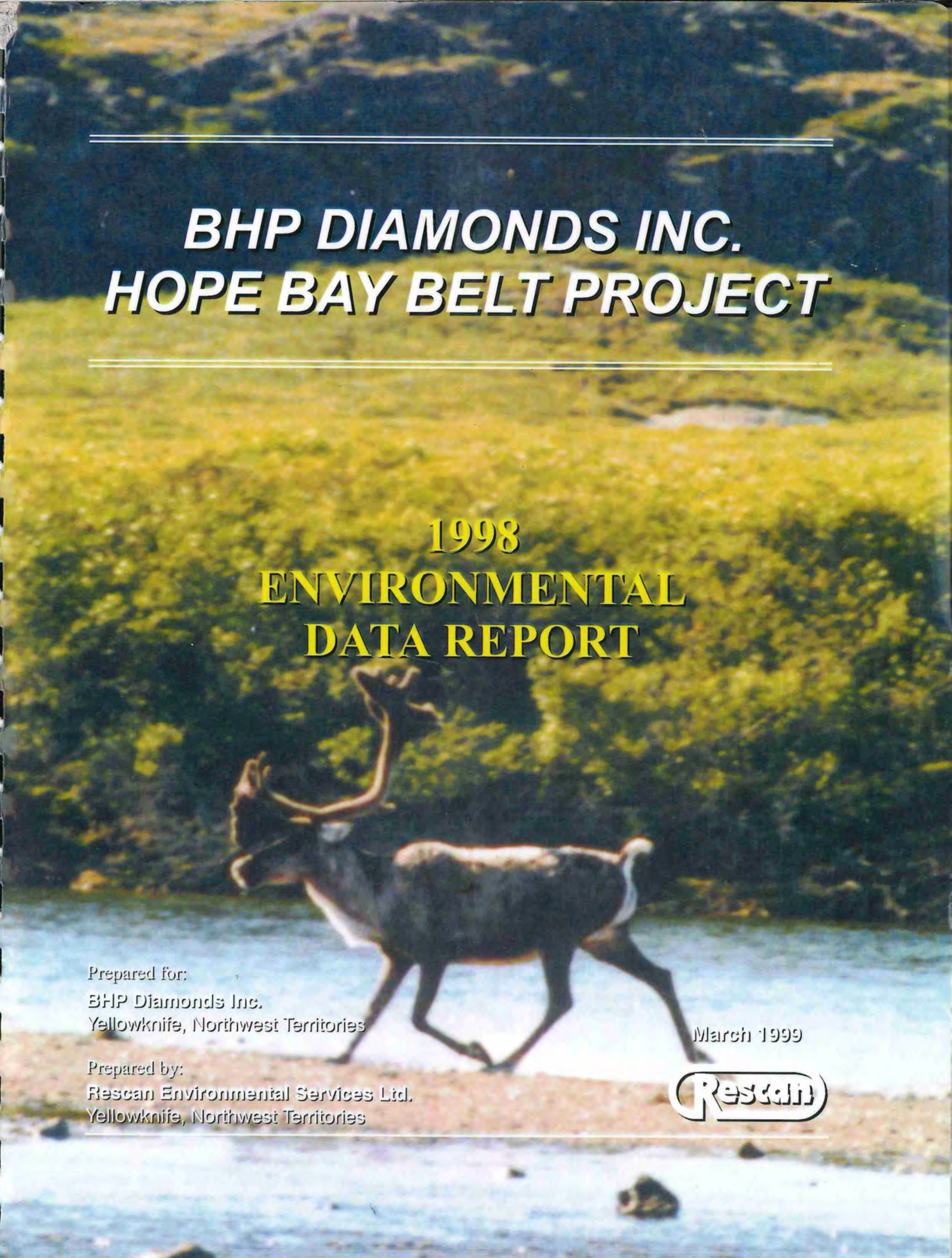
Appendix V5-4E

Hope Bay Belt Project: 1998 Environmental Data Report



BHP DIAMONDS INC.
HOPE BAY BELT PROJECT

1998 ENVIRONMENTAL DATA REPORT

Prepared for:
BHP Diamonds Inc.
Yellowknife, Northwest Territories

March 1999

Prepared by:
Rescan Environmental Services Ltd.
Yellowknife, Northwest Territories

Rescan

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Executive Summary

EXECUTIVE SUMMARY

The 1998 program of work for BHP at the Hope Bay Belt represented a continuation of environmental baseline studies carried out at the Boston Property from 1993 to 1997 and at the Doris Lake Property from 1995 to 1997. However, the program was reduced to match the changing levels of exploration activity as the BHP operations moved from active exploration during the months of February to June to a care and maintenance phase beginning in early June and extending through to the present.

The following summary highlights the results of the 1998 environmental baseline studies program.

Meteorology

Results from the 1998 climatological monitoring program at Windy Lake camp and Boston Property indicate that the temperatures and rainfall during this "El Niño" year were similar to regional stations operated by Environment Canada Atmospheric Environment Service (AES). The mean monthly temperatures for the Boston automated weather station were below freezing for eight of the 12 months that were included in the period of record. The extreme minimum and maximum air temperatures were –44.3 and 27.7°C (February 19 and July 8, 1998, respectively) for the available period of record.

Environment Canada reported that the spring and summer of 1998 were the warmest on record and warmest in 51 years since comparable nationwide temperature records began in 1948.

As in 1997, precipitation during the month of August (51.2 mm for the first 20 days) comprised a large proportion of the estimated mean annual precipitation (200 mm) for the Boston site. From historical data it is expected that over half of the mean annual precipitation falls as rain. This is consistent with data collected at the nearest regional AES stations (Cambridge Bay Airport and Contwoyto Lake; Lupin).

Wind speeds and direction patterns at the Boston automated weather station during 1998 were similar to those in previous years, with the predominant wind direction being from the north and northwest. Calm conditions (*i.e.*, hourly average wind speeds less than 1.0 m/s) were infrequent, occurring only 7% of the time. The maximum instantaneous wind speed for the period of record was 22.7 m/s (81.7 km/h on October 14, 1998).

Class A pan evaporation was monitored at Boston Camp for a portion of the 1998 open water season. The Class A pan evaporation rate was 187.5 mm for an 46-day period of record. However, the evaporation data were not considered to be representative of the 1998 conditions because of the short period of record, the number of days with missing data and animals drinking from the pan. Due to these deficiencies, the 1998 Class A pan evaporation data at Boston were not used to estimate an open water evaporation rate. The closest Class A evaporation pan to the Boston Camp is located at the BHP Ekati Diamond Mine on Polar Lake. The Class A pan evaporation rate at Polar Lake was 439 mm for a 115 day period of record (*i.e.* May 26 to September 25, 1998). The daily evaporation rates are higher at Polar Lake because it experiences warmer temperature from more intense incoming solar radiation. The nearest Environment Canada Atmospheric Environment Service station which has collected evaporation data is Yellowknife airport located approximately 730 km south. However, monitoring of the Class A evaporation pan at Yellowknife was discontinued in 1997 when the weather station was decommissioned. Future monitoring of evaporation rates in the Hope Bay Belt area will provide valuable data for comparison with the 1998 data.

