on water quality in Go Creek are anticipated to be minimal.
- ***Discharge of treated effluent from the sewage treatment plant***. Package sewage treatment plants at the industrial complex and camp will produce effluent that meets drinking water standards. Effluent from the industrial complex will be recycled into the process water balance (Section 2.10: Site Facilities and Infrastructure) and water treatment plant and will ultimately be discharged via the permitted discharge to Go Creek downstream of the Hawkowl confluence. Effluent from the camp sewage treatment plant will be discharged into Go Creek near the camp, with the volume discharged not expected to elevate metal or nutrient levels significantly. Prior to installation of treatment plants, temporary structures, such as outhouses and porta-potties are being used, and are located well away from waterbodies.

Site water management to collect mine water and potentially contaminated runoff in the construction zone and implementation of the erosion and sediment control plant are expected to minimize potential impacts on water quality in the Go Creek basin during construction. Accordingly adverse effects of construction on water and sediment quality in Go Creek are expected to be low magnitude, site specific, short term continuous and reversible.

Money Creek

Money Creek, upstream and downstream of the Go Creek confluence, is low in hardness, slightly alkaline in pH, and generally low in nutrients. Metal levels are within CCME guidelines, with a few small exceptions for copper and iron and for cadmium (up to 0.000024 mg/L compared to a guideline of 0.000017 mg/L).

No project related effects are anticipated for Money Creek during construction, given that effects of facility construction will be confined to Go and Wolverine creeks and that effects of road crossings will be confined to tributary streams where culverts are installed.

Tributaries along the Access Road

The 20 km long access road to the Robert Campbell Highway will cross the headwaters of several streams. The road has been aligned to avoid fish-bearing waters to the greatest extent possible, by traversing the higher elevations. Several identified crossings are of ephemeral streams, which are dry during summer and autumn. Small permanent streams that will be crossed include Pup Creek (tributary of Go Creek), Chip and Bunker Creeks (tributaries of Money Creek), Light Creek and Pitch Creek (tributary of Light Creek).

Construction activities for stream crossings and road right-of-way access that occur within the riparian management area (RMA, defined as a 20-70 m buffer on each side of the stream) may introduce sediment to streams through erosion and removal of vegetation. The erosion and sediment control plan and other aquatic habitat protection measures (Section 9) will help minimize these effects. Culverts will be installed during permitted instream construction windows. Best practices (MWLAP 2004) will be followed to minimize mobilization and downstream transport of suspended sediments (Section 7.8: Fish Resources). The main effect on water quality will be an increase in total suspended solids (TSS) that is expected to be an adverse effect of moderate magnitude, site-specific (300-500 m of the crossing site, depending on gradient and sediment characteristics), short term, of moderate frequency (several days during the period of culvert installation) and reversible. The main concerns regarding increased TSS levels are potential effects on benthic communities (Section 7.7) and fish (Section 7.8).

7.5.4.2 Operations

Wolverine Creek

Potential effects on water and sediment quality in Wolverine Creek that were identified for the construction phase will continue during operations. Site management to collect and treat mine water and potentially contaminated runoff will continue to minimize potential impacts on water quality in Wolverine Creek during the operations phase. Reclamation and stabilization of disturbed areas following construction will further reduce the risk of sedimentation from surface runoff. Effects of underground mining on groundwater flows to Wolverine Creek will continue during operations. No effects on water and sediment quality outside the range of natural variability are expected. Potential adverse effects of project operations on water and sediment quality in Wolverine Creek are therefore characterized as low magnitude, site specific, long term and reversible.

Go Creek

Potential project effects on water and sediment quality in Go Creek that were identified for the construction phase will continue during operations. Site management to collect and treat mine water and potentially contaminated runoff will continue to minimize potential impacts on water quality in the Go Creek basin. Reclamation and stabilization of disturbed areas following construction will further reduce the risk of sedimentation from surface runoff. Low proportions of effluent discharge from the camp sewage treatment plant to Go Creek will continue.

Potable water will be supplied from deep aquifer wells. The majority of water for ore processing will come from mine dewatering and reclaim water from the tailings facility. Small amounts of fresh make-up water will be supplied by a deep well (Section 2.9: Site Water Management). The diversion channel from upper Go Creek to the tailings facility will not be in use during the operation phase, so no effects on Go Creek flows or dilution capacity are predicted.

