Appendix V5-3K

Hope Bay Belt Project: 2010 Freshwater Baseline Report

Hope Bay Mining Limited

HOPE BAY BELT PROJECT
2010 Freshwater Baseline Report

NEWMONT™ NORTH AMERICA

Rescan™ Engineers & Scientists

Rescan™ Environmental Services Ltd.
Rescan Building, Sixth Floor - 1111 West Hastings Street
Vancouver, BC Canada V6E 2J3
Tel: (604) 689-9460 Fax: (604) 687-4277

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HOPE BAY BELT PROJECT
2010 FRESHWATER BASELINE REPORT

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NEWMONT™ NORTH AMERICA

Hope Bay Mining Limited

Prepared by:

Rescan™ Engineers and Scientists

Rescan™ Environmental Services Ltd.
Vancouver, British Columbia

Executive Summary

Executive Summary

Environmental baseline studies were conducted by Rescan Environmental Services Ltd. (Rescan) in 2010, on behalf of Hope Bay Mining Ltd. (HBML), for the Hope Bay Belt Project. The primary objective of the 2010 freshwater program was to collect additional aquatic baseline data to support Phase 2 Project permitting and design. The 2010 aquatic baseline program involved collecting information for the following: bathymetry, physical limnology (winter and summer), lake water quality (winter and summer), lake sediment quality, lake phytoplankton, lake zooplankton, lake benthos, stream water quality, stream sediment quality, stream periphyton, and stream benthos. The program included collecting samples from lakes and streams in areas that could potentially be influenced by the future Phase 2 Project. Two reference lakes (Reference Lakes B and D) and their associated outflows located well away from potential Project activities were also sampled, as was a reference river location on the Angimajuq River. A total of 10 lakes and 16 streams and rivers were sampled in 2010.

Lake Bathymetry

Bathymetric surveys were conducted for six lakes in the Project area: Little Roberts Lake, Imniagut Lake, Trout Lake, Stickleback Lake, and Reference lakes B and D. Bathymetric maps are presented in this report.

Physical Limnology

Dissolved oxygen concentrations in Project area lakes ranged widely from 1.3 mg/L to 13.2 mg/L during winter, with the highest concentrations occurring just beneath the ice layer. Winter dissolved oxygen concentrations were lowest at the shallow Stickleback and Trout lakes. River winter dissolved oxygen concentrations were similar at both sampling sites, averaging 9.3 mg/L. During summer, lakes were generally well-mixed or weakly stratified and dissolved oxygen levels ranged from 8.4 mg/L to 10.4 mg/L. Although water clarity in most lakes surveyed was relatively low, euphotic zone depths extended to the lake bottom in all shallow lakes and extended below 10 m in the deeper lake sampling sites (Aimaokatalok Lake Station 6 and Windy Lake).

Lake Water Quality

Lakes in the study area were near neutral (pH 6.8) to slightly basic (pH 8.1) and contained variable concentrations of metals and nutrients. In some lakes, winter concentrations of certain parameters exceeded summer levels. This was particularly evident for nitrate, hardness, total dissolved solids, ammonia, sulphate, copper and zinc. Turbidity, total suspended solids, aluminum, and lead concentrations showed the opposite trend, tending to be higher in summer than in winter.

Average total phosphorus concentrations ranged from 0.0039 mg/L to 0.027 mg/L in the surveyed lakes. Based on the Canadian Council of Ministers of the Environment (CCME) trophic categorizations for total phosphorus levels (CCME 2004), lakes in the Aimaokatalok Watershed would be considered oligotrophic to meso-eutrophic and Windy Lake would be considered ultra-oligotrophic to oligotrophic.

Some of the lakes surveyed were naturally elevated in a few select metals when compared to the CCME water quality guidelines for the protection of freshwater aquatic life (CCME 2007). CCME guidelines were occasionally exceeded in Stickleback Lake (iron and lead), Trout Lake (aluminum, chromium, copper, and iron), and Aimaokatalok Lake Station 5 (cadmium). Windy Lake was the only lake in which all measured water quality parameters were below CCME guidelines.

Lake Sediment Quality

Lake sediments were largely composed of clay and silt, with lesser amounts of sand and little gravel. The proportion of fine particles in sediments increased with depth. Many sediment parameter concentrations (e.g., available phosphate, cadmium, chromium, mercury, and zinc) were higher in the middle to deep depth zones than in the shallow depth zone, likely due to the increase in fine sediments with depth. There were few clear trends in parameter concentrations among sites.

Some of the lake sediments sampled were naturally elevated in a few select metals when compared to the CCME interim sediment quality guidelines (ISQGs) and probable effects levels (PELs; CCME 2002). Sediment metal concentrations exceeded CCME ISQGs in at least one sample collected from Stickleback Lake (chromium, copper), Trout Lake (chromium), Aimaokatalok Lake Station 13 (arsenic and chromium), Aimaokatalok Lake Station 2 (chromium), Aimaokatalok Lake Station 5 (chromium), Aimaokatalok Station 6 (chromium), Windy Lake Deep (arsenic, chromium, and copper), Wolverine Dike (arsenic, chromium, and copper) and Patch Dike (chromium). Aimaokatalok Lake Stations 11 and 12 and Windy Lake Shallow were the only lake sampling sites in which all measured sediment quality parameters were below CCME ISQGs. Although concentrations of chromium (and to a lesser extent arsenic and copper) in sediments across the study area frequently exceeded CCME ISQGs, concentrations of these metals were always below the CCME PELs.

