3000 0 3000

SCALE 1:100000 METRES

LEGEND

- ✱ MAJOR DRILLING SHOP
- CAMP
- HYDROMETRIC STATION
- CONTOUR (20 m INTERVAL)
- INTERMITTENT STREAM
- WATERCOURSE
- WATERBODY

REFERENCE

Base data obtained from Government of Canada, Natural Resources Canada, Centre for Topographic Information (1:50 000). Landsat 7 imagery captured in 2007, obtained from CanImage. Field data collected by Golder Associates Ltd., 2008.
Projection: UTM Zone 13 Datum: NAD 83

PROJECT

NEWMONT The Gold Company

HOPE BAY MINING LTD.

TITLE

2006 AND 2007 HYDROMETRIC STATION LOCATIONS BOSTON AND MADRID PROJECT AREAS

Golder Associates
Edmonton, Alberta

PROJECT NO. 07-1373-0019			SCALE AS SHOWN	REV. 0
DESIGN	AH	23 Oct. 2008	FIGURE: 2.2	
GIS	BF	07 Jul. 2009		
CHECK	AH	10 Jul. 2009		
REVIEW	GA	10 Jul. 2009		

The data logger at the Windy Lake (H92) station was malfunctioning at the end of the open-water program; continuous data are not available after 4 August 2007.

The transducer at the Glenn Lake (H93) station was found to have failed on 3 July 2007; readings are not available after this date.

In 2006, the transducer at Hope Bay (H88), measuring variations in water level with tidal fluctuations, was installed after ice had left the bay. In 2007, a transducer was not installed.

During visits to stations with flowing water, stream discharge measurements were performed according to the Water Survey of Canada standard described by Terzl et al. (1994). Data were downloaded periodically and pressure transducer readings associated with each discharge measurement were recorded.

During selected data logger downloads, water surface elevations were surveyed from the permanent benchmark, and pressure transducer readings were recorded.

During the last visits of 2006 and 2007, the pressure transducer and data logger were removed from the hydrometric stations to prevent ice damage over the winter. The exception was at Aimaokatalok Lake where measurement devices were left in place to record measurements over-winter.

When all data were available for flowing water stations, the record of water surface elevation versus discharge was used to establish a stage-discharge rating curve for each station. This rating curve was then applied to the continuous record of water surface elevations to derive a continuous record of discharges. For some stations, limited stage-discharge data were available so continuous discharges were not derived. Stage data not used to derive discharges may be used in the future when a more complete stage-discharge data set is available.

2.2.2 Snow Course Surveys

Late winter measurements of snow depths, snow densities, and snow water equivalents were performed to characterize the amount of snow available to contribute to spring runoff over a range of terrain types. Snow course surveys were undertaken on 1 May 2006 and from 28 April to 5 May 2007 using the following methods:

Plot Selection

Plot locations within the Aimaokatalok Lake watershed were selected based on terrain type. These included the following:

- open lake (flat areas on lakes);
- exposed lowland (flat areas at the top of slopes);
- sheltered lowland (flat areas at the toe of slopes); and
- north, east, south, and west aspects (slopes facing these directions).

This was done to identify differences in snow accumulation between terrain types. Where possible, locations sampled in 2006 were re-sampled in 2007.

Snow Depth Measurement

At each plot, 30 depth measurements were taken at locations randomly selected from within a large circle, with approximately 10 m between measurements. Depth was measured by inserting a metre stick into the snowpack and reading the snowline mark.

Snow Density Measurement

Three density measurements were recorded at each plot using a snow density sampler. The sampler was carefully inserted to avoid compacting the snowpack. Snow depth was recorded when the corer reached the soil surface. The corer was then pushed further into the ground to ensure that a plug of soil was extracted with the sampler, thereby preventing granular snow from falling out. After extracting the sampler and carefully removing the soil plug, the sampler weight was measured with and without the snow core, snow mass was measured, and the snow-water equivalent was calculated.

2.2.3 Rainfall

Rainfall monitoring was performed to characterize the amount of rain that contributed to runoff during the open water season. The meteorological station in the Boston Project area was located at the Boston Camp and has sensors to measure the following parameters:

- air temperature (hourly mean, maximum and minimum);
- relative humidity (hourly maximum and minimum);
- vapor pressure (hourly mean, maximum and minimum);
- global solar radiation (hourly mean and total);

- wind speed and direction (value and time of hourly maximum, mean horizontal wind speed, unit vector of mean wind direction, and standard deviation of wind direction for each hour; and
- rainfall (hourly accumulated depth).

Rainfall at this station was recorded in 2006 using a tipping bucket rain gauge, and the rainfall record was used to derive total daily and monthly rainfall during the summer months. Rainfall data are not included for 2007 because of equipment malfunction.

2.3 BOSTON PROJECT HYDROMETRY

2.3.1 H83 Aimaokatalok River

A factsheet describing the location of the hydrometric station and equipment installed at Aimaokatalok River (Station H83) is provided in Appendix A. The appendix also contains stage-discharge data; the derived stage-discharge rating curve based on 2006 data; the derived stage-discharge rating curve based on 2007 data; mean daily discharge and water level data; and manual discharge measurement data and calculation sheets for 2006 and 2007.

The Aimaokatalok River hydrometric station was visited six times (Table 2.1) during the 2006 field program and five times during the 2007 field program; continuous logger data resulted in a hydrograph for the period of 23 June to 10 September 2006 (Figure 2.3) and 4 July to 9 September 2007 (Figure 2.4).

Continuous water level data (2 June to 8 September 2006) for the station are available; however, a reliable stage-discharge rating curve has not yet been derived for discharges prior to 23 June. Water level data for the period prior to 23 June can be used to determine discharges for that period once the rating curve is able to be extended using discharges higher than those measured in 2006.

Between 4 and 21 July 2007, mean daily discharges were derived by interpolation, and discharges between 9 September and 16 October 2007 were estimated based on linear recession to freeze-up (Figure 2.4).

Table 2.1 Station Visits to Aimaokatalok River Hydrometric Station, 2006 – 2007

Date	Activities	Lake	Water Level (non-geodetic)	Outflow	Discharge
02-Jun-06	Installed pressure transducer under ice. Observed onset of spring melt.				
23-Jun-06	Measured discharge and water surface elevation and downloaded data logger.			✓	11.01 m^3/s
17-Jul-06	Measured discharge and downloaded data logger.	n/a		✓	1.51 m^3/s
09-Aug-06	Measured discharge and water surface elevation and downloaded data logger.			✓	0.850 m^3/s
13-Aug-06	Measured discharge and downloaded data logger.			✓	0.994 m^3/s
10-Sep-06	Measured discharge and downloaded data logger. Removed data logger for winter.			✓	1.30 m^3/s
26-May-07	Installed pressure transducer, surveyed ice level.				
04-Jul-07	Measured discharge and water surface elevation.			✓	6.70 m^3/s
21-Jul-07	Measured discharge and water surface elevation.			✓	3.23 m^3/s
18-Aug-07	Measured discharge and downloaded data logger.	n/a		✓	4.61 m^3/s
09-Sep-07	Measured discharge, water surface elevation and downloaded data logger. Removed data logger for winter.			✓	2.50 m^3/s

