Appendix V5-4B

Boston Property N.W.T. Environmental Data Report 1995

BHP World Minerals
Boston Property N.W.T.

ENVIRONMENTAL DATA REPORT 1995

Prepared for:
BHP World Minerals
San Francisco, CA, USA

Prepared by:
Rescan Environmental Services Ltd.
Vancouver, Canada

December 1995

BHP World Minerals
Boston Property N.W.T.

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1.0 Introduction

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1.1 Scope of Work

This report summarizes the results of baseline environmental sampling conducted at the BHP Boston Property, Northwest Territories, in the summer of 1995. Rescan Environmental Services Ltd. carried out this work at the request of BHP World Minerals (BHP) to expand on environmental data collected in 1993 and 1994 (Rescan 1993, 1994). The primary purpose of the 1995 program was to provide sufficient data to support a project description report and ultimately, an Initial Environmental Evaluation regarding the mine site itself and the proposed winter access road, as far as Windy Lake. Other objectives of the study include characterization of existing environmental conditions in order to:

- identify additional data requirements;
- predict potential direct and indirect impacts from mining and associated activities;
- determine appropriate mitigation strategies to avoid or minimize impacts; and
- develop a thorough, cost-effective monitoring program.

The following environmental components were studied; relevant information and data on each is contained within this report:

- meteorology and hydrology;
- water quality;
- abundance and distribution of aquatic resources (algae, zooplankton, benthic invertebrates, fish); and
- wildlife abundance and distribution.

Because mine exploration work in the area has been very limited to date it can be considered that the results of this study represent an estimate of background levels for each of the environmental components.

1.2 Setting

The mine drilling area is located in the Northwest Territories in the Koignuk River watershed (Figure 1-1), approximately 125 km north of the Arctic Circle. The exploration camp is situated near the southern end of Spyder Lake, between Spyder Lake and Stickleback Lake (Figure 1-2). Spyder Lake lies within a north-south, elongated (12 km), narrow (0.5 - 3.0 km), irregularly shaped basin. The lake is part of a glacially scoured river valley system which is confined by a narrow outlet to form the present lake. Physical measurements indicate that the lake is poorly stratified thermally in the summer, with no depletion of dissolved oxygen in near-bottom waters. Stickleback and Trout Lakes are small, oval-shaped, shallow basins with fairly flat bottoms.

The proposed winter road route, extending from the mine site to Roberts Bay, Melville Sound (Figure 1-2), has been sited so that 65% of its length will lie over existing waterbodies to minimize disturbance of the permafrost.

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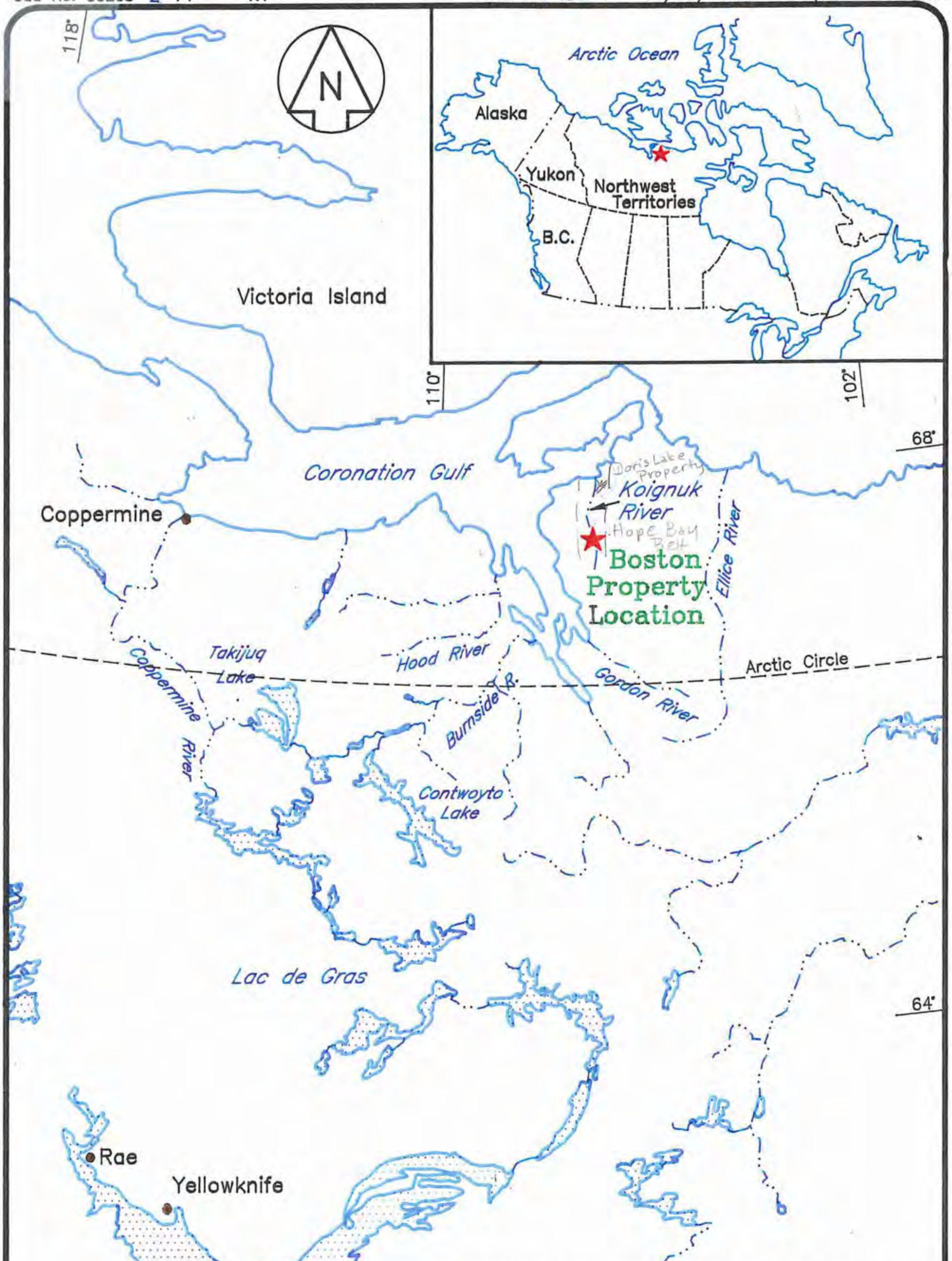

Figure 1-1 : Boston Property Project Location, Northwest Territories

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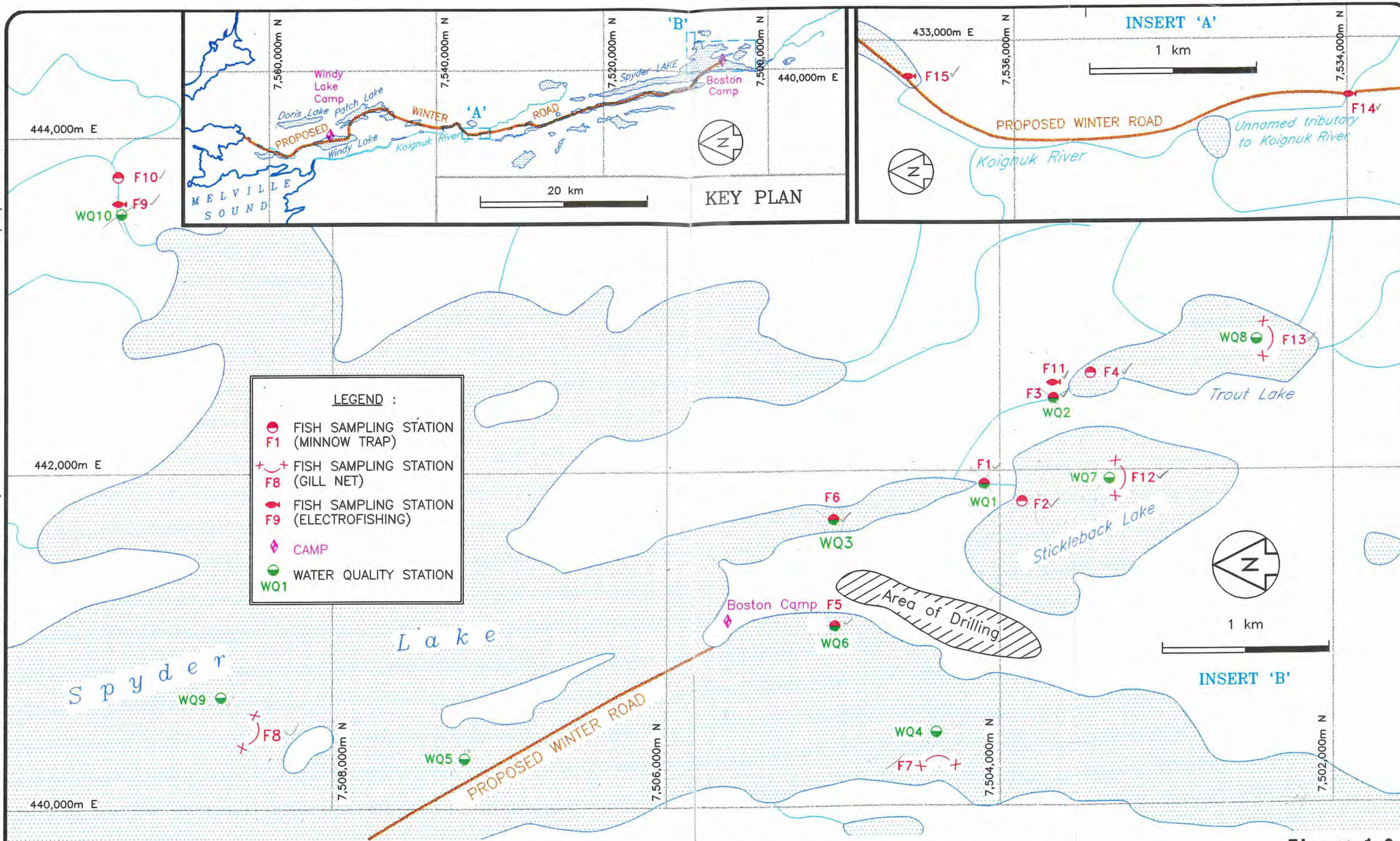

Figure 1-2

BHP Boston Project Site Location, Water Quality and Aquatic Biology Sampling stations, 1995.

2.0 Results of the 1995 Field Program

2.0 RESULTS OF THE 1995 FIELD PROGRAM

2.1 Meteorology

The existing meteorological program at the Boston Property consists of two components: an existing automated station and a manual evaporation pan located at the Windy Lake site, located approximately 48 km north of the Boston Property (Figure 2-1).

The automated weather station datalogger and sensors are mounted on a 10 m aluminum tower. The datalogger is a Campbell Scientific model CR10. There are four sensors mounted on the tower. They include a tipping bucket rain gauge, a temperature/relative humidity probe, an ultrasonic snow depth sensor and a wind monitor which measures wind speed and direction. The station setup is shown on Plate 2-1 and its location is shown on Figure 2-1. All sensors are sampled at five second intervals. The data are processed and written to a storage module every hour and every 24 hours. The station is powered by two 12V batteries which are charged by a solar panel. This power setup permits the station to operate unsupervised through the winter.

The weather station was inspected and downloaded on August 1, 1995. Upon inspection, it was discovered that the cables supplying power to the weather station had been severed, likely by wildlife. Nevertheless, the storage module was downloaded.

The previous download was performed on August 23, 1994. The data record downloaded on August 1, 1995 began on December 26, 1994 and ended on April 11, 1995, likely when the power cables were severed. The data for the available period of record has been plotted and is presented below.

The daily average temperature is plotted (Figure 2-2) for the period from December 27, 1994 to April 10, 1995. The average temperature over the period of record was -27°C. The maximum recorded temperature was -6.6°C and the minimum temperature was -44.3°C.

The daily average relative humidity is plotted in Figure 2-3. The average relative humidity was 68%.

There were no rainfall data collected from the tipping bucket rain gauge. This is expected since the period of record extends from December to April.

The wind data have been plotted in a wind rose (Figure 2-4). The predominant wind direction is from the northeast. The maximum instantaneous wind speed was 90.25 km/hr. The maximum hourly wind speed was 71.50 km/hr from the east.

The average snow depth collected from the ultrasonic snow sensor was 0.02 m. The weather station site is exposed to high winds, therefore, snow does not accumulate for an extended period of time. The maximum depth of snow was 0.08 m.

A Class A evaporation pan was installed at the Windy Lake site since personnel were there for a longer period of time than at the Boston site. The pan and manual rain gauge are shown on Plate 2-2. Data were collected from the evaporation pan installed at Windy Lake from August 5 to September 1, 1995. The total evaporation for this time period was 76 mm or an average evaporation rate of 2.70 mm per day.

2.2 Surface Hydrology

An automated hydrology station was installed on the Spyder River which flows into Spyder Lake. The station is located about three kilometres from the south end of Spyder Lake (Figure 2-1). This station consists of a staff gauge, a 0-5 psi INW pressure transducer and a Terrascience Elf datalogger. The datalogger has been programmed to record the water levels in the river on an hourly basis. Plate 2-3 illustrates the staff gauge and setup of the station. Manual flow measurements were performed in the river on August 2, 1995 and flows of 1.09 m^3/s and 1.10 m^3/s were obtained. These flow measurements are presented in Appendix A.

