# Appendix V5-6C

Aquatic Baseline Studies Boston Project Data Compilation Report 1992 – 2000

# AQUATIC BASELINE STUDIES
# BOSTON PROJECT
# DATA COMPILATION REPORT
# 1992 - 2000

**REPORT ON**

# AQUATIC BASELINE STUDIES
# BOSTON PROJECT AREA DATA COMPILATION REPORT
# 1992 – 2000

**Submitted to:**

Hope Bay Mining Limited
300 - 889 Harbourside Drive
North Vancouver, BC
V7P 3S1

**Submitted by:**

Golder Associates Ltd.
300, 10525 – 170 Street
Edmonton, AB
T5P 4W2

**DISTRIBUTION (Final Report):**

**2 Copies**: Hope Bay Mining Ltd., North Vancouver, BC

**2 Copies**: Golder Associates Ltd., Edmonton, AB

**July 2008** **06-1373-028-1500**

Cover Photo: Koignuk River at Km 18.5, showing the lower part of the 5-m waterfall and a downstream scour pool (photo taken by Tim Antill on 8 July 2007).

Suggested Citation: Golder Associates Ltd. 2008. Aquatic baseline studies Boston project data compilation report 1992 – 2000 Draft Report. Prepared for Miramar Hope Bay Ltd., North Vancouver, BC by Golder Associates Ltd., Edmonton, AB. Golder Report No. 06-1373-028-1500: 211 p. + 5 app.

# EXECUTIVE SUMMARY

## Introduction

The Hope Bay Belt Project area is located in the Canadian Arctic to the east of Bathurst Inlet, approximately 65 km east of the community of Umingmaktok, Nunavut. The project area consists of three main gold deposit zones: Doris, Madrid, and Boston. The Doris and Madrid zones are the northern-most areas and include several lake systems that drain into Roberts Bay. The Boston zone is approximately 50 km south of the Doris and Madrid zones zone and includes several lake and river systems that drain into Hope Bay via Koignuk River.

As part of the mining development plan for the Hope Bay Belt, Miramar Hope Bay Ltd. contracted Golder Associates Ltd. (Golder) to compile and synthesize all aquatic environmental baseline information previously collected within the Boston area. The present synthesis report is based on studies conducted by Rescan Environmental Services Ltd. from 1992 to 2000, as reported in eight separate documents (Rescan 1993, 1994, 1995, 1997, 1998, 1999a, 1999b, 2001). Together with the data from more recent studies conducted in the Boston area in 2007 (Golder 2008), this consolidated report is intended to be used in support of an environmental impact assessment and will form the basis for future monitoring programs.

This report follows a format similar to the one used in the data compilation report for the Doris area (RL&L/Golder 2002). Environmental disciplines are presented as separate chapters in the following order: bathymetry, physical limnology and surface water quality, sediment quality, primary producers, secondary producers, fish populations, and fish habitat assessment.

## Bathymetry

Lake bathymetric surveys were carried out on Aimaokatalok and Stickleback lakes in 1993 and 1994. Aimaokatalok Lake is part of a glacially scoured river valley, which is confined by a narrow outlet to form the present lake. The total lake area is approximately 25.5 $km^2$. Within the area encompassed by the 1994 survey (22.3 $km^2$ or about 87% of the lake), the estimated water volume was 137 x $10^6$ $m^3$ and the mean depth was 6.1 m. The maximum depth of 30 m was recorded in a confined depression near the centre of the middle basin of the lake. The south arm of the lake was surveyed in 1993, indicating a shallower basin with a maximum depth of approximately 12 m.

Stickleback Lake is a small, oval shaped lake with the total area of 1.0 $km^2$. The maximum depth of 3 m was recorded in a small area near the northeast part of the lake. The remainder of the lake featured a consistently flat bottom between 2 and 3 m in depth.

Fickle Duck Lake is a small, oval shaped lake. Its total area is approximately 0.5 $km^2$. It has a fairly flat bottom and is approximately 2 m deep; however, a systematic bathymetric survey has not been carried out.

### Physical Limnology and Surface Water Quality

Physical limnology and surface water quality data were collected in Aimaokatalok, Stickleback, Fickle Duck and Reference lakes. Aimaokatalok Lake is considerably larger and deeper than the other three lakes and its monitoring was more intensive, involving multiple sites and five years of under-ice sampling. In contrast, the other three lakes were sampled at just one site with only a single under-ice sampling event.