The main incremental effects on water and sediment quality in Go Creek during operations will be as follows:

- ***Tailings facility seepage.*** Tailings water with potentially elevated concentrations of metals and nutrients is expected to seep into shallow groundwater. A seepage pond will be located immediately downstream of the tailings facility to intercept and monitor seepage. Seepage water will be recycled to the tailings facility and process water balance and thus will be treated prior to any discharge to Go Creek.
- ***Discharge of water treatment plant effluent to Go Creek downstream of the Hawkowl Creek confluence.*** The process water treatment plant will treat mine water, ore processing effluent, tailings supernatant, sewage treatment plant effluent from the industrial complex, and site drainage. Discharge of treatment plant effluent has the potential to result in elevated metals, sulphate, nitrate or ammonia (from blasting residues) and TSS levels in receiving waters. There may also be effects related to deposition and transport of particulate metals, resulting in increased metal levels in stream sediments. Further discussion of predicted receiving water quality in Go Creek is provided below.

The water balance for mining and ore processing will show a net increase on an annual basis, so discharges from the process water treatment plant to Go Creek will be required. Up to 35.8 m^3/hr of treated effluent will be discharged under permit to Go Creek, approximately 100 m downstream of the Hawkowl Creek confluence (downstream of W15 and W16) when there is sufficient flow in Go Creek to ensure stream water meets site-specific water quality objectives (SS-WQO) at W12, mainly from May through October. Stream flows will also dilute the treated effluent. Go Creek flows increase two-fold downstream of Hawkowl Creek, and two-fold again before the confluence with Pup Creek in the lower watershed, upstream of W12 (Section 7.4: Surface Water Hydrology).

Site W12, 7 km downstream of the effluent discharge, has been selected as the point of compliance with SS-WQO, which will be developed in conjunction with regulatory agencies, and will be based on CCME guidelines for protection of aquatic life. SS-WQO will take into consideration baseline water quality, for example, cadmium levels that already exceed CCME guidelines in Go Creek.

A new site will be established on Go Creek to monitor water quality downstream of the initial effluent dilution zone. To date, water quality at this site has been modeled based on data from W15 and W16. Receiving environment monitoring for MMER and EEM will be conducted in relation to this site. A monitoring site 2 km upstream of W12, at the limit of observed fish distribution, will also be established (Section 7.8: Fish Resources).

Section 2.9 provides a prediction of effluent quality, potential dilution of effluent in Go Creek, and required treatment to meet MMER requirements at the discharge point downstream of W15 and W16 and at SS-WQO at W12. Although effluent will be treated throughout the year, discharge will occur mainly from May through October. The following points are relevant to effluent discharge into Go Creek:

- all discharged effluent will meet MMER effluent criteria, including those for pH
- immediately downstream of the effluent discharge point, dilution alone will be sufficient to meet CCME guidelines and SS-WQO for aluminum, antimony, arsenic, copper, lead, molybdenum, nickel and thallium at any time of year, and for zinc from May through November

- effluent will be treated to reduce levels of ammonia, cadmium and selenium throughout the year; their levels will exceed SS-WQO downstream of the discharge point to W12 and meet SS-WQO at W12 when effluent is released from May through October

Cadmium levels will meet SS-WQO at W12, although they will exceed the CCME guideline (0.000017 mg/L) at W12 during the May through October discharge period at least some of the time, given that baseline levels at W16 and W12 already exceed the guideline at times during the summer (up to 0.000047 mg/L). Historic analyses used relatively high detection limits (0.00002 to 0.0005 mg/L), making it difficult to describe baseline conditions throughout the year. Even complete removal of cadmium from effluent would not ensure that CCME guidelines for cadmium are met year-round.

Nitrate levels are predicted to be elevated relative to baseline conditions throughout Go Creek downstream of the discharge, as indicated in Table 7.5-13. The CCME guideline (13 mg/L) is established in relation to nitrate toxicity, rather than eutrophication potential, and will not be exceeded in Go Creek. The water treatment plant may include some nitrate treatment. Levels downstream of the discharge point are considered a maximum scenario, given that nitrogen inputs from blasting will decrease over the operational phase and that denitrification will reduce nitrate levels in effluent and stream water. Aquatic plants in the creek will also take up and store nitrate during the growing season, and release it later during decomposition, resulting in lower nitrate levels at W12 than indicated in Table 7.5-12. However, the predicted increase in nitrate levels is likely to stimulate periphyton growth in Go Creek. As described in Section 7.5.2.3, nitrate levels tend to be very low (less than detection), while phosphate levels are measurable (0.004 to 0.006 mg/L) during July and August, rendering the stream sensitive to enrichment effects from nitrate. The magnitude and direction of the periphyton response to enrichment will depend on stream flows, light, temperature and available phosphorus, as well as inorganic nitrogen. In oligotrophic systems, some nutrient enrichment can be considered beneficial to benthic communities.