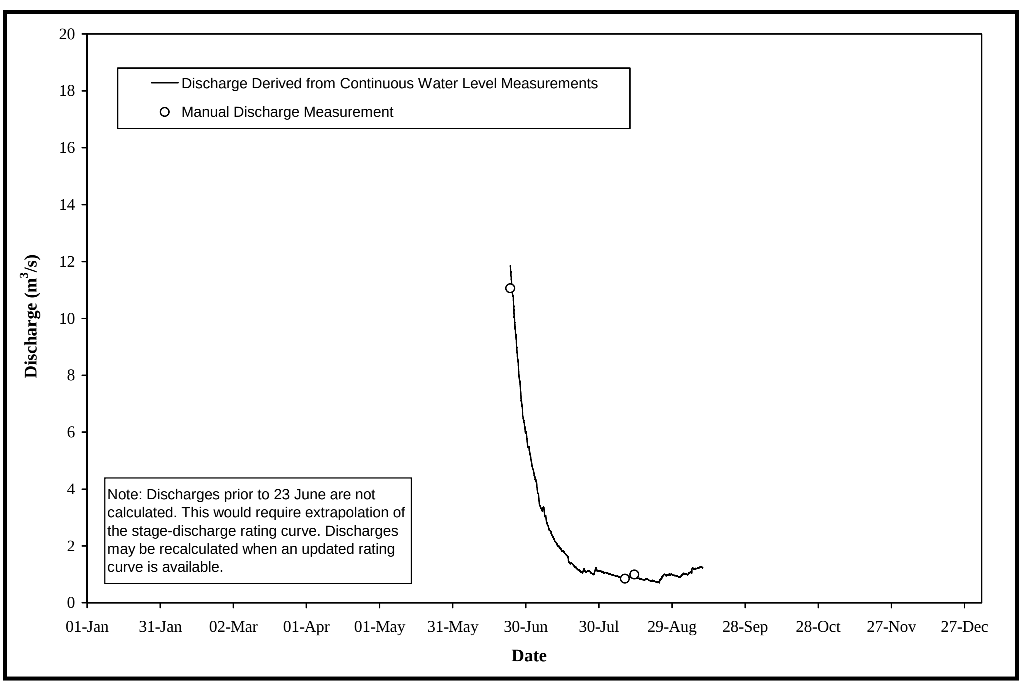


Figure 2.3 Hydrograph for Aimaokatalok River, 2006

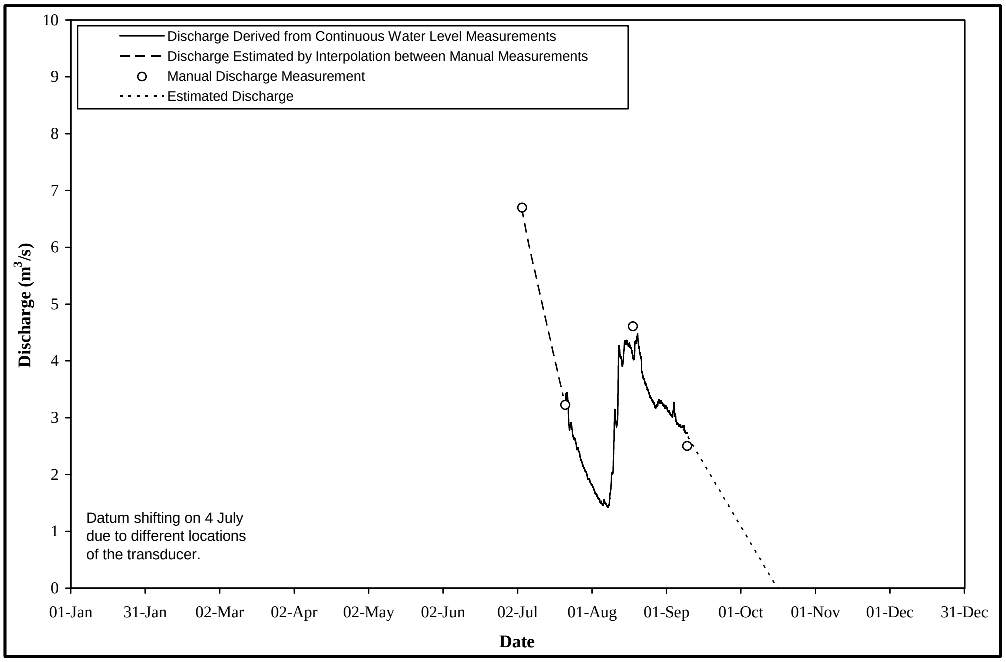


Figure 2.4 Hydrograph for Aimaokatalok River, 2007

2.3.2 H84 Aimaokatalok Lake and Outflow

A factsheet describing the location of the hydrometric station and equipment installed at Aimaokatalok Lake and Outflow (Station H84) is provided in Appendix A. The appendix also contains stage-discharge data; the derived stage-discharge rating curve based on 2006 data; the derived stage-discharge rating curve based on 2007 data; mean daily discharge and water level data; and manual discharge measurement data and calculation sheets.

The Aimaokatalok Lake and Outflow hydrometric station was visited six times during the 2006 field program and five times during the 2007 field program (Table 2.2); a continuous hydrograph was derived for the period of 8 July to 31 December 2006 (Figure 2.5) and 1 January to 10 September 2007 (Figure 2.6) based on continuous logger data.

The field data indicate that Aimaokatalok Lake water levels increase dramatically during spring runoff. The data logger at the station, installed under ice, was submerged when the station was visited on 23 June 2006. It was replaced during the next station visit on 8 July, and a permanent installation with ice protection was constructed on 9 August. At that time, the pressure transducer was installed in deep water for winter and a cold-tested data logger was installed.

Table 2.2 Station Visits to Aimaokatalok Lake and Outflow Hydrometric Station, 2006 – 2007

Date	Activities	Lake	Water Level (non-geodetic)	Outflow	Discharge
02-Jun-06	Installed pressure transducer under ice. Observed onset of spring melt.	✓	97.296 m		
23-Jun-06	Data logger was found submerged and was retrieved. Discharge was not measured because of safety concerns associated with high water levels.				
08-Jul-06	Replaced data logger. No discharge was measured because of safety concerns associated with high water levels.				
09-Aug-06	Measured discharge and water surface elevation and downloaded data logger. Installed transducer in deep water for winter with pipe stem protection for transducer cable.	✓	95.855 m	✓	2.67 m^3/s
13-Aug-06	Measured discharge only.	✓	97.639 m	✓	2.48 m^3/s
10-Sep-06	Measured discharge and downloaded data logger. Removed data logger for winter.			✓	2.21 m^3/s
26-May-07	Installed pressure transducer under ice. Surveyed ice level				
04-Jul-07	Measured discharge and water surface elevation and downloaded data logger.	✓	97.520 m	✓	37.8 m^3/s
20-Jul-07	Measured water surface elevation and downloaded data logger.	✓	96.720 m		
18-Aug-07	Measured discharge and water surface elevation and downloaded data logger.	✓	96.401 m	✓	8.13 m^3/s
10-Sep-07	Measured discharge, water surface elevation and downloaded data logger.	✓	96.082 m	✓	6.88 m^3/s

