Faro Mine Slimy Sculpin Reconnaissance Survey, May 2008

Report Prepared for:

Assessment and Abandoned Mines
Yukon Government
Whitehorse, YT
Y1A 2C6

Report Prepared by:

Minnow Environmental Inc.
Georgetown, Ontario

and

White Mountain Environmental Consulting
Whitehorse, Yukon

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1.0 INTRODUCTION

1.1 Background

The Faro Mine complex, near Faro, Yukon, includes two mines: the Faro Mine and Mill (Faro site) and Vangorda/Grum Mines (Vangorda site), which are located approximately 12 km apart (Figure 1.1). The complex was formerly owned by the Anvil Range Mining Corporation and produced lead and zinc concentrates to be extracted for lead, zinc, silver, and gold. The Faro site was mined between 1969 and 1992, while the Vangorda site was developed and mined between 1986 and 1998. Milling continued at Faro until April 1998, when all operations were terminated due to poor economic circumstances and projections, and the site went into receivership. Since then, management of the mine property has been under the direction of Deloitte and Touche Inc., acting as the court appointed Interim Receiver. In early 2009, Care and Maintenance responsibilities at the site will transfer to a contractor acting on behalf of the Yukon Government.

The Yukon government and its consultants, working with the federal government, Selkirk First Nation, and Ross River Dena Council are currently preparing a comprehensive closure plan for the abandoned Faro Mine complex. Before the closure plan can be implemented, it will be subject to regulatory assessment and approval processes. The plan requires regulatory approval in the form of a Water License issued under the *Waters Act* by the Yukon Water Board and will need to be acceptable to relevant government agencies, the First Nations and the public. The assessment process will be carried out through the Yukon Environmental and Socio-Economic Assessment Board under the *Yukon Environmental and Socio-Economic Assessment Act* (YESAA).

Technical studies conducted at the site, which are nearing completion, have indicated that acidification and leaching processes have the potential to result in dramatic increases in metal loadings to surface waters downstream of the Faro Mine complex over the next several to many decades (SRK 2004, 2005). Consequently, the closure process is proceeding to the regulatory and development assessment phases with considerable focus on identifying the mitigation measures required to protect the aquatic ecosystem downstream of the mines. Related to this, Minnow Environmental Inc. was requested to assist in identifying the requirements of a comprehensive, site-wide environmental monitoring program to be implemented at closure.

As first steps, Minnow reviewed and re-evaluated the results of previous studies and monitoring (Minnow 2007a) and proposed a general framework for the long-term

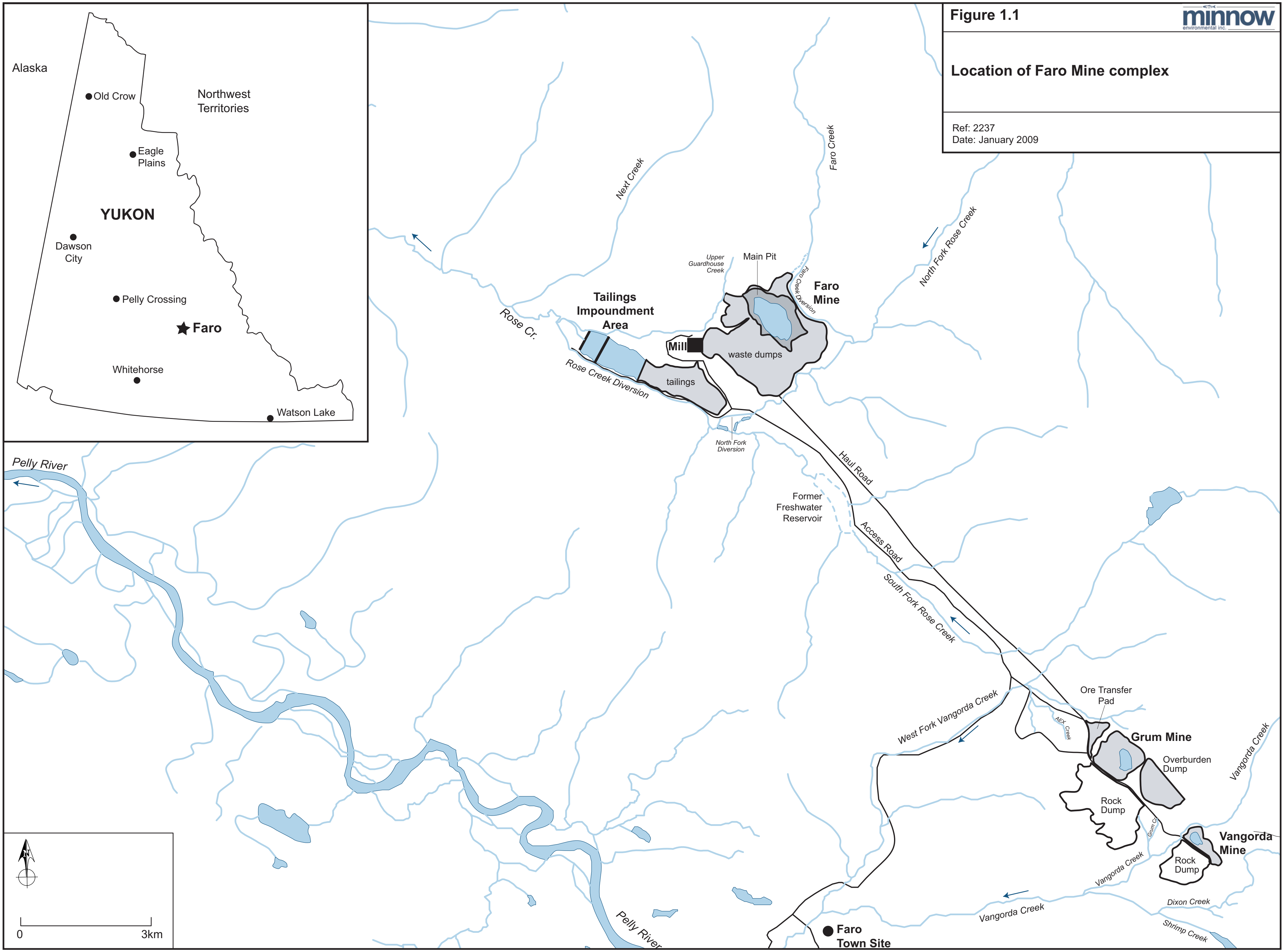

Figure 1.1

Location of Faro Mine complex

Ref: 2237
Date: January 2009

monitoring program (Minnow 2007b). Key information gaps were identified that need to be addressed in order to optimize the long-term monitoring program design (Minnow 2007b). It was thus proposed that an Interim Aquatic Ecosystem Monitoring Program (IAEMP) be implemented in the short-term to address the identified data gaps. This study was undertaken to answer questions related to future assessments of fish health. The results will be used to update recommendations for the long-term aquatic ecosystem monitoring framework for the Faro Mine (Minnow 2007b).