Hydrology

In 1998, the hydrological baseline monitoring program included automated monitoring of stream flows at four sites, including two in the north part of the study area at the outlets of Ogama and Glen lakes. The two automated hydrology stations in the southern portion of the project area were located on the Aimaoktak River upstream of Aimaoktak Lake and at the outflow of Stickleback Lake. Water levels were also monitored periodically at Trout Outflow, Northeast Inflow into Aimaoktak Lake, Aimaoktak Lake Outflow and the Boston Reference Stream.

Data collection began in late May/early June, during the freshet period. Data collected were consistent and compared favorably between site catchments. In the streams monitored, ice break-up commenced on June 9,1998 and maximum daily flows were subsequently recorded on June 10, 1998.

The 1998 annual runoff of streams that were monitored in the project area was slightly above the long-term average. However, the inter annual comparison (*i.e.* 1996 vs. 1997 vs. 1998) of mean flows did not provide any definite trends because of the varying lengths of data records and data sets that included only a portion of freshet flows. Above average temperatures in spring 1998 were the result of a particularly strong "El Nino" year and contributed to an early snowmelt. Due to a shortened monitoring period the recorded minimum flows did not necessarily correspond with annual minimum flows. For the past three years of monitoring the minimum flows were highest in 1998 at Aimaoktak River and Glen Outflow but only second highest at Stickleback and Doris Outflows. The hydrological monitoring program ended on August 21, 1998 before the occurrence of late summer rainstorms, therefore, rainstorm generated peaks were not recorded. The 1998 annual runoff calculated for Aimaoktak River and Stickleback Outflow were 135 and 111 mm, respectively.

Water Quality

Water quality data obtained in lakes and streams in the Boston and Doris Property areas during the 1998 sampling program showed that concentrations of most parameters analyzed remained within the ranges expected for pristine northern aquatic environments. Waters in streams and lakes were generally clear, near or slightly below neutral pH, soft, had low nutrient concentrations and had very low concentrations of most metals of environmental concern. Water quality in Hope Bay and Roberts Bay was typical of similar near-shore, non-polluted marine environments, with low dissolved metal concentrations.

Most metals of environmental concern exist at very low levels in both streams and lakes. Total concentrations of cadmium, chromium, silver, arsenic, lead and mercury were in general low, with values close to or below detection limit at most sites. By comparison with federal water quality guidelines for freshwater aquatic life (CCREM, 1995), total concentrations of some metals (aluminum, copper, chromium and iron) exceeded guidelines, particularly in lake samples collected under ice cover (April).

Water quality sampling of the Koignuk River, which was undertaken in 1998, showed that the pH of the river was slightly acidic during both sampling periods and total metal concentrations were generally low. In most cases, metal concentrations were well below their CCREM criteria. The only metal to exceed the guideline value in both sampling periods was aluminum. The other metals that exceeded their respective CCREM criteria on one occasion (June) were chromium, copper and iron.

Most metals of environmental concern at marine sites in Roberts Bay and Hope Bay were found at concentrations close to or below detection limits. Dissolved concentrations of chromium, cadmium, lead, nickel *etc.*, at both sites were all very low, and typical of other pristine marine arctic environments.

Sediments

Sediment sampling in 1998 was limited to four lakes at the Boston Property and a few marine sites in Hope Bay and Roberts Bay. The samples were examined for physical properties including texture, approximate grain size and color.

The sediment samples from the Boston Property lakes consisted of fine to medium sands, occasionally mixed with clay, with a yellowish orange/brown to olive brown surface horizon and gray to olive gray coloration below the surface layer.

The Hope Bay and Roberts Bay sediments ranged from homogenous clay, clay mixed with sand to homogenous sand and most were a light to moderate olive brown color in the surface layer and medium to dark gray in the subsurface sediments.

Physical Characteristics

Dissolved oxygen/temperature profiles and Secchi depths were measured at lakes within both the Boston and Doris properties in 1998, at three stations in Hope Bay and at five stations in Roberts Bay. Under ice dissolved oxygen/temperature profiles were measured at selected lakes within the Boston and Doris properties during the winter of 1998.

Inverse stratification (colder water temperatures in surface waters) was present for all lakes measured during the winter (April) of 1998. Shallow water temperatures were slightly above 0°C. Bottom water temperatures were at approximately 2.0°C in all of the lakes measured. During the winter at the Boston Property, shallow water dissolved oxygen concentrations were greater in Aimaoktak Lake compared to Boston Reference Lake, but the bottom water at Aimaoktak Lake approached 2.0 mg/L. Similar results were seen at some of the Doris Property lakes, with bottom waters at Windy and Doris approaching 2.0 mg/L at the water-sediment interface.

During July of 1998, all of the shallow lakes at the Boston Property had homogenous water columns. Only Aimaoktak Lake, with a maximum depth of 29 metres, had limited thermal stratification. However, water column dissolved oxygen concentrations at Aimaoktak Lake remained fairly uniform with depth at approximately 10.5 mg/L.

The Hope Bay and Roberts Bay stations recorded variable temperatures and high levels of dissolved oxygen and all were influenced to varying degrees by distance from inflowing rivers or streams.

Primary Producers

Both lake primary producers (phytoplankton) and stream primary producers (periphyton) were examined in Boston Property waters in July of 1998.

During the July sampling period Boston Reference Lake exhibited the greatest abundance of phytoplankton and highest biomass concentrations of any of the lakes sampled. Cyanophyta were the predominant phytoplankton organisms in all lakes except Stickleback Lake where Chrysophyta were predominant. All lakes sampled exhibited a high diversity but the assemblage from Boston Reference Lake was the least diverse.

Samples for periphyton taxonomic analysis and enumeration were collected once and for periphyton biomass twice from Boston Property streams. Periphyton biomass concentrations were greatest in the NE inflow of Aimaoktak Lake compared to other streams and biomass concentrations were similar among the other Boston Property streams. Periphyton densities were higher at NE Aimaoktak Inflow, Trout Outflow and the Aimaoktak River than at other streams sampled. Cyanophyta predominated the assemblages at all stream sites and the Aimaoktak River had the highest diversity among the streams sampled.

Secondary Producers

Zooplankton, lake benthos, larval drift and stream benthos were examined once during the 1998 open water season at Boston Property lakes and marine benthos were sampled at Hope Bay and Roberts Bay.

Stickleback Lake exhibited the highest abundance of zooplankton and Boston Reference Lake the lowest abundance of zooplankton compared to the other lakes sampled. Zooplankton abundance at Aimaoktak Lake varied between stations. Cyclopoid copepods were predominant in Aimaoktak Lake, while rotifers dominated the assemblages in the other Boston Property lakes sampled. Aimaoktak and Trout lakes had the highest zooplankton diversity and Stickleback Lake exhibited the lowest diversity.

Stickleback and Aimaoktak lakes had the greatest densities of benthos in the shallow zone and the deep zone of Aimaoktak Lake at 29 m had the lowest diversity of benthos. Diptera, Annelida and Mollusca comprised the main components of the lake benthos in all lakes sampled. Benthos diversity was generally highest in the shallow communities and lowest in the deepest communities.

All Boston Property streams sampled for larval drift were found to have similar abundances of drift organisms. Diptera were the most prevalent organisms at all sampling locations and times, and all communities exhibited high diversity index values, with the most diverse community occurring in the NE Aimaoktak Inflow.