Surface water discharge measurements were also performed at two of the smaller creeks which flow into Trout and Stickleback lakes. There was no measurable flow rate in either Stickleback Creek or Trout Creek in early August 1995. Plate 2-4 illustrates the dry state of Stickleback Creek on August 2, 1995.

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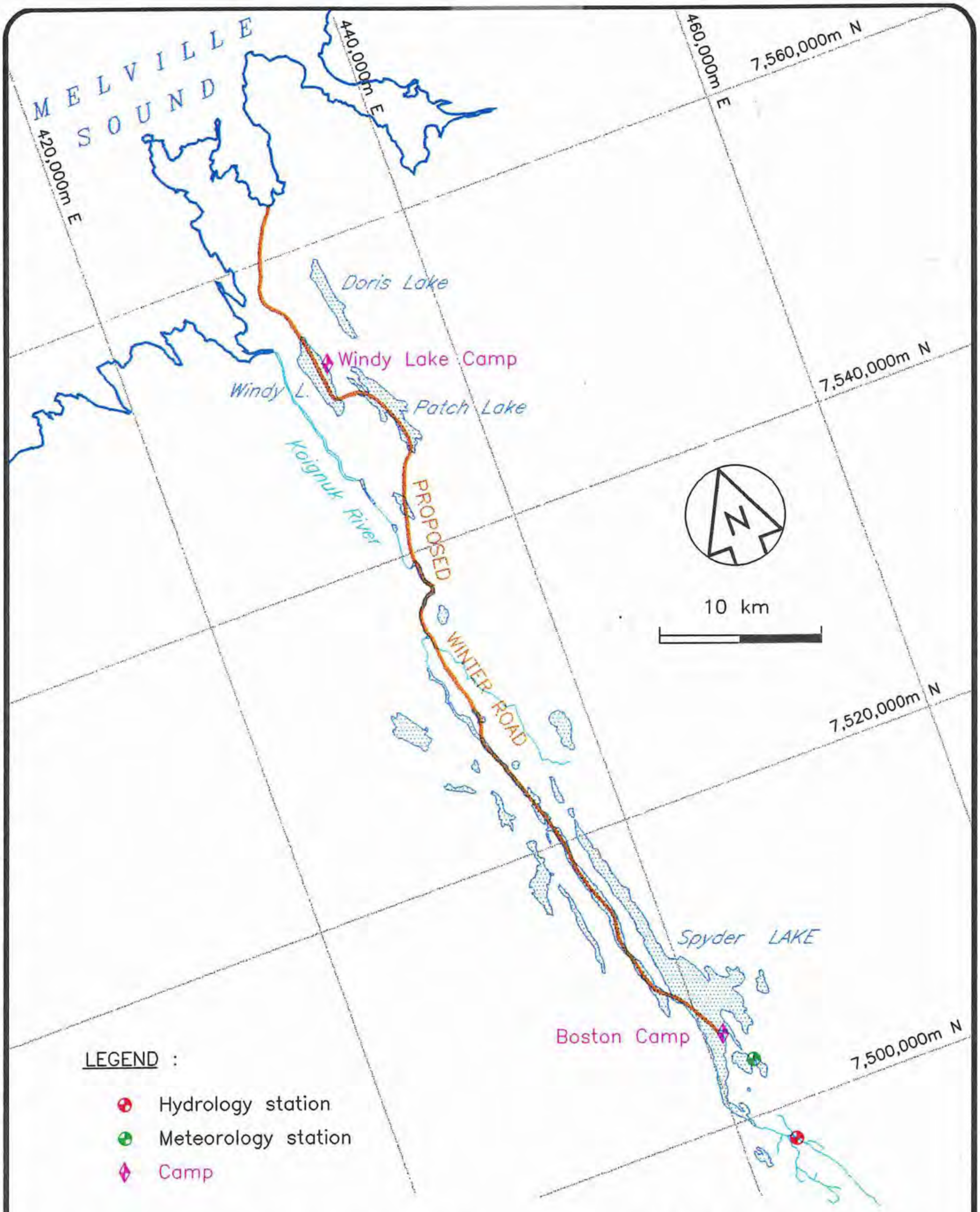

Location of Meteorology Station and Hydrology Station

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Figure 2-1

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Plate 2-1: Weather station near Stickleback Lake.

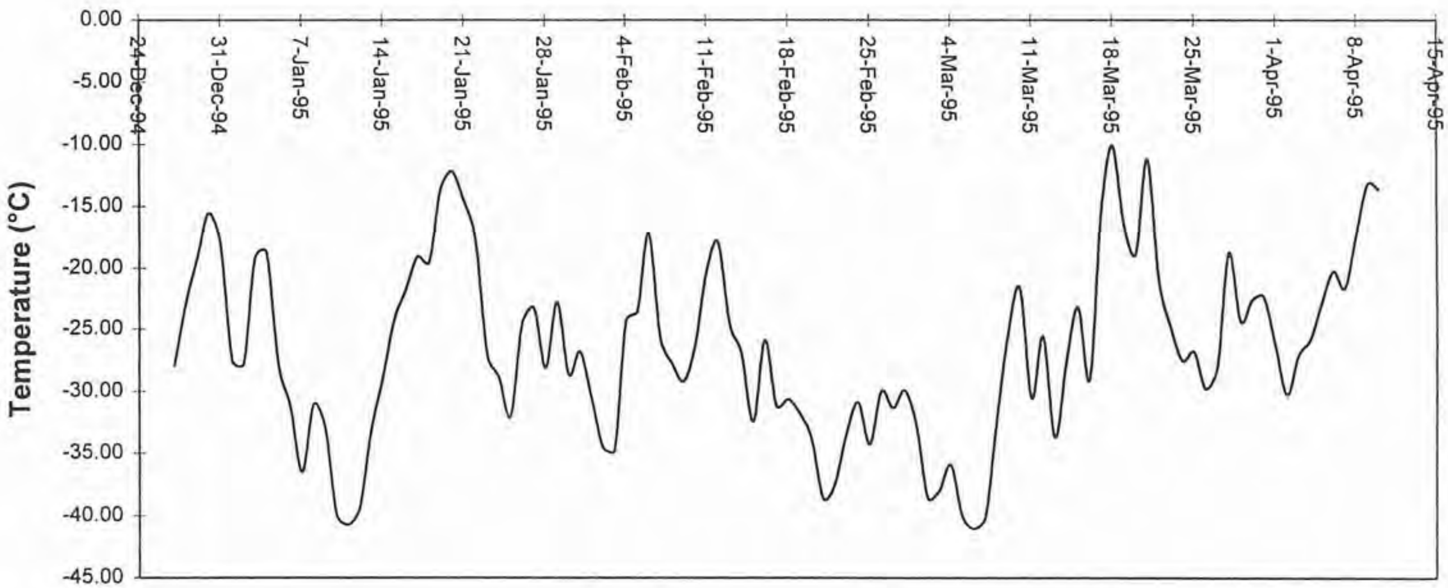

Figure 2-2: BHP Boston Property Daily Average Temperatures - Spyder Lake Meteorology Station

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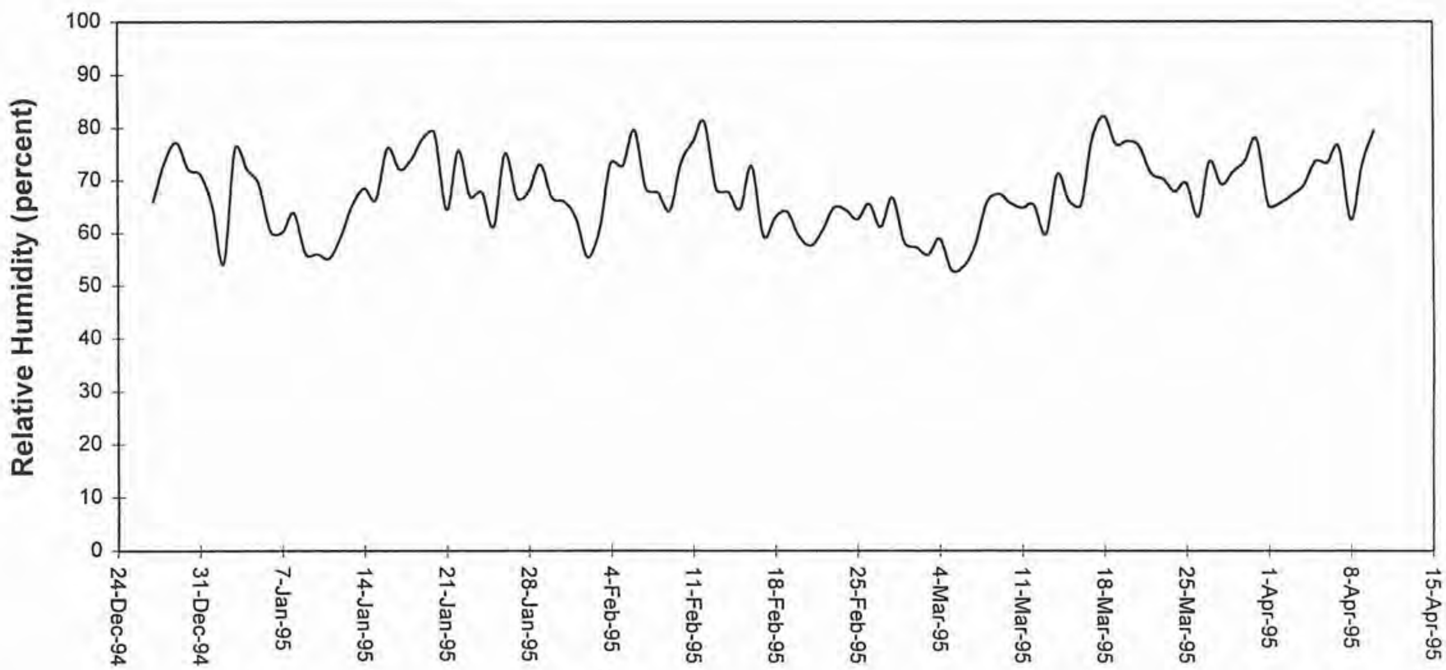
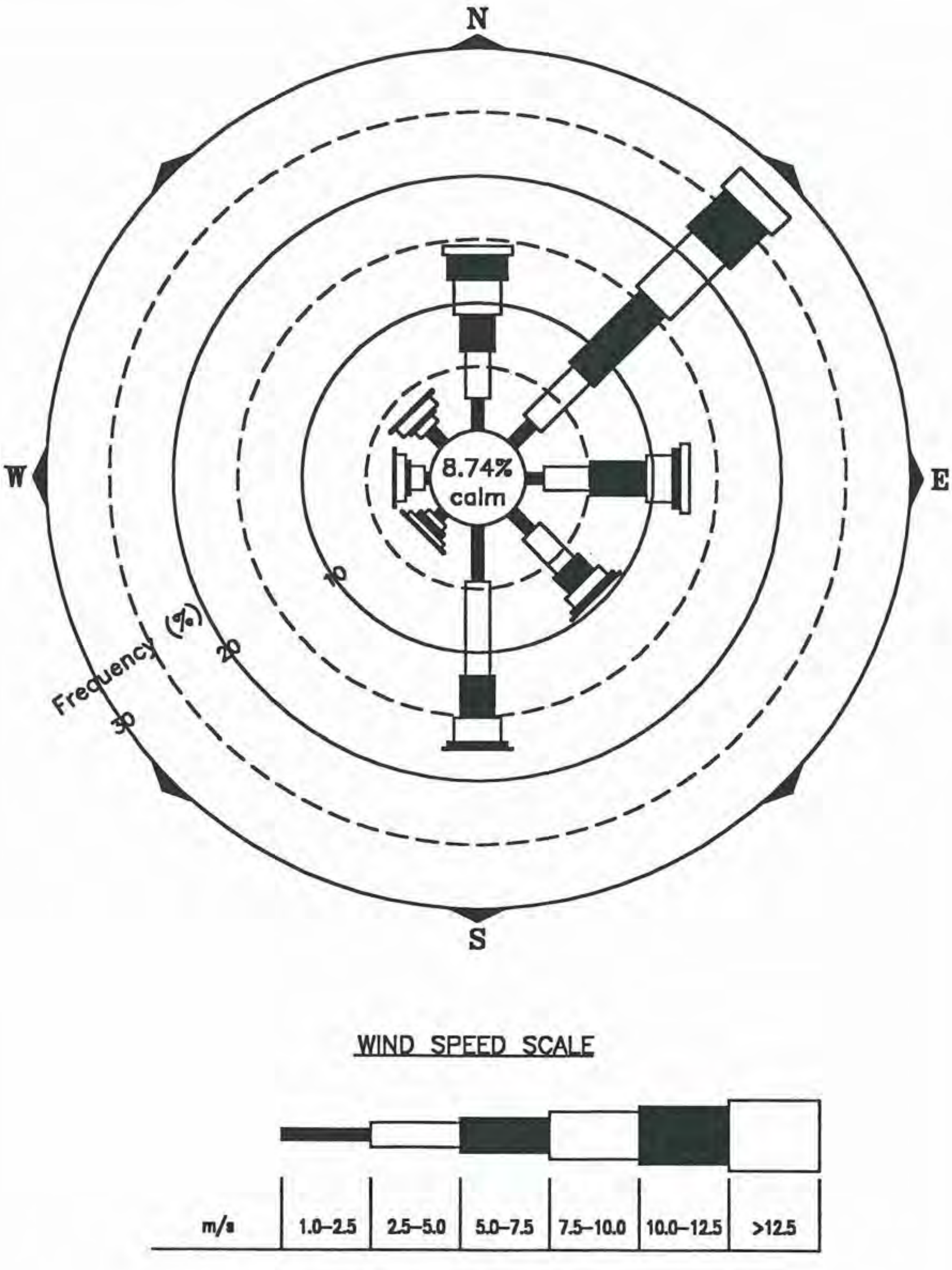


Figure 2-3: BHP Boston Property Daily Average Relative Humidity - Spyder Lake Meteorology Station



Data available from December 26, 1994 to April 11, 1995

Figure 2-4
Wind Rose for Boston Project Weather Station

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Plate 2-2: Evaporation pan near Windy Lake.