1.2 Project Objectives and Approach

The objective of this study was to determine if slimy sculpin (*Cottus cognatus*) can be obtained in sufficient numbers and reproductive condition in spring to permit a fish population health assessment similar to what is done for Environmental Effects Monitoring (EEM) at operating mines under the Metal Mining Effluent Regulations (MMER) of the federal *Fisheries Act* (Environment Canada 2002). While the MMER (and therefore EEM) do not apply to closed mines, the EEM framework has become widely accepted as a basis for assessing the health of sentinel fish populations, so it may prove useful to incorporate a similar approach, or aspects thereof, in the long-term monitoring of fish populations near the Faro Mine. Since previous studies have shown that slimy sculpin is the most ubiquitously distributed fish species in the water bodies near the Faro mine (Minnow 2007b), it may be useful as a "sentinel" species (as defined by Environment Canada 2002) for assessment of fish population health at the Faro Mine.

EEM assessments typically target fish prior to spawning when gonads are well-developed and reproductive investment can thus be evaluated in mine-exposed fish relative to reference fish. Previous assessments of slimy sculpin have taken place in late summer, subsequent to spring spawning. This study was undertaken to identify if spring freshet conditions allow for capture of adequate numbers of pre-spawning slimy sculpin to permit a conventional EEM-type approach to assessment of population health in long-term monitoring.

2.0 METHODS

2.1 Fish Collection

Backpack electrofishing and minnow traps and were used to capture fish from reference and mine-exposed creeks near the Faro mine (Figure 2.1). The areas were chosen to include near-field mine-exposed areas (V8, X14) and potential reference areas (R7, USFR, VR, V1, BLC). Electrofishing was conducted using a battery powered Smith-Root LR-12 backpack electrofisher (Smith Root Inc., Vancouver, WA). Wadable areas of creeks were fished by an operator and a netter, starting at the downstream end of the reach and moving upstream. Depending on the depth and flow of the creek, the area fished ranged from immediately next to the bank (in larger creeks), to the breadth of the creek. All types of habitat were covered when possible. Stop nets were not used due to high flow and rocky habitat conditions and because they were not required to satisfy the study objectives. Fish collected were identified and enumerated on field sheets, and fish other than slimy sculpin were released. For each area, electrofishing settings and effort in seconds were recorded.

Minnow traps (¼" mesh) baited with chum salmon roe were also set overnight along the edges of creeks and anchored to bushes. Locations and times of trap sets were recorded on field sheets, along with habitat notes (below). Up to 16 minnow traps were set at each creek. The first trap was set at an identifiable object or feature next to the stream. This feature was noted and GPS coordinates were recorded to mark its location. The remaining traps were set at suitable points upstream and downstream from this trap, generally all within a distance of 100 m. The distance from the initial trap was recorded to identify where the traps were placed, and assist in their recovery. All traps were removed the following day (16- to 25-hour set duration). Lift times were recorded and all fish were identified and enumerated. Slimy sculpin were retained and all other by-catch were identified, enumerated and released.

2.2 Slimy Sculpin Measurements

Total length was measured on all captured slimy sculpin using digital calipers, accurate to 0.01 mm. Some of the slimy sculpin were sacrificed to determine sex, reproductive status, and to obtain gonad weights. Total body weights for these fish were recorded using an Ohaus Scout Pro Balance (accuracy 0.001g). Following external measurements, abdominal cavities were cut open using a scalpel. If possible (i.e., if gonads were