The lakes were generally well mixed; thermal stratification was observed only once (in July 1997) in Aimaokatalok Lake. Consistently high and uniform dissolved oxygen concentrations were characteristic of both the under-ice and summer profiles for the three smaller lakes (all about 3 m deep). In the deeper waters of Aimaokatalok Lake, dissolved oxygen concentrations occasionally fell below the 6.5 mg/L Canadian Water Quality Guideline (CWQG) for the protection of aquatic life.

Total suspended solids typically varied between <1 and 5 mg/L in the four lakes. The closely-related turbidity ranged from 0.3 to 30 NTU; however, only 10% of the recorded values exceeded 5 NTU.

The pH of lakes was generally near neutral (pH 7), with the overall pH range of 5.7 to 8.4. On a few occasions, the pH of lakes was slightly less than the lower CWQG limit (pH 6.5) for protection of aquatic life.

Susceptibility to acidification, as determined from total alkalinity values, was low only for Stickleback Lake. Aimaokatalok, Fickle Duck and Reference lakes had moderate to high susceptibility to acidification. Total alkalinity concentrations were similar in summer and winter samples from Aimaokatalok Lake; in contrast, the single winter samples collected from the other three Boston area lakes all had anomalously high total alkalinity concentrations compared with their summer values.

Nutrient levels were typical of oligotrophic to mesotrophic lakes. Total phosphorus levels rarely exceeded the 30 µg/L jurisdictional guideline for Northwest Territories and Nunavut and the exceedences co-occurred with high total suspended solids concentrations (suspended sediments being the likely source of elevated phosphorus).

Metal concentrations sporadically exceeded CWQGs in all four lakes. Median copper concentrations in under-ice water samples from Aimaokatalok Lake were two times higher than the CWQG of 2 µg/L. Total copper concentrations also occasionally exceeded the CWQG in Fickle Duck and Reference lakes. The highest copper concentration (30 µg/L) was measured in an under-ice sample from Reference Lake. Total iron was the only metal to substantially exceed its CWQG (300 µg/L) in all four lakes, on at least one occasion. In general, the total number of parameters which exceeded CWQGs was higher in Aimaokatalok and Stickleback lakes compared to Fickle Duck and Reference lakes.

Flowing waters sampled in this study included Aimaokatalok NE Inflow, Aimaokatalok Outflow, Aimaokatalok River, Stickleback Outflow, Fickle Duck Outflow, Koignuk River, and Reference Outflow. Water quality in general was similar in lakes and associated streams, although there was little correspondence in their guideline exceedences.

The greatest number of CWQG exceedences was recorded in Aimaokatalok NE Inflow, where elevated levels of aluminum, cadmium, chromium, copper, iron, lead and zinc were documented on at least one occasion. Total aluminum and total iron comprised the greatest and most frequent exceedences of CWQGs. Only in Aimaokatalok Outflow, both aluminum and iron concentrations were below the CWQGs, whereas Aimaokatalok River was the only other stream site where aluminum (but not iron) was also below the CWQG. Similar to the lake sites, additional exceedences of CWQGs occurred in the concentrations of cadmium, chromium, copper and lead. In contrast to the lake samples, no exceedences of CWQGs occurred for mercury or selenium.

The marine waters of Hope Bay were unstratified and well oxygenated. All metal concentrations were below their CWQG, except for mercury which was slightly higher than the marine guideline of 0.016 µg/L.

### Sediment Quality

Baseline sediment quality data were collected for Aimaokatalok, Stickleback, Fickle Duck and Reference lakes and Stickleback Outflow. Most metal levels in lake sediments were below the Canadian Interim Sediment Quality Guidelines (CISQG). The exceptions were total chromium, arsenic and copper. Of these, total chromium values exceeded the CISQG Probable Effect Level (PEL) in three of the sampled waterbodies.

Total organic carbon levels varied between sediment samples. For sediments with relatively high organic carbon content (Fickle Duck Lake, Stickleback Outflow and Reference Lake), colour and mineralogy indicated that reducing conditions were predominant in the surficial layer, as well as in the underlying sediments. For lake sediments with relatively low to moderate organic carbon concentrations (Aimaokatalok Lake), colour and mineralogy indicated a strong redox gradient between an oxic surficial layer and reducing underlying upper layer. Total organic carbon values from Stickleback Lake were low in 1996 but remarkably higher in 1997.

All of the total metal concentrations in Hope Bay sediments were compliant with the marine sediment quality guidelines.

### Phytoplankton in Lakes

Phytoplankton are tiny, free-floating organisms that use energy from sunlight to convert carbon dioxide and water into organic materials to be used in biological tissues. Phytoplankton samples were collected from four lakes within the Boston area (Aimaokatalok, Stickleback, Fickle Duck and Reference lakes). Between three and seventeen sampling sessions were conducted on each lake between 1993 and 1998.