Plate 2-3: Hydrology Station on Spyder River.

Plate 2-4: Stickleback Creek.

2.3 Water Quality

2.3.1 Sampling and Analysis Methods

A total of ten sites were sampled for water quality, including three stream sites and seven lake sites (Figure 1-2). Field measurements at each site included temperature, dissolved oxygen (D.O.) and pH. Water quality samples were collected at one depth for stream sites and shallow (<5 m) lake sites and 3-5 depths for deeper lake sites (>5 m).

Water quality samples were collected for chemical analyses using an acid-washed Go-Flo sampling bottle (Plate 2-5). In order to collect a discrete water sample from specific depths, the sampling bottle was lowered to the desired depth with both ends open and was triggered shut using a messenger. Sub-samples were then transferred to labelled plastic bottles, which had been rinsed three times with sample water.

All samples were refrigerated after collection and shipped to Elemental Research Inc. (ERI) in Vancouver where dissolved and total metals, nutrients, physical parameters and chlorophyll were analyzed. Water quality analyses performed on the samples employed procedures described in "Standard Methods for the Examination of Water and Wastewater" (American Public Health Association 1993). Table 2-1 lists the parameters that were analyzed for each of the samples and, where appropriate, the analytical detection limits.

2.3.2 Water Quality Analysis Results

The 1995 raw water quality data are presented in Appendix B. At the majority of sampling stations, both the total and dissolved metal concentrations were below detection limits except for aluminum, barium, boron, calcium, iron, magnesium, nickel, potassium, sodium and strontium. Manganese and lead were above detection limits for the total metal fraction only. Of these total metals, Al, Fe and Pb were found to be in concentrations which exceed freshwater aquatic life guidelines. Canadian guidelines (CCREM 1993) for total Al (at pH>6.5) is 100 µg/L, Fe is 300 µg/L and Pb is 1 µg/L (at hardness 0-60 mg/L as $CaCO_3$). In 1995, aluminum and iron exceeded these levels in Trout Lake (WQ8), and Trout

Table 2-1

Water Quality Monitoring Parameters and Appropriate Detection Limits

Parameter		Detection Limit (mg/L)
Physical Tests		
pH		N/A
Conductivity		2.0 µmhos/cm
Total Dissolved Solids	(TDS)	1.0
Total Suspended Solids	(TSS)	1.0
Hardness	(As $CaCO_3$)	1.0
Turbidity		0.1 NTU
Alkalinity		1.0
Acidity		1.0
Anions		
Chloride	(Cl^-)	0.5
Fluoride	(F^-)	0.05
Sulphate	(SO_4^{-2})	0.5
Nutrients		
Nitrogen		
Ammonia	(NH_3)	0.020
Nitrate	(NO_3)	0.01
Nitrite	(NO_2)	0.001
Phosphorus		
Total P		0.002
Dissolved P		0.002
Ortho-phosphate		0.002

(continued)

Table 2-1 (completed)

Water Quality Monitoring Parameters and Appropriate Detection Limits

Parameter		Detection Limit (mg/L)
Total and Dissolved Metals		
Aluminum		0.001
Antimony		0.0001
Arsenic	(TDS)	0.001
Barium	(Sb)	0.0006
Beryllium	(As)	0.0005
Bismuth	(Ba)	0.00005
Boron	(Be)	0.001
Cadmium	(Bi)	0.0002
Calcium	(B)	0.01
Chromium	(Cr)	0.0005
Cobalt	(Co)	0.00008
Copper	(Cu)	0.0005
Iron	(Fe)	0.01
Lead	(Pb)	0.0001
Lithium	(Li)	0.001
Magnesium	(Mg)	0.01
Manganese	(Mn)	0.0002
Mercury	(Hg)	0.00005
Molybdenum	(Mo)	0.0001
Nickel	(Ni)	0.0005
Phosphorus	(P)	0.02
Potassium	(K)	0.05
Selenium	(Se)	0.001
Silver	(Ag)	0.00001
Sodium	(KNa)	0.01
Strontium	(Sr)	0.0001
Thallium	Tlv	0.00005
Tin	(Sn)	0.0001
Titanium	(Ti)	0.0005
Tungsten	(W)	0.0001
Vanadium	(V)	0.001
Zinc	(Zn)	0.001

(WQ2) and Spyder (WQ10) streams. Total iron was also in excess of guideline levels at the inlet to Spyder Lake from Trout Lake (WQ3). Total lead concentrations were above guidelines at Spyder Lake at the 5 m depth at three stations (WQ4, 5 and 9) and at Trout Lake (WQ8).

Water quality analyses were also conducted in August 1994, June and August 1993 and August 1992 at some of the sites sampled in 1995. In 1994, total iron was in excess of guideline levels at Stickleback (WQ1) and Trout (WQ2) streams, and total lead was in excess at Stickleback Lake (WQ7). Analyses conducted in 1993 and 1992 had higher detection limits than guideline levels for some of the metals analyzed. Of those analyzed at a lower detection limit, total lead exceeded guidelines at the inlet of Spyder Lake (WQ3) in 1992 and total iron at three sites on Spyder Lake (WQ4, 5 and 6) in June 1993, and at WQ6 in August 1993.

Spyder Lake (WQ5) was sampled at three depths in three consecutives years: 1993, 1994 and 1995. The mean water column concentration for total aluminium and iron differed significantly over this time period (ANOVA, $p \leq 0.05$). Mean total aluminum values were highest in 1994; iron was highest in 1995. These temporal changes are likely due to natural environmental variation, possibly caused by slight differences in suspended solids concentrations.

At lake sites less than 10 m in depth (WQ4, 5, 9 and 8), pH, D.O., temperature and nutrient concentrations were uniform throughout (Figure 2-5). At the deepest site sampled in Spyder Lake (WQ9), a thermocline was observed between 8-9 m (Figure 2-6). Temperature and D.O. values were lower at stream sites than surface lake sites (Table 2-2).

Water temperatures in August 1995 were between 4-7°C lower than when studies were conducted during the same period in 1993 and 1994 probably reflecting annual air temperature variability. D.O. and pH values in 1995 were similar to values determined in previous years.

Surface waters in the vicinity of the Boston Property are generally soft with low conductivity and neutral pH typical of many high-latitude watersheds. The major ion composition is dominated by calcium, sodium and chloride. This suggests that

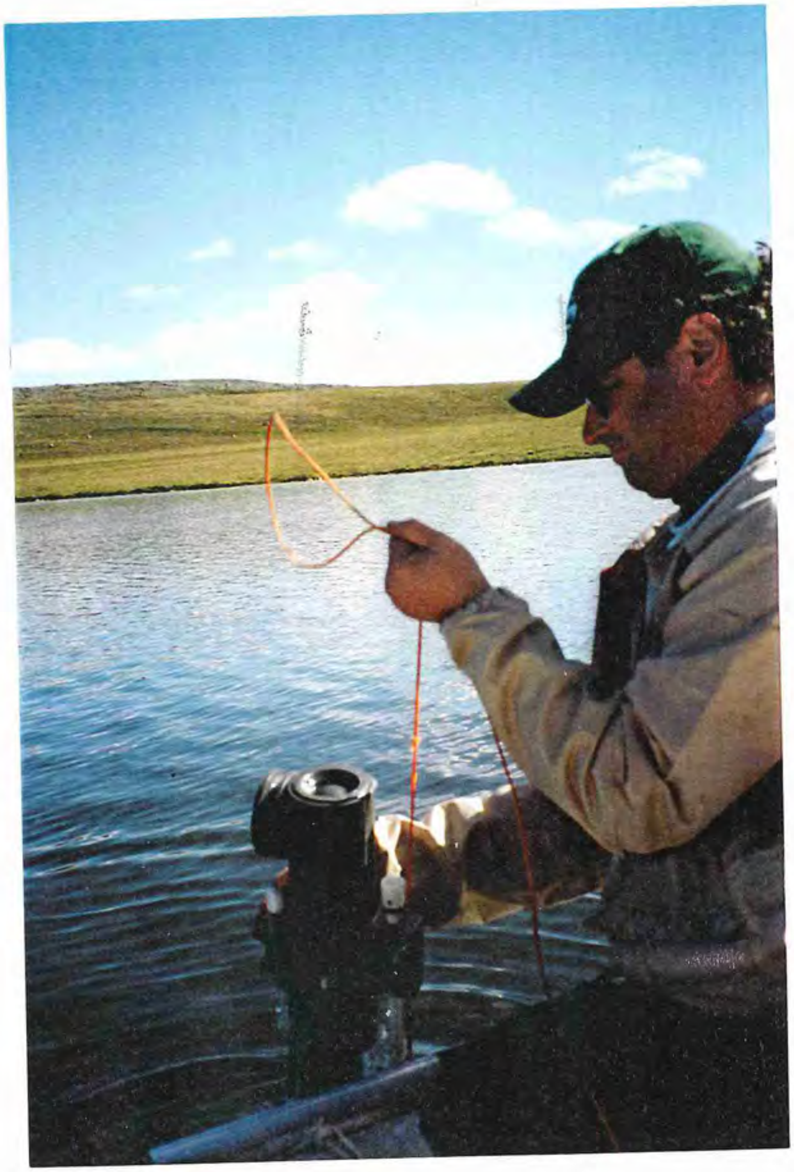

Plate 2-5: A Go-Flo sampling bottle was used in lakes to collect water samples for chemical and biological analyses.

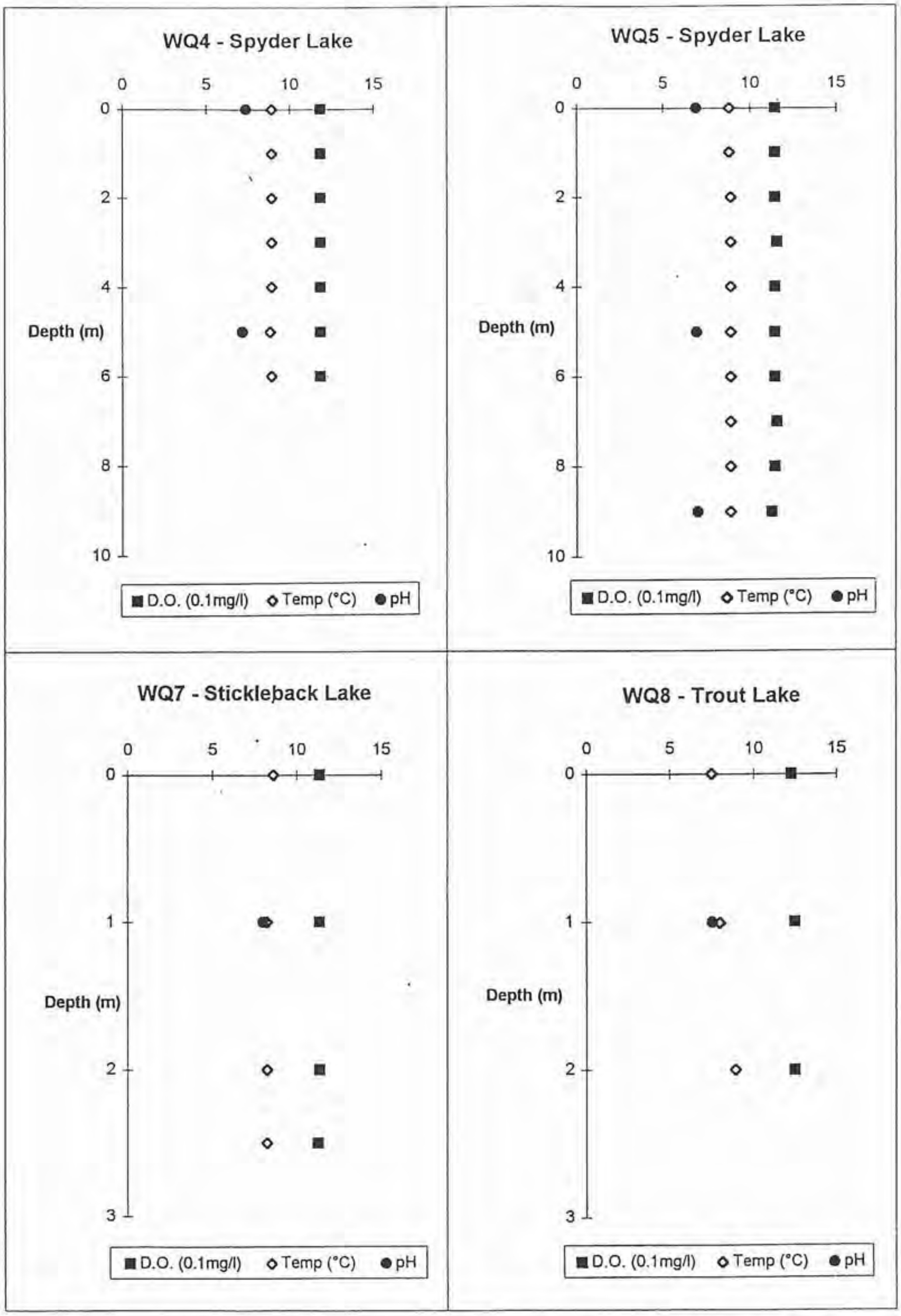

Figure 2-5: Temperature, Dissolved Oxygen and pH Profiles for Shallow Lake Sites (<10 m)

