

APPENDIX 26
AQUATICS BASELINE REPORT, 2006/2007



Pacific Booker Minerals Inc.
Morrison Copper/Gold Project
British Columbia, Canada

Morrison Copper/Gold Project Aquatics Baseline Report 2006-2007



Prepared by:

Rescan™ Environmental Services Ltd.
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Executive Summary

This report presents the 2006/2007 aquatics baseline study for Pacific Booker Minerals Inc (PBM).

PBM's proposed Morrison Copper/Gold Project (the Project) is 65 km northeast of Smithers and 35 km north of the village of Granisle in north-central British Columbia. The Project is on the east side of Morrison Lake on Crown land and falls within the traditional territory of the Lake Babine Nation. Access to the Project site is by road with barge access across Babine Lake, which is 50 km south of the site. The Project is approximately 35 km north of the former Bell and Granisle copper/gold mines.

The Morrison mine will be a 30,000 tpd open pit operation with ore processed in a conventional milling plant and the copper/gold concentrate transported to the Port of Stewart for shipment to offshore smelters. Molybdenum concentrate will be trucked from the mine to a refinery location to be confirmed. The mine will produce approximately 224 Mt of tailings and 170 Mt of waste rock.

The information contained in this baseline is intended to support a full environmental and socio-economic impact assessment of the Project.

The objectives of this assessment are to determine the baseline conditions and characterize aquatic habitats in the proposed mine site receiving environment and along the road route.

Streams in the Project area were surveyed for water and sediment quality and aquatic communities. Morrison Creek, which drains Morrison Lake, was also sampled. Two lakes (Morrison, and Booker lakes) and four pond sites (Ore, X, Y, and Z ponds) were assessed for water and sediment quality, physical limnology, and aquatic communities.

Streams and ponds within the Project area had total cyanide concentrations that frequently exceeded aquatic life water quality guidelines. The majority of the water quality variables had concentrations in 2006 that were noticeably lower than in other sample years. Metals in stream water that exceeded the BC and Canadian Council of Ministers of the Environment aquatic life guidelines included total and dissolved aluminum, total arsenic, total and dissolved copper, total cadmium, total and dissolved iron, total mercury, and total selenium. Though increases in concentrations were evident at some sites the concentrations at Strm4, 5, and Lower7, were consistently high year round and across all sample years, indicating that these concentrations were naturally high. Metal concentrations were very low in pond water, and were often below or close to detection limits. The only aquatic life guidelines that were exceeded in ponds were for total and dissolved aluminum.

Stream sediments were dominated by sand in 2006 and 2007. Nutrient concentrations (total nitrogen and phosphorus) within streams were generally similar across all sites and years, although Strm1, Strm4, Strm5, and Upper7 had high concentrations during sampling. Total organic carbon was variable but consistently higher in streams that contained greater percentages of silt and clay. Average total metal concentrations were generally higher in 2006 than 2007.

Morrison Creek frequently contained the lowest concentrations of several metals. Metals concentrations were consistently highest at Strm5. Guidelines for arsenic, iron, copper (2007) and nickel (2007) were exceeded at all sites.

In 2006, Morrison Lake sediment samples were primarily composed of clay and silt, while in 2007 sediment samples were dominated by silt and sand. Nitrogen values were low across all sites in both years while phosphorus concentrations were higher at the five Morrison Lake sites than at the smaller ponds and lakes. Arsenic was found in high concentrations at two Morrison Lake sites (Site A and E). In both years high copper concentrations were found at Ore Pond. Arsenic, copper, mercury and nickel concentrations exceeded guidelines at all sites in 2006 and/or 2007.

Stream periphyton communities were dominated by Chrysophyta in both 2006 and 2007, with smaller proportions of Cyanophyta and Chlorophyta present at most sites. Community structure was fairly consistent between the years at most sites, except for Lower7, Strm4, and Morrison Creek, where large community shifts were observed. Density and biomass varied greatly between sites and between years, while richness, diversity, and evenness values varied little. Morrison Lake was largely dominated by Cyanophyta and Booker Lake by Cryptophyta. Ore Pond displayed shared dominance between Cryptophyta and Chrysophyta in 2006, but in 2007 was dominated by Cryptophyta. Morrison Lake had much lower productivity compared to the other lake and pond sites.

Stream benthic invertebrate densities were four to five times greater at Strm4 and Morrison Creek than other sites. Dipterans were the dominant taxa with proportions of ostracods, Plecoptera, and Ephemeroptera increasing in 2007. Strm6, Strm26, Upper7 and Lower7 were all above the average similarity to the Strm1. Genus richness in streams in 2006 was greater than in 2007. Benthic invertebrate density was greatest in the smaller mine site lake/pond sites than the Morrison Lake sites. Diptera was the dominant taxa in most sites. Average benthos genus richness at most sites was 10 genera.