Lake Aquatic Life

Lake phytoplankton biomass (as chlorophyll *a*) was low in all lakes, ranging from 0.45 µg chl *a*/L (Windy Lake Deep) to 1.0 µg chl *a*/L (Aimaokatalok Lake Station 5). Phytoplankton abundance ranged from 128 cells/mL (Windy Lake) to 337 cells/mL (Stickleback Lake). Diatoms and chrysophytes were generally the most abundant taxa, making up a combined 61 to 94% of the phytoplankton assemblages in study lakes. Phytoplankton richness and Simpson's diversity ranged from 13 to 23 genera/sample and from 0.71 to 0.93, respectively, and tended to be highest in Aimakatalok Watershed lakes. Phytoplankton diversity and richness generally followed similar trends.

Lake zooplankton abundance ranged between 1,200 organisms/m^3 (Stickleback Lake) and 32,000 organisms/m^3 (Aimaokatalok Lake Station 13) at most lake sites; however, the average zooplankton abundance of 270,000 organisms/m^3 at Trout Lake greatly exceeded this range. The zooplankton assemblages in study lakes consisted of rotifers, cladocerans, and calanoid and cyclopoid copepods. Zooplankton genera richness ranged from 4 to 13 genera/sample and Simpson's diversity ranged from 0.22 to 0.70 among surveyed lakes.

Lake benthos densities ranged widely from 77 organisms/m^2 in Windy Lake to 35,500 organisms/m^2 in Trout Lake. Lake benthic communities were generally dominated by dipterans, although pelecypods, ostracods, and oligochaetes were also abundant. Benthos genera richness in the study lakes ranged from 2 to 17 genera/sample, and Simpson's diversity ranged from 0.28 to 0.86.

Stream Water Quality

Streams and rivers in the study area ranged from slightly acidic (pH 6.2) to slightly basic (pH 8.1). Stickleback OF was the only stream in which the average pH of 6.2 (measured during June sampling) was outside of the CCME guideline range of pH 6.5 to 9. Parameters such as hardness, total dissolved solids, and sulphate tended to be lowest during freshet (June) compared to winter or summer levels. However, for most parameters, the seasonal patterns varied between sites with no clear trends emerging.

Total phosphorus concentrations were variable across stream sites, ranging from 0.003 mg/L at S6 (an eastern tributary to Aimaokatalok Lake) in August and September to 0.060 mg/L at AWRa in June. Aimaokatalok Northeast Inflow, Koignuk Downstream and AWRa generally contained the highest total phosphorus concentrations during the summer months. Maximum summer total phosphorus concentrations at these sites fell within the range expected for a eutrophic waterbody based on the CCME trigger ranges for total phosphorus (CCME 2004). Most sampled streams and rivers would be considered oligotrophic to meso-eutrophic. Stream S6 (an eastern tributary to Aimaokatalok Lake) was the only site that would be categorized as ultra-oligotrophic.

The natural stream and river water quality exceeded several CCME guideline parameters for the protection of freshwater aquatic life (CCME 2007). Total aluminum and total iron most commonly exceeded CCME guidelines in surveyed streams and rivers. CCME guidelines were occasionally exceeded in AWRe (chromium and iron), Aimaokatalok Northeast Inflow (aluminum, cadmium, chromium, and iron), Stickleback Outflow (pH, aluminum, and iron), Trout Outflow (aluminum, chromium, and iron), S12 (copper and iron), S6 (aluminum and iron), AWRd (iron), AWRc (copper and iron), Aimaokatalok Outflow (aluminum), Koignuk River (aluminum and iron), Koignuk Upstream (aluminum, cadmium, chromium, copper, and iron), Koignuk Downstream (aluminum, chromium, copper, and iron), AWRb (aluminum, chromium, and iron), AWRa (aluminum, cadmium, chromium, copper, iron, and silver) and Angimajuq River Reference (aluminum and iron). Aimaokatalok River was the only stream/river site in which all measured water quality parameters were below CCME guidelines.

<u>Stream Sediment Quality</u>

Stream sediments consisted of a highly variable mixture of gravel, sand, silt and clay. Sand and silt were the most common grain sizes at most sites. Trout Outflow, S6, and AWRd streams were dominated by fine sediments, as clay and silt together made up at least 85% of the particle composition at these sites. At all other stream and river sites, fine sediments (clay and silt) made up less than 65% of the particle composition. Sites dominated by fine sediments tended to have higher sediment parameter concentrations (e.g., TOC, available ammonium, total nitrogen, cadmium, copper, and mercury) than sites dominated by coarse sediments.

Similar to lake sediments, some stream and river sediments were naturally elevated in arsenic, chromium, and copper, and concentrations of these metals were sometimes higher than CCME ISQGs. Sediment metal concentrations exceeded CCME ISQGs in at least one sample collected from Trout OF (chromium), S6 (copper), AWRd (arsenic), Koignuk River (copper), Koignuk Upstream (chromium) and AWRb (chromium). All measured sediment parameters were below CCME ISGs in the other streams sites surveyed. Sediment metal concentrations at all sites were below CCME PELs, except arsenic in one replicate collected at AWRd.

<u>Stream Aquatic Life</u>

Periphyton biomass ranged from approximately 0.01 µg chl *a*/cm^2 at Koignuk Downstream to 0.44 µg chl *a*/cm^2 at Aimaokatalok Outflow. Periphyton density ranged from 5,400 cells/cm^2 at AWRd to 176,000 cells/cm^2 at Koignuk U/S. Diatoms were the dominant periphyton taxonomic group in all streams and rivers surveyed. Genera richness ranged from 10 to 18 genera/sample, and Simpson's diversity ranged from 0.47 to 0.88 among stream and river sites.