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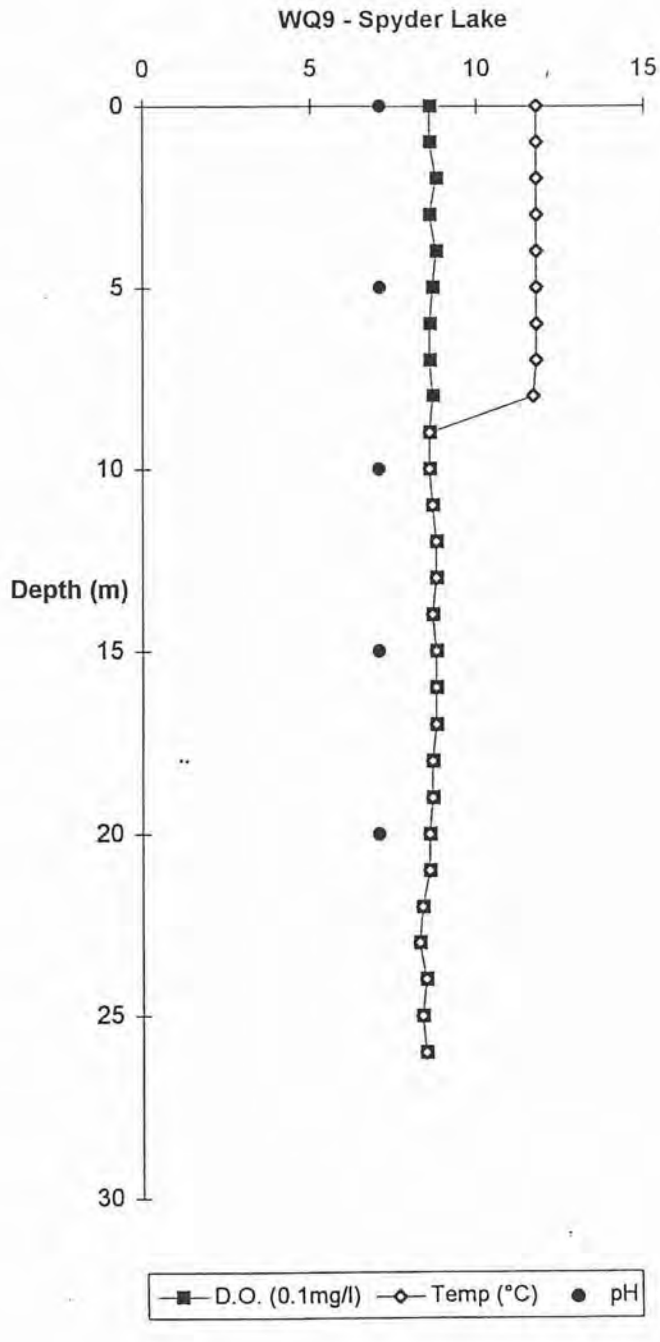

Figure 2-6: Temperature, Dissolved Oxygen and pH Profiles for Spyder Lake (WQ9)

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Table 2-2

Temperature, Dissolved Oxygen and pH for Surface Samples Collected in 1993, 1994 and 1995

Site #	Location	Temperature (°C)			Dissolved Oxygen (0.1mg/L)			pH		
		1993	*1994*	*1995*	*1993*	*1994*	*1995*	*1993*	*1994*	*1995*
WQ1	Stickleback Stream	15.0	14.9	8.0	10.0	9.2	6.3	7.7	8.1	6.9
WQ2	Trout Stream	15.0	12.4	6.0	11.0	8.8	8.2	7.6	6.8	6.7
WQ3	Spyder (inlet from Trout)	14.0	14.2	7.4	11.2	11.0	9.0	7.9	8.2	7.5
WQ4	Spyder (S end)	12.4	13.0	8.9	10.9	10.0	11.8	7.4	6.6	7.3
WQ5	Spyder (NW side)	12.5	13.0	8.8	10.8	8.3	11.4	7.4	6.1	6.9
WQ6	Spyder (drill site)	14.0	12.8	8.5	11.4	10.0	12.2	7.6	8.1	6.4
WQ7	Stickleback Lake	13.6	15.7	8.6	10.8	12.0	11.3	8.5	8.3	7.9
WQ8	Trout Lake	-	13.2	7.5	-	11.0	12.2	-	8.4	7.5
WQ9	Spyder (mid)	-	-	11.8	-	-	8.6	-	-	7.1
WQ10	Spyder Stream (E)	-	-	11.9	-	-	11.9	-	-	7.1

the relative proximity to the ocean, a source of sea-salt aerosols, may be influencing local water chemistry.

Elevated concentrations of total metals are likely due to their association with suspended sediments. As such material is typically dominated by aluminosilicates (*i.e.,* elevated Fe is almost always associated with elevated Al), it has little biological availability.

2.4 Aquatic Ecology

2.4.1 Primary Producers

Studies of primary producers are valuable in aquatic assessments as changes in composition and abundance within communities can be accurate indicators of changes in water quality. The primary producers in streams are the periphyton and in lakes, the phytoplankton.

Sampling and Analytical Methods

At Stickleback (WQ1) and Trout (WQ2) streams, a randomly selected area of colonized rock substrate was sampled *in situ* using a combination syringe-brush to collect two periphyton composites (total area: 9.82 cm^2). Phytoplankton samples were collected using a Go-Flo sample bottle at the surface in Stickleback (WQ7) and Trout (WQ8) lakes, and at the surface and 5 m in Spyder Lake (WQ9). All samples were preserved in Lugol's iodine solution and analyzed for composition and density. Analyses were conducted by Fraser Environmental Services, specialists in the taxonomic identification and enumeration of phytoplankton and periphyton, in accordance with procedures set out in their methods manual (Looy 1994).

Periphyton

Periphyton genera identified for each stream site and their densities (cells/cm^2) are presented in Appendix C. Fifty-six genera were identified from the periphytic community in Stickleback and Trout streams and the dominant taxa were *Lyngbya* (Cyanophyta) and *Stigeoclonium* (Bacillariophyta), respectively.

The periphyton community consisted of three phyla; the cyanophytes and bacillariophytes were dominant, followed by the chlorophytes (Figure 2-7). Trout Stream had the highest density of the two 1995 samples. Comparison of periphyton composition and densities shows a similarity between 1995 Stickleback Stream and 1993 Trout Stream samples but a considerable change in Trout Stream between 1993 and 1995. Annual or seasonal differences in stream periphyton abundance and composition are to be expected due to variation in water temperature, water depth and velocity, and solar radiant energy.

Phytoplankton

Sixty-seven genera from six phyla were identified from lake samples collected in 1995 (Appendix D). The cyanophytes were dominant at all sites except Stickleback Lake (WQ7; Figure 2-8). The remaining phyla were equally represented with the exception of the pyrrophytes.

Stickleback Lake had the lowest density (534 cells/mL). In 1995, the average phytoplankton density was 1,2167 cells/mL which was lower than the average of three samples collected in 1994 (2,283 cells/mL) and one sample collected in 1993 (3,220 cells/mL). However, Spyder Lake (WQ5) was the only site sampled each year and showed varying composition and density (Figure 2-9).

2.4.2 Secondary Producers

Secondary producers are important in lake ecosystems as they are the link between primary producers (periphyton and phytoplankton) and carnivores (invertebrates and fish). The secondary producers in streams are the bottom-dwelling invertebrates, and in lakes they are the zooplankton and benthic invertebrates (benthos). Zooplankton and benthos are aquatic organisms that constitute the animal portion of the pelagic and benthic regions, respectively, in lakes.

Sampling and Analytical Methods

Vertical haul nets were used to sample the entire water column for zooplankton at the deepest part of the lake in Spyder (WQ5), Stickleback (WQ7) and Trout (WQ8) lakes. A 118 μm-mesh net (0.3 m diameter net mouth) was used to collect the samples which were transferred from the cod-end of the net to 500 mL jars and preserved in 10% buffered formalin.