The phytoplankton samples obtained from the Boston lakes contained no uncommon or rare species. The phytoplankton communities (i.e., taxonomic composition) of the four lakes showed little differentiation and were similar in many respects to the communities of other small lakes in the Arctic and sub-Arctic. In general, phytoplankton within the Boston area lakes were numerically dominated by the Cyanophyta species, *Anacystis* spp. and *Lyngbya limnetica*. However, *Crucigenia* spp. (Chlorophyta), *Asterionella formosa*, (Bacillariophyta) and *Dinobryon* spp. (Chrysophyta) also made significant contributions to phytoplankton abundance in some of the lakes. A comparison of mean phytoplankton abundance indicated that Reference Lake was the most productive and that Aimaokatalok and Fickle Duck lakes were the least productive.

### Periphyton in Streams

Periphyton is a term used to describe the often complex matrix of algae, bacteria, fungi, other microorganisms and associated materials attached to solid substrata in aquatic ecosystems. Periphyton samples were collected from five streams within the Boston area. Two to five sampling sessions were conducted on each watercourse between 1993 and 1998.

A comparison of mean periphyton abundance among the study streams suggested that Fickle Duck Outflow was the most productive and Reference Outflow was the least productive. Based on chlorophyll *a* concentrations, which is a biomass estimate of live photosynthetic organisms, Reference Outflow was the most productive, whereas Fickle Duck Outflow was the least productive. Similar to the phytoplankton, the numerical dominance by Cyanobacteria (mainly *Gomphosphaeria nagelianum and Lyngbya limnetica*) suggested that this group was able to take advantage of existing low nitrogen conditions and substantially increase its population. In addition, diatoms (mainly *Tabellaria flocculosa)* and to a lesser extent, green algae, also made significant contributions, and typically co-dominated along with Cyanobacteria. The above observations were consistent with those made in other streams of the Arctic and sub-Arctic regions.

### Zooplankton in Lakes

Zooplankton are small animals that inhabit the water column of lakes and consume phytoplankton. In turn, zooplankton are utilized by large invertebrates and fish as a food source. Zooplankton samples were collected from four lakes within the Boston area. Three to thirteen sampling sessions were conducted on each lake between 1993 and 1998.

The zooplankton samples obtained from the Boston lakes revealed no uncommon or rare species. The taxonomic composition of the zooplankton among the four waterbodies was similar to the communities of other small lakes in the Arctic and sub-Arctic. In general, zooplankton communities were numerically dominated by the rotifer (wheel animal) *Kellicottia longispina*. The most common cladoceran (water flea) was *Daphnia longiremis*. A comparison of mean zooplankton abundance indicated that Aimaokatalok Lake was the most productive and Reference Lake was the least productive.

### Benthic Invertebrates in Lakes

Benthic (bottom-dwelling) invertebrates are an important link in aquatic food webs. Many fish species, including early life history stages of piscivorous species, feed upon benthic invertebrates. Benthic invertebrate samples were collected from four lakes within the Boston area. Three to eighteen sampling sessions were conducted on each lake between 1993 and 1998.

Chironomidae (midges), Pelecypoda (clams), and to a lesser extent Nematoda (round worms) and Oligochaeta (bristle-worms), dominated the benthic communities of the Boston area lakes. A comparison of mean benthic macroinvertebrate abundance suggested that Stickleback Lake was the most productive and the deep areas of Aimaokatalok Lake were the least productive. Although only one Boston area lake had a Chironomidae population that comprised a majority (i.e., more than 50% of total numbers) of the benthic community, Chironomidae was the most numerically abundant taxonomic group within all of the Boston area lakes. The benthic communities of the four study lakes were similar in many respects to the communities of other small lakes in the Canadian Arctic and sub-Arctic.

### Drift Organisms in Streams

Benthic macroinvertebrates in streams can actively or passively enter the water column; this behaviour is known as drift. Also included in the drift are pelagic forms of invertebrates (e.g. zooplankton) that can be entrained from lakes, back-eddies, and calm side-channels of flowing waters. Drift organisms are an important part of the food chain, particularly because they are easily observed and available to fish and other potential predators. Drift samples were collected from five streams within the Boston area. Up to four sampling sessions were conducted on each stream between 1997 and 1998.