In 2007, mean zooplankton densities were generally higher than 2006. In 2006 most Morrison Lake sites were dominated by calanoid and cyclopoid copepods. The smaller lake and pond sites were more variable in zooplankton composition, and in 2006 were primarily dominated by rotifers. In 2007, Daphnidae was the most dominant taxon at the smaller lakes and ponds.

Acknowledgements

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Morrison Copper/Gold Project Aquatics Baseline Report 2006-2007

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Acronyms and Abbreviations

BC	British Columbia
BC MOE	British Columbia Ministry of Environment
BC MWLAP	British Columbia Ministry of Water, Lands, and Air Protection
Canfor	Canadian Forest Products Ltd.
CCME	Canadian Council of Ministers of the Environment
DO	dissolved oxygen
EPT	Ephemeroptera/Plecoptera/Trichoptera
ISQG	Interim Sediment Quality Guideline
LEL	lowest effect level
masl	metres above sea level
MDL	method detection limits
NTS	National Topographic System
NTU	nephelometric turbidity units
PBM	Pacific Booker Minerals Inc.
PEL	probable effect level
the Project	Morrison Copper/Gold Project
QA/QC	quality assurance and quality control
Rescan	Rescan Environmental Services Ltd.
RIC	Resources Information Committee
RPD	relative percent differences
SEL	severe effect level
TDS	total dissolved solid
TSF	tailings storage facility
TOC	total organic carbon
TSS	total suspended solids

1. Introduction

1.1 Project Background

PBM's proposed Morrison Copper/Gold Project (the Project) is 65 km northeast of Smithers and 35 km north of the village of Granisle in north-central British Columbia (Figure 1.1-1). The Project is on the east side of Morrison Lake on Crown land and falls within the traditional territory of the Lake Babine Nation. Access to the Project site is by road with barge access across Babine Lake, which is 50 km south of the site. The Project is approximately 35 km north of the former Bell and Granisle copper/gold mines.

The Morrison mine will be a 30,000 tpd open pit operation with ore processed in a conventional milling plant and the copper/gold concentrate transported to the Port of Stewart for shipment to offshore smelters. Molybdenum concentrate will be trucked from the mine to a refinery location to be confirmed. The mine will produce approximately 224 Mt of tailings and 170 Mt of waste rock.

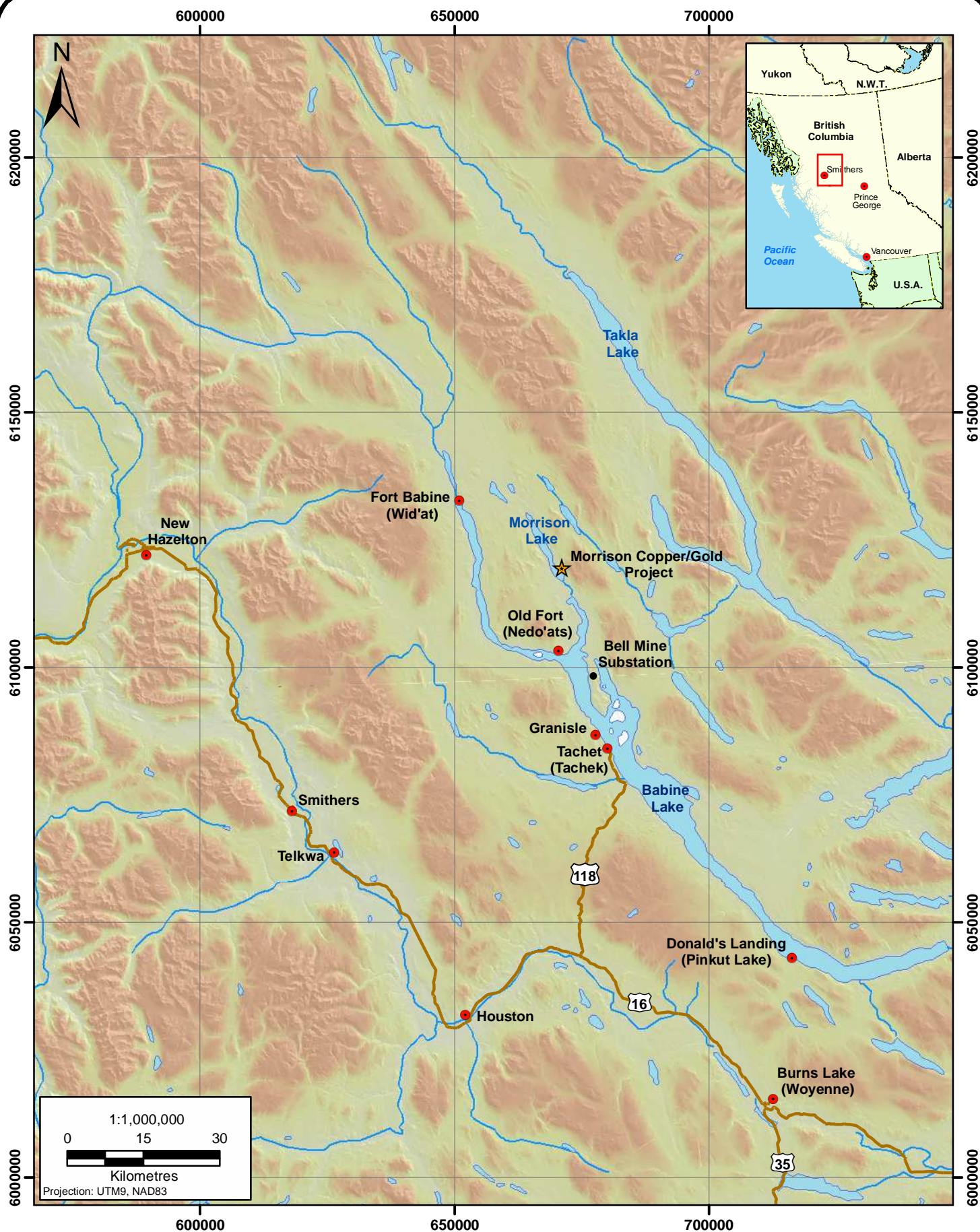
Coordinates of the Morrison property are lat 55°11'24" N and long 126°19'7" W. The National Topographic System (NTS) map sheet that covers the area is 93M01/W. The property elevation ranges from 737 metres above sea level (masl) at Morrison Lake to 890 masl at the top of the ridge southeast of the deposit.