Stream benthos densities were similar at most sites except for the Aimaoktak River site which recorded the lowest benthos density. The most common benthic organisms found were Diptera, Ostracoda and Mollusca. Aimaoktak River and the NE Aimaoktak Inflow exhibited the greatest diversity of dipteran stream benthos communities.

Marine benthos density was similar at all three Hope Bay sites and the highest benthos density was found at the deepest site in Roberts Bay. Nematoda and Polychaeta were the dominant benthos organisms found at all marine stations sampled.

Fish Communities

Pelvic Lake

In August, 1998, a synoptic fish community survey was conducted in Pelvic Lake and a stream fish survey and habitat inventory were conducted in the Koignuk River on the Doris Property of the Hope Bay Belt area.

Pelvic Lake is located 5 km west of the Doris Lake exploration zone. Morphologically, this lake resembles the other lakes of the Doris Property survey conducted in 1997. Primarily because Pelvic Lake is not adjacent to any of the exploration zones, it was selected to serve as the regional reference lake for both the Doris and Boston properties.

Pelvic Lake was surveyed using index gill nets for a period of three continuous days. Survey effort was dispersed across the length of the lake, sampling a variety of habitat types present. The lake was found to have a fish community comprised primarily of lake cisco, lake trout, and lake whitefish. A total of 390 fishes were captured: 158 lake cisco, 32 lake trout, and 200 lake whitefish. Of these fishes, 3 cisco, 8 trout, and 33 whitefish were marked with red Floy tags. In addition, 21 trout and 22 whitefish were euthanized for the harvest of tissue samples for metals analysis.

The catch per unit effort (CPUE) in Pelvic Lake was high in comparison to other lakes surveyed in the Hope Bay Belt. Lake cisco CPUE was higher than for any other lake surveyed. Lake trout CPUE was higher than for other Doris Property lakes but lower than at Aimaoktak Lake. Lake whitefish CPUE was higher than at any previously surveyed lake. Proportionally, whitefish accounted for the majority of the catch, with cisco representing a smaller proportion, followed by lake trout. When biomass is considered, whitefish comprised just less than half the catch, trout accounted for slightly less biomass than whitefish, and cisco contributed much less.

With respect to mean size of the catch, Pelvic Lake cisco were on average smaller than those captured in other Doris Property lakes but larger than Aimaoktak Lake cisco. Pelvic Lake trout were larger than Windy and Aimaoktak trout but smaller than Doris and Patch lake fish. Lake whitefish from Pelvic Lake were smaller than at all other lakes.

Sufficient numbers of lake cisco, lake trout and, and lake whitefish were captured to permit analysis of data towards describing the energy stores, growth, and age structure of the fish populations.

Koignuk River

The Koignuk River receives the outflow of the Aimaoktak Lake watershed and eventually discharges north into Hope Bay of Melville Sound. BHP has proposed to construct a winter road along a portion of the river to provide seasonal access and supply to the Hope Bay Belt properties from a future port at Roberts Bay.

The Koignuk River has also been identified as a traditional source of fish for people living in the area. Because of these factors, a synoptic fisheries survey and a habitat survey were conducted to provide site characterization information of the Koignuk River prior to future project development.

The habitat of the Koignuk River was surveyed and inventoried in August. A 25.5 km section of the Koignuk River was surveyed from the estuary at Hope Bay to a point approximately two thirds of the distance to the Aimaoktak Lake watershed outflow. For the entire surveyed length, the Koignuk River channel is bound to the west by a diabase ridge. Intermittent diabase outcrops also bound the east bank of the river. Together, these outcrops serve to confine the river to a narrow flood plain. The surveyed section was found to consist of three reaches with a fourth unsurveyed reach above.

In addition to the habitat inventory a stream fisheries survey was conducted in the Koignuk River to determine which species of fish were present in the river. In particular, to determine whether Arctic char used the river. During the synoptic habitat survey the river was assessed for the presence of the habitat components necessary to support an Arctic char population. Migration barriers and connections to overwintering lakes were recorded and assessed. Based on these observations, six synoptic survey locations were selected for gill net, angling, and snorkel surveys.

The habitat inventory resulted in the identification of two definite barriers to fish migrations: a five metre waterfall at Km 18. 5 and a ten metre waterfall at Km 23.8. Because these structures pose a barrier to migration within the river, only the major tributaries below the first waterfall were assessed. The results were that none of the three tributaries investigated provided migration routes to the connecting lakes. It was therefore determined that if the Koignuk River supported a char population, it would probably be a river resident population, similar to that found further west in the Tree River, Nunavut Territory.

The stream fisheries survey determined that the Koignuk River had a fish community that includes Arctic grayling, Greenland cod, lake trout, lake whitefish, ninespine stickleback, and slimy sculpin. The habitat provided by the river is classic grayling habitat and has resulted in a dense population of grayling, especially below channel constrictions. The lake trout population is likely derived from fish that wash downstream from lakes. Trout will often venture into rivers and streams. It is possible that the population below the waterfalls is self-sustaining. The presence of these large fish indicates that there is abundant overwintering habitat in the river.

The results of the survey leads to the conclusion that it is unlikely that there is a population of Arctic char using the Koignuk River. The waterfalls at Km 18.5 provide a definite barrier to migration, cutting off any possible migration routes to the lakes above. The tributary streams below these falls do not have sufficient depth or flow to provide migration routes to the adjoining lakes. Therefore, if Arctic char were using the river, the char would have to have a river-based life history, similar to the population inhabiting the Tree River. However, no char were captured or observed during the fisheries survey. Also, although char were observed in or staging in the sea off the mouths of several rivers both east and west along the coast, none were observed in or near-shore to the Koignuk River. Therefore, although char were migrating through nearby rivers, none were moving through the Koignuk River. It was therefore concluded that char do not use the Koignuk River either as a migration route or for overwintering and spawning.

Wildlife Resources

Baseline studies of wildlife resources in the Hope Bay Belt area, Nunavut, were continued during 1998. Goals were to describe the community of terrestrial wildlife and birds, and wildlife habitat present in the area, with a focus on the Boston Property area. Specific objectives were to identify species which used the area, and assess their relative abundance, temporal and spatial changes in use of the area, and to evaluate the relative importance of different habitat types to different species and over time.

Survey components included aerial surveys for ungulates, aerial and ground surveys for carnivores, an aerial survey for nesting raptors, a breeding bird census, and aerial and ground surveys for waterfowl.

Seven aerial ungulate surveys were conducted between February 28 and December 3. The total number of caribou observed on transect ranged from zero to 2,680. On-transect caribou density ranged from 0 to 3.97 caribou/km^2. Caribou density was generally higher in the southern portion of the survey area. Caribou calved within the survey area in 1998; the highest concentrations, however, were observed in the post-calving period. During the February survey, all caribou observed on transect were from mainland herds; most of these animals were concentrated in the southern portion of the survey area. In December, all observed caribou were from Victoria Island and these animals were concentrated in the central to northern portion of the survey area.

The total number of muskoxen observed on transect ranged from 11 to 78; on-transect density ranged from 0.02 to 0.12/km^2. Calves were observed on all surveys. Muskoxen were also most prevalent in the southern portion of the survey area.