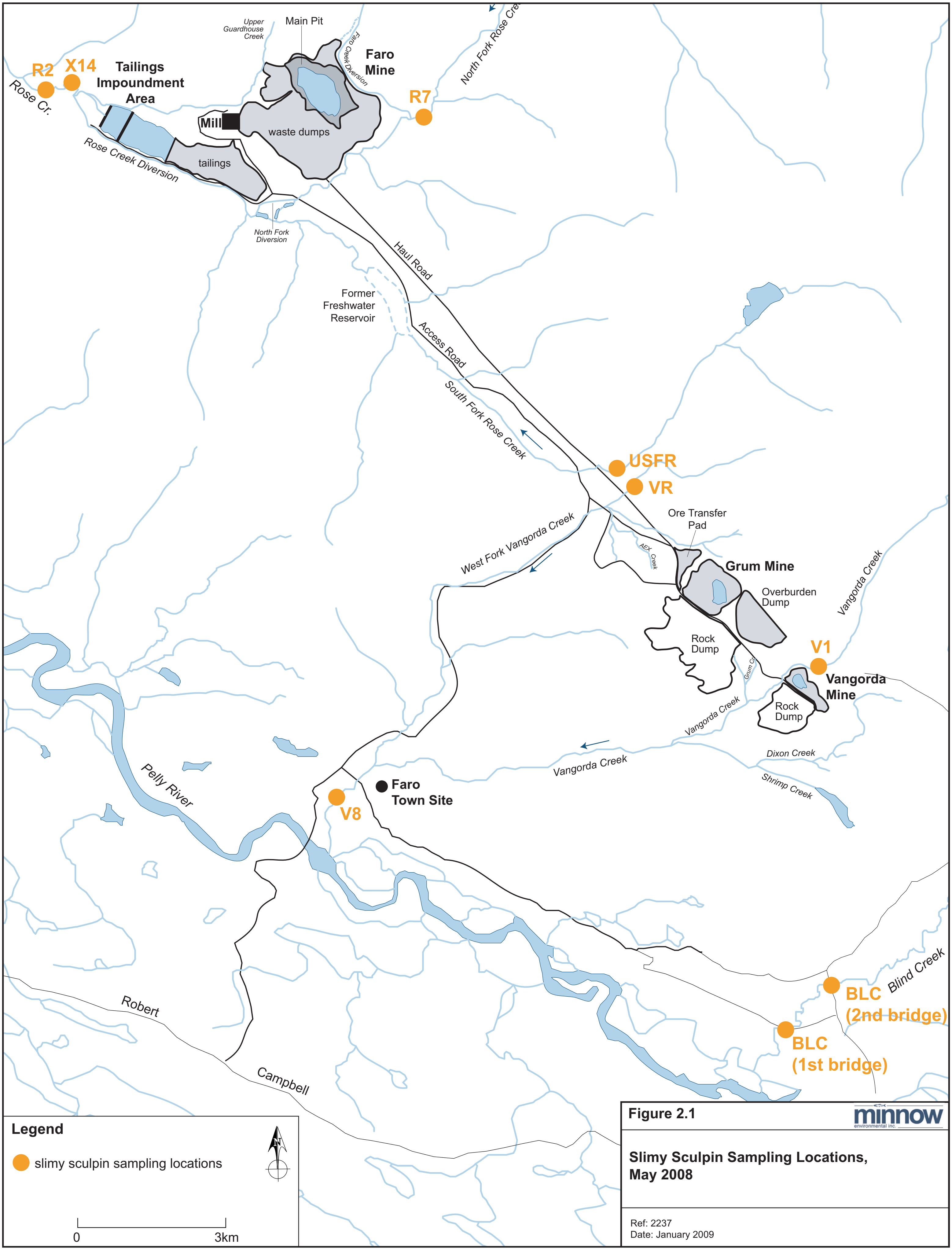

Figure 2.1

Slimy Sculpin Sampling Locations, May 2008

sufficiently developed), sex was identified and gonads were removed and weighed. Any abnormalities (e.g., parasites) were recorded.

2.3 Supporting Measurements and Information

Habitat characteristics, *in situ* water quality measurements, and water samples were noted at each location. GPS coordinates for each location were taken using a hand-held Garmin 72 and recorded on field sheets. Habitat characteristics included width, depth, velocity, substrate type, gradient, and morphology. *In situ* water quality measurements were taken using a YSI 600QS sonde that was calibrated daily. Parameters measured included temperature, dissolved oxygen, conductivity and pH. Tidbit temperature loggers, programmed to take hourly temperature readings, were also placed in three creeks on the first day, including Blind, Vangorda and Rose Creeks. The loggers were removed on the last day of field work. Water samples were collected from each area for analysis of metals and non-metal parameters. Water sample bottles were rinsed in triplicate prior to filling. Preservatives were added to sample bottles, as required, and all bottles were placed in a cooler with ice packs to ensure samples remained cool. Samples were sent to Maxxam Analytical Inc. in Burnaby, B.C. for analysis. The water quality data were compared to water quality benchmarks, typically Canadian or provincial water quality guidelines for protection of aquatic life, which were previously compiled for application in projects related to Faro Mine closure (Minnow 2008a).

3.0 RESULTS AND INTERPRETATION

3.1 Field Conditions

The May 2008 survey coincided with spring freshet, so water levels and flows were considerably higher than had been observed at areas sampled the previous August 2007 (Table 3.1). Upper West Fork Vangorda Creek (VR), which was the smallest stream inspected, was still largely ice-covered at the time of the survey (Appendix Table A.1). Maximum depths and/or fast flows precluded wading fully across some creeks. Creek water was turbid in all areas, sometimes obscuring substrate morphology and composition (Appendix Table A.1)

3.2 Water Quality

Water temperatures at the time of the survey ranged from just above freezing to approximately 5°C (Table 3.2). Temperature loggers showed diurnal fluctuations of 2 to 5°C, with greatest fluctuations observed in lower Vangorda Creek (V8) relative to Blind and Rose Creeks (Figure 3.1). A slight rising trend was evident in increasing maximum and minimum temperatures recorded at each location over the 3-day survey period.

Dissolved oxygen was at or near saturation at all locations (Table 3.2). Conductivity was low (Faro Creek) to moderate at reference areas, and higher at mine-exposed areas. Water pH was slightly basic at all locations, except for slightly acidic conditions measured in Faro Creek (Table 3.2).

Total alkalinity was reduced below the benchmark concentration of 11.1 mg/L only at some of the reference areas (Table 3.3). Higher alkalinities at the mine-exposed areas indicated that any acid generating drainage from waste rock and tailings was not sufficient to reduce alkalinites below the background range downstream of the mine.

The Canadian Water Quality Guideline for long-term exposure to total suspended solids applicable to waters near Faro Mine during clear flow periods is 8 mg/L, which represents 5 mg/L above the natural background concentration of 3 mg/L (Minnow 2008a). However, the guidelines allow for short-term (<24-hour) increases of up to 25 mg/L above background at any time, and longer term exposures to the same value during high flow periods when background levels are between 25 and 250 mg/L (CCME 1999). Adding 25 mg/L to the 95th percentile of background values from this study (95 mg/L based on BLC, R7, USFR, FC, VR and V1) results in a guideline of 120 mg/L which was above the level

Table 3.1: Comparison of August 2007[a] and May 2008 velocity, depth and width measurements of creeks near Faro Mine, Yukon

		Upper South Fork Rose Creek (USFR)		Upper West Fork Vangorda Creek (VR)		Upper Vangorda Creek (V1)		Vangorda Creek (V8)	
		Aug 2008	May 2008	Aug 2008	May 2008	Aug 2008	May 2008	Aug 2008	May 2008
Velocity (m/s)	Mean	0.37	1.4	0.31	1.3	0.22	1.5	0.13	1.8
	Maximum	0.8	2.2	0.65	1	0.5	2.7	0.38	>2
Depth (m)	Mean	0.23	0.5	0.10	0.15	0.17	0.4	0.26	NM
	Maximum	0.45	0.8	0.25	0.2	0.37	0.7	0.39	NM
Width (m)	Wetted	7.7	10	1.6	3	4.7	6	5.2	8
	Bankfull	8.6	10	2.1	4	7.4	8	7.8	20

[a] 2007 data represent mean values for 5 benthic stations

NM - not measured

Table 3.2: In situ water quality measurements, Faro Mine, May 2008

	Reference						Mine-Exposed	
	Blind Creek (BLC)	North Fork Rose Creek (R7)	South Fork Rose Creek (USFR)	Faro Creek (FC/FDU)	Upper West Fork Vangorda Creek (VR)	Vangorda Creek (V1)	Vangorda Creek (V8)	Rose Creek downstream of tailings (R2)
Temperature (^oC)	5.15	1.57	5.66	1.09	0.86	1.74	5.11	2.98
Dissolved Oxygen (mg/L)	12.82	13.10	11.72	12.98	12.83	12.75	12.56	12.92
Dissolved Oxygen (% saturation)	100.7	93.7	93.3	91.6	90.0	91.7	98.6	96.0
Specific Conductance (μS/cm)	78	51	32	9	32	52	156	134
pH (pH units)	7.85	7.42	7.21	6.71	7.20	7.56	8.01	7.64