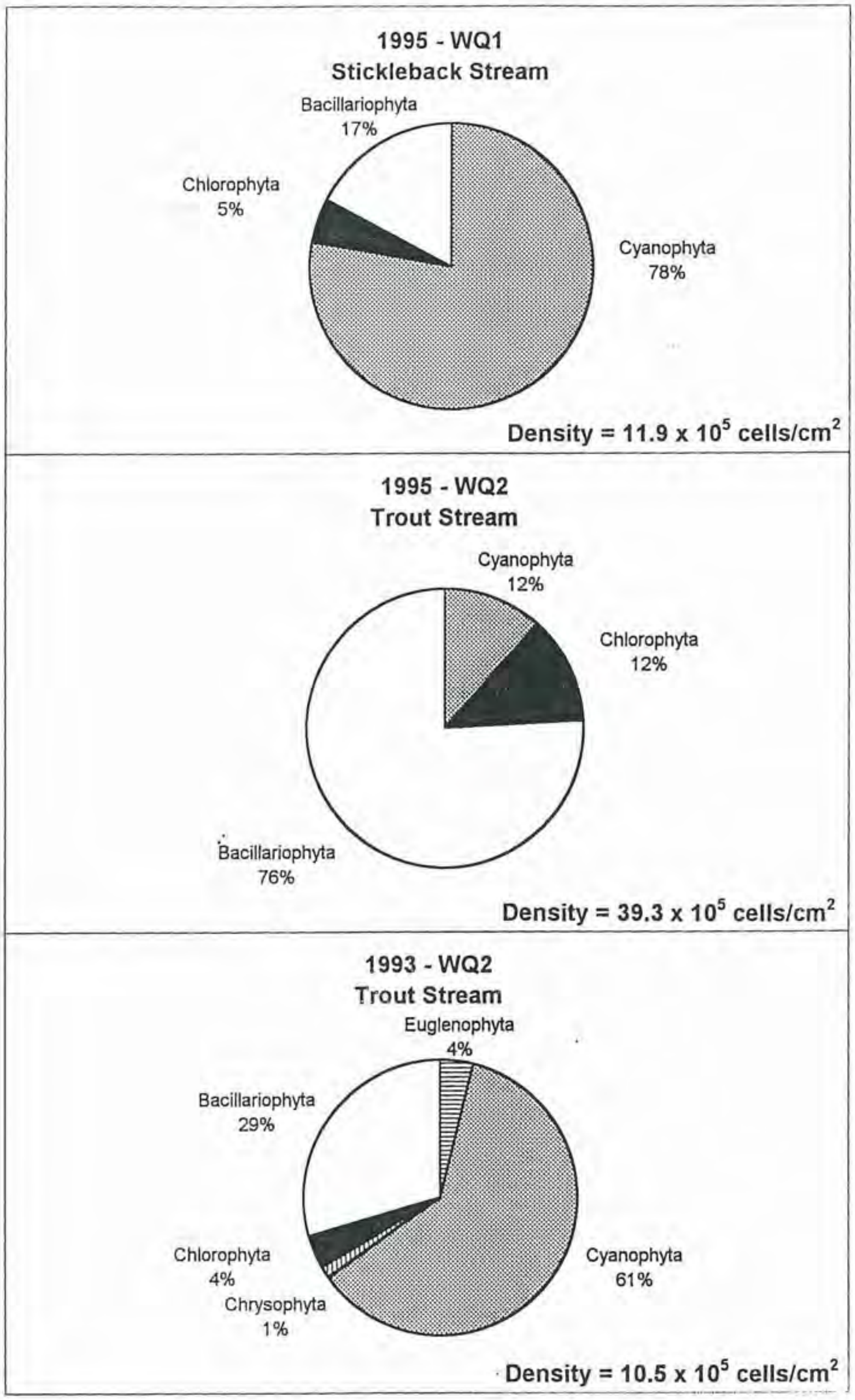

Figure 2-7: Percent Composition and Density of Periphyton for Two Streams

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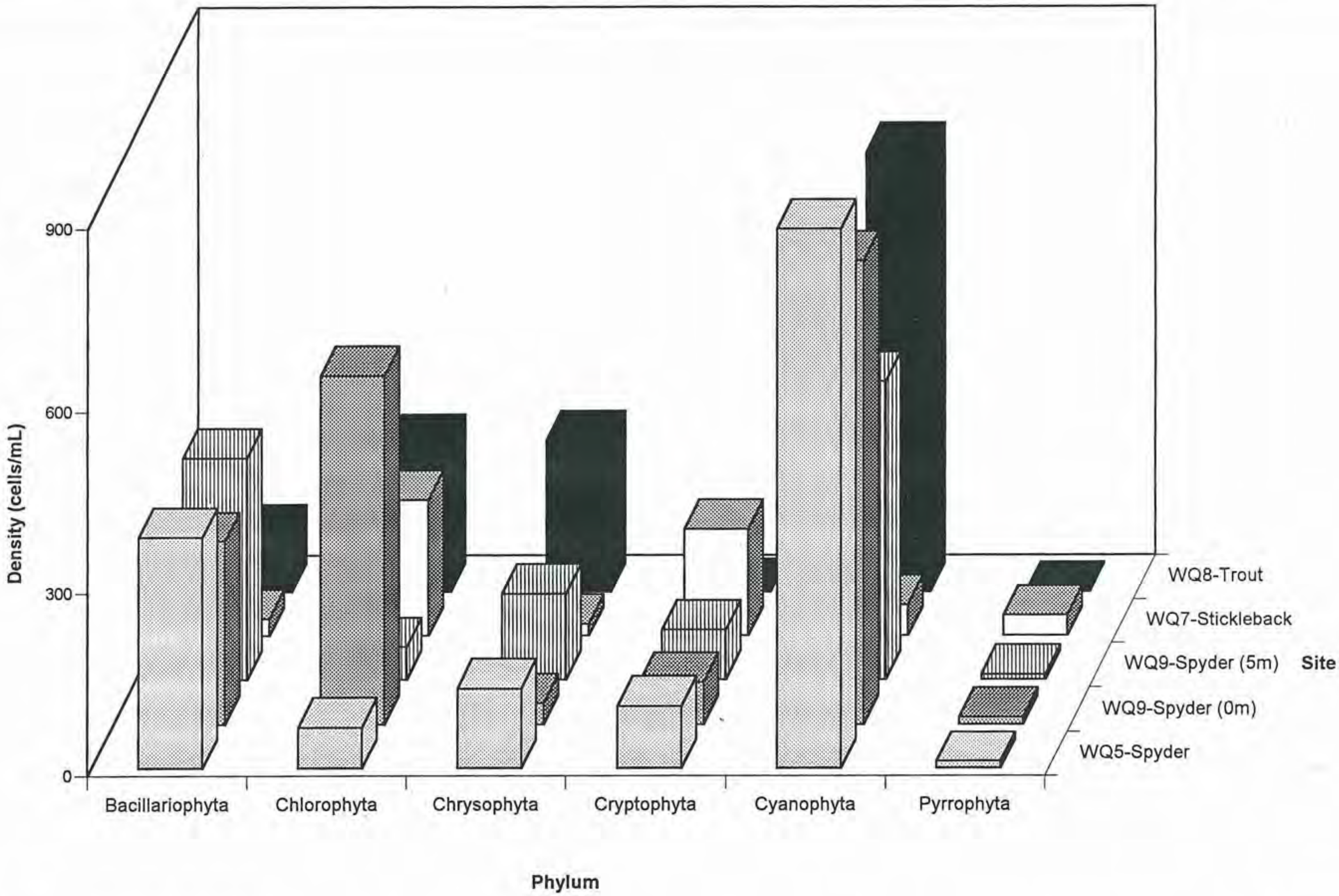

BHP Figure 2-8: Density and Composition of 1995 Phytoplankton Communities Rescan

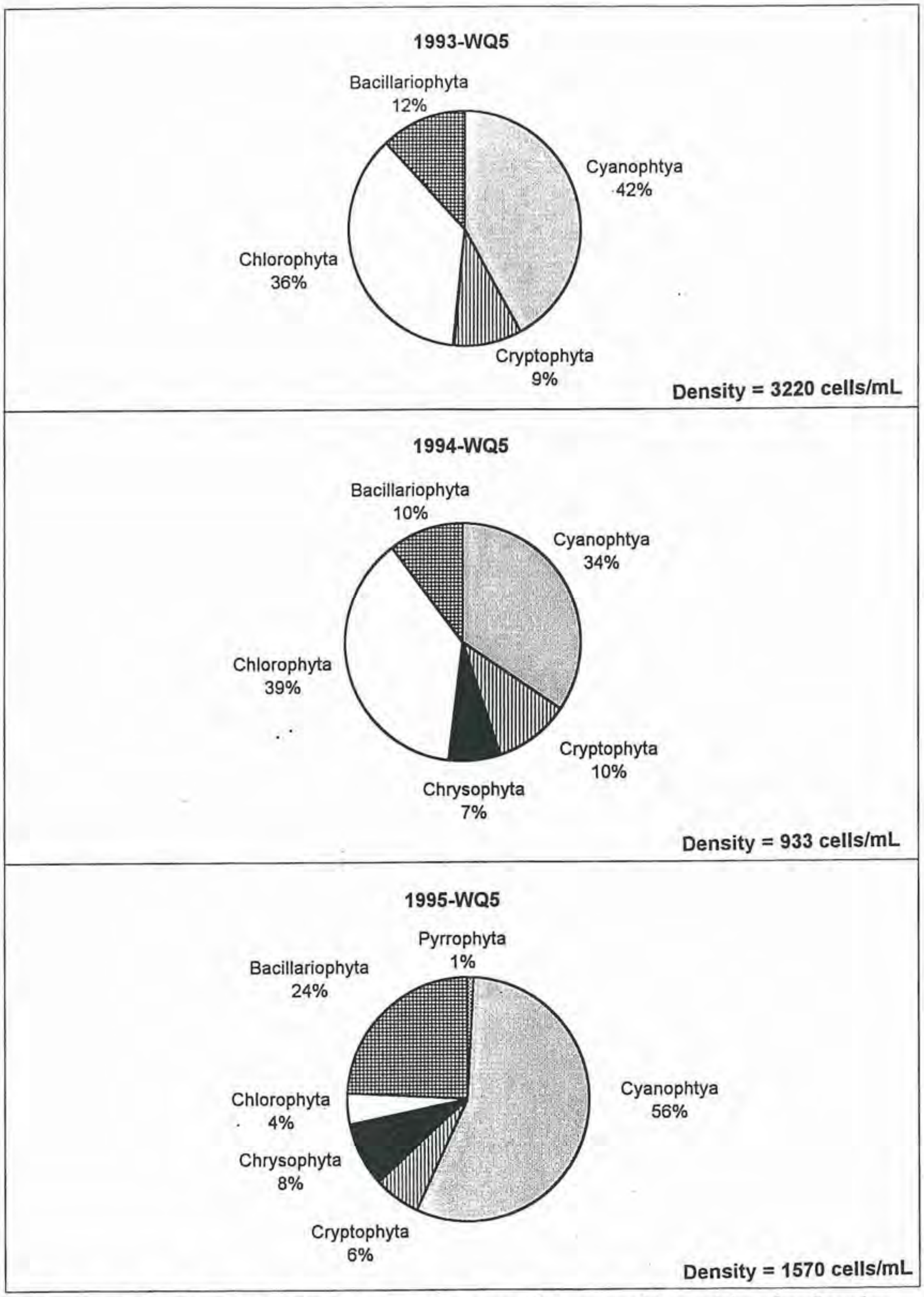

Figure 2-9: Phytoplankton Percent Compositions and Densities for Spyder Lake (WQ5) 1993-1995

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Rescan

An Ekman grab (0.0225 m^2) and a Hess sampler (area 0.096 m^2; 250 µm mesh size) were used at lake and stream sites, respectively, to collect replicate samples of soft-bottom sediments (Plate 2-6). Samples were then screened through a 250 µm sieve to retain the invertebrates for identification. Samples were preserved in 10% buffered formalin.

Identification and enumeration of zooplankton and benthic samples were conducted by Applied Technical Services, Saanichton, B.C., a company which specializes in the taxonomic identification of invertebrates.

Zooplankton

The 1995 zooplankton communities are dominated primarily by copepods in Spyder (WQ5) and Trout (WQ8) lakes, and rotifers in Stickleback Lake (WQ7; Appendix E). Zooplankton taxa and their relative abundance (percent composition) for sampled sites in two periods (1993 and 1995) are presented in Figure 2-10. In both years, the Spyder Lake zooplankton community was solely dominated by one group of organisms, whereas the Stickleback Lake community had greater diversity with at least two groups representing >10%.

In 1995, zooplankton densities were highest for WQ5 and lowest for WQ7 (Table 2-3). Zooplankton abundance was directly related to the concentration of phytoplankton, on which they depend for food.

Benthic Invertebrates

The 1995 benthic communities in Spyder (WQ5) and Stickleback (WQ7) lakes were dominated by dipteran insects and molluscs (Figure 2-11; Appendix F). Trout Lake (WQ8) was dominated by dipterans and secondarily by oligochaetes.

Although benthic compositions were similar at sites WQ5 and WQ7, their densities differed (Figure 2-11). WQ5 had the lowest density and WQ7 had the highest density. The benthic communities in the Stickleback and Trout lake samples differed in composition and density (Figure 2-11). This likely reflects differences in the nature of the substrates sampled. Additional sampling in both lakes will serve to characterize better their benthic invertebrate communities and permit appropriate comparisons.

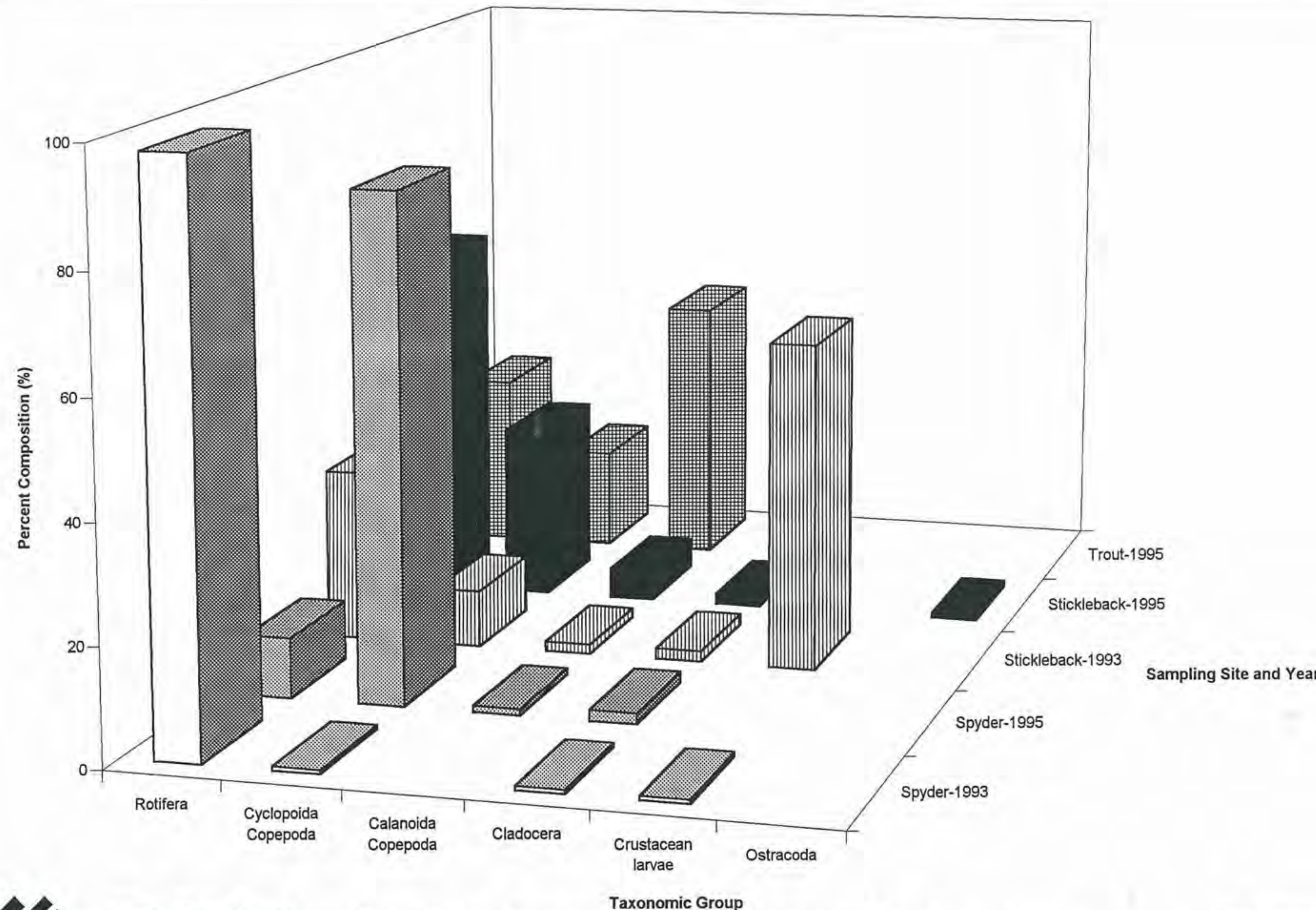

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Figure 2-10: Percent Composition of 1993 and 1995 Zooplankton Communities

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Plate 2-6: A Hess sampler was used at stream sites to sample benthic invertebrates.