Table 7.5-13 Baseline Nitrate Concentrations (mg/L) in Go Creek Upstream (2005) and Predicted Downstream (maximum) of Effluent Discharge Point

Site		May	June	July	Aug.	Sept.	Oct.
Upstream of discharge	W16 (upper Go)	0.0091	0.0146	0.0120	0.0397		
	W15 (Hawkowl	0.0143	-	<0.005	<0.005		
Downstream of discharge	Go downstream of W15	0.16	0.077	0.138	0.255	0.265	0.360
	W12 (lower Go)	0.097	0.048	0.079	0.145	0.164	0.193
Upstream of discharge	W11 (Money upstream of Go	0.0058		<0.005	<0.005		

The effect of nutrient enrichment can be considered to continue over long distances, given the continual cycle of uptake in algae, decomposition and nutrient release, commonly described as “nutrient spiralling” (Wetzel 2001). As a result, some effects on Money Creek may be anticipated.

Sulphate levels will also be elevated in effluent and in Go Creek downstream of the discharge. Dilution will reduce levels to 40 mg/L or less in Go Creek, up from baseline concentrations of up to 15 mg/L. In comparison, BC water quality guidelines for protection of aquatic life recommend a sulphate level in stream water of 100 mg/L (50 mg/L to protect aquatic mosses). Accordingly, no adverse effects of sulphate on water quality are predicted.

Based on the feasibility of treatment and the dilution capacity of Go Creek, it is predicted that SS-WQO will be met at W12 (the compliance point) for all parameters. During operations, adverse project effects on water and sediment quality in Go Creek between the discharge and W12 (7 km distance) are predicted to be moderate magnitude, local, long-term in duration, and reversible when effluent discharge ceases. The effects are related to elevated cadmium, selenium and ammonia levels, which may have an adverse effect on benthic invertebrates and periphyton in this reach, and fish in the lower 2 km. A nutrient enrichment effect (adverse or positive) may extend into Money Creek.

Accumulation of selenium and other metals in depositional areas has become an issue of concern for mines (McDonald and Strosher 2000, Chapman 2004), with research ongoing into the relationship between ambient levels and organism responses. Selenium has been noted to bio-accumulate in fish tissue, probably through consumption of benthic invertebrates that dwell in close contact with the metal-containing sediment. Current recommendations are for a maximum of 2 mg/kg in sediment (BC Ministry of Environment 2005). Selenium levels in Go Creek sediment have been below that level (Table 7.5-9), but will be monitored during mine operations. If levels show an increasing trend and are approaching guideline levels, additional sampling of benthic invertebrates and fish (sculpin) for tissue metals analysis will be conducted in downstream fish-bearing areas. In the event of an increasing trend in sediment and tissue concentrations, adaptive management, such as enhanced treatment to reduce bio-available selenium levels, will be implemented.

Money Creek

No project related effects are anticipated for Money Creek, aside from possible nitrate enrichment downstream of the Go Creek confluence. Metals in discharged effluent will meet SS-WQO by W12, upstream of the confluence with Money Creek. There is further four-fold dilution at the Money confluence (Section 7.4: Surface Water Hydrology). Baseline water quality in Money Creek is similar to that of Go Creek. The potential for accumulation of transported metal-bearing particulate matter from effluent discharges into the fish-bearing Money Creek is considered low, given the levels discharged, the distance to be covered (more than 7 km in Go Creek) and the number of potential depositional areas in Go Creek behind beaver dams. However, monitoring of sediment metal levels, following methods used in 2005, will continue during operations to check and confirm this prediction.

Tributaries along the Access Road

There is potential for road runoff carrying metals, hydrocarbons and sediment to enter the tributaries along the access road during operation of the mine. Potential effects on water quality and benthic communities will be minimized by situating the road in headwater areas wherever possible and by implementing the YZC erosion and sediment control program (Section 9: Environmental Management Plans).

7.5.4.3 Decommissioning

Decommissioning will include backfilling of the underground mine workings and sealing of the portal, dismantling of the ore processing facilities and offices, modifications of the tailings embankment as required to ensure long term saturation of tailings and provide a spillway for ultimate passive decanting of the pond at closure, recontouring and revegetation of disturbed areas, decommissioning of clean water diversions and reinstatement of natural drainage patterns.

Decommissioning is expected to progress in two phases. An initial phase will remove all extraneous project facilities and reclaim the disturbed areas left by their removal. The water treatment plant will remain operational following the first phase, as contingency to provide treatment to tailings facility water for a period of at least five years. Once the tailings pond has stabilized and there is no further leaching of metals or process reagents, the treatment plant and related infrastructure will be removed and the remainder of the site contoured and reclaimed.

The sequence of decommissioning will allow stabilization and reclamation of large disturbed areas prior to removal of site water management facilities (drainage collection ditches and settling ponds) and implementation of the erosion and sedimentation plan (Section 9: Environmental Management Plans) in order to minimize effects of erosion and sedimentation on surface waters.