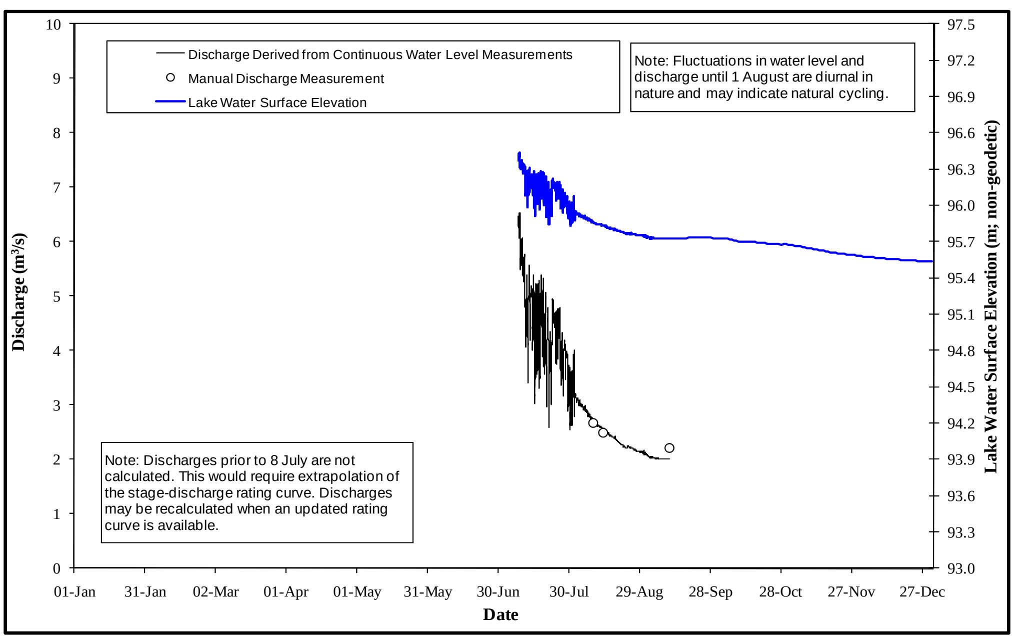


Figure 2.5 Hydrograph for Aimaokatalok Lake and Outflow, 2006

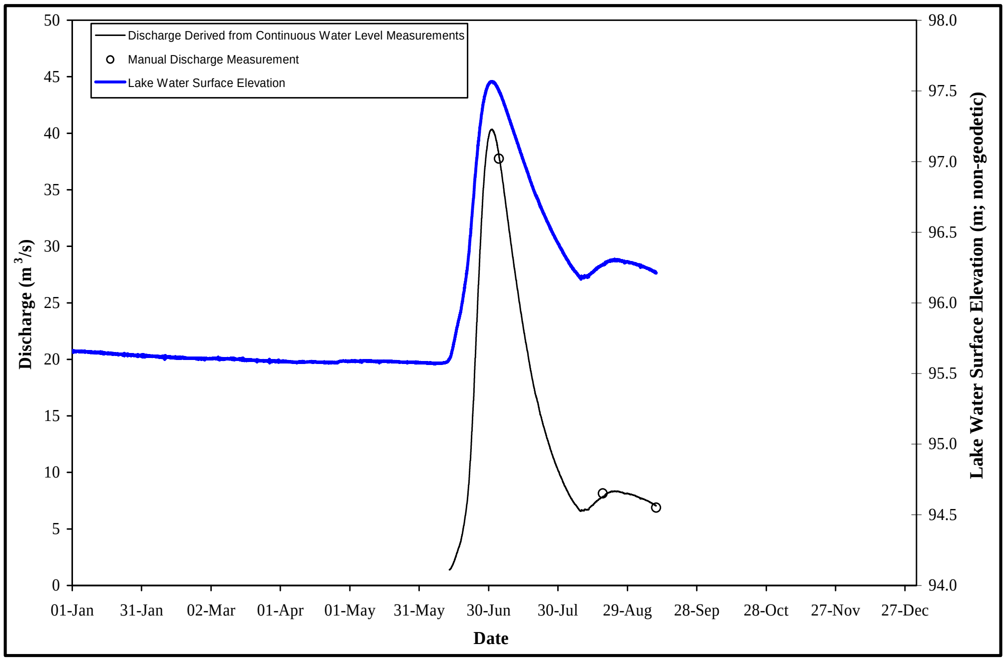


Figure 2.6 Hydrograph for Aimaokatalok Lake and Outflow, 2007

2.3.3 H86 Fickle Duck Lake and Outflow

A factsheet describing the location of the hydrometric station and equipment installed at Fickle Duck Lake and Outflow (Station H86) is provided in Appendix A. The appendix also contains stage-discharge data; the derived stage-discharge rating curve based on 2006 data; the derived stage-discharge rating curve based on 2007 data; mean daily discharge and water level data; and manual discharge measurement data and calculation sheets.

The Fickle Duck Lake and Outflow hydrometric station was visited six times during the 2006 field program and six times during the 2007 field program (Table 2.3). Continuous hydrographs were generated for the periods 3 to 17 June and 8 July to 10 September 2006 (Figure 2.7) and 23 July to 12 August 2007 (Figure 2.8). A gap exists between 17 June and 8 July 2006 because lake water levels dropped below the transducer elevation during this period. There was no observable flow recorded during discharge sampling in July 2006 and 2007.

Table 2.3 Station Visits to Fickle Duck Lake and Outflow Hydrometric Station, 2006 – 2007

Date	Activities	Lake	Water Level (non-geodetic)	Outflow	Discharge
03-Jun-06	Installed pressure transducer under ice. Observed onset of spring melt.	✓	99.087 m		
24-Jun-06	Measured discharge and downloaded data logger.			✓	0.074 m^3/s
08-Jul-06	Measured discharge and water surface elevation and downloaded data logger.	✓	98.697 m	✓	0.002 m^3/s
17-Jul-06	Measured discharge and downloaded data logger.			✓	0.000 m^3/s
13-Aug-06	Measured discharge and water surface elevation and downloaded data logger.	✓	98.697 m	✓	0.006 m^3/s
10-Sep-06	Measured discharge and water surface elevation and downloaded data logger. Removed data logger for winter.	✓	98.702 m	✓	0.013 m^3/s
26-May-07	Installed pressure transducer.				
23-Jun-07	Measured discharge and water surface elevation and downloaded data logger.	✓	98.470 m	✓	1.33 m^3/s
20-Jul-07	Measured water surface elevation, reinstalled transducer.			✓	Very low flow, approximately zero
22-Jul-07	Downloaded data logger.				
19-Aug-07	Measured discharge and water surface elevation and downloaded data logger.	✓	98.972 m	✓	0.427 m^3/s
09-Sep-07	Measured discharge and downloaded data logger. Removed data logger for winter.	✓	98.800 m	✓	0.053 m^3/s