Table 2-3

Phytoplankton, Benthic Invertebrate and Zooplankton Densities for Three Lake Sites

Site #	Location	Densities		
		Phytoplankton (cells/mL)	Zooplankton (# individuals/m^3)	Benthic Invertebrates (# individuals/m^2)
WQ5	Spyder Lake	3,220	7,629	18
WQ7	Stickleback Lake	933	1,652	479
WQ8	Trout Lake	1,570	3,750	136

Note these ↑ #s are exactly same as Fig 2-9 #s for historical WQ5 data.

& Diff from #s you get from summing appendice D data.

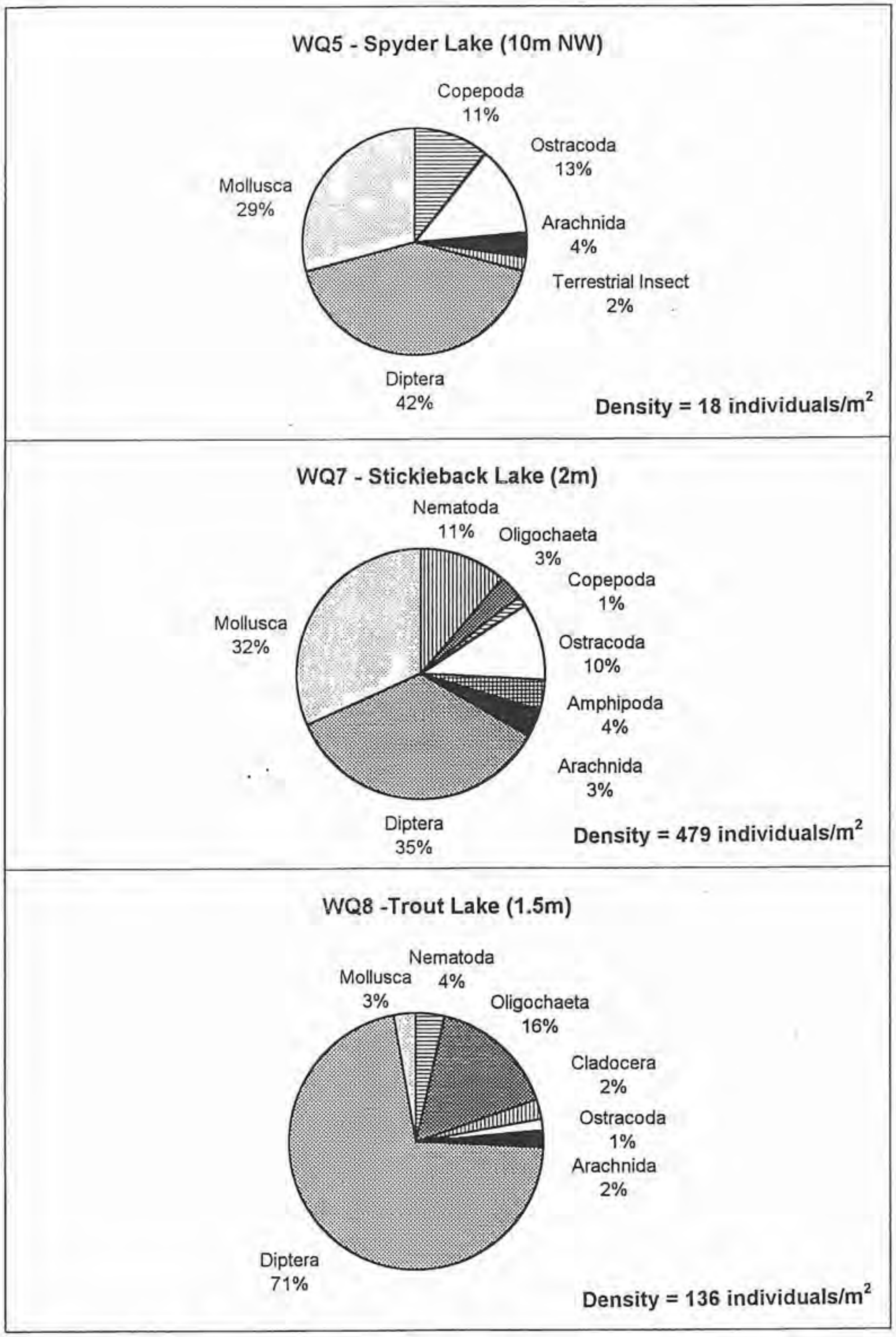

Figure 2-11: Percent Composition and Density of Lake Benthic Invertebrates

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Stickleback (WQ1) and (WQ8) Trout streams were dominated by ostracods and dipterans in reciprocal proportions (Figure 2-12; Appendix G). Benthic invertebrate density was higher at WQ1 than WQ2 in 1995, and both were comparable to the 1994 density at WQ2 (3,862 individuals/m^2; Figure 2-12). Invertebrate assemblages in Trout Stream in 1994 and 1995 were similar, as dipterans represented >58% of the population, followed by the ostracods at 19%.

2.5 Fish

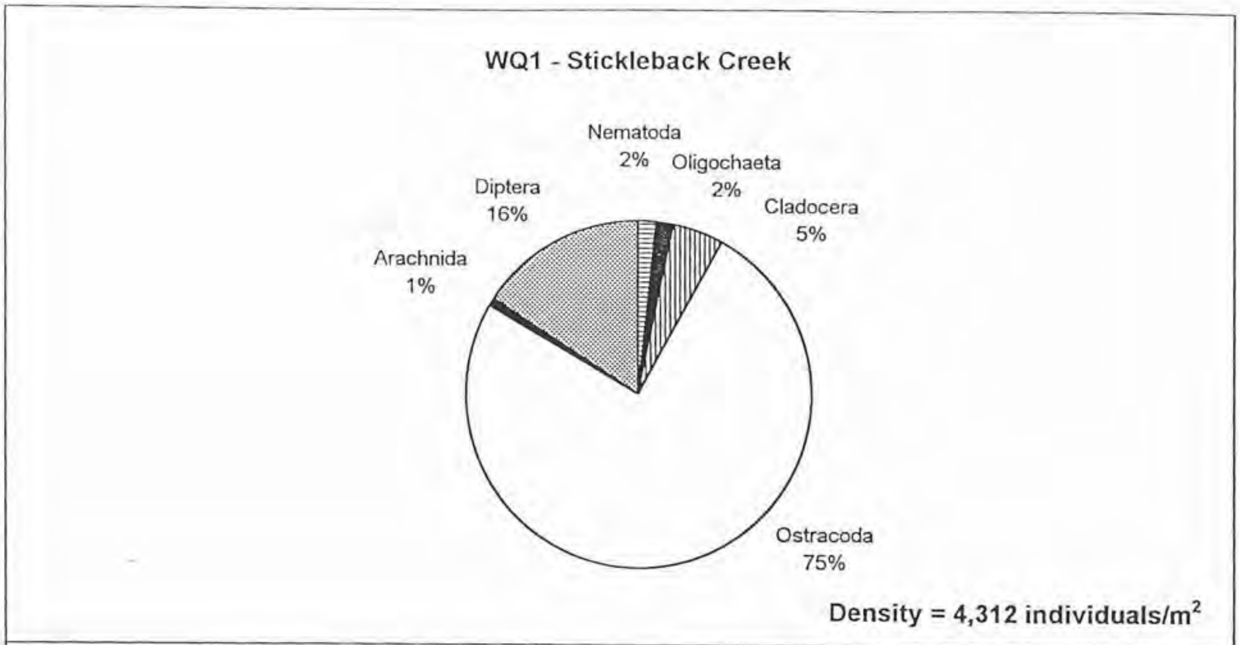
The fish sampling component of the 1995 field program expanded on work carried out in 1993 and 1994. The fish study has been designed to identify the fish species in the area surrounding future mine operations, determine their relative abundance and population characteristics and document trace metal concentrations in the tissues of individual fish. The program also included aerial reconnaissance of the Spyder Lake to Windy Lake portion of the proposed winter road route to Roberts Bay to identify potential fish habitats along this corridor.

2.5.1 Sampling Sites and Methods

The 1993 and 1994 sampling programs focused on collecting fish by gillnetting in the south end of Spyder Lake and in Stickleback Lake (Rescan 1994). Additional sampling was conducted in 1995, as follows:

- gillnets were set in Trout Lake;
- fish were sampled by gillnet in Spyder Lake four kilometres north of the site sampled previously;
- minnow traps were set in the outlet streams of Trout and Stickleback lakes and in the littoral zones of Spyder, Trout and Stickleback lakes; and
- Electrofishing was conducted to determine the species and age classes of fish in stream habitats adjacent to Spyder, Stickleback and Trout lakes and in two locations along the proposed winter road corridor.

The locations of all 1995 fish sampling sites are shown in Figure 1-2. The sampling gear used and the numbers of each species caught at each site are presented in Table 2-4.



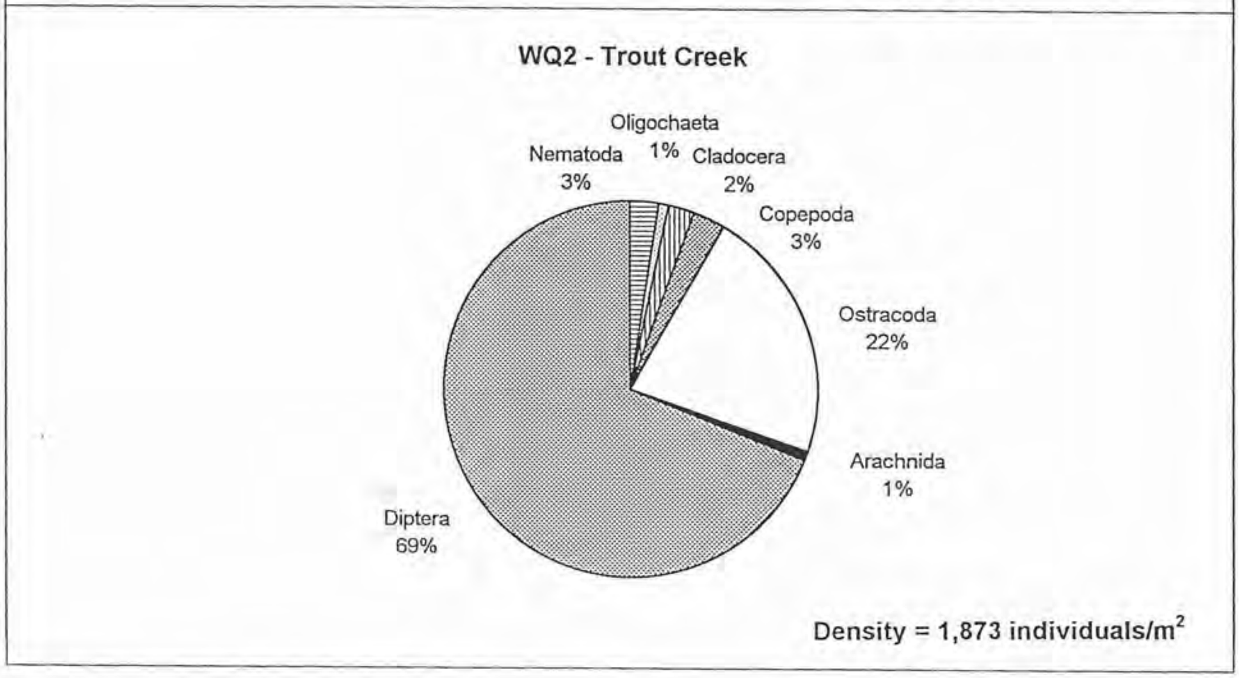


Figure 2-12: Percent Composition and Density of Stream Benthic Invertebrates

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Table 2-4

Fish Sampling Methods and Catches in the Boston Project Area, 1995

Date	Location	Site ID	Water Depth (metres)	Sampling Method	Duration	Species Caught	No. Caught Adult	No. Caught Juvenile
Jul-31-95	Stickleback Creek	F1	<0.3	minnow trap	22 hours	ninespine stickleback	68	
Jul-31-95	Stickleback Lake	F2	0.4	minnow trap	22 hours	ninespine stickleback	19	
Jul-31-95	Trout Creek	F3	<0.3	minnow trap	22 hours	ninespine stickleback	82	
Jul-31-95	Trout Lake	F4	0.4	minnow trap	22 hours	ninespine stickleback	3	
Jul-31-95	Spyder Lake	F5	0.5	minnow trap	23 hours	none caught		
Jul-31-95	Spyder Lake	F6	<0.3	minnow trap	23 hours	ninespine stickleback	75	
Aug-1-95	Spyder Lake	F7	5	gill net	28.5 hours	lake trout	10	
						lake whitefish	4	
Aug-1-95	Spyder Lake	F8	12 to 15	gill net	24 hours	lake trout	13	
						lake whitefish	1	
Aug-1-95	Spyder Lake	A		angling		lake trout	2	
Aug-1-95	Spyder L. tributary	F9	<0.5 to 1.0	electrofishing	484 seconds	Arctic grayling		4
Aug-1-95	Spyder L. tributary	F10	0.3	minnow trap	27 hours	Arctic grayling		1
Aug-3-95	Trout Creek	F11	<0.5	electrofishing	73 seconds	ninespine stickleback	40	
Aug-3-96	Stickleback Lake	F12	3	gill net	11.5 hours	none caught		
Aug-3-95	Trout Lake	F13	3.5	gill net	9.5 hours	Arctic grayling	4	
Aug-3-95	Koignuk R. Tributary	F14	<0.3 to 1.0	electrofishing	440 seconds	Arctic grayling		7
Aug-3-95	Koignuk River	F15	<0.4	electrofishing	347 seconds	ninespine stickleback	4	

The following methods were employed for each gear type:

- *Minnow traps*: Conventional galvanized metal traps with a screen opening of 0.65 cm (diagonal measure) were baited with salmon eggs and totally submerged parallel to the direction of flow (Plates 2-7 and 2-8). At the end of the sampling period fish were identified, counted and released.
- *Gillnets* (Plate 2-9): The gillnets used were constructed of green nylon monoflament and consisted of three panels attached together, each 15.3 m long and 2.4 m deep and each being of a different mesh size: 3.8 cm, 6.4 cm and 8.9 cm, respectively. These gang nets were fished near the surface in all but one site, at F8 (Figure 1-2), where weights were used to sink the net so that it would fish near the bottom. Fish were removed from the nets, stored in separate plastic tubs for each location and refrigerated for several hours until processing. The arctic grayling caught in Trout Lake were frozen and processed three days later.