Wolverine Creek

At the end of operations, mine dewater will cease and underground areas will continue to be backfilled. The groundwater table will gradually rise in the mine area over a 2.5 year period, then start contributing to Wolverine Creek flows, with a return to pre-mining levels within another 13.5 years. During decommissioning, the contribution of groundwater discharge to surface flows in Wolverine Creek will gradually increase, with attendant increases in creek flows. Over time, as groundwater moves through the mine backfill it may carry elevated metals levels to the surface stream (see Closure below).

Go Creek

The tailings facility closure design will ensure that tailings are saturated (designed for 1:100 year low flow, three years in a row). The facility will be covered with a minimum of 0.5 m of water, so that minimal metals leaching will occur (Section 2.8: Tailings Facility). Based on humidity cell tests, it is expected that aging of tailings and equilibration with surface water will occur such that most parameters (antimony, arsenic, copper, lead, molybdenum, silver, thallium, zinc, nitrate) will meet SS-WQO within five years of decommissioning, although it may take six years for ammonia, eight years for selenium and nine years for cadmium. ARD-ML is not predicted to occur, should tailings be exposed to the air, given that humidity cell tests conducted for 14 weeks (longer than would occur in a dry summer) have not shown evidence of leaching. Tailings supernatant will be monitored following the first phase of decommissioning and the water treatment plant will remain operational for at least five years to provide treatment if required before discharge to Go Creek.

An average outflow rate of 8.3 m^3/hr over the tailings pond spillway has been calculated (Section 2.8: Tailings Facility), which accounts for 0.5-2.6% of Go Creek flows at W16, based on mean monthly flows of 320-1700 m^3/hr for the May through October open water season (Section 7.4: Surface Water Hydrology). This outflow rate is approximately

25% of the previous effluent discharge rate and, combined with treatment of tailings supernatant in the water treatment plant over the first five years, should result in water quality of Go Creek meeting SS-WQO downstream of the tailings pond spillway for all metals. Additional dilution will be provided at the Hawkowl Creek confluence. As a result, potential effects on water quality are expected to be low for Go Creek between the tailings pond and Hawkowl Creek, given that SS-WQO will be met throughout the creek.

Tributaries along the Access Road

No further ground disturbance will occur at stream crossings along the access road at closure, as the road will remain in place at the request of the Kaska First Nation.

7.5.4.4 Closure

The mine closure plan is described in Section 3.4.

Wolverine Creek

Groundwater recharge after closure of the mine may eventually have a notable effect on metal levels in Wolverine Creek (Section 7.6: Groundwater). It will take 2.5 years for underground areas to fill with groundwater, during which time, metal levels will equilibrate. After that, groundwater will seep into Wolverine Creek and may lead to elevated metals levels in the creek, and probably Little Wolverine Lake, over an indefinite period of time. An estimate was made for zinc levels, as other metals of concern were reported in previous humidity cell tests on mine water at below detection limits (Section 2.4). However, the detection limits used were ten to one hundred times higher than CCME guidelines for protection of aquatic life, so are not useful in estimating potential contributions of other metals to groundwater. Tests currently being conducted will employ detection limits appropriate to comparisons with CCME guidelines. Based on existing groundwater and stream data, it is likely that cadmium and selenium levels will also be elevated in groundwater during closure. Cadmium, selenium and zinc levels already exceed CCME guidelines in the creek and separate SS-WQO may be developed for Wolverine Creek.

Potential effects on Wolverine Creek water quality will be reduced by through the use of alkaline materials in the paste backfill (i.e., lime in cement), which should buffer sulphide oxidation, contribute to precipitation of dissolved metals and reduce mobilization of dissolved metals in groundwater. Long groundwater travel times from the mine to Wolverine Creek have been estimated (13 years at shallow depth to 52 years at lowest mine elevation) and may dilute any elevated metals in the creek. The likelihood of a measurable adverse effect on surface water quality in Wolverine Creek is unknown, and will be assessed, in part, during monitoring of groundwater quality when portions of the mine are decommissioned during operations (this will provide insights into effectiveness of lime additions and saturation of the backfill in managing ARD and metal leaching). This will enable adaptive management measures to be implemented and monitored, as needed. Post-closure monitoring is recommended for Wolverine Creek to assess effectiveness of these measures to management of groundwater quality.

As a result, the effect of discharge of potentially contaminated groundwater on receiving water or sediment of Wolverine Creek or Little Wolverine Lake has been rated as not significant, based on adverse, low to moderate magnitude, local extent, far future in duration and ultimately reversible attributes, with an unknown likelihood of occurrence (Section 7.6: Groundwater).