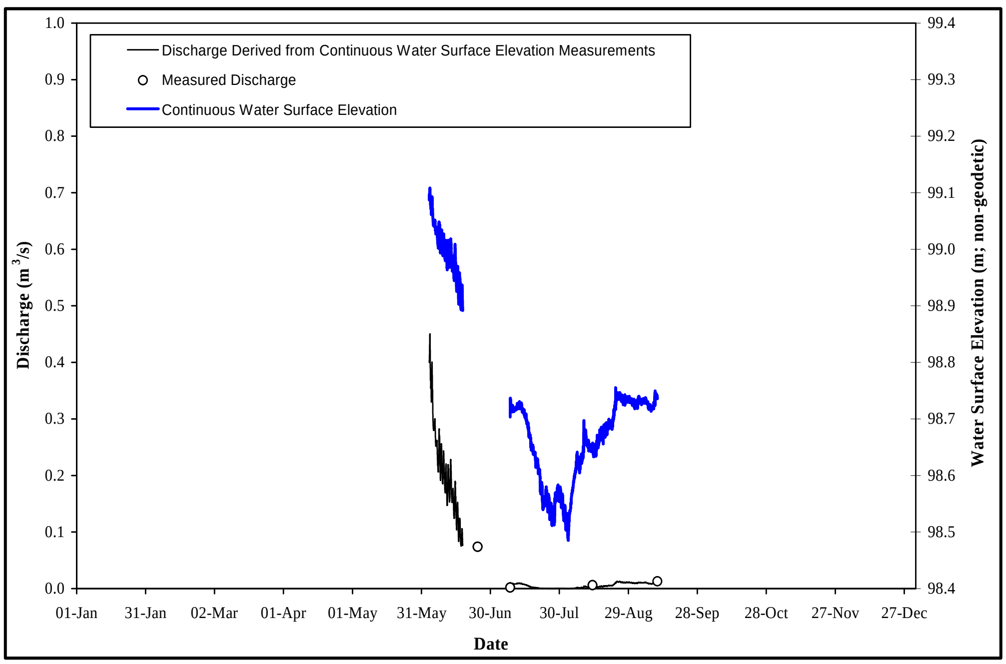


Figure 2.7 Hydrograph for Fickle Duck Lake and Outflow, 2006

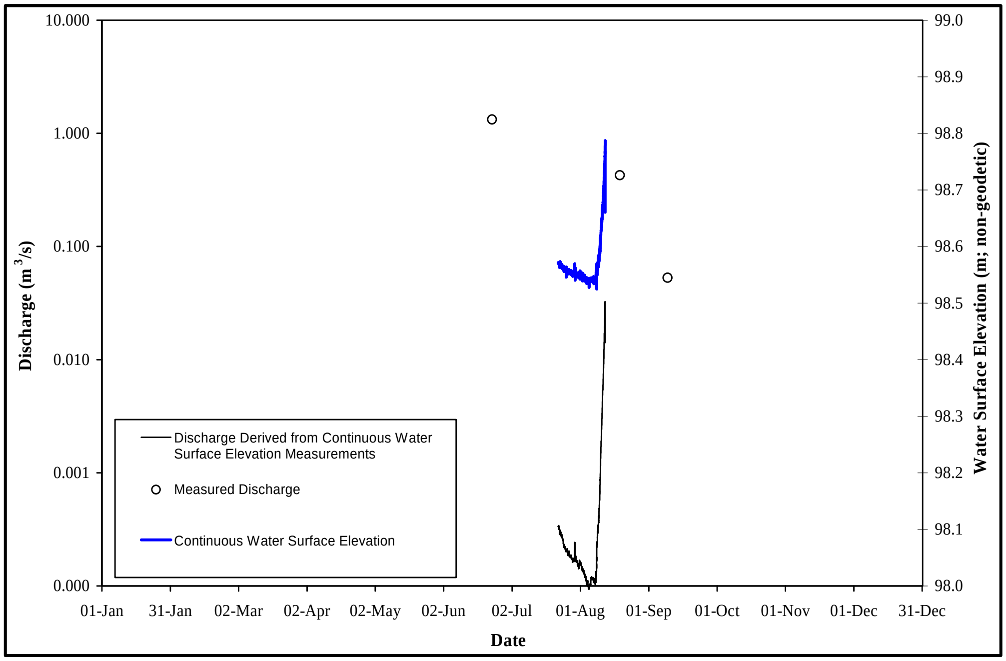


Figure 2.8 Hydrograph for Fickle Duck Lake and Outflow, 2007

2.3.4 H85 Koignuk River

A factsheet describing the location of the hydrometric station and equipment installed at Koignuk River (Station H85) is provided in Appendix A. The appendix also contains stage-discharge data; the derived stage-discharge rating curve based on 2006 data; the derived stage-discharge rating curve based on 2007 data; mean daily discharge and water level data; and manual discharge measurement data and calculation sheets.

The Koignuk River hydrometric station was visited five times during the 2006 field program and six times during the 2007 field program (Table 2.4). A continuous hydrograph was generated for the period from 21 July to 8 September 2006 (Figure 2.9) and 2 July to 13 September 2007 (Figure 2.10).

Continuous water level data (29 May to 8 September 2006 and 2 July to 13 September 2007) for the station are available; however, a reliable stage-discharge rating curve has not yet been derived for discharges prior to 21 July.

Table 2.4 Station Visits to Koignuk River Hydrometric Station, 2006 – 2007

Date	Activities	Lake	Water Level (non-geodetic)	Outflow	Discharge
29-May-06	Installed pressure transducer under ice. Observed onset of spring melt.				
03-Jul-06	Measured water surface elevation and downloaded data logger. Discharge was not measured because of safety concerns associated with high water levels.				
21-Jul-06	Measured discharge and downloaded data logger.	n/a		✓	9.64 m^3/s
14-Aug-06	Measured discharge water surface elevation and downloaded data logger.			✓	4.51m^3/s
08-Sep-06	Measured discharge and water surface elevation and downloaded data logger. Removed data logger for winter.			✓	2.82 m^3/s
25-May-07	Installed pressure transducer under ice.				
01-Jul-07	Measured discharge and water surface elevation.			✓	72.9 m^3/s
19-Jul-07	Measured water surface elevation and downloaded data logger. Discharge not measured because of safety concerns associated with high water levels.				
16-Aug-07	Measured water surface elevation. Discharge not measured because of safety concerns associated with high water levels.	n/a			
31-Aug-07	Measured discharge and water surface elevation and downloaded data logger.			✓	20.2 m^3/s
13-Sep-07	Measured discharge and water surface elevation and downloaded data logger. Removed data logger for winter.			✓	14.8 m^3/s

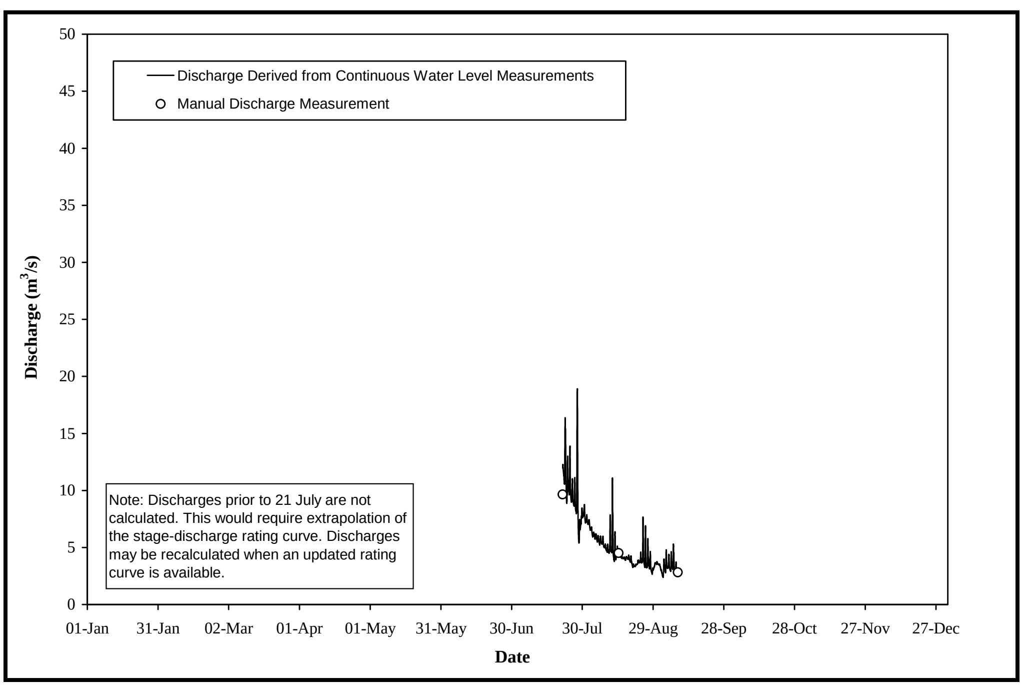


Figure 2.9 Hydrograph for Koignuk River, 2006

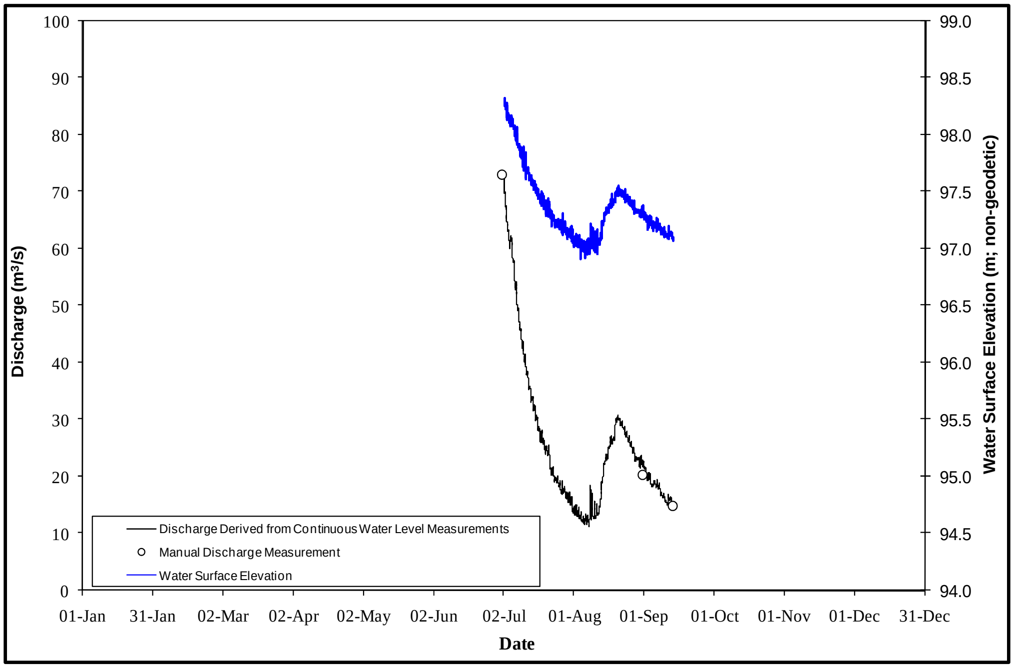


Figure 2.10 Hydrograph for Koignuk River, 2007

2.3.5 H87 Stickleback Lake and Outflow

A factsheet describing the location of the hydrometric station and equipment installed at Stickleback Lake and Outflow (Station H87) is provided in Appendix A. The appendix also contains stage-discharge data; the derived stage-discharge rating curve based on 2006 data; the derived stage-discharge rating curve based on 2006 data; mean daily discharge and water level data; and manual discharge measurement data and calculation sheets.