Electrofishing (Plate 2-10): A Smith Root Model 15-A electroshocker was used at all sites. Twin probes were used as the anode and cathode. Power was supplied by a gasoline generator. Voltage was regulated at each location so that fish were attracted to the anode but were not killed. Sampling was conducted to determine presence of fish but not population densities, so stop or barrier nets were not used. Fish were identified and released. Individual juvenile fish which could not be identified in the field were packed in plastic bags and preserved for later identification.

Fish (other than juveniles) were measured with a tape measure and weighed with a spring scale to the nearest 0.1 kg. A two centimetre square section of muscle from just below the dorsal fin and a portion of the liver from each fish were placed in Whirlpaks® and frozen immediately. The sex of each fish was determined from internal examination and otoliths were removed from approximately one-third of the fish. Scales were sampled from all fish but were later determined to be unsuitable for accurate ageing.

Fish tissues were analyzed for trace metals by Elemental Research Inc. of North Vancouver as follows: One gram (wet weight) of tissue was added to a teflon digestion vessel. Concentrated nitric acid was added to the sample and then sealed. The vessel was then heated until the sample was completely dissolved,

Plate 2-7: A minnow trap, baited with salmon eggs, placed in the outlet stream from Trout Lake.

Plate 2-8: Numerous ninespine sticklebacks (*Pungitius pungitius*) were caught in baited minnow traps in the outlet streams from Stickleback and Trout Lakes.

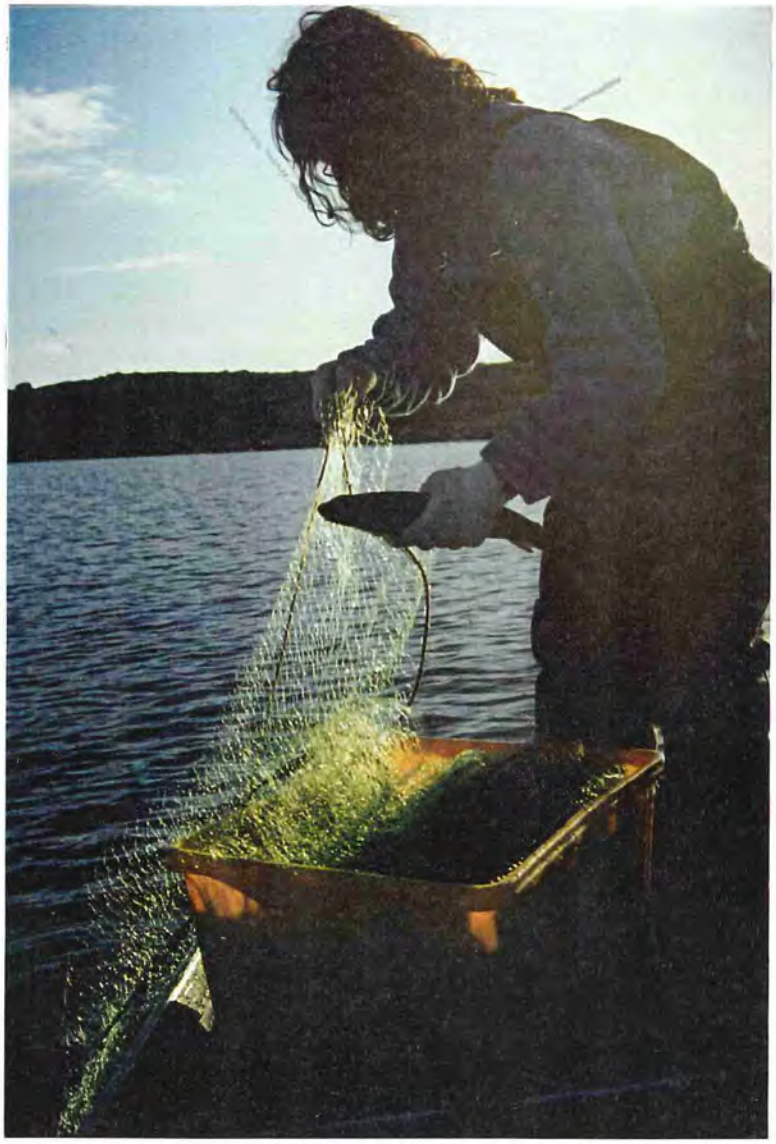

Plate 2-9: Gillnetting effectively sampled lake trout and lake whitefish in Spyder Lake and arctic grayling in Trout Lake.

Plate 2-10: Streams were electrofished to determine fish presence or absence.

usually overnight. The vessel was then cooled, opened and made up to volume with ASTM type 1 water prior to analysis by inductively coupled plasma mass spectrometry.

2.5.2 Sampling Results

The following are fish community and population characteristics that emerge from a review of the fish sampling results shown in Table 2-5 and in Appendix H. For comparison, vital statistics of fish caught in Spyder Lake in 1994 are provided in Appendix I.

Lake Trout (Salvelinus namaycush)

Lake trout is numerically dominant among the three major species sampled in Spyder Lake. Fish were generally large (mean total length of 65 cm) and old. The smallest lake trout caught, 38 cm, was 19 years old and the largest (88 cm) was estimated to be 38 years old. From the seven fish whose ages were determined using otoliths, regression analysis failed to show a significant relationship between fish length and age ($F=1.47$; $p=0.28$). These results are consistent with observations on other Arctic populations of lake trout. Johnson (1976, 1983) remarked on the great range in age for fish of similar lengths and that the majority of fish fall within a fairly narrow length range. In the present study, over 40% of fish (larger than 40 cm) are 60-70 cm (Figure 2-13) yet range considerably in age (Appendix H). It is therefore not possible to construct a predictive length-age regression curve; lake trout must be aged individually.

Lake trout lengths were distributed bimodally in 1994 in Spyder Lake (Figure 2-14), in contrast to the unimodal distribution found in 1995 (Figure 2-13). Data comparison between the two years must be approached cautiously since the 1994 sampling was conducted at only one site in the lake and the total catch was small. However, it is still apparent from this data that large lake trout (>40 cm) predominate in the population.

Mean lengths and weights for lake trout were not significantly different between the two locations in Spyder Lake gillnetted in 1995 ($p>0.1$). The northern sampling location is 12 to 15 m deep and is adjacent to the deepest portion of the lake (26 m; Figure 2-15). In contrast, the more southerly site is in water that is six

Table 2-5

Summary of Lengths, Weights and Condition Factors of Fish Sampled at Spyder and Trout Lakes, 1995

Location	Species	n	Total Length (cm)		Fork Length (cm)		Weight (gm)		Condition Factor[1]	
			Mean	Std. error	Mean	Std. error	Mean	Std. error	Mean	Std. error
Spyder Lake	lake trout	25	65.6	2.3	60.9	2.2	2528	270.2	0.81	0.02
Spyder Lake	lake whitefish	5	43.6	1.3	40.4	1.2	900	114	1.03	0.1
Trout Lake	arctic grayling	4	39.1	0.9	35.8	1	750	64.5	1.2	0.1

1: Condition Factor (K) = (Weight (gm) x 10^5) / Length (mm).

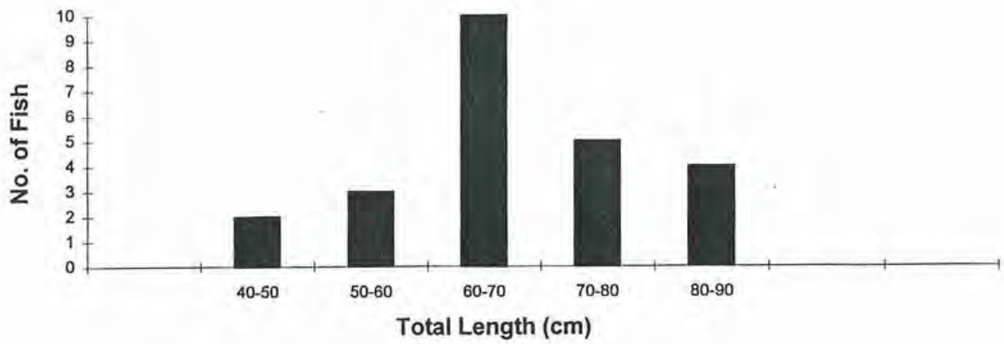

Figure 2-13: Length Frequencies for Lake Trout Caught in Spyder Lake, August, 1995

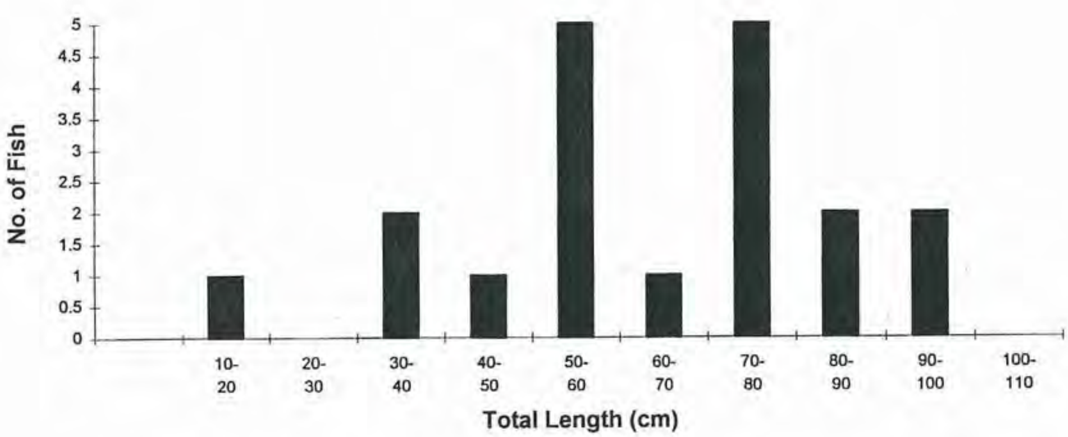

Figure 2-14: Length Frequencies for Lake Trout Caught in Spyder Lake, August, 1994

BHP

Rescan

to eight metres deep in an arm of the lake not exceeding a depth of 10 m. At least during summer it therefore appears that adult lake trout are not distributed according to their size; larger and smaller fish are each found at sites with different depths.

Condition factor is a length-weight relationship which provides an index of the plumpness or robustness of a fish. It is calculated as:

$$K = \frac{(W \times 10^5)}{L^3}$$

where; K = condition factor
W = weight in grams, and
L = length in millimetres.

A fish with a condition factor of 1.0 is considered to be in good condition, generally indicating an adequate food supply. However, condition factor is also a function of fish shape and age and can vary significantly from a value of 1.0 without indicating fish in poor condition. The mean condition factor for lake trout in Spyder Lake was calculated to be 0.81 (Table 2-5). This value is very uniform for the entire sample of fish indicating that relative food consumption is similar for all size classes of adult lake trout. There was no significant difference ($p=0.36$) between mean condition factors for lake trout captured in 1994 and 1995. This indicates that food availability has not changed and that this mean condition factor is probably normal for trout in Spyder lake.