No recent grizzly bear dens were found in the study area in 1998. There were, however, several observations of bears. Six radiocollared bears used areas on the east side of Bathurst Inlet in 1998, and 3 of these used portions of the Hope Bay Belt. Wolves were occasionally observed during 1998, but no evidence of successful breeding was detected.

During a survey for raptor nests in July, a total of 44 raptor observations was made. Twenty-nine of these included active nests. Species recorded were gyrfalcon, peregrine, rough-legged hawk, and golden eagle. The study area provides important nesting habitat for each of these species, particularly in the northern portion near the coast. In addition to these species, common ravens also occur and nest within the study area.

Thirteen breeding bird census plots were surveyed. Twenty-nine species were identified, nearly twice the total for 1997, and a total of 1,156 birds was counted on plot. Shrub habitats supported the highest density of birds, and most of the nests that were found. Surveys for waterfowl identified 10 species, plus sandhill cranes. Canada geese were the most commonly observed. Few waterfowl broods were observed. White-fronted geese, tundra swans, and Pacific loons were also widely distributed and common.

Acknowledgements

ACKNOWLEDGEMENTS

The logistic demands of this project were considerable, but were greatly facilitated by the efforts of Lauren Anonby, Dave Clark, Chris Hanks, and Jeremy Howe.

Personnel who assisted in the field, cheerfully and competently, with various components of the 1998 baseline program included Ron Bjorge, Martina Kapolak, George Keyok, Clarence Klengenberg, Noah Kuptana, Anthony Okpatauyak, John Paczkowski, George Panegyuk, Saundi Stevens, and Joseph Tikhak. The pilots of Great Slave Helicopters provided skillful and courteous service.

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HOPE BAY BELT PROJECT

1998 ENVIRONMENTAL DATA REPORT

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1. Introduction

1. INTRODUCTION

In May of 1998, BHP Minerals Canada Inc. amalgamated with BHP Diamonds Inc., and assumed ownership of the Boston and Doris Lake gold properties in the Hope Bay Belt area located near Omingmaktok, Nunavut. Prior to this time, and dating back to 1993, BHP Minerals had managed the environmental baseline study program developed to generate a comprehensive database, including biophysical, socio-economic, heritage and cultural information needed for exploration and future development approvals.

The BHP Hope Bay Belt Project includes the Boston Property, the Doris Lake Property, the Madrid Property, the proposed Roberts Bay port site, Hope Bay, and a winter trail corridor connecting these areas. This report presents the data generated in the 1998 environmental surveys. The location of the Hope Bay Belt Project is shown in Figure 1-1. Figure 1-2 is an overview map which indicates the lakes and marine areas that were studied in 1998 for the Hope Bay Belt area.

The 1998 program of work represented a continuation of the environmental baseline studies carried out at the Boston Property from 1993 to 1997 and at Doris Lake from 1995 to 1997. The 1998 program was reduced, however, to match a decrease in exploration activity as the BHP operations moved from active exploration during the months from February to June, to a care and maintenance phase that began in early June and extends through to the present time.

The disciplinary studies included in the 1998 program were meteorology, hydrology, surface water quality, sediment quality, acid rock drainage characterization (ABA and kinetic testing), primary producers in lakes (phytoplankton) and streams (periphyton), secondary producers (zooplankton, lake benthos, larval drift and stream benthos), fisheries (community structure) limited marine sampling and wildlife. No archaeological work was conducted during the 1999 season.

The results of the ARD characterization are reported separately in Rescan, 1999. All other study results are presented in the following chapters and appendices.