The Stickleback Lake and Outflow hydrometric station was visited six times during the 2006 field program and four times during the 2007 field program (Table 2.5). Data were used to generate a continuous hydrograph for the period between 2 June to 10 September 2006 (Figure 2.11) and 10 June to 9 September 2007 (Figure 2.12). Discharges between 8 and 10 June 2007 were estimated based on linear interpolation between the onset of runoff and the first transducer readings unaffected by ice. Discharges between 9 and 19 September 2007 were estimated based on linear interpolation between the last measurement and the estimated freeze-up date.

Table 2.5 Station Visits to Stickleback Lake and Outflow Hydrometric Station, 2006 – 2007

Date	Activities	Lake	Water Level (non-geodetic)	Outflow	Discharge
03-Jun-06	Installed pressure transducer under ice. Observed onset of spring melt.	✓	99.498 m		
24-Jun-06	Measured discharge and water surface elevation and downloaded data logger.	✓	99.473 m	✓	0.021 m^3/s
08-Jul-06	Measured discharge and water surface elevation and downloaded data logger.	✓	99.417 m	✓	0.009 m^3/s
17-Jul-06	Measured discharge and downloaded data logger.			✓	0.001 m^3/s
13-Aug-06	Measured discharge and water surface elevation and downloaded data logger.	✓	99.361 m	✓	0.001 m^3/s
10-Sep-06	Measured discharge and water surface elevation and downloaded data logger. Removed data logger for winter.	✓	99.346 m	✓	0.0005 m^3/s
25-May-07	Installed pressure transducer under ice.				
23-Jun-07	Measured discharge and water surface elevation and downloaded data logger.	✓	98.876 m	✓	0.043 m^3/s
19-Aug-07	Measured discharge and water surface elevation and downloaded data logger.	✓	98.757 m	✓	0.013 m^3/s
06-Sep-07	Measured discharge and water surface elevation and downloaded data logger. Removed data logger for winter.	✓	98.785 m	✓	0.005 m^3/s

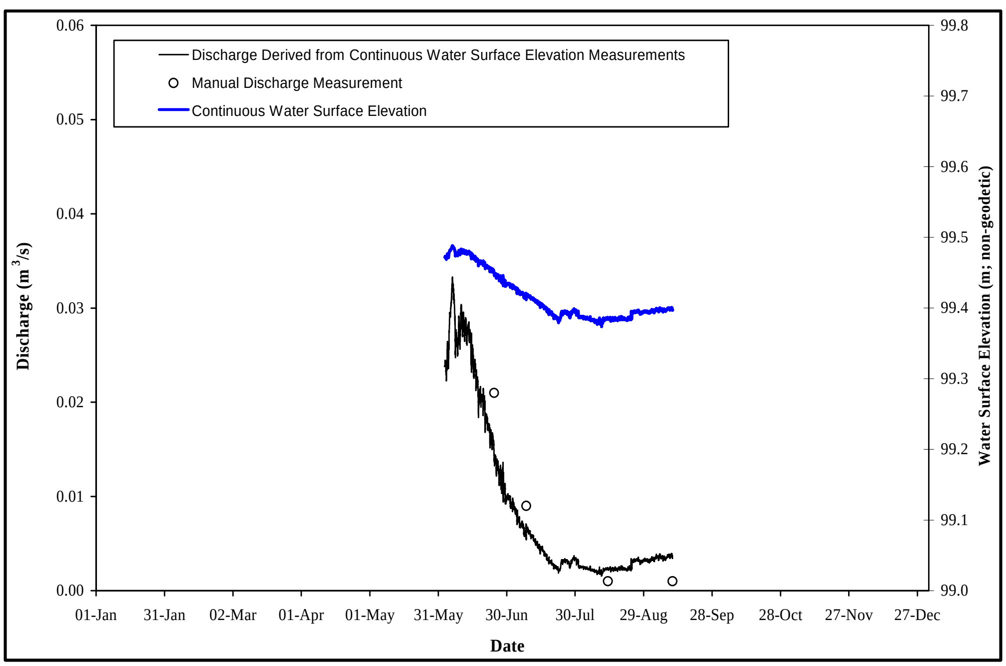


Figure 2.11 Hydrograph for Stickleback Lake and Outflow, 2006

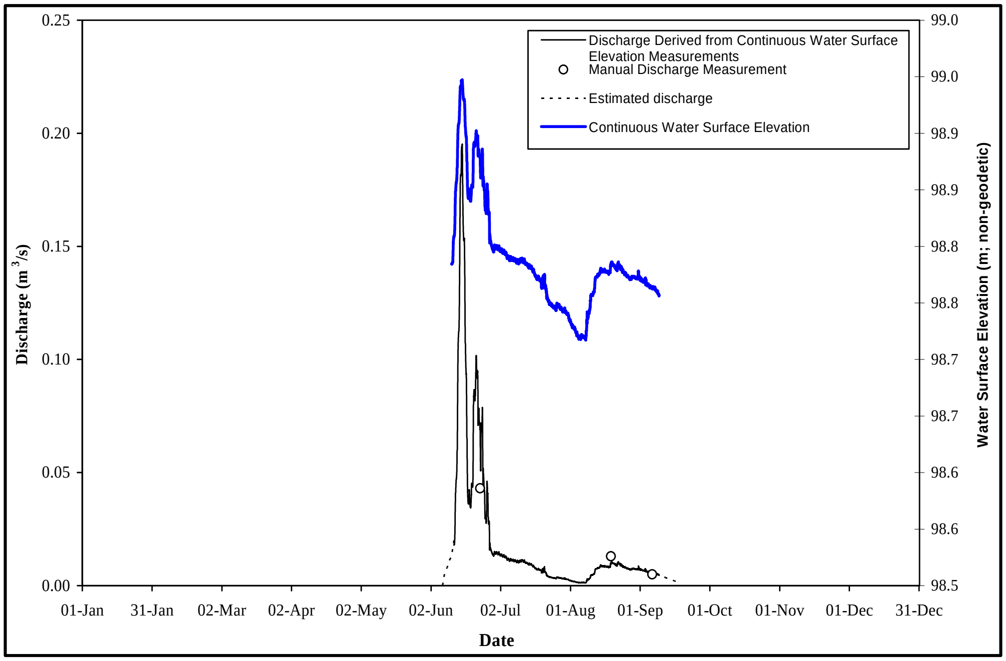


Figure 2.12 Hydrograph for Stickleback Lake and Outflow, 2007

2.3.6 H88 Hope Bay Tide

A factsheet describing the locations of the hydrometric station and equipment installed at Hope Bay Tide (Station H88) is provided in Appendix A. The appendix also contains stage data and daily maximum and minimum water level data.

The Hope Bay Tide hydrometric station was visited four times (Table 2.6) during the 2006 field program, and a continuous hydrograph was derived for the period from 3 July to 8 September (Figure 2.13).

The data collected at the Hope Bay tide gauge show that the daily tidal range is typically between 0.3 and 0.4 m. The minimum daily tidal range over the monitoring period was 0.20 m and the maximum daily tidal range was 0.61 m. The minimum measured water surface elevation was 0.38 m below the mean for the monitoring period, and the maximum monitored water surface elevation was 0.55 m above the mean for the monitoring period. The variability in water surface elevation shown in Figure 2.13 is due to a combination of diurnal variation, longer-term tidal variation, and the effects of wind.