A comparison of mean total drift abundance suggested that Stickleback Outflow was highly productive, and that Reference Outflow was the least productive. Chironomidae, Simuliidae (black flies), and Ostracoda (seed shrimp) dominated the drift of the Boston area streams. Differences in composition and abundance of drift organisms could largely be ascribed to physical characteristics of the study streams. For example, the very high numbers of drift encountered in Stickleback Outflow may be due to the low flow rates encountered at this site. The high proportion of zooplankton in the drift samples from Stickleback Outflow may be an artifact of positioning the drift nets in close proximity to the lake.

### Benthic Invertebrates in Streams

Stream benthic macroinvertebrates are adapted to living in flowing waters; thus, the species encountered in streams are different than those in lake environments. Stream invertebrates are an important part of the food chain; particularly if they are situated within fish rearing and adult feeding locations. Benthic samples were collected from five streams within the Boston area. Two to five sampling sessions were conducted on each stream between 1993 and 1998.

A comparison of mean total benthic invertebrate abundance suggested that Reference Outflow was the most productive and Aimaokatalok River was the least productive. Chironomidae, Ostracoda and ‘other’ invertebrates (Gastropoda and Malacostraca) dominated the benthic communities of the Boston area streams. Trichoptera was very common in Aimaokatalok River (43.2% of total numbers) on one sampling date. All streams sampled featured high proportions (at least 55% of total numbers) of Chironomidae on at least one sampling date.

### Benthic Invertebrates in Hope Bay

Similar to freshwater invertebrates, benthic forms of marine invertebrates are an important link in food webs. Benthic marine invertebrate samples were collected from three sites within Hope Bay. A single sampling session was conducted in July 1998.

Polychaeta (lugworms, tube worms, and marine bristle worms), Nematoda and Chironomidae dominated the benthos of Hope Bay. The composition of benthic communities within Hope Bay was typical for the Arctic region. Differences in composition and abundance of the benthos among the three stations could be ascribed to physicochemical (e.g., water depth, salinity) characteristics at the sampling locations. A comparison of mean benthic macroinvertebrate abundance among the three Hope Bay stations indicated that greater faunal densities corresponded with increased water depth.

### Fish Communities in Lakes

In total, 300 fish representing four species were captured in gill nets and through angling in three Boston area lakes during fisheries surveys conducted between 1993 and 1997. The captured species included (in the order of abundance in the total catch) lake trout (56%), lake whitefish (38%), cisco (6%), and Arctic grayling (0.3%). Ninespine stickleback were also present in all lakes.

The fish populations in Aimaokatalok Lake included lake trout, lake whitefish, cisco, Arctic grayling and ninespine stickleback. In Fickle Duck Lake, only Arctic grayling and ninespine stickleback were caught, and in Stickleback Lake only ninespine stickleback were caught. Considering that Fickle Duck and Stickleback lakes are similar in size and depth, the absence of Arctic grayling in Stickleback Lake is likely related to the lack of suitable spawning habitat in the outlet stream.

### Fish Communities in Streams

Fish surveys during the 1993-2000 period were conducted in watercourses within the Aimaokatalok Lake drainage that included Fickle Duck and Stickleback outflows, Aimaokatalok NW Inflow, as well as several small inflows to Aimaokatalok Lake and one to Fickle Duck Lake. The Koignuk River, Boulder Creek (tributary to the Koignuk River) and three small streams where permanent road crossings were proposed were also sampled.

Streams in the Boston area, excluding the lower sections of the Koignuk River, were inhabited by at least three fish species (lake trout, Arctic grayling and ninespine stickleback). Two additional species (Greenland cod and lake whitefish) were present in the lower section of the Koignuk River. Slimy sculpin were also observed but not captured.

Ninespine stickleback was the most common species (74%) in the total catch of more than 471 fish. This species was also most widely distributed among the sampled streams; it was recorded in 11 of the 13 stream sites. Lake trout was second in abundance (20% of the total catch) and was recorded at six sites. Arctic grayling contributed 6% to the total catch and were recorded at seven sites. Juveniles and adults were present in the catch of both lake trout and Arctic grayling.

### Fish Tissues

Fish tissue (dorsal muscle and liver) samples were collected from 70 lake trout, 43 lake whitefish, and five Arctic grayling to provide baseline data on metal concentrations in Aimaokatalok and Fickle Duck lakes. Samples were collected every year from 1993 to 1997; however, most (70%) of the samples were collected in 1995 or 1997.

Analyses of fish tissues indicated generally low levels of metal accumulation; however, exceedences of the federal guidelines for human consumption were noted for mercury. In lake trout, approximately 43% of muscle tissues and 74% of liver tissues exceeded the federal food consumption guideline of 0.5 µg/g for mercury. For lake whitefish, none of the muscle samples, but 43% of liver samples exceeded the guideline. Consistent with bioaccumulation up the food chain, older and larger fish had greater concentrations of mercury in their tissues and these fish were most likely to have mercury concentrations above the federal guideline.