Average benthos density in most streams and rivers ranged between 600 organisms/m^2 (Koignuk Downstream) to 9,300 organisms/m^2 (AWRb). The exception was Aimaokatalok Outflow which had a much higher average density of 24,500 organisms/m^2. At most stream and river sites, dipterans were the most numerous benthic organism, making up 33 to 81% of the benthos assemblages. Aimaokatalok Outflow was a notable exception to this, as Coelenterata (specifically, the genus *Hydra*) made up 94% and dipterans made up only 3% of the benthos in this stream. Ostracods and oligochaetes were also abundant in some study streams and rivers. Benthic genera richness ranged from 10 to 20 genera/sample, and Simpson's diversity ranged from 0.12 to 0.87 among stream and river sites.

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Glossary and Abbreviations

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AEMP	Aquatic Effects Monitoring Program
Allochthonous	External inputs of carbon and nutrients into aquatic systems, for example plant debris or soils from riparian systems.
ALS	ALS Environmental Services
Autotrophic	Organisms that can synthesize complex organic compounds from simple inorganic molecules, often using light energy (photosynthesis), e.g., plants.
BC	British Columbia
$CaCO_3$	Calcium carbonate
CCME	Canadian Council of Ministers of the Environment
DEM	Digital Elevation Model
D	Simpson's Diversity Index
DO	Dissolved Oxygen
D_s	Secchi Depth
EC	Environment Canada
ESR	Environmental and Social Responsibility Department
EZD	Euphotic Zone Depth
GPS	Global Positioning System
HBML	Hope Bay Mining Limited
Heterotrophic	Organisms that are unable to synthesize organic compounds from inorganic molecules, and must therefore consume organic compounds for growth (e.g., animals and fungi).
HSLP	Health, Safety and Loss Prevention Department
IF	Inflow
ISQG	Interim Sediment Quality Guideline
Lentic	Habitats with standing or still water
NC	Not Collected
NI	Not Included
NTU	Nephelometric Turbidity Units
OF	Outflow
PEL	Probable Effects Level
QA/QC	Quality Assurance and Quality Control
TDS	Total Dissolved Solids

Thermocline	Location in water column where the change in temperature (with depth) is greatest
TIN	Triangular Irregular Network
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TSS	Total Suspended Solids

1. Introduction

1. Introduction

The Hope Bay Belt Property is located approximately 125 km southwest of Cambridge Bay, Nunavut, on the south shore of Melville Sound (Figure 1-1). The nearest communities are Omingmaktok (75 km to the southwest of the property), Cambridge Bay, and Kingaok (Bathurst Inlet; 160 km to the southwest of the property).

The property consists of a greenstone belt running in a north/south direction, approximately 80 km long, with three main gold deposit areas. The Doris and Madrid deposits are located in the northern portion of the belt, and the Boston deposit is located in the southern end. The northern portion of the property consists of several watershed systems that drain into Roberts Bay, and a large river (Koignuk River) that drains into Hope Bay. Watersheds in the southern portion of the belt ultimately drain into the upper Koignuk, which drains into Hope Bay.

Hope Bay Mining Limited (HBML) is proceeding with the development of the Doris North Project. Required licences and permits are in place for the development of the Doris North Gold Mine, and construction of the project commenced in 2010.

HBML plans to develop additional deposits in the belt, and planning for this Phase 2 Project development has commenced. Baseline studies to support the permitting of the Phase 2 Project were carried out in 2009, and were continued in 2010. The environmental baseline program conducted in 2010 was intended to fill in information gaps in order to support the permitting process for the Phase 2 Project. The site layout options considered for the 2010 Phase 2 environmental baseline program are shown in Figure 1-2.

Results from the 2010 Phase 2 Project environmental baseline program are being reported in a series of reports, as follows:

- 2010 Hydrology Baseline Report
- 2010 Freshwater Baseline Report
- 2010 Freshwater Fish and Fish Habitat Baseline Report
- 2010 Marine Baseline Report
- 2010 Marine Fish and Fish Habitat Baseline Report
- 2010 Terrain and Soils Baseline Report
- 2010 Ecosystems and Vegetation Baseline Report
- 2010 Marine Wildlife Baseline Report

In addition, numerous reports are being produced as part of the Doris North Project compliance requirements, and many of these reports cover the geographical areas of the proposed Phase 2 Project. Examples of Doris North Project compliance reports generated in 2010 that are relevant to the proposed Phase 2 Project include:

- 2010 Meteorology Compliance Report, Doris North Project

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Figure 1-1

Hope Bay Belt Project Location

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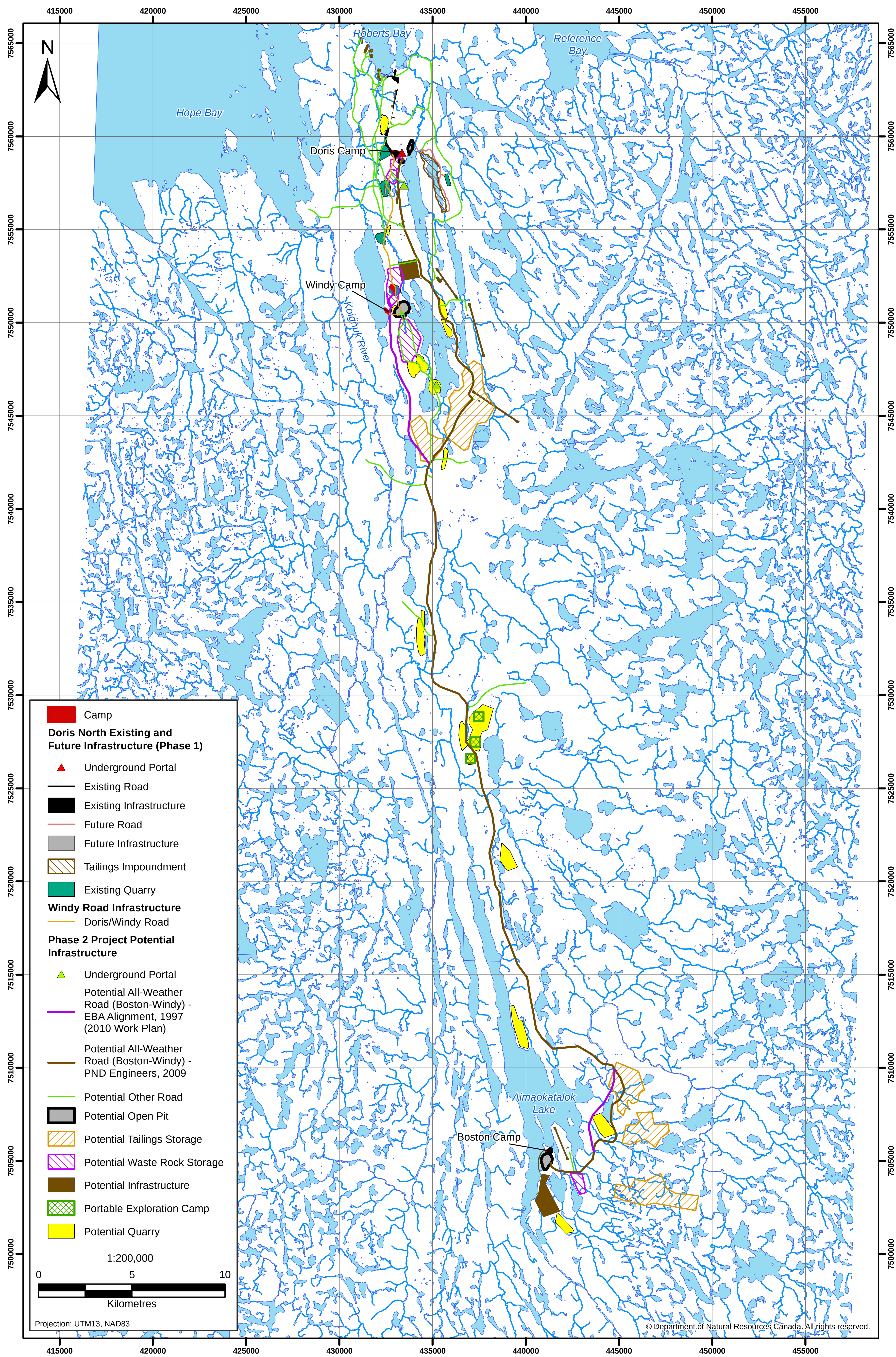

Figure 1-2

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Site Layout Options Considered for Phase 2 Baseline Program, 2010

Figure 1-2

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- 2010 Hydrology Compliance Report, Doris North Project
- 2010 Aquatic Effects Monitoring Program Report, Doris North Project
- 2010 Wildlife Monitoring and Mitigation Report, Doris North Project
- 2010 Wildlife DNA Study, Doris North Project
- 2010 Air Quality Compliance Reports, Doris North Project

Archaeology work was also conducted in 2010 and is being reported separately.

This report presents the results from the freshwater baseline portion of the 2010 Phase 2 environmental baseline program.

The 2010 freshwater baseline program involved collecting information for the following: lake water quality (winter and summer), physical limnology (winter and summer), lake sediment quality, lake phytoplankton, lake zooplankton, lake benthos, stream and river water quality, stream and river sediment quality, stream and river periphyton, and stream and river benthos. The 2010 baseline sampling focused on waterbodies that could be affected by future Phase 2 Project development in the mid to southern portion of the belt, complementing 2009 baseline data collected in the northern portion of the belt. Two reference lakes (Reference Lakes B and D) and their associated outflows located well away from potential Project activities were also sampled, as was a reference river location on the Angimajuq River. Note that most of the data collected from Reference Lakes B and D and their outflows are presented in the *2010 Aquatic Effects Monitoring Program Report* (Rescan 2011), and only supplemental data from these sites that were not previously reported are presented in this baseline report. A total of 10 lakes and 16 streams/rivers were sampled in 2010.

Analytical results from all samples collected as part of the 2010 freshwater baseline program are provided as appendices to this report. A survey of the occurrence of microcystin-LR (a hepatotoxin produced by certain genera of cyanobacteria) was also undertaken in lakes in and around the Hope Bay Belt area in 2010; the results of this microcystin-LR survey are described in the memorandum *Microcystin Sampling Results in Regional Project Area, 2010* (Appendix 1-1).

Chapter 2 of this report presents the sampling locations and methods used for the 2010 freshwater baseline work. Chapter 3 presents the results of the 2010 freshwater baseline sampling program as well as a discussion of key findings. Chapter 3 also includes comparisons between data collected as part of the 2010 freshwater baseline program and historical data available for the area.

2. Methods

2. Methods

2.1 MONITORING LOCATIONS AND SAMPLING PROGRAM

The 2010 aquatic baseline program focused on the mid and southern portions of the belt that could be influenced by potential Phase 2 activity, as well as reference areas well away from future Phase 2 Project activities.

The following components were sampled as part of the 2010 freshwater baseline program (Table 2.1-1):

Lakes:

- Bathymetry;
- Physical Limnology;
- Water Quality;
- Sediment Quality;
- Phytoplankton;
- Zooplankton; and
- Benthic Invertebrates.

Streams and Rivers:

- River Physical Limnology;
- Water Quality;
- Sediment Quality;
- Periphyton; and
- Benthic Invertebrates.