Table 2.6 Station Visits to Hope Bay Tide Hydrometric Station, 2006

Date	Activities	Ocean	Water Level (non-geodetic)	Outflow	Discharge
3-Jul-06	Installed transducer and logger. Surveyed water level and downloaded data logger.	✓	0.090 m	n/a	
21-Jul-06	Downloaded data logger.				
14-Aug-06	Surveyed water level and downloaded data logger.	✓	-0.238 m		
8-Sep-06	Surveyed water level and downloaded data logger. Removed transducer and logger for winter.	✓	0.093 m		

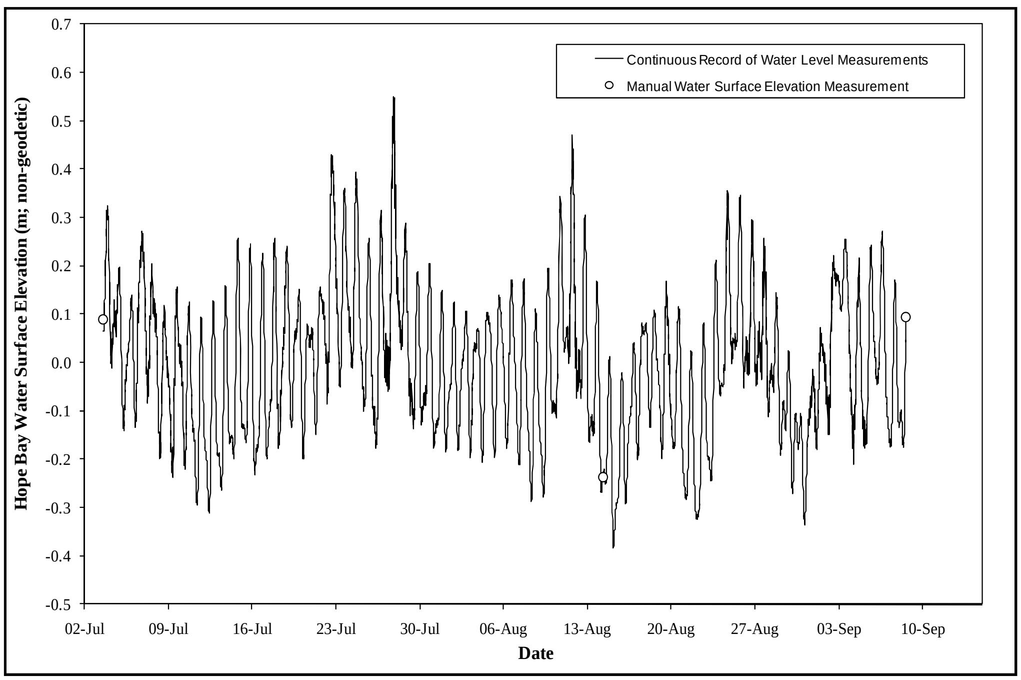


Figure 2.13 Hydrograph for Hope Bay Tide Gauge, 2006

2.4 MADRID PROJECT HYDROMETRY

2.4.1 H93 Glenn Lake and Outflow

A factsheet describing the locations of the hydrometric station and equipment installed at Glenn Lake and Outflow (Station H93) is provided in Appendix A. The appendix also contains stage-discharge data; the derived stage-discharge rating curve based on 2006 data; the derived stage-discharge rating curve based on 2007 data; mean daily discharge and water level data; and manual discharge measurement data and calculation sheets.

The Glenn Lake and Outflow hydrometric station was visited five times during the 2006 field program and six times during the 2007 field program (Table 2.7). Continuous hydrographs were derived for 29 May to 8 September (Figure 2.14) and 29 May to 3 July 2007 (Figure 2.15). Data are not available after 3 July because the transducer failed. During field visits, the transducer readings appeared normal but at the end of the open water program, the transducer was found to be malfunctioning.

Table 2.7 Station Visits to Glenn Lake and Outflow Hydrometric Station, 2006 – 2007

Date	Activities	Lake	Water Level (non-geodetic)	Outflow	Discharge
29-May-06	Installed transducer and data logger. Surveyed lake water level. Ice-covered conditions with no flow.	✓	97.200 m		
03-Jul-06	Measured discharge and water level. Downloaded data logger.	✓	97.044 m	✓	0.287 m^3/s
21-Jul-06	Measured discharge and downloaded data logger.			✓	0.140 m^3/s
12-Aug-06	Measured discharge and water level. Downloaded data logger.	✓	96.972 m	✓	0.077 m^3/s
08-Sep-06	Measured discharge and water level. Downloaded data logger. Removed transducer and logger for winter.	✓	96.916 m	✓	0.038 m^3/s
24-May-07	Installed transducer and data logger. Ice-covered conditions with no flow.				
22-Jun-07	Measured discharge. Downloaded data logger.			✓	0.695 m^3/s
07-Jul-07	Measured water surface elevation. Downloaded data logger.	✓	97.207 m		
19-Jul-07	Measured discharge and water level. Downloaded data logger.	✓	97.042 m	✓	0.201 m^3/s
16-Aug-07	Measured discharge and water level. Downloaded data logger.	✓	96.994 m	✓	0.088 m^3/s
15-Sep-07	Measured discharge and water level. Downloaded data logger. Removed transducer and logger for winter.	✓	97.108 m	✓	0.139 m^3/s