None of the fish samples from Aimaokatalok or Fickle Duck lakes exceeded the federal food consumption guidelines for arsenic and lead (3.5 and 0.5 µg/g, respectively).

### Fish Habitat in Streams

Stream habitat assessments were conducted at 21 stream sites between 1996 and 2000. In addition, 21 ephemeral drainages were visually assessed from the air and deemed to contain no fish habitat. A detailed habitat map was elaborated for the lower reaches of the Koignuk River in 1998.

Large streams (Aimaokatalok NE Inflow, Aimaokatalok River and the Koignuk River) supported the highest diversity of fish habitat for rearing, adult feeding, spawning, and migration. Most of the small inflow tributaries that did not feature a lake or pond upstream were found to be either ephemeral, run-off from melt waters, or provided only marginal rearing and feeding habitat near their mouths.

During high water periods, Stickleback Outflow provided good rearing opportunity but poor migration habitat. Fickle Duck Outflow featured mainly riffles and was assessed to provide fair adult feeding and rearing but poor spawning habitat.

# ACKNOWLEDGEMENTS

Golder Associates Ltd. would like to thank Terri Moloof, Manager of Environmental Permitting and Compliance, for initiating this data compilation project. The timely and courteous assistance of Jonathan Olsen and Deborah Muggli of Rescan Environmental Services Ltd. is also gratefully acknowledged for providing digital data in 2002.

The following Golder personnel participated in the preparation of the report:

| | |
|---|---|
| Gary Ash | - Study Director and Senior Review |
| Jacek Patalas | - Project Manager and Editor |
| Edyta Jasinska | - Author of Water Quality Section |
| Mike Christensen | - Author of Primary and Secondary Producers Sections |
| Sean Faulkner | - Author of Fish Populations and Habitat Sections |
| Angela Holzapfel | - Water Quality Data Analysis |
| Alison Ondrack | - Fish Data Analysis |
| Claire Classen | - Contributing Author and Editor |
| Rob Wesson | - Drafting |
| Cory Pedersen | - GIS |
| Brian Rankin | - GIS |
| Rob Cassells | - GIS |
| Kelsey Jones | - Word Processing |

## TABLE OF CONTENTS

**SECTION** **PAGE**

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF APPENDICES

# 1 INTRODUCTION

## 1.1 GENERAL

The Hope Bay Belt area is located in the Canadian Arctic to the east of Bathurst Inlet, approximately 65 km east of the community of Umingmaktok, Nunavut (Figure 1.1). The Hope Bay Mining Ltd. project area consists of three main gold deposit zones: Doris, Madrid, and Boston. The Doris zone is the northern-most area and the surrounding area includes several lake systems that drain into Roberts Bay. The Madrid zone is centered around Patch Lake located approximately 10 km south of the Doris area. The Boston zone is approximately 50 km south of the Doris zone and includes several lake and river systems that drain into Hope Bay via the Koignuk River.

Environmental baseline studies were carried out within the Boston area from 1992 to 1998 and in 2000. As part of the planning to start the permitting process for development of the Boston Project mines, Miramar Hope Bay Ltd. contracted Golder Associates Ltd. (Golder) to compile and synthesize all aquatic environmental baseline information previously collected prior to the current baseline studies within the Boston area. The present synthesis report is based on studies conducted by Rescan Environmental Services Ltd. from 1992 to 2000 as reported in eight separate documents (Rescan 1993, 1994, 1995, 1997, 1998, 1999a, 1999b, 2001). Together with the data from more recent studies conducted in the Boston area in 2006 and 2007 (Golder 2008), this compilation report is intended to be used in support of an environmental impact assessment and will form the basis for future monitoring programs.

## 1.2 1992-2000 SAMPLING PROGRAM

Aquatic baseline studies conducted in the Boston zone during 1992-2000 included the following major disciplines: bathymetry, physical limnology, water and sediment quality, primary producers (phytoplankton and periphyton), secondary producers (zooplankton, benthos, and drift organisms), fish populations, and fish habitat.