The Morrison property is to the east of the southern end of Morrison Lake, approximately 65 km northeast of Smithers and 35 km north of the village of Granisle. Although there are many possible access routes via the forest service road network, the selected route for mine use is by road north off Highway 16 at Topley via Granisle Highway to Michelle Bay, then by an all-season barge across Babine Lake to Nose Bay then north via forest service roads directly to the Morrison property.

The Morrison property is less than 30 km from two former producing copper/gold mines, Bell and Granisle, and is within the forest management area of Canadian Forest Products Ltd. (Canfor). The two mines are no longer active, but there is a long history of forestry activity in the area that continues today. The result of these activities is an extensive forest service road network established and maintained by forestry companies operating in the area. The proposed mine will consist of two development areas: the mine site encompassing the open pit, mill, and waste rock disposal, and the tailings storage facility (TSF) north of the main mine site. A corridor for tailings transport, process reclaim water, vehicle access road, and power transmission will connect the two development areas.

1.2 Study Objectives

This report presents the results of the baseline aquatics assessment to date. Aquatic components (water quality, sediment quality, and primary and secondary producers) were assessed in streams, wetlands (referred to as ponds in this report), and lakes. The objectives of this assessment were to determine the baseline conditions and characterize these aquatic components in the proposed mine receiving environment and proposed access corridor. Baseline data should provide an understanding of the natural variation in each component of the freshwater environment to enable future monitoring programs during Project activities.



2. Methodology

2.1 Streams

In this report, the streams sampled in 2006 and 2007 include those that drain the mine site area, waste management facility, and reference sites.

2.1.1 Study Design

Streams were surveyed for water and sediment quality and aquatic communities in the area of proposed Project activities (Figure 2.1-1). Stream sites are along the access road (sites 1, 6, and 26), in the proposed mine pit and stockpile area (sites 4 and 5), and draining the waste management area (sites upper and lower 7, 8, 9, and 10). Morrison Creek, which drains Morrison Lake, was also sampled just north of Babine Lake.

Water quality data are available for some sites as of 2004. Variable amounts of data are available for each site primarily because of site access issues. Aquatic biology and sediment quality were sampled in 2006 and 2007, although in 2006 several sites were either dry or flowing at very low levels, which limited the data that were available for that year.

In 2007, 10 stream sites were assessed for periphyton, benthic invertebrates, sediment quality, and water quality (Figure 2.1-1).

2.1.2 Water Quality

One water sample was collected per site per sampling period using standardized methods (RIC 1997). Water samples were analyzed for general physico-chemical variables, anions, nutrients, total cyanide, total organic carbon (TOC), and total and dissolved metals at the lowest feasible detection limit by ALS Environmental Services of Vancouver.