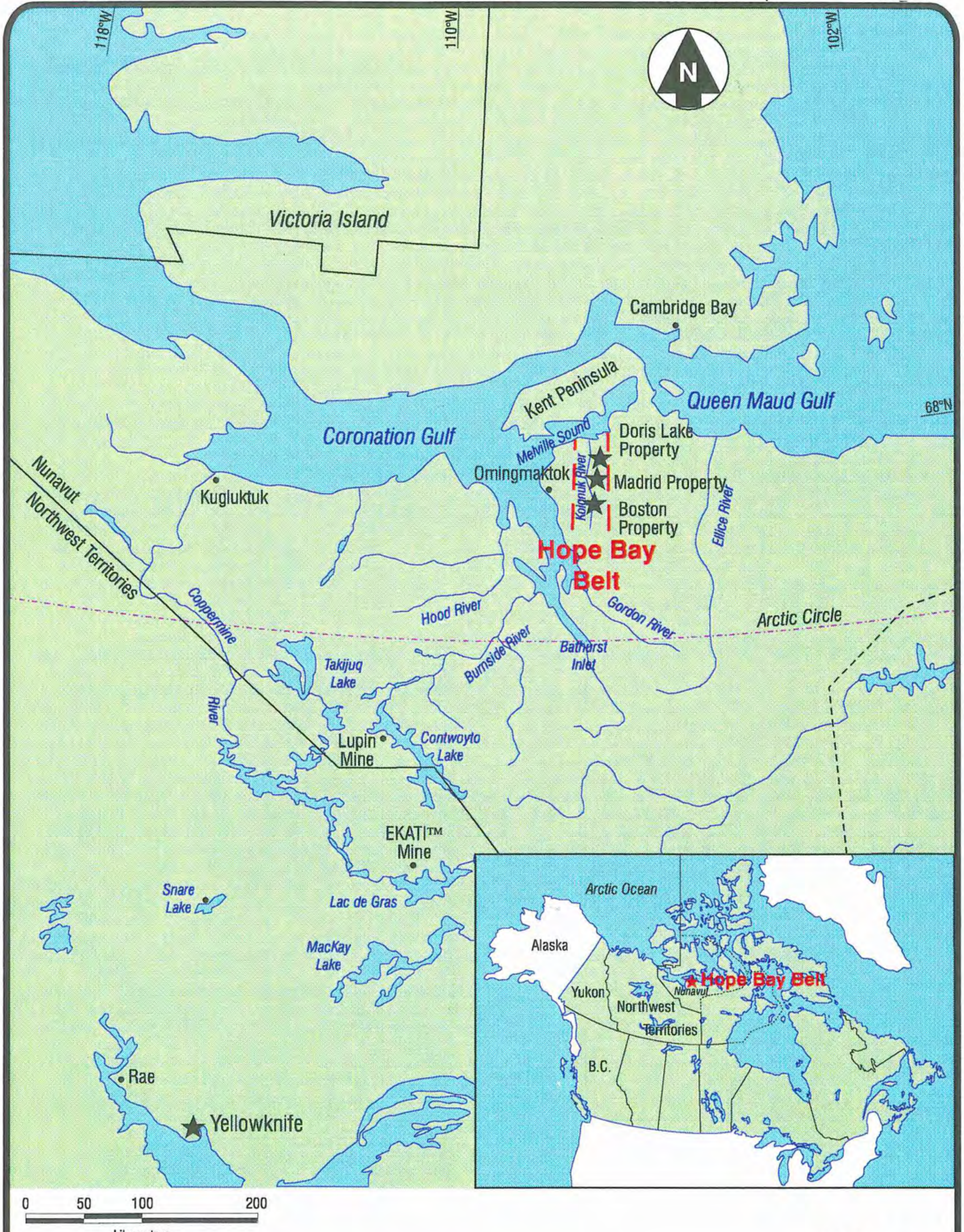

FIGURE 1-1

Project Location Map

BHP

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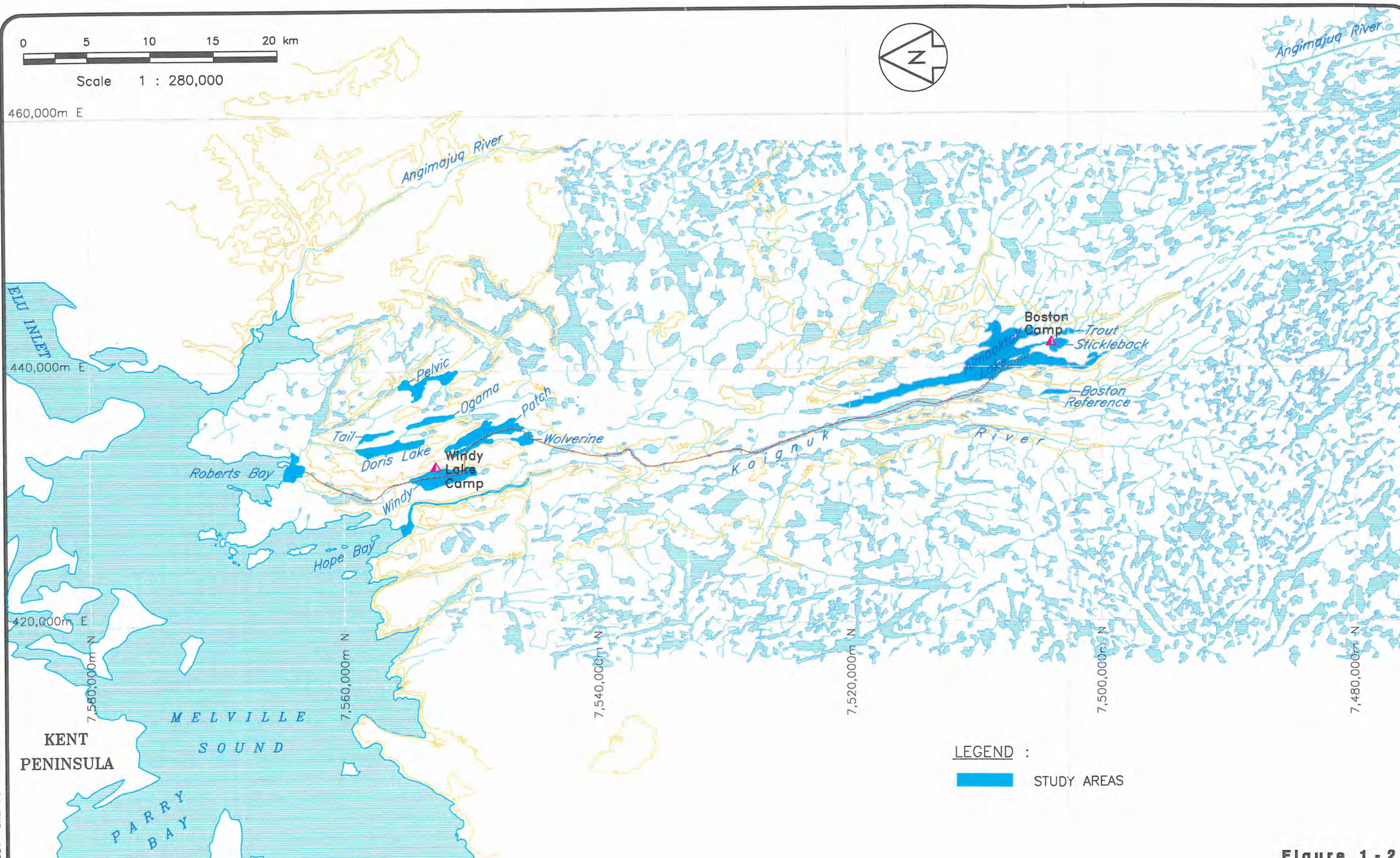

Figure 1 - 2

Locations of 1998 Study Lakes and Marine Areas, Hope Bay Belt

BHP Rescan

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2. Meteorology

2. METEOROLOGY

The 1998 climatological monitoring program for the Hope Bay Belt area consisted of the operation of automated weather stations at the Boston Property and Roberts Bay, a Class A evaporation pan at the Boston Property, and a semi-automatic datalogger at the Windy Lake camp. Few climatological data were available from the Windy Lake exploration camp due to its early closure during 1998 open water season. A description of the monitoring methods, setting, results and discussion follows.

2.1 Methods and Setting

An automated weather station has been in continuous operation at the Boston Property since July 1993. The weather station utilizes a Campbell Scientific CR10 datalogger and includes a tipping bucket rain gauge, temperature and relative humidity sensor, ultrasonic snow depth gauge, and wind monitor (direction and speed). The station is powered by two 12 V deep cycle marine batteries that are recharged by a 30 W solar panel. The sensors are read at five-second intervals. Hourly and daily averages are saved to the final storage of the datalogger and transferred to a data storage module.

Data collection continued in 1998 at the weather station and the data storage module was downloaded on several occasions (February 27, April 19, May 28, June 26, July 30 and August 21) and checked to ensure that all of the sensors were working properly. The sensors were maintained and re-calibrated, as necessary. The temperature, relative humidity and snow depth sensors were out of service from September 12/97 to October 7/97 (26 days). The wind monitor was out of service from September 12/97 to March 27/98 (197 days). The available data were added to the existing database and augmented by data collected from regional stations.

During the mid-June visit, a manual rain gauge and maximum-minimum thermometer were re-installed near the Boston camp. Data collected daily from these instruments were used to verify the data collected by the automated station. The semi-automatic weather station located at Windy Lake monitored the following parameters once per day; air temperature, relative humidity, approximate wind speed and direction.

An automated weather station was also installed at Roberts Bay, the potential port site, to obtain wind loading data for port design (Plate 2.1-1). The weather station was equipped with sensors mounted on a 3 m tripod tower that monitored wind direction and speed with the same logging interval and power supply equipment as the Boston Camp station. The Roberts Bay station was installed to monitor wind during the open water season. The station was installed on June 3, 1998 and decommissioned on December 1, 1998.

Due to the consistency of the regional topography, data collected at the Boston weather station are considered representative of the climatological conditions for the Doris Lake Project, the road corridor and the Roberts Bay areas.

A Class A evaporation pan was installed at the beginning of the ice-free period of 1998 (June 17th) at the Boston exploration camp (Plate 2.1-2). The pan was moved to Boston from Windy Lake in 1997 due to the higher likelihood that a future tailings impoundment would be constructed at the outflow of Stickleback Lake near the Boston camp rather than at Windy Lake. The hook gauge for the evaporation pan was read daily along with precipitation from a manual rain gauge and daily maximum and minimum temperatures. An on-site technician was trained in early June, 1998 to collect data from the manual climate monitoring instruments.

The manually operated Nipher shielded snow gauge that was located near the Windy Lake Camp during 1997 was moved to Boston camp in June 1998. The snow gauge has been used in the past to measure snowfall once a day. The snow collected in the copper cylinder is melted and the resulting volume of water is measured in units of millimetres of water equivalent. Unfortunately Nipher snow gauge data are not available for 1998 because the on site staff did not monitor it on a daily basis and the camp was not operational during the winter months.