Figure 1.2 provides an overview of waterbodies in the Boston area. Lakes that were sampled as part of the baseline studies within the project area included Aimaokatalok (also known as Spyder and Aimaoktok), Fickle Duck (also known as Trout), and Stickleback lakes. Also sampled were selected inflow and outflow streams within the lake basins, including Koignuk River, and the marine environment of Hope Bay as the main receiving waterbody downstream of the proposed mining development. In addition, sampling was conducted in Reference


**LEGEND**

- Town/Village
- Project Location
- Capital City
- Hope Bay Belt
- Territorial Border
- Waterbodies
- Canada

125 0 125

SCALE 1:4000000 KILOMETRES

MIRAMAR HOPE BAY LTD.

Boston Project
Data Compilation

**REFERENCE**

Sources: Environmental Systems Research Instittute (ESRI)
Projection: Canada Lambert Conformal Conic Datum: NAD 83
This map is for information purposes only. Golder Associates Ltd. does not accept any liability arising from its misuse or misrepresentation.

TITLE

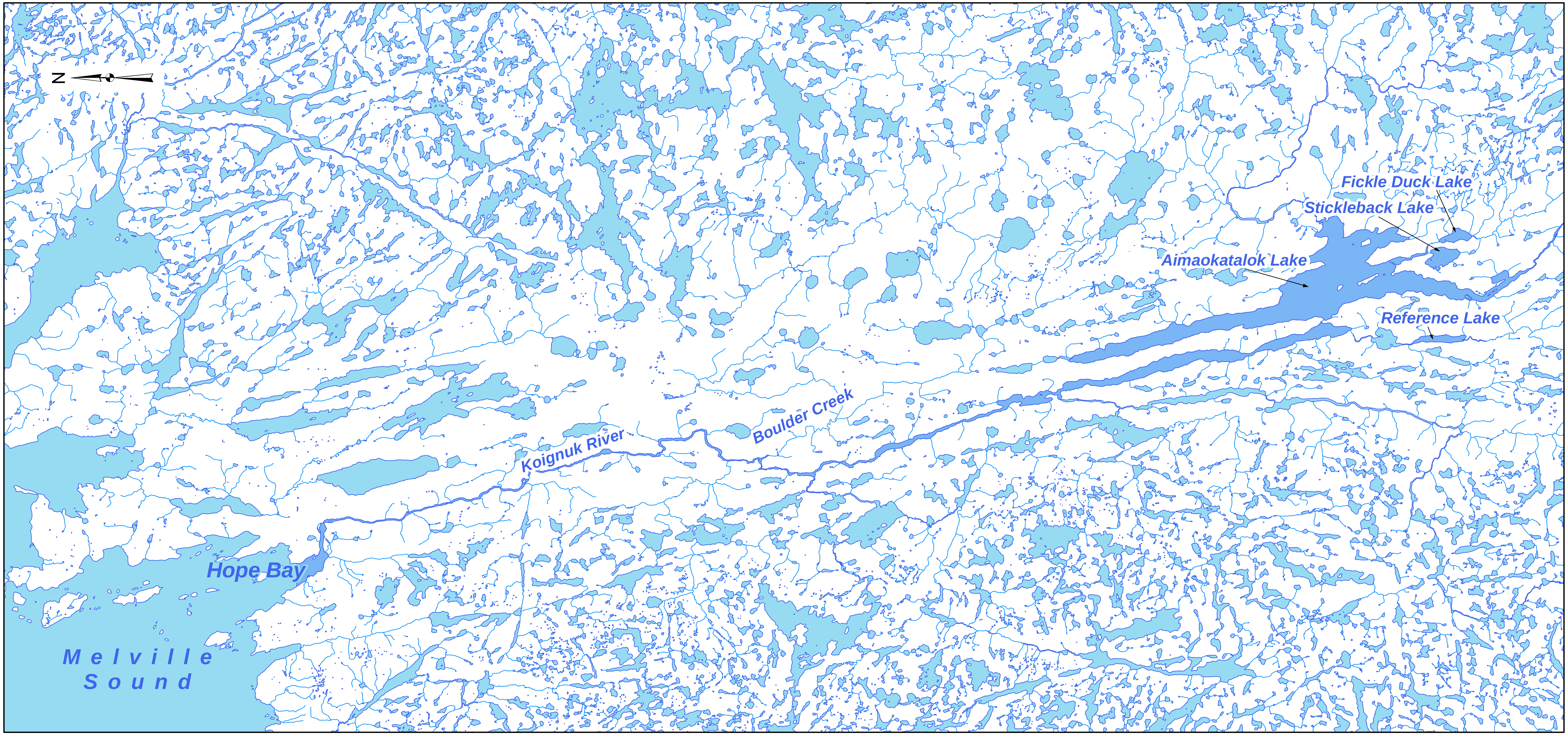
# Project Location Map

Golder Associates
Edmonton, Alberta

| PROJECT No. 06-1373-028 | | | SCALE AS SHOWN | REV. 0 |
|---|---|---|---|---|
| DESIGN | AH | 4 April 2008 | FIGURE 1.1 | |
| GIS | RC | 7 April 2008 | | |
| CHECK | AH | 11 April 2008 | | |
| REVIEW | GA | 14 May 2008 | | |