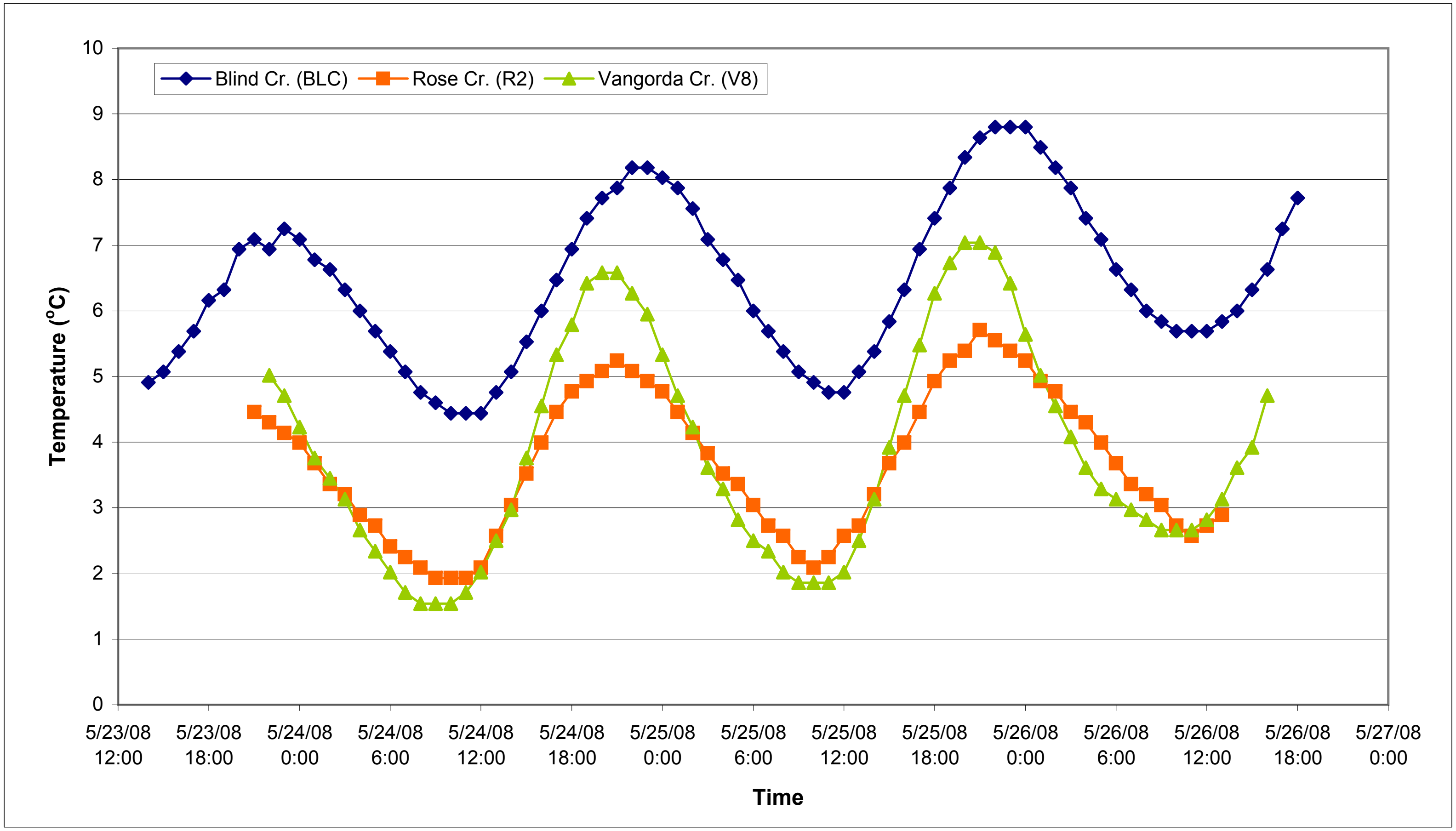

Figure 3.1: Hourly water temperatures as recorded by temperature loggers

Table 3.3: Water quality data compared to benchmarks, Faro Mine, Yukon, May 2008.