Go Creek

At closure the quality of tailings pond supernatant will not cause a change in the quality of Go Creek water beyond the natural variability established over the period of baseline monitoring, as discussed above for the decommissioning phase. Accordingly there will be no further effects of the project on Go Creek at closure.

7.5.5 Residual Project Effects and Significance

Residual adverse effects of the project on water and sediment quality are discussed below.

Access road construction and culvert installation

Disturbance of streambeds and riparian areas for culvert installation may have short-term effects on water, primarily in headwaters of tributaries to Go, Money and Light Creeks. Effects are predicted to be low magnitude, site-specific, short-term, low frequency and reversible, with a high likelihood of occurrence. The road will be retained at the request of the Kaska; therefore, no incremental effects on water and sediment quality are predicted during decommissioning and closure.

Using criteria described in Section 7.5.3, the adverse effects of access road construction on water and sediment quality are expected to be not significant throughout all phases of the project. The likelihood of effects occurring as predicted is high.

Treatment Plant Effluent - Go Creek

Residual effects during operations are expected to include elevated levels of cadmium, selenium and ammonia in Go Creek for a distance of up to 7 km downstream of the discharge point for treated effluent, with potential accumulation of metals in stream sediments in the same region. Downstream of W12, the compliance point, levels of these substances will be below SS-WQO. Other metals will meet SS-WQO immediately downstream of discharge. No adverse effects are predicted downstream in fish-bearing waters of lower Go Creek (Section 2.9: Site Water Management).

There is potential for localized accumulation of metals in depositional sediment within the affected reach, with potential for uptake in periphyton and benthos, although this is considered unlikely due to the annual freshet that will mobilize and disperse stream sediments. From an ecological perspective, elevated metals in benthic invertebrates that drift downstream into fish-bearing reaches could contribute to bioaccumulation of metals in fish, although the likelihood of this is unknown, given the intervening areas of beaver pond and riffle habitat. Baseline fish tissue data has been collected for future reference. The EEM program will monitor water and sediment metals levels. If increasing trends are noted in sediment concentrations, follow-up monitoring of metals in fish tissue will be conducted to assess the possibility of bioaccumulation and improve mitigation, if necessary.

Treatment will reduce nutrient levels; however, effluent will contain elevated levels of ammonia and nitrate relative to baseline conditions (Section 2.9: Site Water Management). Ammonia levels are predicted meet guidelines at W12. Elevated ammonia and nitrate levels have the potential to stimulate periphyton growth and lead to altered community composition in Go Creek between the discharge point and W12, which may have a stimulatory (positive or adverse) effect on benthic communities.

Accordingly the effects magnitude is predicted to be moderate in Go Creek below the effluent discharge point and low downstream of the compliance point. There is no predicted potential effect related to metals from effluent discharge on Money Creek. However, the elevated nitrate levels in Go Creek may result in a measurable increase in Money Creek, which may stimulate periphyton growth.

The project will be subject to the Metal Mining Effluent Regulations (MMER) and will be required to monitor effluent discharges and the receiving environment using an EEM program, overseen by Environment Canada. Benthic invertebrate and fish communities will be monitored on a multi-year cycle to provide data about effectiveness of the water management plan and environmental effects of discharges on the benthic community of Go Creek, and will guide decisions on mine practices and monitoring requirements.

In summary, in the Go – Money Creek system, the greatest effect of treatment plant effluent discharges on water quality will be in the 7 km reach of Go Creek between the effluent discharge point and the compliance point during operations. Effects in this reach are rated as adverse, moderate, local, long term and reversible. All other effects on Go Creek are rated as low magnitude. Using criteria in Section 7.5.3, the adverse effects of effluent discharge on water and sediment VECCs are expected to be not significant, throughout all phases of the project and at closure. The likelihood of effects occurring as predicted is high.

Flow Regime Changes - Go Creek

Some changes to flow regimes of Go Creek are anticipated (Section 7.4: Surface Water Hydrology) as a result of partial diversion of Go Creek water during construction of the tailings facility, from May to mid-July of one year. Flows will remain higher than summer low flows. Using criteria in Section 7.5.3, the adverse effects of flow regime changes on water and sediment VECCs are expected to be not significant, throughout all phases of the project and at closure. The likelihood of effects occurring as predicted is high.

Tailings Pond discharge - Go Creek at Closure

Tailings will be covered with a minimum of 0.5 m of water following decommissioning of the mine, so that minimal metals leaching will occur. Tailings supernatant will be monitored and treated, as required, in the water treatment plant, which will remain in use for at least five years. Within five years, aging of tailings and equilibration with surface water is expected to occur, so that most metals will meet SS-WQO, although it may take six years for ammonia, eight years for selenium and nine years for cadmium. With an average outflow rate of 8.3 m^3/hr over the tailings pond spillway, the tailings supernatant is not predicted to result in adverse effects on Go Creek water quality.