To obtain the requisite verification of the on-site data for a potential future environmental impact statement, the climatological databases for the Boston and Doris Lake projects have been augmented with data collected by Environment

Plate 2.1-1 The automated weather station installed at Roberts Bay was in operation from June 3 to December 1, 1998 (181 days). The wind data will be used for potential future port design.

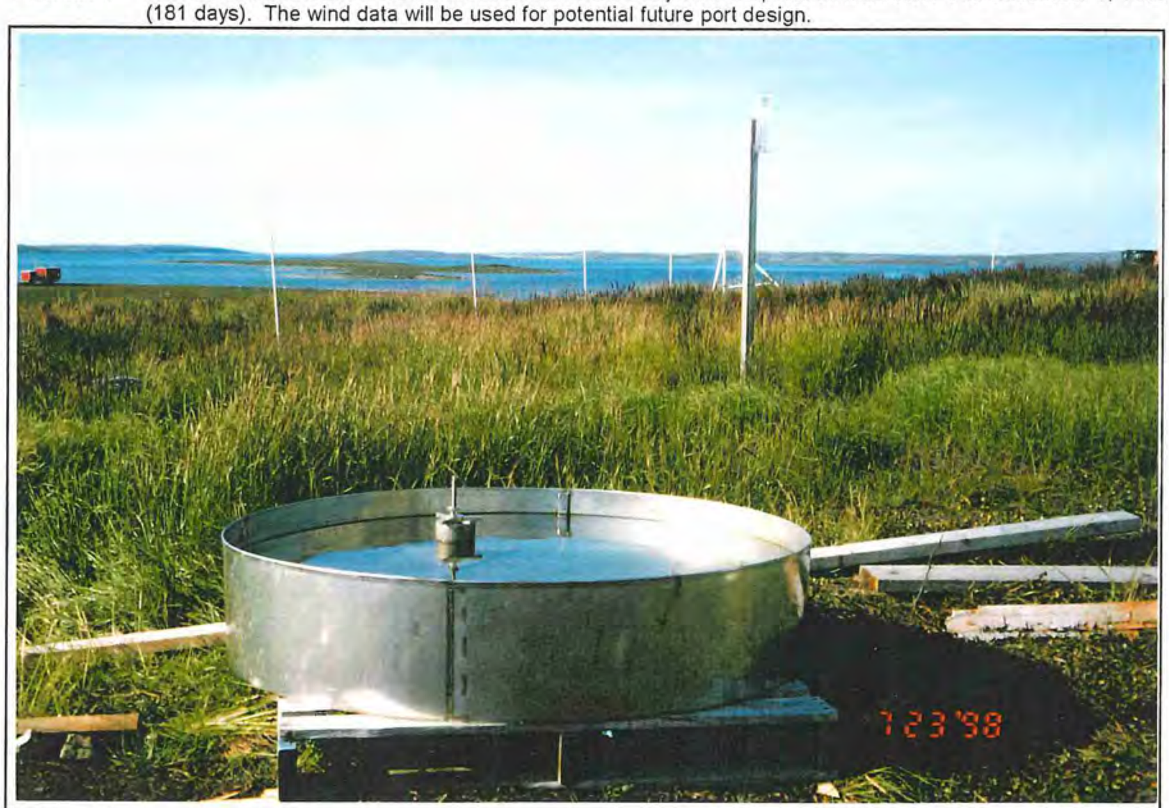

Plate 2.1-2 A Class A Evaporation pan was installed at the Boston exploration camp to monitor evaporation. The hook gauge and stilling well can be seen in the middle of the pan. The instrument required daily supervision and was only read when the camp was occupied. Daily rainfall data from the manual rain gauge (behind and to the right of the pan) are also required for evaporation calculations.

FIGURE 2.1-1

BHP

Location of Regional Climate Stations

Rescan

Canada Atmospheric Environment Service (AES). The locations of the regional AES weather stations are indicated on Figure 2.1-1. The locations of the automated weather stations at Boston, Roberts Bay and the manual climate monitoring instruments at the Windy Lake and Boston Exploration camps are indicated on Figure 3.1-2 that appears in the next chapter.

2.2 Results

Results of the 1998 baseline study for air temperature, precipitation, wind speed and direction, and evaporation are presented and general comparisons to previous years and regional data have been made.

2.2.1 Air Temperature

The nearest regional AES climatological stations are located at Cambridge Bay Airport, Echo Bay Mine (Lupin), and Lady Franklin Point Airport. The Boston Property automated weather station had similar monthly mean temperatures for the period of record (September 10, 1997 to August 21, 1998) to all three of the regional AES stations (Table 2.2-1 and Figure 2.2-1).

Monthly average temperatures for 1997-1998 at the Boston Property were slightly warmer than Cambridge Bay. The differences in mean monthly air temperatures for the four stations were greater during the summer months than fall and winter. The daily mean air temperatures from the Boston automated weather station are summarized in Appendix 2-1.

The mean annual temperature calculated for the Boston weather station (September 1997 to August 1998) was –10.2°C. The mean annual temperature calculated for Cambridge Bay was –13.2°C (July 1997 to June 1998). Cambridge Bay has historically recorded a lower mean annual temperature compared to the Boston station. The mean annual temperature calculated for Lupin was –8.7°C (July 1997 to June 1998). In the previous year the mean annual temperature at Lupin was slightly cooler than at Boston camp, so this year may be an exception. The mean annual air temperature at Lady Franklin Point Airport was calculated to be –9.9°C (September 1997 to August 1998). The mean annual temperature at Lady Franklin Airport has in the past been slightly cooler than Boston camp, so once again this year seems to be an exception.

The extreme hourly average maximum and minimum air temperatures logged at the Boston weather station for the period of record were 27.7 and -44.3°C (July 8 and February 19, 1998, respectively). The maximum and minimum daily air temperature data collected manually by personnel at the Boston camp (June 17, 1998 to August 12, 1998) were in agreement with data collected by the Boston Property automated weather station. The daily temperatures collected at the Windy Lake semi-automatic weather station were consistent with the data collected at the Boston automated station.

Overall the trend for air temperatures in Northwest Territories and Canada has been a gradual increase. Environment Canada reported that the summer of 1998 was the warmest on record. This summer ranks as the warmest in 51 years. A large portion of Northern Canada experienced temperatures more than 2°C above normal. Spring 1998 was also the warmest on record and warmest in 51 years since comparable nationwide temperature records began in 1948 (Environment Canada 1998b).

Table 2.2-1
Average Monthly Temperature (°C)
at Boston Camp and Regional AES Stations

Month	Boston Camp	Cambridge Bay Airport[5]	Echo Bay Mine (Lupin)[5]	Lady Franklin Point Airport[5]
September 1997	3.7[1]	-0.7	4.7	2.2
October	-13.2[2]	-12.6	-10.6	-9.7
November	-15.8	-18.7	-15.1	-13.0
December	-25.3	-27.1	-23.0	-23.3
January 1998	-32.9	-35.3	-33.4	-31.4
February	-29.6	-33.7	-25.6	-28.4
March	-24.4	-26.8	-22.1	-23.5
April	-12.8	-17.1	-10.7	-13.7
May	-4.2	-6.5	-0.4	-3.7
June	6.3	4.7	8.3	4.6
July	13.4	n/a	n/a	10.8
August	12.2[3]	n/a	n/a	10.5
12 month mean (Sept. 97 to Aug. 98)	**-10.2**	**-13.2[4]**	**-8.7[4]**	**-9.9**

1: Data available only for September 1 to 12.
2: Data available only for October 7 to 31.
3: Data available only for August 1 to 21.
4: 12 Month mean was calculated from July 1997 to June 1998.
5: Source Environment Canada 1998a.
Note: n/a = not available.