Parameter	Units	MDL[a]	Water Quality Benchmark[b]		Reference						Mine-Exposed	
			Value	Source	Blind Creek (BLC)	North Fork Rose Creek (R7)	South Fork Rose Creek (USFR)	Faro Creek (FC/FDU)	Upper West Fork Vangorda Creek (VR)	Vangorda Creek (V1)	Vangorda Creek (V8)	Rose Creek downstream of tailings (R2)
Misc. Inorganics & Physical Properties												
Fluoride (F)	mg/L	0.01	0.12	CWQG[b]	0.07	0.05	0.05	0.05	0.06	0.05	0.11	0.065
Weak Acid Dissoc. Cyanide (CN)	mg/L	0.0005	0.005 (free)	CWQG[b]	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Dissolved Organic Carbon (C)	mg/L	0.5	-		11.4	9.6	6.6	9.3	11.9	7.5	7.7	8
Alkalinity (Total as CaCO3)	mg/L	0.5	11.1	OPWQO[c]	28	17	7.6	1.9	7.7	15	53	28.5
Alkalinity (PP as CaCO3)	mg/L	0.5	-		< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Bicarbonate (HCO3)	mg/L	0.5	-		34	21	9.2	2.3	9.4	18	65	35
Carbonate (CO3)	mg/L	0.5	-		< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Hydroxide (OH)	mg/L	0.5	-		< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Dissolved Sulphate (SO4)	mg/L	0.5	-		< 0.5	< 0.5	< 0.5	< 0.5	3.4	1.6	23	28
Dissolved Chloride (Cl)	mg/L	0.5	250	CDWQG[b]	1.2	1.9	0.9	1	0.6	0.8	3.1	0.9
Total Suspended Solids	mg/L	1	8	CWQG[b]	45	33	20	82	100	16	120	32.5
Total Dissolved Solids	mg/L	10	500	CDWQG[b]	70	52	34	52	34	52	120	105
Total Hardness (CaCO3)	mg/L	0.5	-		38.8	25.2	15.3	7.1	16.4	23.1	88.8	63.85
Total Organic Carbon (C)	mg/L	0.5			11.5	10.4	6.7	9.5	12.2	8	8.4	9.35
Nutrients												
Ammonia (N)	mg/L	0.01	0.24	CWQG[b]	0.14	0.15	0.16	0.03	< 0.01	0.13	0.19	0.095
Nitrite (N)	mg/L	0.005	0.06	CWQG[b]	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.007	< 0.005
Nitrate (N)	mg/L	0.02	13	CWQG[b]	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.05	0.03
Nitrate plus Nitrite (N)	mg/L	0.02	-		< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.05	0.03
Dissolved Phosphorus (P) [g]	mg/L	0.002	0.03	OPWQO[c]	0.018	0.021	0.014	0.02	0.015	0.013	0.025	0.021
Total Total Kjeldahl Nitrogen (Calc)	mg/L	0.02			0.24	0.28	0.24	0.25	0.28	0.17	0.16	0.255
Total Nitrogen (N)	mg/L	0.02			0.24	0.28	0.24	0.25	0.28	0.17	0.21	0.28
Total Metals												
Aluminum (Al)	mg/L	0.0002	0.1	CWQG[b]	0.285	0.281	0.15	0.385	0.421	0.137	0.454	0.2635
Antimony (Sb)	mg/L	0.00002	0.02	OPWQO[c]	0.00009	0.00009	0.00004	0.00004	0.00004	0.00003	0.00012	0.000085
Arsenic (As)	mg/L	0.00002	0.005	CWQG[b]	0.00105	0.00141	0.00056	0.00047	0.00153	0.00063	0.00152	0.001195
Barium (Ba)	mg/L	0.00002	1.0	CDWQG[b]	0.0518	0.0308	0.0237	0.0255	0.0354	0.0248	0.0604	0.03375
Beryllium (Be)	mg/L	0.00001	1.1	OPWQO	0.00003	0.00005	0.00004	0.00009	0.00014	0.00003	0.00006	0.00005
Bismuth (Bi)	mg/L	0.000005	0.26	Alternative[d]	0.000005	0.000007	0.000008	0.000021	0.000015	< 0.000005	0.000009	0.000014
Boron (B)	mg/L	0.05	1.2	BCWQO[e]	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cadmium (Cd)	mg/L	0.000005	0.00003	CWQG[b]	0.000071	0.000071	0.000033	0.000099	0.000127	0.000047	0.000219	0.000079
Calcium (Ca)	mg/L	0.05	116	Alternative[d]	11.4	7.87	4.98	2.15	5.09	7.4	22.8	19.6
Chromium (Cr)	mg/L	0.0001	0.001	CWQG[b]	0.0003	0.0004	0.0002	0.0004	0.0003	0.0001	0.0009	0.0005
Cobalt (Co)	mg/L	0.000005	0.004	BCWQO[e]	0.000342	0.000316	0.000144	0.000468	0.000455	0.000255	0.00135	0.000819
Copper (Cu)	mg/L	0.00005	0.002	CWQG[b]	0.00239	0.00239	0.00115	0.00268	0.00272	0.00123	0.00549	0.00269
Iron (Fe)	mg/L	0.001	0.3	CWQG[b]	0.555	0.893	0.44	0.75	0.488	0.344	1.02	0.851
Lead (Pb)	mg/L	0.000005	0.002	CWQG[b]	0.000794	0.000954	0.000719	0.00425	0.00543	0.000748	0.00769	0.00684
Magnesium (Mg)	mg/L	0.05	82	Alternative[d]	2.5	1.34	0.7	0.42	0.89	1.12	7.75	3.63
Manganese (Mn)	mg/L	0.00005	1	BCWQO[e]	0.0707	0.0752	0.0445	0.0558	0.0781	0.0471	0.141	0.4385
Molybdenum (Mo)	mg/L	0.00005	0.073	CWQG[b]	0.00031	0.00024	0.00023	< 0.00005	0.00008	0.0001	0.00036	0.00025
Nickel (Ni)	mg/L	0.00002	0.065	CWQG[b]	0.00157	0.00124	0.00052	0.00084	0.00097	0.00082	0.00454	0.002435
Potassium (K)	mg/L	0.05	53	Alternative[d]	0.88	0.93	0.74	0.8	0.79	0.98	0.98	1.07
Selenium (Se)	mg/L	0.00004	0.001	CWQG[b]	0.00012	0.00013	0.00006	< 0.00004	0.00005	0.00008	0.00027	0.00011
Silver (Ag)	mg/L	0.000005	0.0001	CWQG[b]	0.000011	0.000012	0.000006	0.000014	0.000014	0.000009	0.00001	0.0000105
Sodium (Na)	mg/L	0.05	200	CDWQG[b]	1.39	0.71	0.84	0.69	0.8	0.96	1.21	1.495
Strontium (Sr)	mg/L	0.00005	9.3	Alternative[d]	0.0473	0.0385	0.0293	0.0148	0.0292	0.0378	0.0903	0.0653
Thallium (Tl)	mg/L	0.000002	0.0008	CWQG[b]	0.000007	0.000008	0.000006	0.000012	0.000013	0.000005	0.00002	0.0000155
Tin (Sn)	mg/L	0.00001	0.35	Alternative[d]	< 0.00001	0.00001	0.00001	< 0.00001	< 0.00001	< 0.00001	0.00001	0.00003
Titanium (Ti)	mg/L	0.0005	1.83	Alternative[d]	0.0068	0.0113	0.0047	0.0084	0.0087	0.0021	0.0099	0.0076
Uranium (U)	mg/L	0.000002	0.015	Sask[f]	0.000392	0.000385	0.000871	0.000596	0.00169	0.000613	0.00129	0.000543
Vanadium (V)	mg/L	0.0002	0.006	OPWQO[c]	0.0005	0.0006	0.0003	0.0009	0.0006	< 0.0002	0.0011	0.0005
Zinc (Zn)	mg/L	0.0001	0.03	CWQG[b]	0.0084	0.01	0.0089	0.0164	0.0137	0.0058	0.0412	0.0673
Zirconium (Zr)	mg/L	0.0001	0.004	OPWQO[c]	0.0004	0.0003	0.0002	0.0003	0.0004	0.0001	0.0005	0.00025

[shaded] Indicates value exceeds selected benchmark, except for alkalinity for which values below the benchmark are shaded.

[a] Method Detection Limit.

[b] CWQG - Candaian Water Quality Guidelines, CCME (Canadian Council of Ministers of the Environment). 1999. Canadian Environmental Quality Guidelines. 1999 (plus updates), Canadian Council of Ministers of the Environment, Winnipeg

[c] OPWQO - Ontario Provincial Water Quality Objectives, OMOE (Ontario Ministry of Environment and Energy). 1994. Policies, Guidelines, Provincial Water Quality Objectives of the Ministry of the Environment and Energy (Ontario), July 1994

[d] Alternative - toxicity reference value for most sensitive aquatic receptor (aquatic plants, phytoplankton, benthic invertebrates, zooplankton, fish). From Senes Consultants Limited, Richmond Hill, Ontario.