Groundwater discharge - Wolverine Creek at Closure

Groundwater recharge after closure of the mine may lead to elevated metal levels in Wolverine Creek and, perhaps, Little Wolverine Lake following the 2.5 year recharge period. The long travel times calculated for groundwater movement (13-52 years) means that effects might not be noticeable for many years. However, potential effects have been rated as not significant for Wolverine Creek and Little Wolverine Lake, based on use of alkaline material in the paste backfill materials and monitoring of backfilling during the operational phase to enable adaptive management measures to be implemented.

7.5.6 Cumulative Effects and Significance

The only other development in the RSA that could affect water and sediment quality in stream basins affected by the project is the Robert Campbell Highway. The highway crosses Money Creek more than 25 km downstream of the project area and 15 km downstream of the closest project access road crossing, and crosses Light Creek at least 4 km downstream of the closest access road crossing. Cumulative effects could potentially arise from introduction of pollutants to these streams from road accidents, spills and maintenance (sediment or salt introductions from road drainage).

As noted above, residual project effects on water and sediment quality in the Money and Light Creek watersheds are expected to be local in extent with no likelihood of overlap with potential effects from the Robert Campbell Highway. Localized residual effects of the project on water and sediment quality are expected to be not significant, and will not affect the overall ecological health of the streams. Contaminants from the Robert Campbell Highway could potentially influence the lower 1 km of these streams. Effects on benthic communities could vary depending on the nature and volume of contaminants introduced, the season of occurrence and the associated ecological importance of these stream reaches to fish production at the time. Effects could vary from not significant to significant. Any contribution of project related effects to cumulative effects arising from the Robert Campbell Highway are expected to be not significant.

Potential effects of metals inputs from groundwater recharge into Wolverine Creek and Little Wolverine Lake following mine closure are a regional concern, given the valued fish populations in Wolverine and Little Wolverine Lakes. These effects are addressed above in Section 7.5.5, and rated as not significant.

7.5.7 Mitigation Measures

Mitigation measures are described in Table 7.5-14.

Table 7.5-14 Mitigation Measures for Effects on Water and Sediment Quality

Potential Project Effect	Mitigation Measures
Construction	
Changes in water and sediment quality in Wolverine and Go Creeks from contaminated construction site runoff, waste rock storage, ore stockpiles	• Implement erosion and sediment control plan (Section 9.2: Environmental Protection Plan) and water management plan (Section 2.9: Site Water Management) to ensure no contaminated drainage water enters Wolverine Creek and all drainage is treated prior to discharge to Go Creeks
Minesite and road right-of-way clearing causing loss of riparian vegetation and increased sediment input to Go and Wolverine Creeks	• Locate buildings, tanks & facilities outside Riparian Management Area (RMA, 20-70 m buffer along affected streams) • Minimize vegetation removal and soil disturbance within RMA • Implement erosion and sediment control plan and water management plan (Section 9.2) to ensure no sediment laden water enters Wolverine or Go Creeks • Revegetate disturbed areas as soon as possible
Sediment inputs during construction of stream crossings (culvert installations) on access road in Upper Go, Hawkowl, Pup, Chip, Bunker, Pitch and Light Creeks	• Observe instream construction windows • Implement erosion and sediment control plan (Section 9.2: Environmental Protection Plan). • Restore streambed to pre-construction status • Adhere to appropriate guidance documents for work around watercourses such as the British Columbia Standards and Best Practices for Instream Works: Stream Crossings (MWLAP 2004) • Revegetate cleared stream banks with native flora
Operations	
Changes in water and sediment quality from tailings facility seepage to Go Creek (metals TSS, nutrients)	• Intercept seepage in collection pond, and recycle back to tailings and process water balance. Ultimate discharge to Go Creek will be via water treatment plant. • Monitor effluent and receiving water quality and initiate adaptive management as required.
Changes in water and sediment quality in Go Creek from treatment plant effluent discharges (metals, TSS, nutrients)	• Ensure adequate treatment and effluent quality to meet SS-WQO at W12 • Discharge wastewater in accordance with Yukon and federal regulations • Monitor effluent and receiving water quality, initiate adaptive management as needed.
Accumulation of metals (Se) in sediment of Go Creek with increased potential for bioaccumulation	• Monitor water and sediment concentrations in Go Creek. If results indicate increasing trend, collect benthic invertebrates and sculpin for tissue metals analysis. • Apply adaptive management measures if necessary (enhanced effluent treatment)
Introduction of sediment and other road runoff contaminants into Upper Go, Hawkowl, Pup, Chip, Bunker and Light Creeks	• Reclaim/revegetate disturbed areas in riparian zones • Implement sediment and erosion control plan (Section 9.2: Environmental Protection Plan)
Decommissioning	
Changes in water and sediment quality in Wolverine and Go Creeks from site runoff where facilities have been removed and/or the ground recontoured	• Implement erosion and sediment control plan (Section 9.2: Environmental Protection Plan) and water management plan (Section 2.9: Site Water Management) to ensure no contaminated drainage water enters Wolverine Creek and all drainage is treated prior to discharge to Go Creek • Reseeding of recontoured areas as soon as possible
Changes in water and sediment quality in Go Creek from tailings water treatment and effluent discharges (metals, TSS, nutrients)	• Ensure adequate treatment and effluent quality to meet SS-WQO at W12 • Discharge wastewater in accordance with Yukon and federal regulations • Monitor effluent and receiving water quality and initiate adaptive management as required.
Closure	
Changes in water and sediment quality of Go Creek from ongoing tailings storage	• Adhere to the mine closure plan • Test and treat during decommissioning to confirm effectiveness of management • Maintain water cover over the disposed tailings as designed
Changes in water quality (Cd, Se, Zn) of Wolverine Creek related to groundwater discharge affected by underground mine backfill	• Follow the mine closure plan • Monitor groundwater in backfilled areas during operation, refine hydrogeological model and apply adaptive management if required.