Project: M:\Projects\2007\1373\0019\MapDocs\Fig1_1_HopeBay_BostonCompilation.mxd - Plot: M:\Projects\2007\1373\0019\MapDocs\PDFs\Fig1_1_HopeBay_BostionCompilation.pdf

Project: M:\Projects\2007\1373\0019_Miramar_ EM_ II\MapDocs\FigX_WaterbodiesSampled_BostonHope.mxd - Plot: M:\Projects\2007\1373\0019_Miramar_ EM_ II\PDFs\FigX_WaterbodiesSampled_BostonHope.pdf




**LEGEND**

- Streams
- Study area waterbodies
- Waterbodies

4800 0 4800

SCALE 1:175000 METRES

MIRAMAR HOPE BAY LTD.

Boston Project Data Compilation

**REFERENCE**

Sources: Data Obtained from the Government of Canada, Natural Resources Canada, Centre for Topographic Information
Projection: UTM Zone 13N Datum: NAD 83

This map is for information purposes only. Golder Associates Ltd. does not accept any liability arising from its misuse or misrepresentation.

TITLE

Studied Waterbodies in the Boston Area, 1992 - 2000

Golder Associates
Edmonton, Alberta

| PROJECT No. 06-1373-028 | | | SCALE AS SHOWN | REV. 0 |
|---|---|---|---|---|
| DESIGN | JP | 22 April 2008 | FIGURE: 1.2 | |
| GIS | RC | 23 April 2008 | | |
| CHECK | JP | 12 May 2008 | | |
| REVIEW | GA | 16 May 2008 | | |

Lake and its outflow. The Reference drainage is located outside of the potential zone of impact from the project. As such, it was considered as a control basin and was sampled to provide reference data for future aquatic effects monitoring programs.

The sampling programs conducted from 1992 to 2000 focused on different disciplines and waterbodies each year (Table 1.1). As such, some of the data sets presented in this report are based on eight years of sampling (e.g., water quality), whereas other discipline data are based on fewer years of sampling. Sampling details and methodology are provided for each discipline in subsequent chapters.

## 1.3 OVERVIEW OF REPORT

This report follows a format similar to the one used in the data compilation report for the Doris zone (RL&L/Golder 2002). Aquatic environmental disciplines are presented as separate chapters in the following order: bathymetry, physical limnology and surface water quality, sediment quality, primary producers, secondary producers, fish populations, and fish habitat assessment.

All of the relevant original data and analytical results (as presented in the annual data reports) are provided as appendices at the end of the report. In cases where the information in the text of the annual data reports did not agree with the data presented in the corresponding appendices, the appendix values were generally assumed to be correct and were used as bases for all statistical analyses. Where it was obvious that the appendix values were erroneous (e.g., fish lengths that did not agree with the corresponding weights), these data were clearly marked in the appendices (i.e., placed in parenthesis) and were omitted from all statistical analyses.

In the cases of primary and secondary producers, the present report includes only those taxa that were ecologically targeted. For instance, analytical laboratories typically provide results of all specimens encountered. As such, the benthic invertebrate data sets included vertebrates (e.g., fish), non-benthic / non-aquatic invertebrates [e.g., *Thysanoptera* (thrips), *Hymenoptera* (ants and bees)] and terrestrial adult forms of aquatic species. Although these non-targeted data were included in the appendices (marked as shaded rows), they were omitted from all statistical analyses. As it was not always apparent how these non-targeted taxa were treated during previous analyses, summary numbers presented in this report may not match those provided by Rescan in the annual reports.