While juvenile lake trout are obviously present in Spyder Lake, they were not captured in minnow traps or by electrofishing in any of the sample locations. This is not unusual since the post-emergence habitats and movements of juvenile lake trout are not well known (Scott and Crossman 1973). It is thought, however, that the juveniles may quickly move into deeper water after a short period of feeding and growth in the littoral zone (Ford *et al.* 1995; Royce 1951). The shore area near the proposed mine site conforms to the following criteria proposed by MacLean *et al.* (1990) to describe generalized lake trout spawning habitat:

Cad No. C0590 4 P3 | Job No. 485-1 | RES_BF

DEPTH (m)	PERIMETER (m)	AREA (sq. m.)	VOLUME (cu. m.)
0.0	51759+823+2400+267		
0.0	+82+264+1266+191+116	22312366	
2.0	35549+102+1738+412	14214021	36526387
4.0	38966+731+415+540+1051		
4.0	+135	11675878	25889899
6.0	36674+184+937+728+998		
6.0	+368+1445	9016585	20692463
8.0	1637+26847+7189+512		
8.0	+525+347+227	6938489	15955074
10.0	998+18132+4708+174		
10.0	+240+375+111+279+712		
10.0	+149+4846+1280+846	5048777	11987267
12.0	6940+9929+3670+159		
12.0	+570+444+1370+2138		
12.0	+166+616	3658883	8707660
14.0	4164+9603+696+341+2294		
14.0	+323+731+1062+659+271		
14.0	+331	2550088	6208971
16.0	3613+7244+316+511+792		
16.0	+515+504+298+676+241	1595583	4145671
18.0	3064+4162+1763+97	1022668	2618251
20.0	4039+2480+953	679281	1701949
22.0	1144+2346+2048	405639	1084920
24.0	1221+242+820+585+709	205857	611497
26.0	989+130+314+305+524	91932	297789
28.0	569+224	23510	115442
30.0	225	3204	26714

Cumulative Volume = 136569954 (cu. m.)

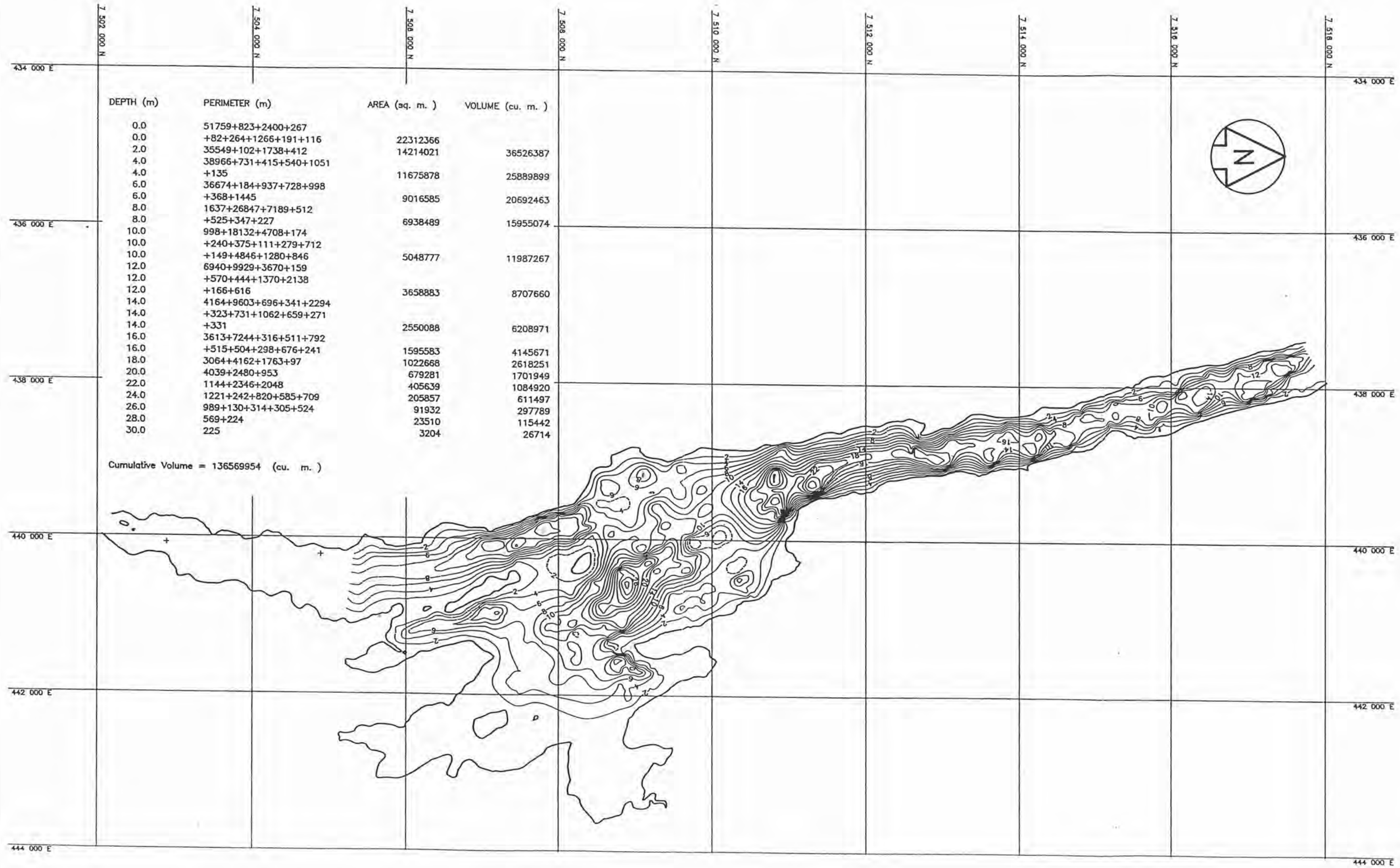

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Figure 2-15 : Bathymetry of Mid Portion of Spyder Lake

Rescan

Water depth	<4 m
Distance from shore	<15 m
Distance from inlet stream	>20 m
Fetch	>0.5 km
Substrate	Clean, 5-30 cm

Arctic Grayling (Thymallus arcticus)

Arctic grayling adults were captured only in Trout Lake although there are anecdotal reports of their presence in the northern end of Spyder lake. The absence of grayling in gillnet surveys in 1993, 1994 and 1995 in Spyder Lake indicates that their population in the southern end of the lake is, at most, very low or highly seasonal. Grayling were not found in Stickleback Lake in any of the three years that it was sampled. However, they were caught in Trout Lake in 1995. Since Trout and Stickleback lakes are similar in depth (< 5 metres) and size, the absence of arctic grayling in Stickleback Lake may reflect the lack of suitable spawning habitat in its outlet stream. This watercourse averages <0.5 m in width, <0.3 m in depth and has an organic or mud bottom. Conversely, the outlet stream from Trout Lake is >1.0 m wide, <0.5 m deep and has a mixed gravel, cobble, boulder substrate with several areas suitable for grayling spawning.

While only four grayling were caught during this study, their mean condition factor was calculated to be 1.2, indicating an abundant food supply (primarily invertebrates) for these fish.

Juvenile arctic grayling were caught in very small numbers by minnow trap and electrofishing in a tributary on the east side of Spyder Lake and in a tributary to the Koignuk River , respectively (Table 2-4; Figure 1-2). No juvenile grayling were caught in the Trout Lake outlet stream despite its apparent suitability for spawning and rearing. This could be explained by low water levels in the stream at the time of sampling.

Lake Whitefish (Coregonus clupeaformis)

Lake whitefish were caught at two gillnet sampling stations in Spyder Lake in 1995 (Table 2-4). While a relatively greater number of whitefish were caught in 1994 (22 fish), this does not indicate a change in fish community structure. Gillnet sampling in both years was designed to determine species presence or absence and not to quantify fish populations.

Mean condition factors for 40-50 cm whitefish did not differ significantly ($p=0.86$) between 1994 and 1995. These values of 1.0 and 1.1, respectively, indicate healthy individuals having an adequate food supply. Interestingly, the mean condition factors for whitefish smaller and larger than 40 cm (0.8 and 1.1, respectively, from 1994 catch data) were found to be significantly different ($p<0.001$). It is probable that larger whitefish have a competitive advantage in capturing prey (molluscs, crustaceans, insects, fish eggs and small fish) which is reflected in their overall condition.

The majority of arctic lakes at the same latitude as Spyder Lake have fish communities dominated by lake trout and whitefish (Johnson 1976). The present data suggests that lake trout are predominant in Spyder Lake, but this conclusion could only be supported by additional, quantitative population sampling.

Whitefish juveniles were not found during this study probably due to limited sampling effort directed toward their capture. Spawning and nursery habitat requirements for lake whitefish vary considerably (Bryan and Kato 1975). Spawning has been observed over substrates ranging from silt to boulders, in slight currents to moderately strong river flows. In general, Scott and Crossman (1973) suggest that spawning generally takes place at depths less than eight metres over a hard or stony bottom. These conditions are common within the littoral zone of Spyder Lake which can be characterized as providing abundant spawning and nursery habitat.

Ninespine Sticklebacks (Pungitius pungitius)

These small forage fish are an important component of the diet of other fishes. Lake trout sampled in 1994 from Spyder Lake were found to contain sticklebacks in their stomachs. Ninespine sticklebacks were caught in large numbers in this study in Spyder, Stickleback and Trout lakes and in their tributaries (Table 2-4).

Proposed Road Route

The proposed winter road route from Spyder Lake to Windy Lake was surveyed at low elevation from a helicopter on August 3, 1995. Along this route only one stream crossing site was identified as potentially possessing suitable water and habitat conditions to support fish. Electrofishing at this location, a tributary to the Koignuk River (site F14; Figure 1-2; Plate 2-11), revealed eleven 3-5 cm young of year arctic grayling. Along this route no other streams have the potential to support any significant fisheries resource.

2.5.3 Tissue Analyses

Trace metals concentrations in liver and muscle samples taken from fish caught in Spyder lake in August, 1995, are shown in Appendices J and K, respectively. For comparison, similar data for fish caught in Spyder Lake in August, 1994, are provided in Appendices L and M. Mean trace metal concentration values for lake trout caught in Spyder Lake in 1994 and 1995 are provided in Table 2-6. It is important to document the concentrations of potentially harmful elements in fish tissues prior to the start of mining to enable future monitoring of excessive trace metal bioaccumulation, if any, due to mining operations.

Table 2-6

Mean Trace Metal Concentrations (mg/kg wet weight ± std. error) in Spyder L. Lake Trout Liver and Muscle Samples, 1994 and 1995

Metal	1994 Samples[2]		1995 Samples[3]	
	Liver	Muscle	Liver	Muscle
Arsenic	det[1]	det	det	det
Cadmium	0.04 ± 0.004	det	0.06 ± 0.01	det
Copper	12.1 ±2.0	0.43	14.7 ± 1.2	0.4 ± 0.02
Lead	0.01 ±0.002	0.07	0.04 ± 0.004	0.05 ± 0.01
Magnesium	148.4 ±6.6	245.7	167.6 ± 5.2	246.7 ± 5.2
Manganese	1.2 ±0.1	0.15	1.5 ± 0.1	0.12 ± 0.01
Mercury	0.8 ±0.2	det	1.4 ± 0.2	0.7 ± 0.06
Nickel	0.04 ±0.01	0.03	det	det
Selenium	0.9 ±0.15	0.16	0.9 ± 0.14	0.20 ± 0.01
Silver	0.13 ±0.03	det	0.2 ± 0.06	det
Tellurium	det	det	det	det
Zinc	26.9 ±1.5	3.9	32.9 ± 1.0	4.7 ± 0.27

1: "det" indicates that some or all of the analysis results were below detection limits.
2: n=10.
3: n=25.

Mercury is the only trace metal for which there are guidelines for human consumption set by Health and Welfare Canada. The maximum allowable level of mercury in muscle tissue of fish sold in Canada for human consumption is 0.5 mg/kg wet weight (CCREM 1993). However, a guideline of 0.2 mg/kg wet weight is recommended when fish constitutes a major portion of food consumption. In this study, the mean muscle tissue mercury concentration of lake trout in Spyder Lake of 0.7 mg/kg was above the 0.5 mg/kg guideline level (Table 2-6). Muscle mercury concentrations in lake trout ranged from 0.23 to 1.44 mg/kg, while liver concentrations ranged from 0.2 to 3.5 mg/kg. Elsewhere at northern latitudes, reported values for lake trout muscle mercury concentration are lower than those found in Spyder Lake fish (BHP and Diamet 1995). However, comparisons are complicated by differences in mean fish size and age between the two locations. Lake whitefish muscle tissue mercury levels were well below the 0.5 mg/kg guideline (Appendix K).

The muscle mercury concentrations in lake trout caught in 1994 appear to be lower than in fish caught in 1995. However, comparison of mean muscle mercury levels between the two years for fish greater than 60 cm reveals no significant difference in mercury concentrations ($p=0.73$). Regression analysis showed a very strong, positive relationship between fish length and muscle mercury concentration ($R^2=0.40$; $F=15.05$; $p=0.0008$).

Concentrations of other trace metals found in fish tissues in this study appear to be within the ranges expected for similarly sized fish in arctic lakes.

2.6 Wildlife

2.6.1 Methods

A reconnaissance-level survey of wildlife resources within the BHP Boston property was conducted during July 31 to August 3, 1995. Objectives were to identify bird and mammal species present, and to identify, if possible, important habitats.

Methods employed included ground and aerial searches of the area. All surveys were conducted by 1-3 experienced observers. Foot surveys were conducted of the area within a 4-km radius of the Boston campsite, and usually within the first and

Plate 2-11: Tributary to the Koignuk River at a stream crossing site along the proposed winter road route (site # F14, Figure 2-F1). Electrofishing revealed young of the year arctic grayling at this location.