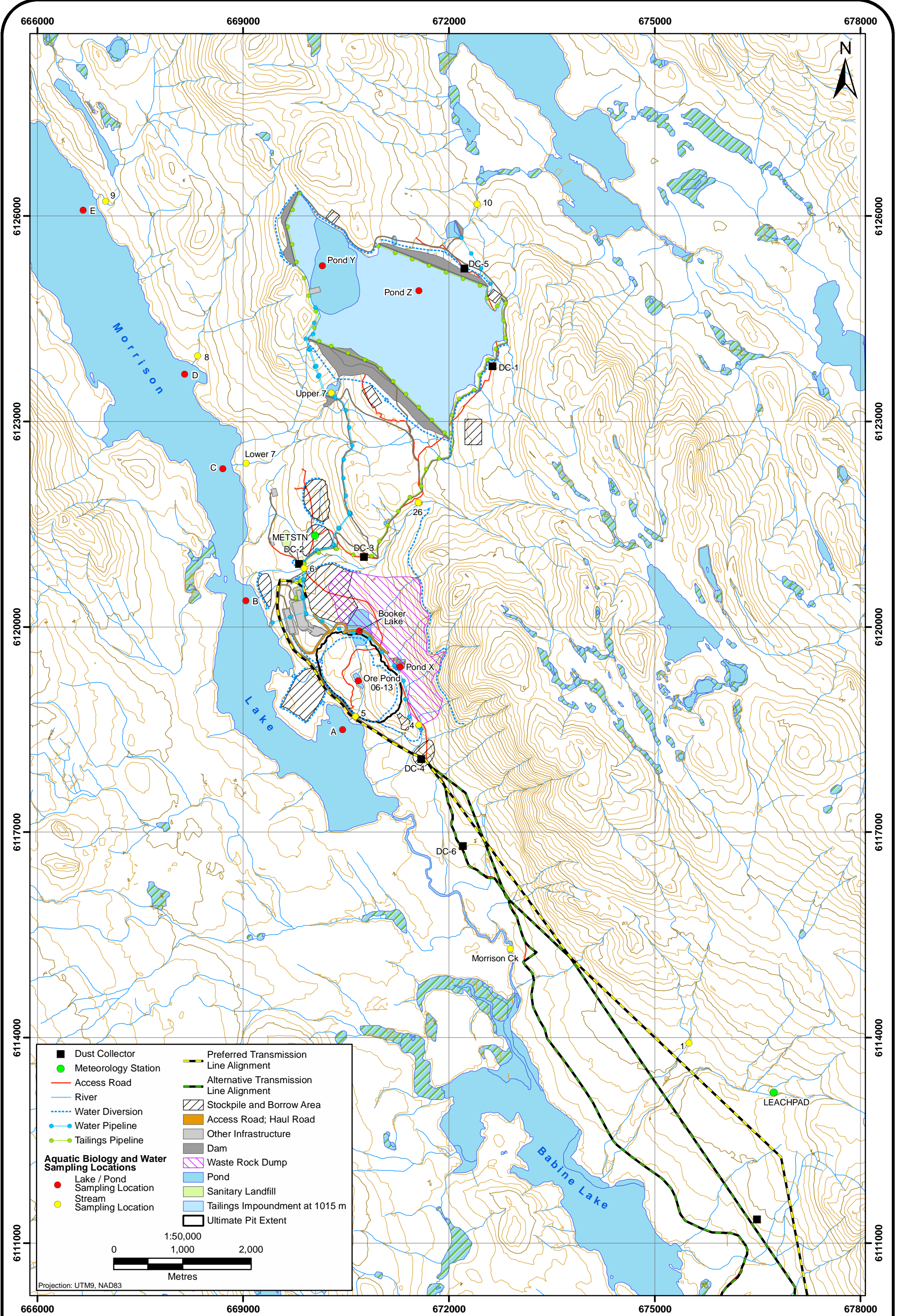
For each sample, the collector stood facing upstream and triple-rinsed the bottle and cap prior to filling. Preservatives were added for total metals (ultra-pure nitric acid), TOC (hydrochloric acid), and total cyanides (NaOH). No air bubbles were left in any of the bottles. A list of all routine chemistry variables is presented along with general method detection limits (MDL) in Table 2.1-1.

All data are presented in appendices (listed in Section 3.1) and variables thought to be most relevant to potential water quality issues within the Project area are presented graphically. The analyzed data were then summarized for each variable by site. Some variables could not be measured reliably below a specified detection limit and are reported by the analytical laboratory as below that detection limit. When required for the purpose of statistical analyses and graphical presentation, these values (called non-detects) were replaced with half of the detection limit.

A summary table showing the percentage of sites exceeding guidelines is presented in Section 3.1 with all available Canadian Council of Ministers of the Environment (CCME) and BC water quality guidelines (CCME 1999; BC MOE 2006).