The sampling location within a waterbody was selected based on one or more of the following criteria: the site was previously sampled, it was the deepest section in the lake, or it was a spatially significant location (i.e., nearby, within or outside of potential Phase 2 infrastructure or activities). The site selection rationale is presented in Table 2.1-2. In lakes with no bathymetric information or prior sampling history, winter sampling occurred near the middle of the lake, or in the middle of any obvious basins as estimated by the surrounding topography. At such sites, coarse-level bathymetry (using a depth sounder) was carried out prior to summer sampling and the sampling location was moved if more suitable areas were found.

Reference Lake B and Reference Lake D and their outflows are part of the approved Doris North Aquatic Effects Monitoring Program (AEMP). In 2010, supplemental data was collected from these lakes and their outflows that were not used in the annual AEMP. These raw data are included in appendices of this report. The following data were collected that could be used in the future: phytoplankton and zooplankton abundance and taxonomy at the deep site in Reference Lake B and in Reference Lake D, sediment quality and benthos abundance and taxonomy at the shallow site in Reference Lake B (data from the deep site are included in the 2010 AEMP), and periphyton biomass, abundance, and taxonomy from plates installed between early August and early September at Reference B Outflow and Reference D Outflow.

Table 2.1-1. Bathymetry, Water Quality, Sediment Quality, and Aquatic Biology Sampling Locations, Hope Bay Belt Project, 2010

Watershed	Site Name	Abbreviated Name	Bathymetry	Winter Water Quality and Limnology	Summer/Freshet Water Quality and Limnology	Sediment Quality	Phytoplankton/ Periphyton	Zooplankton	Benthos
Lake Sites									
Aimaokatalok	Stickleback Lake	Stickleback	X	X	X	X	X	X	X
	Trout Lake	Trout	X	X	X	X	X	X	X
	Aimaokatalok Lake: Station 13	Aim. Stn 13	-	-	X	X	X	X	X
	Aimaokatalok Lake: Station 2	Aim. Stn 2	-	-	-	X	-	-	X
	Aimaokatalok Lake: Station 12	Aim. Stn 12	-	-	-	X	-	-	X
	Aimaokatalok Lake: Station 5	Aim. Stn 5	-	X	X	X	X	X	X
	Aimaokatalok Lake: Station 11	Aim. Stn 11	-	X	X	X	X	X	X
	Aimaokatalok Lake: Station 6	Aim. Stn 6	-	X	X	X	X	X	X
Windy	Windy Lake Shallow	Windy Shallow	-	-	-	X	-	-	X
	Windy Lake Deep	Windy Deep	-	X	X	X	X	X	X
Doris	Wolverine Lake Dike	Wolverine Dike	-	-	-	X	-	-	X
	Patch Lake Dike	Patch Dike	-	-	-	X	-	-	X
	Imniagut Lake	Imniagut	X	-	-	-	-	-	-
	Little Roberts Lake†	Little Roberts	X	-	-	-	-	-	-
Reference B	Reference Lake B Shallow†	Ref. B Shallow	X	-	-	X	-	-	X
	Reference Lake B Deep†	Ref. B Deep	X	-	-	-	X	X	-
Reference D	Reference Lake D †	Ref. D	X	-	-	-	X	X	-
Stream/River Sites									
East	AWRe	AWRe	-	-	X	X	-	-	-
	Aimaokatalok Northeast Inflow	Aim. NE IF	-	-	X	X	X	-	X
Aimaokatalok River	Aimaokatalok River	Aim. R.	-	X*	X	X	X	-	X
	Stickleback Outflow	Stickleback OF	-	-	X	X	X	-	X
	Trout Outflow	Trout OF	-	-	X	X	X	-	X
	South #12	S12	-	-	X	-	-	-	-
	South #6	S6	-	-	X	X	-	-	-
	AWRd	AWRd	-	-	X	X	X	-	-
	AWRc	AWRc	-	-	X	X	X	-	X
	Aimaokatalok Lake Outflow	Aim. OF	-	X‡	X	-	X	-	X
Koignuk/Aimaokatalok	Koignuk River	Koig. R.	-	X	X	X	X	-	X
	Koignuk Upstream	Koig. U/S	-	X	X	X	X	-	X
	Koignuk Downstream	Koig. D/S	-	X*	X	X	X	-	X
	AWRb	AWRb	-	-	X	X	X	-	X
	AWRa	AWRa	-	-	X	X	X	-	X
Reference B	Reference Lake B Outflow†	Ref. B OF	-	-	-	-	X	-	-
Reference D	Reference Lake D Outflow†	Ref. D OF	-	-	-	-	X	-	-
Angimajuq	Angimajuq River Reference	Ang. R. Ref.	-	X*	X	-	-	-	-

Notes:

** No samples were collected from these locations because the river was frozen to the bottom or it was unsafe for sampling.*

† These are approved AEMP sites; data presented in this report (as appendices) are supplemental to data presented in the 2010 AEMP report (Rescan 2011).

‡ Water was flowing at the time of winter sampling; samples were collected as surface grabs.