**Table 1.1 Boston Area Aquatic Sampling Program, 1992 to 2000**

| Waterbody | Bathymetry | | Water Quality | | | | | | | | Sediments | | | 1° & 2° Producers | | | | | | Fish Populations | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | '93 | '94 | '92 | '93 | '94 | '95 | '96[b] | '97 | '98 | '00 | '93 | '96 | '97 | '93 | '94 | '95 | '96 | '97 | '98 | '93 | '94 | '95 | '96 | '97 | '98 |
| Aimaokatalok Lake [a] | 8 | 8 | 8 | 6,8 | 8 | 7,8 | 4,8 | 4,7,8 | 4,7 | | 8 | 8 | 7 | 8 | 8 | 8 | 8 | 7,8 | 7 | 8 | 8 | 7,8 | 7,8 | 8 | |
| Stickleback Lake | 8 | | | 8 | 8 | 8 | | 4,7,8 | 7 | | | 8 | 7 | 8 | 8 | 8 | 8 | 7,8 | 7 | 8 | 8 | 7,8 | | 8 | |
| Fickle Duck Lake | | | | | 8 | 8 | 8 | 4,7,8 | 7 | | | 8 | 7 | | | 8 | 8 | 7,8 | 7 | | | 7,8 | 8 | | |
| Reference Lake | | | | | | | | 7,8 | 4,7 | | | | 7 | | | | | 7,8 | 7 | | | | | | |
| Aimaokatalok NE Inflow | | | | | | 8 | 8 | 6,7,8 | 6 | | | | | | | | 8 | 7,8 | 6,7 | | | 8 | 7 | 6,8 | |
| Aimaokatalok River | | | | | | | | 6,7,8 | 5,6 | | | | | | | | | 8 | 7,8 | | | | 8 | | |
| Aimaokatalok Outflow | | | | | | | | | 5,6,8 | | | | | | | | | | | | | | | | |
| Stickleback Outflow | | | 8 | 6,8 | 8 | 7 | 6,8 | 6,7,8 | 6 | | | | | | | 8 | 8 | | 7,8 | 8 | 8 | 7,8 | | | |
| Fickle Duck Outflow | | | 8 | 6,8 | 8 | 7 | 6,8 | 6,7,8 | 6 | | 8 | | | 8 | | 8 | | 7,8 | 7,8 | 8 | 8 | 7,8 | 7 | 6,8 | |
| Reference Outflow | | | | | | | | 7,8 | 6,8[c] | | | | | | | | | 7,8 | 7,8 | | | | | | |
| Koignuk River | | | | | | | | | 6,8 | 6,9 | | | | | | | | | | | | 8 | 8 | | 8 |
| Hope Bay (marine) | | | | | | | | 8 | 7 | | | | 8 | | | | | | | | | | | | |

NOTE: Numbers in the table indicate months when sampling was conducted (e.g., 4 = April).

[a] Multiple sites were sampled in Aimaokatalok Lake.

[b] In 1996, samples were collected more than once per month.

[c] In 1998, samples were collected twice in June.

# 2 BATHYMETRY

## 2.1 METHODS

In August 1993, cursory bathymetric surveys were conducted in the southern arm of Aimaokatalok Lake and in Stickleback Lake using a Raytheon echosounding chart recorder to record depths and a topographic map for positioning (Rescan 1993). In 1994, a more detailed bathymetric survey was conducted in the mid portion of Aimaokatalok Lake using a differential GPS and a Lowrance depth sounder (Rescan 1994).

## 2.2 SURVEYED LAKES

### 2.2.1 Aimaokatalok Lake

Aimaokatalok Lake lies within an elongated (12 km), narrow (0.5 - 3.0 km), irregularly shaped basin. The lake is part of a glacially scoured river valley, which is confined by a narrow outlet to form the present lake. The total lake area is approximately 25.5 $km^2$. The 1994 bathymetric survey of the middle sections of the lake indicated a maximum depth of 30 m in a confined depression near the centre of the widened channel (Figure 2.1). Depths up to 24 m were recorded at the base of the narrow north arm of the lake. Within the area encompassed by the 1994 survey (22.3 $km^2$ or about 87% of the lake), the estimated water volume was $137 \times 10^6$ $m^3$ and the mean depth was 6.1 m. The south arm of the lake (west of Stickleback Lake) was surveyed in 1993, indicating a shallower basin with a maximum depth of approximately 12 m (Figure 2.2).

### 2.2.2 Stickleback Lake

Stickleback Lake is a small, oval shaped lake, slightly elongated along its north-south axis (1.0 x 1.4 km). The total lake area is approximately 1.0 $km^2$. The 1993 bathymetric survey indicated a maximum depth of 3 m in a small area near the northeast arm of the lake (Figure 2.2). The remainder of the lake featured a consistently flat bottom between 2 and 3 m in depth and steep slopes along the shoreline, especially on the east side of the lake.

### 2.2.3 Fickle Duck Lake

Fickle Duck Lake is a small, oval-shaped lake, elongated along its north-south axis (0.5 x 1.5 km). The total lake area is approximately 0.5 $km^2$. It has a fairly flat bottom, approximately 2 m in depth (Rescan 1994); however, a systematic bathymetric survey of this lake has not been carried out.