Table 2.1-1
Water Quality Parameters and Method Detection Limits, 2007

Parameter	Units	Detection Limit	Parameter	Units	Detection Limit
Physical/Dissolved Anions			Total and Dissolved Metals (cont'd)		
Colour	Cu	5	Selenium	mg/L	0.001
Conductivity	uS/cm	2	Silicon	mg/L	0.05
pH	pH	0.01	Silver	mg/L	0.00001
Total Suspended Solids	mg/L	3	Sodium	mg/L	2
Turbidity	NTU	0.1	Strontium	mg/L	0.0001
Total Dissolved Solids	mg/L	1	Thallium	mg/L	0.0001
Hardness	mg/L	0.5	Tin	mg/L	0.0001
Alkalinity, Bicarbonate (as CaCO ₃)	mg/L	1	Titanium	mg/L	0.01
Alkalinity, Carbonate (as CaCO ₃)	mg/L	1	Uranium	mg/L	0.00001
Alkalinity, Hydroxide (as CaCO ₃)	mg/L	1	Vanadium	mg/L	0.001
Total Alkalinity (as CaCO ₃)	mg/L	1	Zinc	mg/L	0.001
Acidity	mg/L	1	Dissolved Metals		
Bromide	mg/L	0.05	Aluminum	mg/L	0.001
Chloride	mg/L	0.5	Antimony	mg/L	0.0001
Fluoride	mg/L	0.02	Arsenic	mg/L	0.0001
Sulphate	mg/L	0.5	Barium	mg/L	0.00005
Nutrients			Beryllium	mg/L	0.0005
Ammonia Nitrogen	mg/L	0.005	Bismuth	mg/L	0.0005
Nitrate	mg/L	0.005	Boron	mg/L	0.01
Nitrite	mg/L	0.001	Cadmium	mg/L	0.00005
Total Kjeldahl Nitrogen	mg/L	0.05	Calcium	mg/L	0.02
Total Nitrogen	mg/L	0.02	Chromium	mg/L	0.0005
Total Phosphorus	mg/L	0.002	Cobalt	mg/L	0.0001
Cyanides			Copper	mg/L	0.0001
Total Cyanide	mg/L	0.005	Iron	mg/L	0.03
Total and Dissolved Metals			Lead	mg/L	0.00005
Aluminum	mg/L	0.001	Lithium	mg/L	0.005
Antimony	mg/L	0.0001	Magnesium	mg/L	0.005
Arsenic	mg/L	0.0001	Manganese	mg/L	0.00005
Barium	mg/L	0.00005	Mercury	mg/L	0.00001
Beryllium	mg/L	0.0005	Molybdenum	mg/L	0.00005
Bismuth	mg/L	0.0005	Nickel	mg/L	0.0005
Boron	mg/L	0.01	Phosphorous	mg/L	0.3
Cadmium	mg/L	0.00002	Potassium	mg/L	0.05
Calcium	mg/L	0.02	Selenium	mg/L	0.001
Chromium	mg/L	0.0005	Silicon	mg/L	0.05
Cobalt	mg/L	0.0001	Silver	mg/L	0.00001
Copper	mg/L	0.0005	Sodium	mg/L	2
Iron	mg/L	0.03	Strontium	mg/L	0.0001
Lead	mg/L	0.00005	Thallium	mg/L	0.0001
Lithium	mg/L	0.005	Tin	mg/L	0.0001
Magnesium	mg/L	0.005	Titanium	mg/L	0.01
Manganese	mg/L	0.00005	Uranium	mg/L	0.00001
Mercury	mg/L	0.00001	Vanadium	mg/L	0.001
Molybdenum	mg/L	0.00005	Zinc	mg/L	0.002
Nickel	mg/L	0.0005	Organic Parameters		
Phosphorous	mg/L	0.3	Total Organic Carbon	mg/L	0.5
Potassium	mg/L	0.05			



2.1.2.1 Monthly Water Quality Data

Where possible, water quality samples were collected on a monthly basis during 2006 and 2007. Data for each site were compared to the CCME and BC water quality guidelines. Results are plotted with sites grouped from south to north as follows: Strm1, Morrison Creek, Strm4, Strm5, Strm6, Strm26, Lower7, Upper7, Strm8 and Strm10. Strm1 and Strm9 are considered reference sites since they drain areas not affected by Project activities. Strm9 was intended to be a reference although it was found dry in previous sampling efforts. It will be sampled in 2008.

2.1.2.2 Quality Assurance and Quality Control

A separate set of bottles for field and travel blanks were included as part of the field quality assurance and quality control (QA/QC) program. The travel blank bottles were filled with distilled de-ionized water in the lab and remained closed throughout the field trip. This allowed assessment of contamination associated with the lab procedures. The field blank bottles were also filled with distilled de-ionized water, but were opened in the field and preserved as required for various analyses. This allowed assessment of contamination associated with field sampling (airborne contamination, contamination of the lid/bottle, etc.) and preservation procedures. All data for field and travel QA/QC are reported in appendices. The frequency of any variable concentration above the MDL was noted for both travel and field blanks, indicating possible contamination.

For QA/QC purposes, a minimum of 10% of the water samples were randomly collected in duplicate to assess the magnitude and potential causes of variability between samples. For each pair of QA/QC field duplicate water samples, the relative percent differences (RPD) were calculated:

where:
$$RPD = 100 | rep1 - rep2 | / [(rep1 + rep2) / 2]$$

The RPD between the duplicates is a measure of the variability inherent in field sampling (environmental heterogeneity, sampler handling leading to contamination). Water quality variables where one or both values were less than five times the MDL were not included in the RPD calculation. This is because variability near the MDL is too high, according to the BC Field Sampling Manual (BC MWLAP 2003). Also, RPD values less than 20% were not considered notable. The BC provincial government suggests that any field duplicates with RPD values exceeding 20% should be noted and data should be interpreted accordingly. The results of RPD calculations were examined to detect patterns of high variation for multiple variables within sample pairs, indicating possible contamination during field sampling. These results are discussed in Section 3.1.3 and the tables summarizing the RPD calculations can be found in appendices.