[e] BCWQO - BC Water Quality Objective, BCMOE (British Columbia Ministry of Environment). 2006. British Columbia Approved Water Quality Guidelines (Criteria), 2006 Edition. Updated August 2006. For parameters with both maximum and 30-day average values, the 30-d average is shown.

[f] Sask - Saskatchewan Environment. 2006. Surface Water Quality Objectives. Interim Edition. EPB356. July 2006. 9pp.

[g] guideline is for total phosphorous

measured at X14 in Rose Creek and was met but not exceeded at V8 downstream of the Vangorda Mine (Table 3.3).

Consistent with elevated dissolved solids levels, aluminum and iron concentrations were also elevated in all reference and mine-exposed areas relative to guidelines (Table 3.3). Copper, cadmium, and lead also exceeded applicable guidelines at some or all reference areas, but concentrations of these substances, as well as zinc, were generally higher at the two mine-exposed areas (Table 3.3).

3.3 Fish Capture

Electrofishing yields of fish were low at all locations in May 2008 despite a reasonable, reconnaissance-level fishing effort (Tables 3.4, 3.5). This was attributed to the high flows and turbidity associated with spring freshet. Comparison of 2008 CPUE results for X14 and V8 relative to other years indicates that electrofishing is more productive in August when flows tend to be lower and water is clearer (Table 3.5). Late summer electrofishing involving 1000+ seconds of current would yield at least 20 sculpin in most areas of Rose Creek, although an order of magnitude greater effort would be required at V8 to achieve the same yield (Table 3.5). The reference locations sampled in 2008 have not been sampled in recent years, so further study is required to determine if similar catch success might be achieved in a late summer survey of those areas.

Minnow trap yields of slimy sculpin have been low, regardless of season (Table 3.6).

Some of the adult slimy sculpin captured in Blind Creek were sacrificed to determine reproductive condition. The largest sculpin (≥68 mm) had gonads that were differentiated (male versus female) and relatively ripe, while all other sculpin that were examined internally were sexually immature (Table 3.7). None of the largest sculpin captured appeared to have spawned already, suggesting that spawning occurs (at least in Blind Creek) when mean daytime temperatures are at least 7°C and minimum diurnal temperatures are more than 5 or 6°C (Figure 3.1). Based on the condition of sculpin caught in Blind Creek, it was expected that spawning would occur in less than one week. This was corroborated by evidence of ripe and spent sculpin in Judas Creek in the vicinity of Whitehorse prior to and after this study, respectively. Ripe sculpin were abundant in daytime temperatures of 5° to 7°C in Judas Creek prior to the Faro study and were spent subsequent to the Faro study in daytime temperatures of 9° to 10°C. The warmer water and sculpin spawning coincided with the waning of the snow melt freshet and occurred during high flows in turbid water. (P. Sparling, White Mountain Environmental Consulting, pers. comm.).

Table 3.4: Results of May 2008 fishing effort, Faro Mine

Area	Electrofishing		Minnow Trapping	
	Effort (seconds)	Catch	Effort (trap days)	Catch
Rose Creek (R2)	387	0	11.2	0
Vangorda Creek (V8)	795	1 grayling, 2 round whitefish, 12 juvenile chinook, 1 sculpin, 1 lake chub	13.9	5 juvenile chinnook 2 lake chub
Faro Creek (FC/FDU)	- [a]	- [a]	9.7	0
Upper Vangorda (V1)	283	0	7.3	0
Blind Creek (BLC, 2nd bridge)	825	16 sculpin 2 juvenile chinook	9.3	6 juvenile chinook 2 sculpin
Blind Creek (BLC, 1st bridge)	240	0	6.5	3 sculpin 3 juvenile chinook
South Fork Rose Creek (USFR)	499	5 grayling	10.8	0
North Fork Rose Creek (R7)	374	0	- [b]	- [b]

[a] electrofishing not possible due to high water levels and flow rates

[b] minnow trapping not conducted due to high water levels and flow rates

Table 3.5: Electrofishing results for May 2008 compared to August sampling for previous years

Station	Year Month	Effort (sec)	Grayling (sub ad. & adult)		Grayling (juvenile)		Sculpin (adult)		Sculpin (fry)		Burbot		Juvenille Chinook Salmon		Round Whitefish		Lake Chub	
			Catch	**CPUE**	**Catch**	**CPUE**	**Catch**	**CPUE**	**Catch**	**CPUE**	**Catch**	**CPUE**	**Catch**	**CPUE**	**Catch**	**CPUE**	**Catch**	**CPUE**
South Fork Rose Creek (R1)	2004 Aug	-	-	0.36	-	1.8	-	3.47	-	0	-	0.24	-	0.36	-	0.12	-	0
	2005 Aug	-	-	0	-	1.53	-	4.83	-	0	-	0.24	-	0	-	0	-	0
	2006 Aug	-	-	0	-	0	-	1.75	-	0	-	0	-	0	-	0	-	0
	2007 Aug	-	-	0	-	0.34	-	3.09	-	0.11	-	0	-	0	-	0	-	0
Rose Creek downstream of tailings (R2)	2004 Aug	-	-	0.27	-	0	-	15.65	-	1.1	-	0.27	-	0	-	0	-	0
	2005 Aug	-	-	1.81	-	0.11	-	8.6	-	0.79	-	0.79	-	0.23	-	0	-	0
	2006 Aug	-	-	0	-	0	-	4.22	-	0.55	-	0.08	-	0	-	0	-	0
	2007 Aug	-	-	0	-	0.18	-	5.12	-	0.18	-	0	-	0	-	0	-	0
	2008 May	387	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rose Creek downstream (R4)	2004 Aug	-	-	0.11	-	0	-	2.86	-	0	-	0	-	0	-	0	-	0
	2005 Aug	-	-	0.57	-	0	-	4.31	-	0.58	-	0	-	0	-	0	-	0
	2006 Aug	-	-	0	-	0.1	-	8.37	-	5.1	-	0	-	0	-	0	-	0
	2007 Aug	-	-	0.11	-	0.68	-	11.12	-	0	-	0.11	-	0	-	0	-	0
Anvil Creek Reference (R6)	2004 Aug	-	-	0.11	-	0	-	2.86	-	0.11	-	0	-	0	-	0	-	0
	2005 Aug	-	-	0	-	0	-	4.21	-	0.1	-	0	-	0	-	0	-	0
	2006 Aug	-	-	0	-	0	-	6.29	-	1.28	-	0.26	-	0	-	0	-	0
	2007 Aug	-	-	0	-	0	-	5.02	-	0	-	0.18	-	0	-	0	-	0
Vangorda Creek (V8)	2004 Aug	-	-	1.08	-	0.59	-	0.69	-	0	-	0	-	16.6	-	0	-	0
	2005 Aug	-	-	0.3	-	0	-	0.49	-	0	-	0	-	18.62	-	0	-	0
	2006 Aug	-	-	1.02	-	0	-	0.26	-	0	-	0.13	-	4.99	-	0	-	0
	2007 Aug	-	-	2.58	-	2.57	-	0.22	-	0	-	0.11	-	15.45	-	0.11	-	0
	2008 May	795	1	0.13	0	0	1	0.13	0	0	0	0	12	1.51	2	0.25	1	0.13
Upper Vangorda Creek (V1)	**2008 May**	283	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper South Fork Rose Creek (USFR)	**2008 May**	499	0	0	5	1	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Rose Creek (R7)	**2008 May**	374	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blind Creek (BLC, 1st bridge)	**2008 May**	240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blind Creek (BLC, 2nd bridge)	**2008 May**	825	0	0	0	0	16	1.94	0	0	0	0	2	0.24	0	0	0	0