Table 2.1-2. Rationale for Sampling Location Selection, Hope Bay Belt Project, 2010

Watershed	Site Name	Reason for Site Selection
Lake Sites		
Aimaokatalok	Stickleback	In immediate vicinity of proposed footprint; historical sampling location
	Trout	In immediate vicinity of proposed footprint; historical sampling location
	Aim. Stn 13	In immediate vicinity of proposed footprint
	Aim. Stn 2	Within proposed infrastructure footprint (pit/dike); historical sampling location
	Aim. Stn 12	In immediate vicinity of proposed footprint
	Aim. Stn 5	In immediate vicinity of proposed footprint; historical sampling location
	Aim. Stn 11	Downstream of proposed tailings areas
	Aim. Stn 6	Deep location within lake; historical sampling location
Windy	Windy Shallow	Possible drinking water source; historical sampling location
	Windy Deep	Possible drinking water source; historical sampling location
Doris	Wolverine Dike	Within proposed infrastructure footprint (pit/dike)
	Patch Dike	Within proposed infrastructure footprint (pit/dike)
	Imniagut	In immediate vicinity of proposed footprint; historical sampling location
	Little Roberts	AEMP sampling location
Reference B	Ref. B Shallow	Reference site; historical sampling location
	Ref. B Deep	AEMP sampling location; reference site
Reference D	Ref. D	AEMP sampling location; reference site
Stream/River Sites		
East	AWRe	Proposed all-weather road stream crossing
	Aim. NE IF	Major inflow to Aim. Lake; downstream of proposed tailings areas and road crossing; historical sampling location
Aimaokatalok River	Aim. R.	Major inflow to Aim. Lake; historical sampling location
	Stickleback OF	In immediate vicinity of proposed footprint; historical sampling location
	Trout OF	In immediate vicinity of proposed footprint; historical sampling location
	S12	Within proposed tailings area footprint
	S6	Within proposed tailings area footprint
	AWRd	Proposed all-weather road stream crossing
	AWRc	Proposed all-weather road stream crossing
	Aim. OF	Downstream sampling location for proposed Boston infrastructure; historical sampling location
Koignuk/Aimaokatalok	Koig. R.	Downstream sampling location for proposed Boston infrastructure; historical sampling location
	Koig. U/S	Downstream sampling location for proposed Boston infrastructure; historical sampling location
	Koig. D/S	Downstream sampling location for proposed Boston infrastructure; historical sampling location
	AWRb	Proposed all-weather road stream crossing
	AWRa	Proposed all-weather road stream crossing
Reference B	Ref. B OF	AEMP sampling location; reference site; historical sampling location
Reference D	Ref. D OF	AEMP sampling location; reference site
Angimajuq River	Ang. R. Ref.	River reference location; historical sampling location

Table 2.1-3 provides a summary of the sampling details for each aquatic component, including sampling frequency, timing, and replication. Tables 2.1-4 and 2.1-5 present the sampling dates for each lake and stream site. Figures 2.1-1 through 2.1-3 present an overview of the 2010 sampling locations along with the major watersheds in the area. Figures 2.1-4 to 2.1-13 present individual lake maps depicting lake bathymetry (where available) and the 2010 sampling locations.

2.2 LAKE BATHYMETRY

Bathymetric surveys were conducted from a small aluminum boat for six lakes in the area: Imniagut Lake, Stickleback Lake, Trout Lake, Little Roberts Lake, and Reference lakes B and D.

Continuous depth measurements were collected along lateral transects spaced 100 to 300 m apart. Data were also collected from longitudinal transects down the centre of the lake, as well as transects placed perpendicular to the centreline, and around topographical features of interest (e.g., sudden changes in depth). Surveys were conducted with the use of a Garmin GPS Map 526s depth sounder connected to a Trimble XRS Pro GPS unit with 0.5 m horizontal accuracy.

Recorded depths were imported into the ArcGIS software package. Using the 3D Analyst extension, a triangulated irregular network (TIN) was created from the depth sounder data. The TIN was used in the Spatial Analyst extension to create a grid of depth points at a density that matched that of the sounding data along a transect. These depth sounding data points and generated supplemental points were used to interpolate a digital elevation model (DEM) and contours using the TopoToRaster tool. This created smooth contours without altering any ‘real’ data points.

All bathymetry data were recorded, and are presented, in relation to the water level at the time of the survey. The water level at the time of data collection was also surveyed in relation to an onshore benchmark (Appendix 2.1-1).

2.3 LAKES AND RIVER PHYSICAL LIMNOLOGY

2.3.1 Winter Lake Physical Limnology

Winter dissolved oxygen and temperature profiles were collected in April 2010. To conduct the profiling, a hole was first drilled through the ice with an auger fitted with a 25-cm diameter flute. Once the hole was drilled, a weighted metred line was used to measure the bottom depth. Water column profiling and water quality sampling depths were calculated based on bottom depth.

Temperature and dissolved oxygen profiles were collected from the water column using a YSI meter. At shallower lake stations (<20 m), temperature and dissolved oxygen values were recorded at 0.5 m intervals, while at deeper lake stations (>20 m), values were recorded at 1 m intervals. The profiles ended at approximately 0.5 m above the sediment surface to minimize the disturbance of bottom sediments.

2.3.2 Summer Lake Physical Limnology

Summer dissolved oxygen and temperature profiles and Secchi depths were collected in August 2010. Summer temperature and dissolved oxygen profiles were taken at the same locations as winter profiles, unless new bathymetric data prompted the relocation of a sampling site to a deeper location.

Light attenuation was estimated in each lake using a Secchi disk. Measurements were collected at each site by lowering the disk (20-cm diameter, black and white) on a metred line through the water column on the shaded side of the boat until it disappeared from sight. The depth of disappearance was recorded as the Secchi depth (D_s), which was then used to calculate the depth of the euphotic zone (see formula in Section 2.14-2).