Analyses were conducted using the lowest possible detection limit. For some samples, detection limits were greater because of interference from high conductivity, high total suspended solids (TSS), or a high metal value. These samples were diluted, resulting in a higher detection limit.

2.1.3 Sediment Quality

Sediment was collected at 8 stream sites in 2006 and 10 sites in 2007. Three composite samples were collected at each site. Methods for stream sediment sampling were standardized (RIC

1998) and involved the use of a stainless steel bowl and spoon to collect multiple grab samples within or alongside stream stations. Sediment was spooned from the top 5 cm at three to four points along the river. It was pooled (excess water drained off) and manually homogenized for one minute in the mixing bowl. Sediment was then carefully spooned into clean, pre-labelled Whirl-Pak bags, sealed (no air bubbles), and kept cool in the dark until analysis by ALS Environmental Services of Vancouver. This was done at three distinct areas per site (different braids, or different stretches of the main channel), covering a total stretch of 50 to 250 m, depending on site width and access, and resulted in three separate replicates per site.

Whole sediment samples were analyzed for moisture, particle size, nutrients, TOC, and total metals using the lowest feasible detection limit. A list of sediment test variables and detection limits is presented in Table 2.1-2. Non-detects were replaced by half of the detection limit. Data are summarized by site, and compared to CCME and BC sediment quality guidelines (CCME 1999; BC MOE 2006). BC guidelines include both the Lowest Effect Level (LEL) and Severe Effect Level (SEL), and the CCME guidelines include the Interim Sediment Quality Guideline (ISQG) and the Probable Effect Level (PEL). Whole sediment samples were also analyzed for particle size distribution.

**Table 2.1-2
Sediment Quality Variables and Detection Limits, 2007**

Parameter	Units	Detection Limit (mg/kg dry weight)	Parameter	Units	Detection Limit (mg/kg dry weight)
Physical Tests			Total Metals (cont'd)		
Moisture	%	0.10%	Lithium	mg/kg	2
Particle Size	%	0.10%	Magnesium	mg/kg	50
Nutrients			Manganese	mg/kg	1
Available Phosphate	mg/kg	1	Mercury	mg/kg	0.005
Total Nitrogen	%	0.01	Molybdenum	mg/kg	4
Total Metals			Nickel	mg/kg	5
Aluminum	mg/kg	50	Phosphorus	mg/kg	50
Antimony	mg/kg	20	Potassium	mg/kg	200
Arsenic	mg/kg	5	Selenium	mg/kg	2
Barium	mg/kg	1	Silver	mg/kg	2
Beryllium	mg/kg	0.5	Sodium	mg/kg	200
Bismuth	mg/kg	20	Strontium	mg/kg	0.5
Cadmium	mg/kg	0.5	Thallium	mg/kg	1
Calcium	mg/kg	50	Tin	mg/kg	5
Chromium	mg/kg	2	Titanium	mg/kg	1
Cobalt	mg/kg	2	Vanadium	mg/kg	2
Copper	mg/kg	1	Zinc	mg/kg	1
Iron	mg/kg	50	Organic Parameters		
Lead	mg/kg	2	Total Organic Carbon	%	0.01

2.1.4 Primary and Secondary Producers

2.1.4.1 Periphyton

Periphyton sampling was conducted at 8 stream sites in 2006 and 10 streams in 2007 when sediment and biological surveys were scheduled (Figure 2.1-1). Samples were collected from three separate rocks per site using a razor to gently scrape a known surface area, along with a brush and rinse bottle. Multiple areas were scraped from each rock to accurately characterize the periphyton coverage and community composition.

For each sample, half was used for a taxonomic identification and enumeration, and the other half for measurement of chlorophyll *a* biomass. Taxonomic samples were stored in 250 mL plastic bottles and preserved in Lugol's iodine solution. Taxonomic identification and enumeration was conducted by Biologica Environmental Services (Victoria, BC). For each sample, genus richness, and diversity (as Simpson and Evenness diversity indices) were calculated and mean and standard error by site was determined and graphed. Notably, the eight Cyanophyta species that were identified in these streams were counted as mm/cm² because of their filamentous nature. This differs from cells/m² but for the sake of comparison 1 mm/m² was made equivalent to the cell counts used for all other species. This is not expected to affect analyses noticeably since these species were generally rare across sites.