Table 7.5-14 Mitigation Measures for Effects on Water and Sediment Quality (cont'd)

Potential Project Effect	Mitigation Measures
All Phases	
Introduction of sediment at multiple road crossings, long-distance transport of metals from effluent discharge, and potential introduction of sediment or contaminants from Robert Campbell Highway affecting Money and Light Creeks.	• Mitigation measures for project-related effects will ensure effects on water and sediment quality are localized and minimize the potential for cumulative effects.

7.5.8 Monitoring and Follow-up

Follow-up Studies

Recommendations for follow-up baseline studies to improve predictive confidence or the database for effects monitoring purposes will be made when all data for the 2005 field program are reviewed. Results and recommendations will be provided in the addendum report, to be submitted in early 2006. At this point, it is felt that the 2005-2006 baseline study will provide sufficient data for seasonal baseline water quality and sediment characterizations at most relevant locations within the LSA and RSA, although two new water quality sites should be established and monitored on Go Creek (in the effluent discharge area downstream of Go and Hawkowl Creeks and at the compliance point 4.5 km downstream of the discharge). Table 7.5-16 contains a list of routine water monitoring sites that should be maintained during the next year. Additional sites in the mine area may be sampled as required.

Table 7.5-15 Recommended Routine Water Monitoring Sites for 2005 - 2006

Site Description	Site #	Site Description	Site #
Nougha Cr. 100 m downstream of Wolverine L.	W1	Money Cr. 50 m u/s Robert Campbell Highway	W22
Wolverine Cr. 50 m u/s beaver dam at mouth	W9	Money Cr. upstream of Dollar Cr.	W23
Money Cr. 60 m upstream of Go Cr.	W11	Go Creek upstream of airstrip	W31
Go Cr. 20 m upstream of Pup Cr.	W12	Little Wolverine Creek upstream of portal	W32
Pup Cr. 20 m upstream of mouth	W13	Money Creek below Robert Campbell Highway	W40
Money Cr. 100 m downstream of Go Cr.	W14	Chip Creek (upper watershed)	W69
Hawkowl Cr. 30 m upstream of Go Cr.	W15	Pitch Creek	W71
Go Cr. 15 m upstream of Hawkowl Cr.	W16	Light Creek	W72
Headwaters of Go Cr. (right tributary)	W18	Bunker Creek at proposed crossing (Sept. 2005)	W73
Upper Hawkowl Cr.	W19	Chip Creek	W74
Nougha Cr. 30 m u/s Robert Campbell Highway	W21		

Monitoring Programs

Monitoring programs are recommended where the likelihood of project effects is unknown and there is concern that effects on the VECC might give rise to a management issue in a regulatory or social context. These programs are summarized in Table 7.5-16. Monitoring will be implemented by YZC.

The main monitoring program identified to determine effects on water and sediment quality from residual and cumulative effects will be the EEM program required under MMER for mines operating with a permitted discharge point. Monitoring for metal levels, particularly selenium, in sediment (depositional areas) is also recommended.

Construction monitoring for release of sediment (TSS) to streams will be conducted as part of the sediment and erosion control program (Section 9: Environmental Management Plans) during facility and access road construction, to monitor effectiveness of mitigation measures.

Go and Wolverine Creek flows will be monitored to assess predicted effects of hydrologic changes.