Table 2.1-3. Sampling Details for Physical Limnology, Water Quality, Sediment Quality, and Aquatic Biology, Hope Bay Belt Project, 2010

Monitoring Parameter	Sampling Frequency	Sampling Replication	Sampling Dates/Timing
Lakes			
Winter Limnology			
Dissolved oxygen/temperature profile	1 x	n = 1	April
Summer Limnology			
Dissolved oxygen/temperature profile; Secchi depth	1 x	n = 1	August
Winter Lake Water Quality			
Physical, nutrients, total & dissolved metals	1 x	n = 1 at 1 m below the ice and 2 m above water-sediment interface + 20% replication	April; coincident with winter DO/T profiles
Summer Lake Water Quality			
Physical, nutrients, total & dissolved metals	1 x	n = 1 at 1 m below the surface and 2 m above water-sediment interface + 20% replication	August
Lake Sediment Quality			
Physical, nutrients, metals	1 x	n = 3	August
Summer Phytoplankton			
Biomass (as chlorophyll *a*)	1 x	n = 3 at 1 m below surface	August
Abundance and taxonomy	1 x	n = 3 at 1 m below surface	August
Zooplankton			
Abundance and taxonomy	1 x	n = 3 vertical hauls from 1 m above bottom or horizontal tows of ~10 m	August
Lake Benthos			
Density and taxonomy	1 x	n = 5 composite samples	August
Streams and Rivers			
Winter Limnology			
Dissolved oxygen/temperature profile	1 x	n = 1	April
Winter River Water Quality			
Physical, nutrients, total & dissolved metals	1 x	n = 2	April
Summer Stream and River Water Quality			
Physical, nutrients, total & dissolved metals	3 x	n = 2	freshet (early June), summer (August), fall (September)
Stream and River Sediment Quality			
Physical, nutrients, metals	1 x	n = 3	August
Periphyton			
Biomass (as chlorophyll *a*)	1 x	n = 3	artificial samplers installed in early August; retrieved in early September
Density and taxonomy	1 x	n = 3	artificial samplers installed in early August; retrieved in early September
Stream and River Benthos			
Density and taxonomy	1 x	n = 5 composite samples	August

Table 2.1-4. Lake Sampling Dates, Hope Bay Belt Project, 2010

Watershed	Lake	Winter: DO/Temp	Winter: Water Quality	Summer: DO/Temp & Secchi Depth	Summer: Water Quality	Summer: Sediment Quality	Summer: Phytoplankton	Summer: Zooplankton	Summer: Benthos
Aimaokatalok	Stickleback	Apr. 26	Apr. 26 (1)	Aug. 19	Aug. 19 (1)	Aug. 19 (2.5)	Aug. 19	Aug. 19 (horiz.)	Aug. 19 (2.5)
	Trout	Apr. 26	Apr. 26 (1)	Aug. 16	Aug. 15 (1)	Aug. 16 (2.5)	Aug. 15	Aug. 21 (horiz.)	Aug. 16/17 (2.5)
	Aim. Stn 13	NC	NC	Aug. 13	Aug. 13 (1)	Aug. 14 (3.7)	Aug. 13	Aug. 13 (horiz.)	Aug. 14/15 (3.8)
	Aim. Stn 2	NC	NC	Aug. 18	NC	Aug. 18 (3)	NC	NC	Aug. 18 (3)
	Aim. Stn 12	NC	NC	Aug. 21	NC	Aug. 22 (0.3)	NC	NC	Aug. 21/22 (0.3)
	Aim. Stn 5	Apr. 25	Apr. 25 (1)	Aug. 12	Aug. 12 (1)	Aug. 12 (2.5)	Aug. 12	Aug. 12 (horiz.)	Aug. 12 (2.5)
	Aim. Stn 11	Apr. 25	Apr. 25 (1)	Aug. 16	Aug. 15 (1)	Aug. 17 (2.5)	Aug. 15	Aug. 22 (horiz.)	Aug. 17 (2.5)
	Aim. Stn 6	Apr. 25	Apr. 25 (1, 26)	Aug. 14	Aug. 14 (1, 26)	Aug. 14 (28)	Aug. 14	Aug. 14 (26)	Aug. 14 (28)
Windy	Windy Shallow	NC	NC	NC	NC	Aug. 23 (3)	NC	NC	Aug. 23 (3)
	Windy Deep	Apr. 19	Apr. 19 (2.8, 16)	Aug. 21	Aug. 21 (1, 16)	Aug. 22 (17)	Aug. 21	Aug. 21 (16)	Aug. 22 (17)
Doris	Wolverine Dike	NC	NC	NC	NC	Aug. 27/29 (2.5)	NC	NC	Aug. 27/29 (2.5)
	Patch Dike	NC	NC	NC	NC	Aug. 26 (3.5)	NC	NC	Aug. 26 (3.5)
Reference B	Ref. B Shallow	NC	NC	NC	NC	Aug. 23 (5.5)	NC	NC	Aug. 23 (5.5)
	Ref. B Deep	NI	NI	NI	NI	NI	Aug. 24	Aug. 25 (8.5)	NI
Reference D	Ref. D	NI	NI	NI	NI	NI	Aug. 11	Aug. 11 (horiz.)	NI

Notes:

Values in parentheses are the approximate sampling depths in metres. Horiz. = horizontal tow.

DO - dissolved oxygen

NC - not collected

NI - not included as these were part of the 2010 AEMP report (Rescan 2011)