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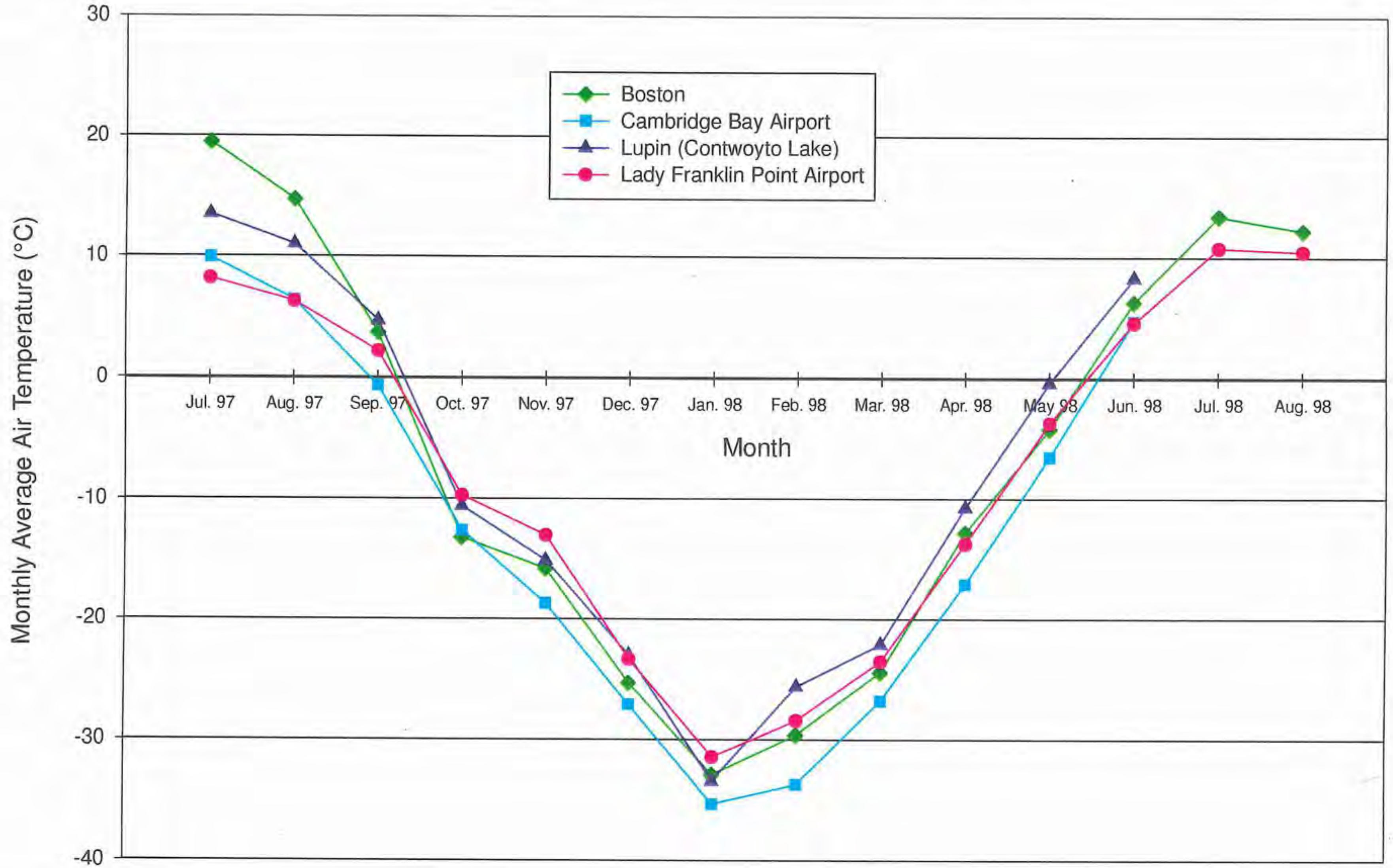


FIGURE 2.2-1

Monthly Average Air Temperatures for Boston Property and Regional AES Stations 1997-98

BHP   Rescan

2.2.2 Precipitation

Precipitation occurs every month of the year although it is often higher during the late summer to early winter period. Precipitation was monitored at three different sites in the Hope Bay Belt area. However, the Nipher shielded snow gauge was moved from Windy Lake camp to Boston camp in June 1998. The instrument measures snow-water equivalent precipitation when the camp is occupied. The Nipher snow gauge was not monitored in 1998 because either snowfall did not occur, or personnel at the Boston exploration camp were unavailable. A manual rain gauge was installed at the Boston Property in mid-June where the monitoring continued until mid-September. This manual rain gauge served two purposes. Firstly, it was installed near the Class A evaporation pan to provide data for calculation of daily evaporation rates. Secondly, it provided validation of the data collected by the tipping bucket rain gauge at the Boston automated weather station. The tipping bucket rain gauge recorded one-minute rainfall data during periods of rainfall. The period of record for the Boston automated weather station was September 1, 1997 to August 21, 1998.

The results of the 1998 total precipitation monitoring program are summarized in Table 2.2-2. For 1998 the fall coincided with the highest monthly precipitation rates recorded by the Boston Project manual rain gauge and regional AES stations.

Data were obtained from the regional AES stations at Cambridge Bay Airport and Echo Bay Mine (Lupin) for comparison with the data collected at the Boston weather station. The historical data, compiled from the Canadian Climate Normals (Environment Canada, 1992) for periods before 1990, indicated that the mean annual precipitation for the Boston project site is approximately 200 mm. This estimate is based on interpolation of data from the nearest regional AES stations. The annual precipitation calculated for the Boston Property for 1997, 133.4 mm, was underestimated because it was not possible to collect snow-water-equivalent data from the Nipher snow gauge during the entire winter. Ideally the Nipher snow gauge should be monitored on a daily basis, however, the Windy Lake camp was not occupied during the majority of the winter months. Similarly, the annual precipitation calculated for the Boston Property for 1998, 189.3 mm, was also underestimated. The monthly total precipitation values reported in Table 2.2-2 for the winter months have been estimated from the snow depth readings recorded by the ultrasonic sensor at the automated weather station.