Table 7.5-16 Monitoring and Follow-up Programs for Water and Sediment Quality

Potential Project Effect	Program Objectives	General Methods	Reporting	Implementation
Follow-Up Programs				
None				
Monitoring Programs				
Construction monitoring for suspended sediments	• To confirm effectiveness of mitigation and immediately address compliance issues	• Monitor TSS at settling basins and in receiving waters according to permit schedule	• YTG and DFO as required	Proponent
Effects of treatment plant effluent discharge	• To identify effects of metals and nutrients on receiving environment quality	• EEM program conducted on 3-year cycle following EEM methods	• Reporting schedule according to MMER	
Accumulation of selenium and other metals in depositional habitat	• To check potential for bioaccumulation. As needed, initiate contingency plans to address unexpected effects	• Concurrent with EEM program on three-year cycle • Initiate benthic invertebrate or fish tissue sampling based on results of sediment analysis	• Report to YTG and DFO.	Proponent

7.5.9 Summary of Effects

Project and cumulative effects are summarized in Table 7.5-17. Adverse effects that are rated moderate in magnitude and far future in duration are considered significant, as are those rated high in magnitude, that are local or regional in extent and of high likelihood or site specific, far future in duration or irreversible and of high likelihood.

Table 7.5-17 Summary of Effects on Water and Sediment Quality

Potential Effect	Level of Effect[1]						Effect Rating[2]	
	Direc-tion	Magni-tude	Extent	Duration/ Frequency	Reversi-bility	Like-lihood	Project Effect	Cumulative Effect
Construction								
Changes in water and sediment quality in Wolverine and Go Creeks from contaminated construction site runoff, waste rock storage, ore stockpiles	Adverse	Low	Site-specific	Short term, Moderate frequency	Reversible	Low	Not significant	N/A
Minesite and road right-of-way clearing causing loss of riparian vegetation and increased sediment input to Go and Wolverine Creeks	Adverse	Low	Site-specific	Long term	Reversible	Low	Not significant	N/A
Sediment inputs during construction of stream crossings (culvert installations) on access road in Upper Go, Hawkowl, Pup, Chip, Bunker, Pitch and Light Creeks	Adverse	Low	Site-specific	Short term, Moderate frequency (several days during culvert installation)	Reversible	Low	Not significant	N/A
Operations								
Changes in Go Creek flow regime related to mine dewatering and diversion, affecting dilution capacity.	Neutral	See below	See below	See below	See below	See below	See below	See below
Changes in water and sediment quality from tailings facility seepage to Go Creek (metals TSS, nutrients, SO_4)	Adverse	Low	Site-specific	Long term	Reversible	Unknown	Not significant	N/A
Changes in water and sediment quality in Go Creek from treatment plant effluent discharges (metals, TSS, nutrients, SO_4)	Adverse	Moderate	Local	Long term	Reversible	High	Not significant	N/A
Changes in nitrate levels in Go Creek from effluent discharges	Adverse? Positive?	Moderate	Local to Regional	Long term	Reversible	Unknown	Not significant	N/A
Accumulation of metals (Se) in sediment of Go Creek with increased potential for bioaccumulation in benthic communities and higher trophic levels	Adverse	Low	Site-specific	Long term	Reversible	Unknown	Not significant	N/A

Table 7.5-17 Summary of Effects on Water and Sediment Quality (cont'd)

Potential Effect	Level of Effect[1]						Effect Rating[2]	
	Direc-tion	Magni-tude	Extent	Duration/ Frequency	Reversi-bility	Like-lihood	Project Effect	Cumulative Effect
Introduction of sediment and other road runoff contaminants into Upper Go, Hawkowl, Pup, Chip, Bunker and Light Creeks	Adverse	Low	Site specific	Long term	Reversible	High	Not significant	N/A
Decommissioning								
Changes in water and sediment quality in Wolverine and Go Creeks from site runoff where facilities have been removed and/or the ground recontoured	Adverse	Low	Site specific	Short term	Reversible	High	Not significant	N/A
Changes in water and sediment quality in Go Creek from tailings water treatment and effluent discharges (metals, TSS, nutrients, SO_4)	Adverse	Low	Site specific	Medium term	Reversible	High	Not significant	N/A
Closure								
Changes in water and sediment quality of Go Creek from ongoing tailings supernatant discharge	Adverse	Low	Site specific	Far future	Reversible	Unknown	Not significant	N/A
Changes in water quality (Cd, Se, Zn) of Wolverine Creek related to groundwater discharge affected by underground mine backfill	Adverse	Low	Site specific	Far future	Reversible	Unknown	Not significant	N/A

Notes:
1. Based on criteria in Table 7.5-11
2. Based on criteria in Section 7.5.7
N/A = not applicable