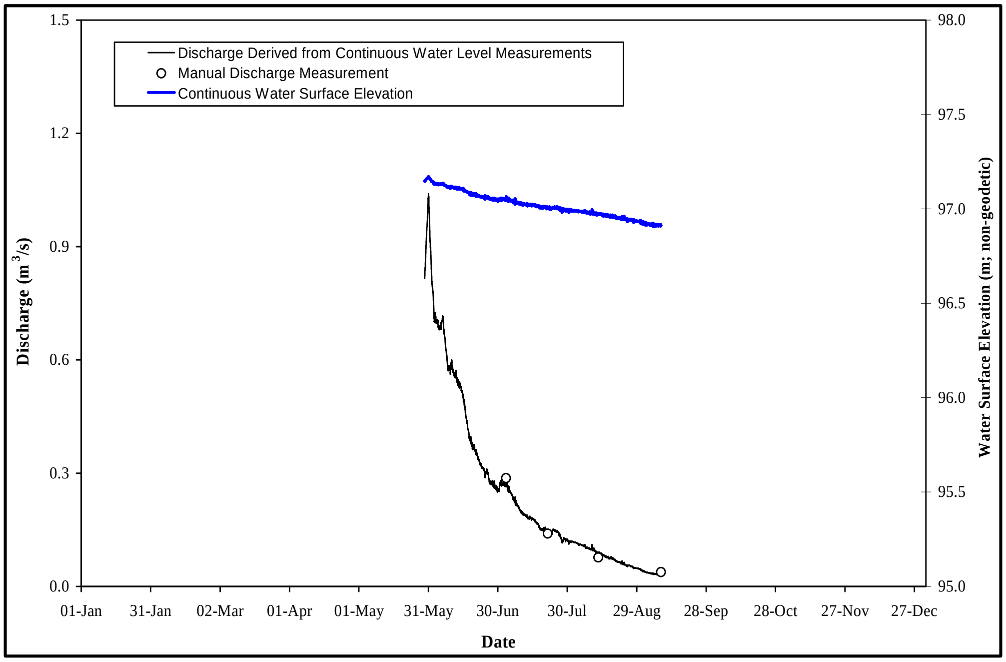


Figure 2.14 Hydrograph for Glenn Outflow, 2006

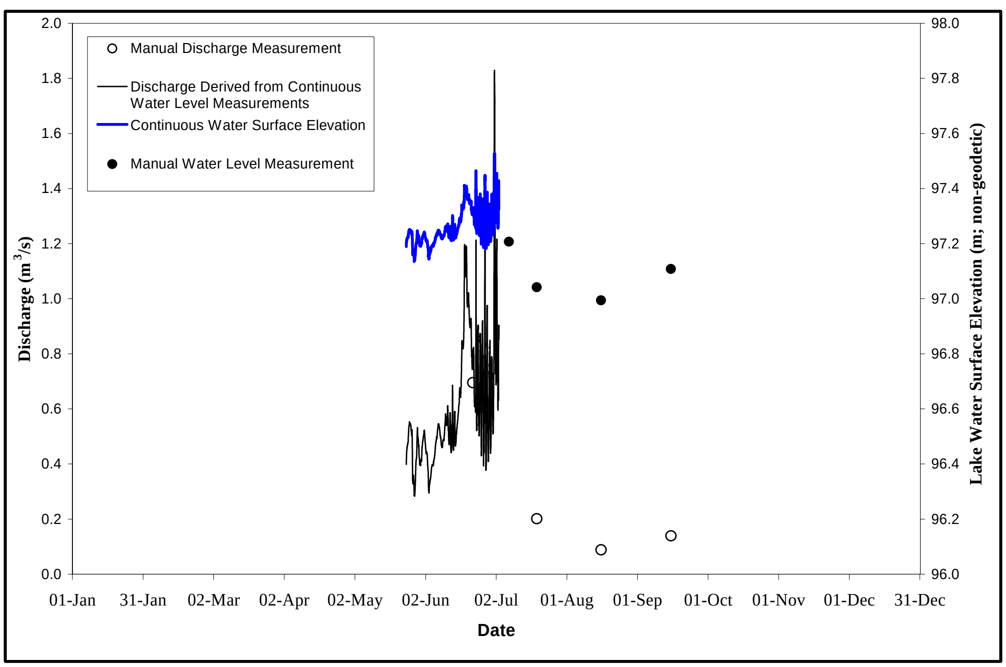


Figure 2.15 Hydrograph for Glenn Outflow, 2007

2.4.2 H82 Ogama Lake and Outflow

A factsheet describing the location of the hydrometric station and equipment installed at Ogama Lake and Outflow (Station H82) is provided in Appendix A. The appendix also contains stage-discharge data; the derived stage-discharge rating curve based on 2006 data; the derived stage-discharge rating curve based on 2007 data; mean daily discharge and water level data; and manual discharge measurement data and calculation sheets.

The Ogama Lake and Outflow hydrometric station was visited five times during the 2006 field program and seven times during the 2007 field program (Table 2.8). A continuous hydrograph was derived from data collected between 31 May to 8 September 2006 (Figure 2.16) and 19 June to 14 September 2007 (Figure 2.17). Discharges between 15 and 19 June 2007 were estimated based on linear interpolation between the onset of runoff and the first transducer readings unaffected by ice. Discharges between 14 September and 9 October 2007 were estimated based on linear interpolation between the last measurement and the estimated freeze-up date.

Table 2.8 Station Visits to Ogama Lake and Outflow Hydrometric Station, 2006 – 2007

Date	Activities	Lake	Water Level (non-geodetic)	Outflow	Discharge
31-May-06	Installed pressure transducer under ice. Observed onset of spring melt.				
03-Jul-06	Measured discharge and water surface elevation and downloaded data logger.	✓	97.732 m	✓	0.539 m^3/s
22-Jul-06	Measured discharge and downloaded data logger.			✓	0.141 m^3/s
12-Aug-06	Measured discharge and water surface elevation and downloaded data logger.	✓	97.639 m	✓	0.122 m^3/s
08-Sep-06	Measured discharge and downloaded data logger. Removed data logger for winter.			✓	0.059 m^3/s
23-May-07	Installed pressure transducer.				
22-Jun-07	Measured discharge.			✓	1.236 m^3/s
03-Jul-07	Measured water surface elevation.	✓	98.507 m		
10-Jul-07	Measured discharge and water surface elevation.	✓	98.446 m	✓	0.789 m^3/s
19-Jul-07	Measured discharge and water surface elevation and downloaded data logger.	✓	98.360 m	✓	0.329 m^3/s
16-Aug-07	Measured discharge and water surface elevation and downloaded data logger.	✓	98.370 m	✓	0.425 m^3/s
14-Sep-07	Measured discharge, water surface elevation and downloaded data logger. Removed data logger for winter.	✓	98.381 m	✓	0.400 m^3/s

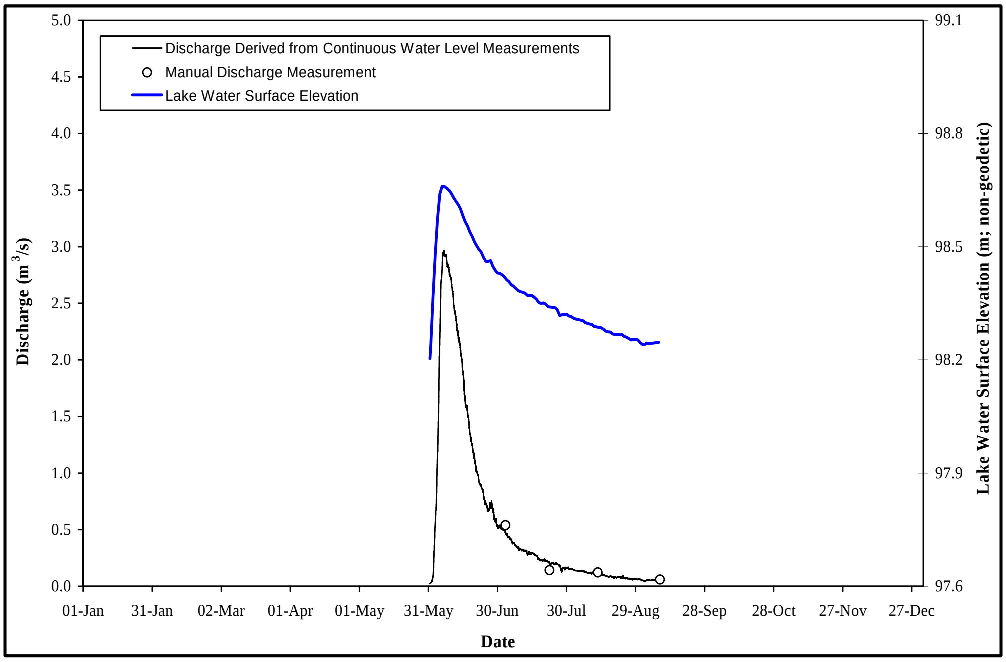


Figure 2.16 Hydrograph for Ogama Lake and Outflow, 2006

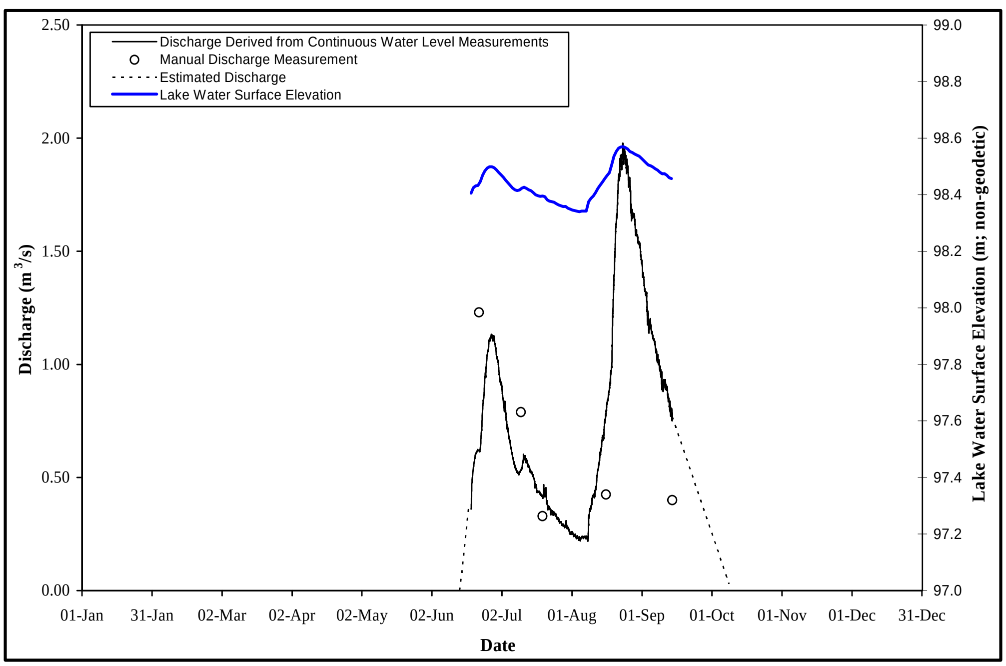


Figure 2.17 Hydrograph for Ogama Lake and Outflow, 2007

2.4.3 H81 Patch Lake and Outflow

A factsheet describing the location of the hydrometric station and equipment installed at Patch Lake and Outflow (Station H81) is provided in Appendix A1. The appendix also contains stage-discharge data; the derived stage-discharge rating curve based on 2006 data; mean daily discharge and water level data; manual discharge measurement data and calculation sheets; channel survey graphic between Patch Lake and P.O. Lake; and manual discharge measurement data and calculation sheets. Because of backwater effects from P.O. Lake, a single rating curve does not exist for Patch Outflow.