Chlorophyll *a* samples were prepared by filtering the sample through a 0.45 µm filter, folding it in half and wrapping it in tinfoil, and labelling and freezing it until analysis by ALS Environmental Services of Vancouver. Biomass as chlorophyll *a* (mean ± SE) was graphed by site.

2.1.4.2 Benthic Invertebrates

Benthic macroinvertebrate (benthos) communities were sampled at four streams (Morrison Creek, Strm4, Strm6, and Strm26) in 2006 and all 10 stream sites in 2007. Stream benthic samples were collected using a Hess sampler with a surface area of 0.096 m² and a mesh size of 250 µm. Five composite replicates were collected at each site. Each composite was composed of three pooled grab samples taken 5 to 10 m apart or on separate braids of the stream.

For each stream subsample, the Hess sampler was driven at least 10 cm into the sediment of an undisturbed riffle zone, facing upstream with the cod-end trailing downstream (Plate 2.1-1). Larger gravel and rocks inside the sampler were carefully cleaned of dirt and debris (washed into the sampler area water) and thrown away. The sediment was then stirred, scrubbed, raised up and dropped inside the Hess sampler for one minute, allowing the stream current to wash benthos into the cod-end. The mesh of the sampler was carefully washed and rinsed into the cod-end to capture all benthos contained in the sampler area. Once the three subsamples were collected, all contents were then carefully transferred to a clean 500 mL, pre-labelled, plastic jar that was then filled with 10% buffered formalin. Replicate samples were preserved separately in plastic jars. Taxonomic identification and enumeration was conducted by Biologica Environmental Services (Victoria, BC). Invertebrates were sorted and identified to the lowest possible taxonomic level (usually genus). Genus richness, evenness, Simpson's Diversity and Bray-Curtis Similarity indices were calculated for each sample. Richness of Ephemeroptera/Plecoptera/Trichoptera (EPT), which are three important taxonomic groups usually associated with pristine stream environments, was also

calculated for stream sites. Their constant exposure to substrate and potential contaminants make benthic invertebrates important indicators of aquatic effects, and therefore an important feature of aquatic environmental effects monitoring programs (Environment Canada 2003).



Plate 2.1-1. Stream sampling for benthic invertebrates at Strm26.

2.2 Lakes and Ponds

2.2.1 Study Design

Booker Lake, Ore Pond, and the smaller ponds X, Y and Z were assessed for water quality, physical limnology, sediment quality, phytoplankton, benthic invertebrates, and zooplankton (Figure 2.1-1). Sampling occurred in mid-July in 2007, with the objective of characterizing aquatic communities and habitat in the receiving environment that will be directly affected by Project activities. Morrison lake samples (Lake A, B, C, D, and E) were collected in August of 2006 (and will also be sampled in 2008).

2.2.2 Water Quality

Water samples from ponds and lakes were collected once at each site during 2006 and 2007. Water sample preservation and analysis was identical to that done for stream water samples. All data are presented in appendices (listed in Section 3.1) and variables thought to be most relevant to potential water quality issues within the Project area are presented graphically. As with stream water quality samples, field and travel blanks were collected and RPD duplicate samples were analyzed. These results are discussed in Section 3.4.3 and the tables summarizing the RPD calculations can be found in appendices.

2.2.3 Physical Limnology

Physical limnology parameters were measured at all pond and lake sites. These variables included Secchi depth, surface pH and conductivity, and dissolved oxygen and temperature depth profiles measured at the deepest point in the lake.

Secchi depth, a measure of water transparency, was determined using a standard 20-cm black and white Secchi disk. Using a metered line, the weighted Secchi disk was lowered over the shaded side of the boat until it was no longer visible in the water column. The disk was then slowly raised until it once again became visible, and the depth was recorded to the nearest 10 cm.

Depth profiles were measured using a YSI Model 550A meter and probe to determine the degree and position of stratification, if present. Both before and after conducting a profile, the probe's membrane was checked for air bubbles. If air bubbles were present, the membrane was replaced and the profile redone. After initial calibration, measurements were taken just below the surface and at 1-m intervals. The probe was lowered to a depth of 1 m above the sediment-water interface (as indicated by the depth sounder).

2.2.4 Sediment Quality

Sediment was collected at all pond and lake sites in 2006 and all but the Morrison Lake sites in 2007. Three composite samples were collected at each site. An Ekman sampler was used to collect bottom sediment. Three distinct zones were sampled at each pond or lake. At each zone, three separate grabs were collected at a minimum of 5 m apart from each other and sediment was then pooled into one composite. Sediment was first photographed and physical appearance (organics, homogeneity, and organisms) noted. Sediment was then spooned off the top 4 cm of the Ekman grab sample and deposited into a clean stainless steel bowl. The top layer contents of three separate grabs were then homogenized using a stainless steel spoon for one minute, and sediment was then spooned into clean, pre-labelled Whirl-Pak bags, sealed (no air bubbles), and kept cool in the dark until analysis by ALS Environmental Services of Vancouver.