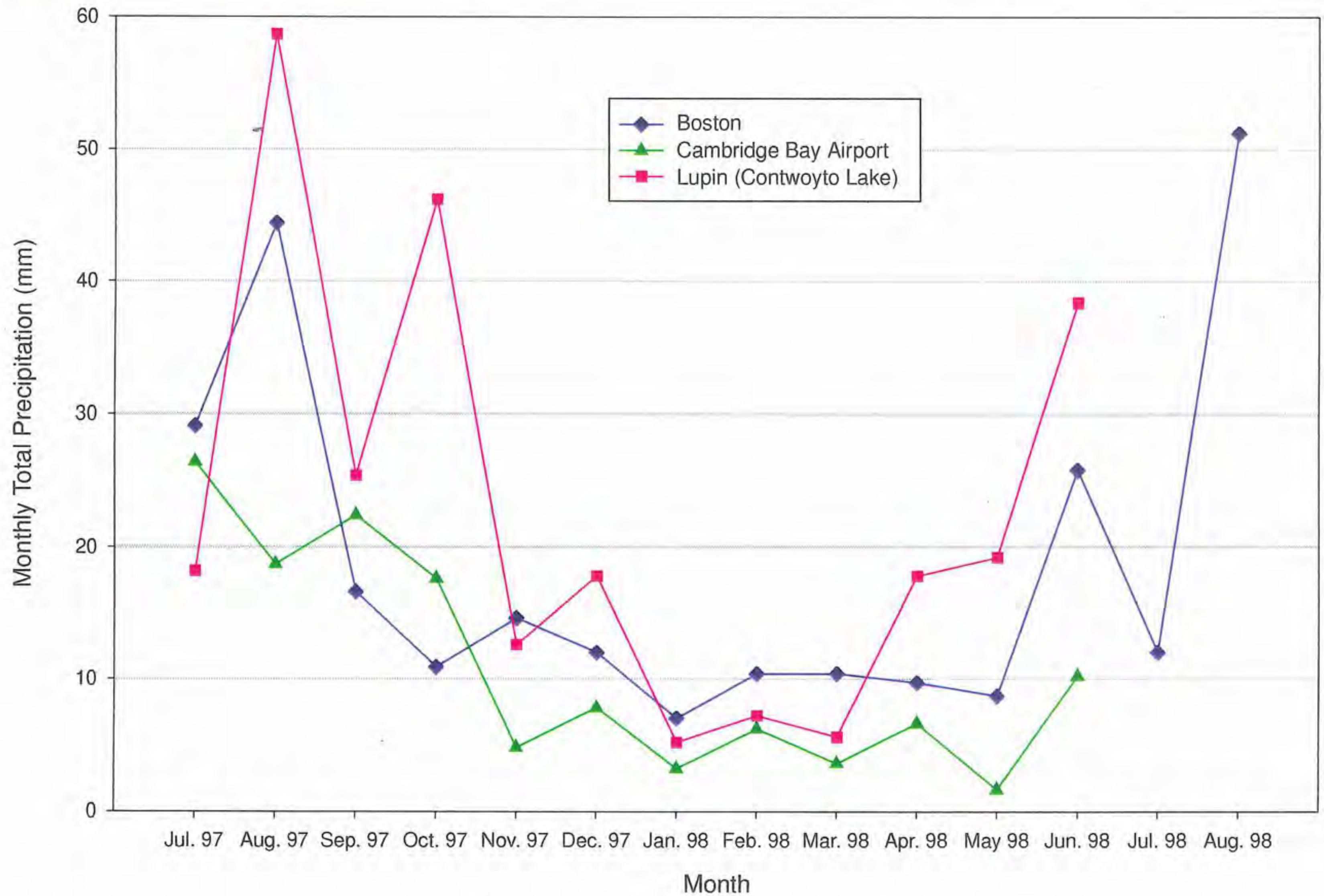
Table 2.2-2
Total Precipitation (mm) at Boston Camp and Regional AES Stations

Month	Boston Camp	Cambridge Bay Airport[4]	Echo Bay Mine (Lupin)[4]
September 1997	16.6[1]	22.4	25.4
October	10.9	17.6	46.2
November	14.6	4.8	12.6
December	12.0	7.8	17.8
January 1998	7.0	3.2	5.2
February	10.4	6.2	7.2
March	10.4	3.6	5.6
April	9.7	6.6	17.8
May	8.7	1.6	19.2
June	25.8	10.2	38.4
July	12.0	n/a	n/a
August	51.2[2]	n/a	n/a
September	n/a	n/a	n/a
Total Annual Precipitation (Sept. 97 to Aug. 98)	**189.3**	**130.1[3]**	**272.2[3]**

1: Data available only for September 1 to 11 for the ultrasonic snow depth sensor.
2: Data available only for August 1 to 20.
3: 12 Month total for July 1997 to June 1998.
4: Source Environment Canada 1998a
Note: n/a = not available.

Continuous precipitation data have not been collected at the Boston Property in the past (*i.e.* continuous Nipher snow gauge data have never been collected) therefore, no direct comparisons of annual precipitation are possible. However, trends in the data have been delineated. August yielded the highest total monthly precipitation. This is consistent with the several years of previous monitoring. In 1997, the trend continued with 33% (44.4 mm) of the total annual precipitation (133.4 mm) at the Boston Property occurring in August. In 1998 approximately 27% (51.2 mm) of the total annual precipitation (189.4 mm) occurred in the first 20 days of August. At all of the regional stations, including the BHP Ekati Diamond Mine located approximately 300 km south of the Hope Bay Belt project, the precipitation from October through April contributed less than 25% to the total annual precipitation. The least amount of precipitation occurred during the winter months as shown in Figure 2.2-2.

The total precipitation recorded by the manual rain gauge at Windy Lake in August, 1996 was 79.2 mm. This is significantly higher than the precipitation recorded in 1997 during the same period, 44.4 mm. The rainfall recorded in



BHP

Monthly Total Precipitation for Boston Property and Regional AES Stations 1997-98

FIGURE 2.2-2

Rescan

August 1995, 18.7 mm, (Klohn-Crippen, 1995) tends to support the opinion that the precipitation in 1996 was unusually high. As previously discussed the total precipitation recorded in August 1998, 51.2 mm, was close to that recorded in 1997 for the same month. Generally, the total precipitation recorded at the regional AES stations agreed with the data collected at the Boston Camp.

As previously discussed, snow-water-equivalent precipitation was calculated from the data collected by the ultrasonic sensor located at the automated weather station. The sensor determines the distance to a target by sending out ultrasonic sound pulses and listening for the echoes returning off the target. The time from transmit to return of the echo is the basis for obtaining the distance measurement. All depth measurements were corrected by subtracting an average depth recorded during the snow-free period, assumed to be July 1 to August 31, 1997. Average snow depth measurements are shown in Figure 2.2-3.

Metcalfe *et. al.* 1994 indicated that measuring snow is much more difficult than rainfall because snow cover has a highly variable temporal and spatial structure related to land cover and terrain and redistribution by wind. In addition, snowfall is difficult to measure because of varying density, significant errors in gauge measurements due to wind, wetting and evaporation losses. Metcalfe *et. al.* 1994 determined that the mean snowfall density for the NWT barrens (east and west of longitude 110°) was approximately 141 kg/m^3. For the Boston automated weather station the depth measurements from the ultrasonic sensor were converted to accumulated snow depths and then based on the typical snow density for the region, 14%, snow-water-equivalents were calculated. The resulting snow-water-equivalents are presented in Table 2.2-3 along with similar data from regional AES stations.

During the months of November through March, the data collected from the ultrasonic sensor indicated that the snow accumulation at the Boston Property was most similar to that recorded at Lupin rather than at Cambridge Bay Airport. This is misleading because the amount of snow accumulation is highly dependent on the location of the ultrasonic sensor. The weather station at Boston Property is situated on a hill near Stickleback River. The area is often swept clear of snow due to strong prevailing winds. This phenomenon may explain the low level of snow precipitation at Boston Property compared to the Lupin station.