CPUE - catch per unit effort expressed as number of fish per 100 seconds electrofishing
2004 - 2006 data collected by P. Sparling of White Mountain Environmental Consulting

Table 3.6: Slimy sculpin minnow trapping effort and catch, 2004 - 2008

Station	2004 (Aug 12-15)			2005 (Aug 14-18)			2006 (Aug 16-20)			2007 (Aug 15-18)			2008 (May 22-26)		
	Effort (trap days)	Catch	CPUE (catch/trap day)	Effort (trap days)	Catch	CPUE (catch/trap day)	Effort (trap days)	Catch	CPUE (catch/trap day)	Effort (trap days)	Catch	CPUE (catch/trap day)	Effort (trap days)	Catch	CP (catc da
Upper South Fork Rose Creek (USFR)													10.83	0	0.[illegible]
South Fork Rose Creek (R1)	6.14	3	0.49	6.78	2	0.30	5.53	1	0.16	6.94	0	0.00			
Faro Creek (FC/FDU)													9.66	0	0.[illegible]
North Fork Rose Creek (R8)							10.13	2	0.20						
Rose Creek downstream of tailings (R2)	13.68	2	0.15	5.93	2	0.34	6.51	1	0.15	5.81	2	0.39	11.24	0	0.[illegible]
Rose Creek downstream (R4)	5.88	0	0.00	9.79	3	0.31	10.52	3	0.28	8.79	12	1.37			
Anvil Creek (R5)	5.65	4	0.71												
Anvil Creek Reference (R6)				9.52	2	0.21				8.05	2	0.25			
Upper Vangorda Creek (V1)													7.34	0	0.[illegible]
Vangorda Creek (V8)	4.91	0	0.00	9.09	0	0.00	8.32	0	0.00	5.94	0	0.00	13.87	0	0.[illegible]
Blind Creek (BLC, 2nd bridge)	7.54	1	0.13	18.66	6	0.32	14.38	0	0.00	6.27	0	0.00	9.31	2	0.[illegible]
Blind Creek (BLC, 1st bridge)										6.18	1	0.16	6.52	3	0.[illegible]

2004 - 2007 data provided by P. Sparling of White Mountain Environmental Consulting

Table 3.7: Slimy sculpin characteristics, May 2008

Fish ID		Total Length (mm)	Body Weight (g)	Gonad Weight (g)	Sex	Comments
Blind Creek (BLC)	BC-SS-01	85.55	6.223	0.1	M	
	BC-SS-02	70.44	4.535	0.052	M	
	BC-SS-03	73.45	4.062	0.033	M	
	BC-SS-04	82.85	6.417	0.118	M	
	BC-SS-05	57.62	1.523	-	I	tape worm
	BC-SS-06	67.3	3.072	-	I	tape worm (8 mm)
	BC-SS-07	61.5	2.342	-	I	tape worm
	BC-SS-08	68.26	2.938	0.474	F	eggs 1.8-2.7 mm
	BC-SS-09	24.8	0.12	-	-	released
	BC-SS-10	60.72	1.72	-	IF	
	BC-SS-11	60.79	1.719	-	IF	
	BC-SS-12	47	-	-	-	released
	BC-SS-13	49	-	-	-	released
	BC-SS-14	48	-	-	-	released
	BC-SS-15	49	-	-	-	released
	BC-SS-16	45	-	-	-	released
	BC-SS-17	43	-	-	-	released
	BC-SS-18	42	-	-	-	released
	BC-SS-19	44	-	-	-	released
	BC-SS-20	45.85	0.862	-	I	
	BC-SS-21	48.62	0.885	-	I	
Vangorda Creek (V8)	VC-SS-01	63.61	2.25	-	IF	

M - Male

F - Female

I - Immature

IF - Immature Female

4.0 CONCLUSIONS AND RECOMMENDATIONS

Slimy sculpin spawning has been reported at water temperatures ranging from 5-10°C, depending on location (Scott and Crossman 1998). While the slimy sculpin caught in May 2008 had not yet spawned, it appeared that spawning was imminent; suggesting that reproduction near the Faro Mine likely coincides with mean water temperatures of slightly more than 7°C. This occurs during spring freshet when water levels, velocity, and turbidity are all elevated, greatly hampering collection of fish. Electrofishing, which appears to be the most effective means of capturing slimy sculpin later in the summer, is particularly difficult under spring freshet conditions. This indicates it will not be feasible to undertake an EEM-type pre-spawning sentinel species assessment using sculpin.

Slimy sculpin caught in August 2007 did not show evidence of post-spawning reproductive reinvestment (i.e., gonads were still small; Minnow 2008b), so a conventional EEM approach conducted at that time would lack data related to relative reproductive capacity or success in mine-exposed versus reference areas. Environment Canada has also developed guidance for an alternative approach involving non-lethal collection and assessment of fish populations, which can be applied during the post-spawning period (Environment Canada 2002, 2005). However, application of this approach at the Faro Mine may necessitate deviation from national guidance, since the associated sample size requirements (collection of at least 100 adults and 20 young-of-the-year (YOY) in each sampling area) may not be realistically achievable based on low densities. This should not deter an attempt to implement such a survey and adapt the approach, as necessary, to suit the monitoring objectives and site-specific limitations at the Faro Mine.