Pond and lake whole sediment samples were analyzed for the same variables (nutrients, total metals, TOC, particle size) as done for stream sediment samples (Table 2.1-2). Procedures for sample handling, transport, and data comparison to guidelines were identical to those described for stream samples (see Section 2.1.3).

2.2.5 Primary and Secondary Producers

2.2.5.1 Phytoplankton

At each mine site pond and lake, phytoplankton communities were sampled for biomass (chlorophyll *a*) as well as taxonomic composition and enumeration in 2006 and 2007. Morrison Lake sites were sampled in 2006 and will be sampled again in 2008. A replicate consisting of a pair of 1 L pre-labelled plastic bottles were filled with surface water. Samples were collected by immersing the pre-labelled 1 L clear plastic sample bottles just below surface. One bottle from each replicate pair was used for determination of chlorophyll *a* biomass, and the other was used to determine taxonomic composition and enumeration.

The samples were kept cool and dark and transported back to camp. Known volumes of the 1 L samples for biomass determination were filtered onto 47 mm membrane filters using a hand pump and filter apparatus. The filters (with 0.45 µm pore size) were carefully folded in half, wrapped in aluminum foil, labelled with sampling information, and frozen. Samples were kept frozen and transported to ALS Environmental Services in Vancouver for analyses.

Samples for taxonomic identification were preserved with Lugol's iodine solution, kept in a cool, dark place, and transported to Biologica Environmental Services (Victoria, BC), for taxonomic identification and enumeration.

2.2.5.2 Benthic Invertebrates

Benthic macroinvertebrate communities were sampled at each pond and lake site concurrently with primary producer surveys. Samples were collected with a standard Ekman grab at each zone within the site. Each replicate was composed of three grabs pooled together to form a composite sample. Each Ekman grab was brought to the surface and the contents released into a 500 µm mesh sieve bucket. The bucket was submersed in the water up to one-third its volume while sieving and spinning continued until no silt clouds were produced in surrounding water. Residual contents containing benthos from three successful grabs were rinsed into a clean, pre-labelled 500 ml jar. Procedures for sample handling, preservation, transport, and analysis were identical to those described for receiving environment stream samples.

2.2.5.3 Zooplankton

Zooplankton communities were sampled for taxonomic composition and enumeration at each pond and lake site. As with other sampling, three separate zones were identified to provide three composite replicates per site. Each replicate sample was made up of the contents of three separate zooplankton hauls using a 0.3 m diameter (118 µm mesh) net. For each haul, the net was lowered to a known depth just above the sediment using a metered cable line. The net was then raised to the surface at a constant speed of approximately 0.5 m/s. Each time the net was brought to the surface, the contents of the cod end were transferred into the same pre-labelled, clean, 500-ml wide mouth plastic jar. Buffered formalin was added to a final concentration of 10% by volume. Sample jars were closed, agitated gently, and kept cool and dark during storage and transport to Biologica Environmental Services (Victoria, BC), for taxonomic identification and enumeration. Data were analyzed for density, relative abundance, genus richness, and

diversity. Zooplankton densities were normalized to number of organisms/m³ by calculating the volume of water the zooplankton net screened.

2.2.6 Data Analysis

The number of organisms per sample was converted to density (organisms/m³ for zooplankton, organisms/m² for benthos, and cells/L for phytoplankton) by dividing each sample by the area sampled and calculating the mean of all replicates. All graphically represented data and the calculation of means and standard errors were produced using SigmaPlot software (SYSTAT 2006). Generic richness, diversity indices, and Bray-Curtis Similarity were calculated using Primer (Clark and Gorley 2006). The results presented from the Bray-Curtis analysis are similarity values, not dissimilarity values, since similarity is interpreted more intuitively. Richness is defined as the number of separate genera present in a sample. In assessing genus richness multiple species of the same genus were pooled together. For sites where the available data only occurred at higher taxonomic levels (e.g., Family or Order), a single genus was considered to be present in the sample.

Simpson's Index is a dominance-type index and is calculated based on the formula:

$$D_s = \sum_{i=1}^s [n_i(n_i-1)] / [N(N-1)]$$

where n_i is the number of individuals in the i^{th} species and N is the total number of individuals.

2.2.7 Quality Assurance and Quality Control

The same QA/QC measures that were used for stream water sampling were applied to pond and lake samples, including the use of field and travel blanks to monitor for contamination during sampling and transport (see Section 2.1.2.2). Triplicate samples for phytoplankton were collected at each lake station, and three replicates (composites) were taken for sediment, zooplankton, and benthos sampling. Additionally, at 20% of the wetland and lake sites, one sediment sample was split for QA/QC purposes to ensure that sample homogenization was thorough. The RPD statistic was used to assess the degree of homogenization and is discussed in the results section. Variables where one or both values were less than five times the MDL were not included in the RPD calculations because variability near the MDL is too high, according to the BC Field Sampling Manual (BC MWLAP 2003).