Table 2.1-5. Stream and River Sampling Dates, Hope Bay Belt Project, 2010

		Winter		Summer						
			Water	Water Quality			Sediment	Periphyton		
Watershed	Stream/River	DO/Temp	Quality	Freshet (June)	Aug	Sept	Quality	Installation	Retrieval	Benthos
East	AWRe	NC	NC	Jun. 18	Aug. 16	Sept. 16	Aug. 16	NC	NC	NC
	Aim. NE IF	NC	NC	Jun. 18	Aug. 16	Sept. 16	Aug. 16	Aug. 10	Sept. 7	Aug. 16
Aimaokatalok River	Aim. R.	NC	(Apr. 26)*	Jun. 18	Aug. 21	Sept. 16	Aug. 18	Aug. 10	Sept. 8	Aug. 18
	Stickleback OF	NC	NC	Jun. 18	Aug. 16	Sept. 16	Aug. 16	Aug. 10	Sept. 8	Aug. 16
	Trout OF	NC	NC	Jun. 18	Aug. 16	Sept. 16	Aug. 16	Aug. 10	Sept. 8	Aug. 16
	S12	NC	NC	Jun. 18	NC	Sept. 16	NC	NC	NC	NC
	S6	NC	NC	Jun. 18	Aug. 18	Sept. 16	Aug. 18	NC	NC	NC
	AWRd	NC	NC	Jun. 18	Aug. 16	Sept. 16	Aug. 16	Aug. 10	Sept. 7	NC
	AWRc	NC	NC	Jun. 18	Aug. 15	Sept. 16	Aug. 15	Aug. 10	Sept. 7	Aug. 15
	Aim. OF	NC	Apr. 25‡	Jun. 18	Aug. 16	Sept. 16	NC	Aug. 10	Sept. 8	Aug. 16
Koignuk/Aimaokatalok	Koig. R.	Apr. 25	Apr. 25	Jun. 18	Aug. 18	Sept. 16	Aug. 18	Aug. 10	Sept. 8	Aug. 18
	Koig. U/S	Apr. 18	Apr. 18	Jun. 17	Aug. 14	Sept. 15	Aug. 14	Aug. 10	Sept. 7	Aug. 14
	Koig. D/S	NC	(Apr. 19 & 23)*	Jun. 17	Aug. 14	Sept. 15	Aug. 14	Aug. 10	Sept. 7	Aug. 14
	AWRb	NC	NC	Jun. 18	Aug. 15	Sept. 15	Aug. 15	Aug. 10	Sept. 7	Aug. 15
	AWRa	NC	NC	Jun. 18	Aug. 15	Sept. 15	Aug. 15	Aug. 10	Sept. 7	Aug. 15
Reference B	Ref. B OF	NC	NC	NI	NI	NI	NI	Aug. 9	Sept. 7	NI
Reference D	Ref. D OF	NC	NC	NI	NI	NI	NI	Aug. 10	Sept. 9	NI
Angimajuq River	Ang. R. Ref.	NC	(Apr. 18)†	Jun. 19	NC	Sept. 15	NC	NC	NC	NC

Notes:

DO - dissolved oxygen

NC - not collected

NI - not included as these were part of the 2010 AEMP report (Rescan 2011)

** River was frozen to the bottom at time of sampling; no samples were collected.*

† Surface flow at this site prohibited safe sampling; no samples were collected.

‡ Water was flowing at this site at the time of winter sampling; samples were collected as surface grabs.

2.3.3 Winter River Physical Limnology

Winter river dissolved oxygen and temperature profiles were collected in April 2010. To access the water, a 15-cm diameter hole was drilled through the surface ice using an auger. Ice occasionally extended to the river bottom because some sampling sites were less than 2 m deep (the approximate ice thickness in the area). If little or no water was found on initial drilling, additional holes were drilled based on the topography of the river ice and basic river dynamics. Under-ice dissolved oxygen and temperature readings were collected at 0.5 m depth intervals using a YSI meter.

2.4 LAKE WATER QUALITY

2.4.1 Winter Lake Water Quality

Winter lake water quality samples were collected in mid to late April 2010. Under-ice samples collected in April reflect the late winter 'worst case scenario' for water quality (i.e., limited biological uptake, therefore highest annual concentrations), which makes this time period important to characterize. All water quality samples were compared to guidelines for the protection of freshwater aquatic life published by the Canadian Council of Ministers of the Environment (CCME 2007).

Lake water quality samples were collected with a modified, 2.5 L skinny Niskin bottle in winter. The Niskin bottles were acid-cleaned at ALS Environmental Services (ALS), Burnaby, BC, and contained acid-cleaned silicone to avoid metal contamination. A dual rope system was used for bottle closure and to ensure the collection of discrete samples.

Water quality samples were collected from the same locations as physical limnology measurements. Two depths were sampled: shallow depth (1 m below the ice) and deep depth (2 m from the bottom). One sample was collected at each depth, with 20% replication. The Niskin was lowered on a metred cord to the desired sampling depth and was triggered closed by a teflon-coated messenger released from the surface. Water from the Niskin was transferred into the appropriate sample containers. Preservatives were added to total metals (ultra-pure nitric acid), total organic carbon (TOC; hydrochloric acid), and total Kjeldahl nitrogen (TKN; sulphuric acid) sample containers.

All water samples were kept cold and sent to ALS in Yellowknife on the first available flight out of camp. Samples were then sent to ALS's Burnaby, BC, laboratory where the lowest metal detection limits are available. Dissolved metals samples were filtered by ALS in their Burnaby laboratory to avoid contamination issues related to field filtration. All water samples were analyzed for general physical parameters, nutrients, TOC, and total and dissolved metals. A full list of analyzed parameters including analytical detection limits is presented in Table 2.4-1.

Method detection limits were lower than, or equal to, the CCME guidelines for the protection of aquatic life. Realized detection limits were occasionally higher than the method detection limit presented in Table 2.4-1. This occurred when dilution of a sample was required to compensate for other interfering parameters. Realized detection limit ranges are indicated on all relevant figures in this report.

2.4.2 Summer Lake Water Quality

Summer water quality samples were collected in August 2010, using metal-clean techniques. An acid-cleaned and teflon-lined 5 L GO-FLO bottle was used for water collection. The GO-FLO was lowered on a metred cord to a depth 0.5 m lower than the desired sampling depth before being raised to the sampling depth and closed with the use of a weighted messenger. The water collected was used to triple-rinse the laboratory-provided sample containers, before filling and preserving them as described for winter lake water quality (Section 2.4.1).