It is recommended that a hybrid approach be considered that would involve a non-lethal survey of slimy sculpin, as suggested above, combined with a broader fish community assessment similar to what has been conducted at Faro Mine in the past (e.g., WMEC 2005). The slimy sculpin survey should aim to collect as many adults and young-of-the-year as can be obtained from each area with reasonable fishing effort (e.g., <5000 seconds of electric current per area). Fishing should be conducted in near-field areas (e.g., X14/R2 and possibly V8) as well as at least two reference areas. Salmon spawning in late summer in Blind Creek means that regulators will not authorize collection of slimy sculpin there at that time of year using electrofishing, so other reference areas will need to be considered. Lengths and weights should be measured on all specimens collected, along with notes respecting any external abnormalities (e.g, lesions, deformities). If it appears that sacrificing a sub-set of the adult fish (e.g., 5-10 each males and females) will not adversely impact population sustainability (e.g. there appear to be adequate numbers of adults and juveniles present), it is recommended that liver weights and ages (otoliths) be measured as well. This would allow for comparisons of fish growth (size at age), condition (weight at length), liver size, and reproductive success (relative abundance of young-of-the-year) in mine-exposed compared to reference areas.

Fish community assessments should be done at the same time as the slimy sculpin population surveys. Sometimes nets are used to block off stream reaches of a specific size in order to estimate species abundance or biomass density per unit area. However, the steep gradients, fast-flowing water, and/or rocky substrates of many creeks generally preclude this type of approach in the vicinity of Faro Mine. Instead, it is recommended that similar (standardized) collection methods and effort be used to capture fish in both reference and exposure areas to qualitatively track any changes in community composition over time, similar to what has been done in past fisheries surveys at Faro Mine.

The above recommendations should be developed in more detail before implementation and these details should be included in an updated framework for aquatic ecosystem monitoring at the Faro Mine (e.g, an update of Minnow 2007b). The recommended approach and methods should be re-evaluated, and updated as appropriate, after the first, survey is implemented.

5.0 REFERENCES

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APPENDIX A

Habitat Descriptions And Photographs

Table A.1: Habitat summary for Slimy Sculpin sampling areas, Faro Mine, May 2008.

Characteristics		Reference						Mine-Exposed	
		Blind Creek (BLC)	Upper Vangorda Creek (V1)	Upper West Fork Vangorda Creek (VR)	Upper South Fork Rose Creek (USFR)	North Fork Rose Creek (R7)	Faro Creek (FC/FDU)	Vangorda Creek (V8)	Rose Creek downstream of tailings (R2)
UTM Coordinates Zone 8V	Easting	0594701	0594434	0590681	0590197	0586496	0585359	0584725	0579417
	Northing	6897077	6903714	6906908	6907340	6914366	6916761	6899934	6914967
Average Length of Reach Assessd (m)		200	50	60	70	100	50		100
Velocity (m/s)	Mean	1.67	1.45	1.28	1.39	2	1.75	1.8	1.45
	Maximum		2.71	1	2.2	2.4	2.55	>2	>2
Depth (m)	Mean		0.35	0.15	0.5	>1.5	0.6		1.75
	Maximum		0.7	0.2	0.75	>2	>1		>2
Width (m)	Wetted	20	6	3	10	8	7	8	18
	Bankfull	20	8	4	10	8	7	20	18
Gradient	%	3.5	4.5	2.25	4	<1%	3%	1.25	0.5
Water Appearance		turbid, brown	clear, slight yellow		slight turbidity, slight yellow	turbid	turbid, yellow	turbid, slight brown	turbid, slight brown
General Morphology	%pool	0	0	0	0	0	0	10	0
	%riffle	100	80	95	80	30	70	30	10
	%run	0	20	5	20	70	30	60	90
Bank Condition		stable	stable	stable	stable	moderate	stable, no erosion	stable	moderate to stable
Substrate (% areal coverage)	%bedrock		0	0	0		0	0	
	%boulder		30	20	30		20	5	
	%cobble		50	60	50		50	70	
	%gravel		20	20	20		20	25	
	%sand&finer		0	0	0		10	0	
Instream Cover (%total Surface)	undercut banks	0	0	0	0	10	<5	0	5
	boulder	0	15	10	30	0	10	5	0
	woody debris	10	0	5	5	0	20	5	0
	deep pool	0	0	0	0	20	0	5	10
	overhaning vegetation	0	0	0	0	5	0	0	0
Overhead Canopy (%Surface)	Dense	0	0	0	0	0	30	0	0
	Partially Open	10	5	0	5	0	50	5	0
	Open	90	95	100	95	100	20	95	100
Riparian Vegetation Types	descending dominance	alder, spruce poplar	alder, spruce	black poplar, willow, spruce	black poplar, willow, spruce	spruce, willow	black poplar, grasses	alder, willow	willow, spruce
Surrounding Land Use		forest	forest	forest	forest	forest	forest	forest, old road	forest, mine discharge
Evidence of Anthropogenic Disturbance		access road, bridge	road, culvert dowstream	haul road downstream	haul road downstream	staff guage downstream	access road	old road, bridge removed	mine discharge, acess road
General Comments/Notes				>50% covered with ice, very straight and uniform	looks like creek was diverted with fill to pass through culvert, gradient > 10% around corner upstream	deep U shaped channel, close to spilling banks, evidence of water levels about 1 m higher than present.	flow up >15 cm from previous day, standing waves in middle of creek, higher turbidity	station 100m upstream from Pelly River, several shallower side channels, not yet at bankfull.	water up >0.5m from first visit, U shaped channel

Figure A.1: Blind Creek (BLC) in August 2007 (top) and May 2008 (bottom)

Figure A.2: Faro Creek (FC) in August 2007 (top) and May 2008 (bottom)

Figure A.3: North Fork Rose Creek (R7) in August 2007 (top) and May 2008 (bottom)

Figure A.4: South Fork Rose Creek (USFR) in August 2007 (top) and May 2008 (bottom)

Figure A.5: Upper Vangorda Creek (V1) in August 2007 (top) and May 2008 (bottom)

Figure A.6: Upper West Vangorda Creek (VR) in August 2007 (left) and May 2008 (right)

Figure A.7: Vangorda Creek (V8, upper bridge) in August 2007 (top) and May 2008 (bottom)

Figure A.8: Vangorda Creek (V8, lower crossing) in August 2007 (top) and May 2008 (bottom)

Figure A.9: Rose Creek near X14 in September 2006 (top) and May 2008 (bottom)