The Patch Lake and Outflow hydrometric station was visited five times during the 2006 field program and seven times during the 2007 field program (Table 2.9). Resulting data were used to generate a continuous hydrograph for the period of 1 June to 9 September 2006 (Figure 2.18) and 25 June to 12 September 2007 (Figure 2.19).

Table 2.9 Station Visits to Patch Lake and Outflow Hydrometric Station, 2006 – 2007

Date	Activities	Lake	Water Level (non-geodetic)	Outflow	Discharge
1-Jun-06	Installed pressure transducer under ice. Observed onset of spring melt.				
3-Jul-06	Measured discharge and water surface elevation and downloaded data logger.	✓	98.984 m	✓	0.300 m^3/s
22-Jul-06	Measured discharge and downloaded data logger.			✓	0.109 m^3/s
12-Aug-06	Measured discharge and water surface elevation and downloaded data logger.	✓	98.831 m	✓	0.085 m^3/s
9-Sep-06	Measured discharge and downloaded data logger. Removed data logger for winter.			✓	0.029 m^3/s
23-May-07	Installed pressure transducer, surveyed ice level.				
22-Jun-07	Measured discharge - no discharge, ice on bottom of channel.			✓	
3-Jul-07	Measured water surface elevation.	✓	98.996 m		
10-Jul-07	Measured discharge and water surface elevation.	✓	98.984 m	✓	0.279 m^3/s
19-Jul-07	Measured discharge and water surface elevation and downloaded data logger.	✓	98.958 m	✓	0.149 m^3/s
14-Aug-07	Measured discharge and water surface elevation and downloaded data logger.	✓	97.945 m	✓	0.117 m^3/s
12-Sep-07	Measured discharge, water surface elevation and downloaded data logger. Removed data logger for winter.	✓	98.932 m	✓	0.051 m^3/s

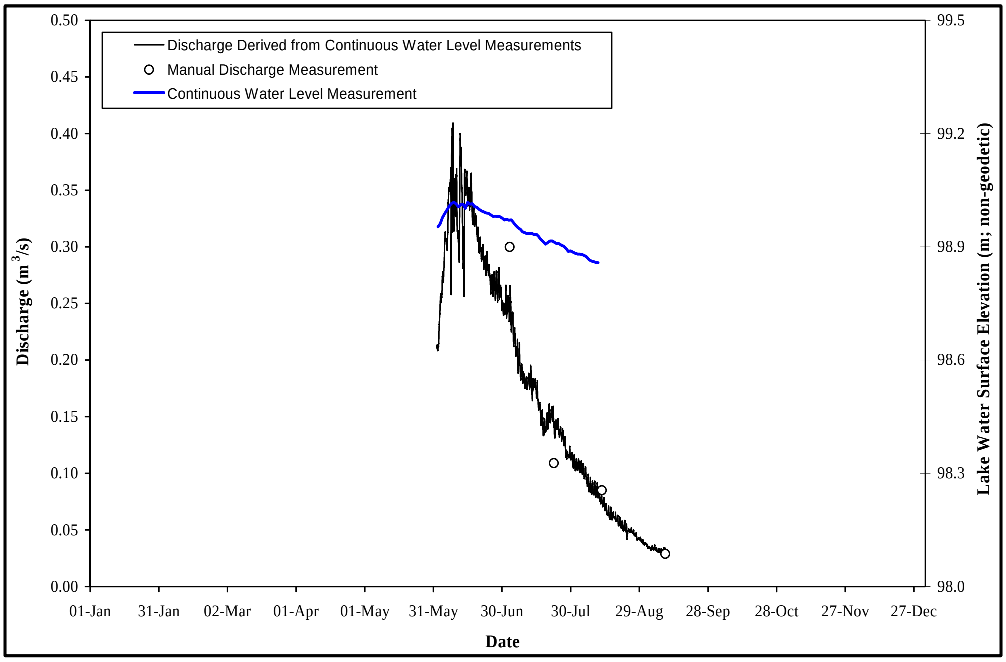


Figure 2.18 Hydrograph for Patch Lake and Outflow, 2006

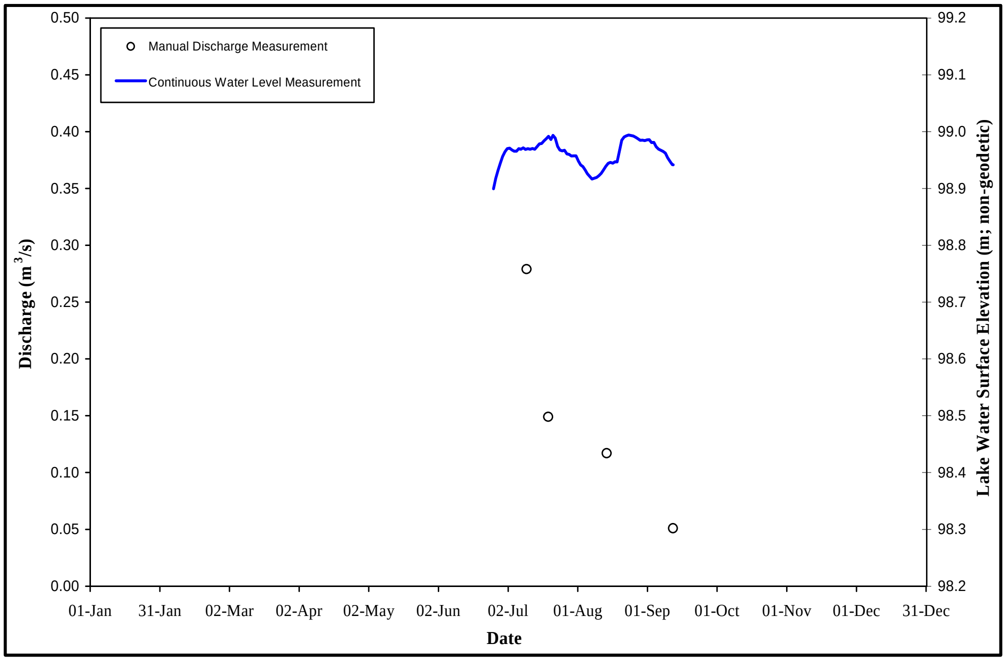


Figure 2.19 Hydrograph for Patch Lake and Outflow, 2007

2.4.4 H89 P.O. Lake and Outflow

A factsheet describing the locations of the hydrometric station and equipment installed at P.O. Lake and Outflow (Station H89) is provided in Appendix A.

The appendix also contains stage-discharge data; the derived stage-discharge rating curve (2007 data); mean daily discharge and water level data; and manual discharge measurement data and calculation sheets.

The P.O. Lake and Outflow hydrometric station was visited seven times (Table 2.10) during the 2007 field program, and a hydrograph was derived for the period from 18 June to 14 September (Figure 2.20).

Table 2.10 Station Visits to P.O. Lake and Outflow Hydrometric Station, 2007

Date	Activities	Lake	Water Level (non-geodetic)	Outflow	Discharge
14-Jun-07	Installed transducer. Ice-covered conditions with no outflow.				
22-Jun-07	Measured discharge. Downloaded data logger.			✓	0.111 m^3/s
3-Jul-07	Downloaded data logger.				
10-Jul-07	Measured water level and discharge. Downloaded data logger.	✓	99.241 m	✓	0.441 m^3/s
14-Aug-07	Measured discharge and downloaded data logger.			✓	0.425 m^3/s
12-Sep-07	Downloaded data logger.				
14-Sep-07	Measured discharge and downloaded data logger. Removed transducer and logger for winter.			✓	0.261 m^3/s

Discharges between 14 September and 12 October 2007 were estimated based on linear interpolation between the last measurement and the estimated freeze-up date.

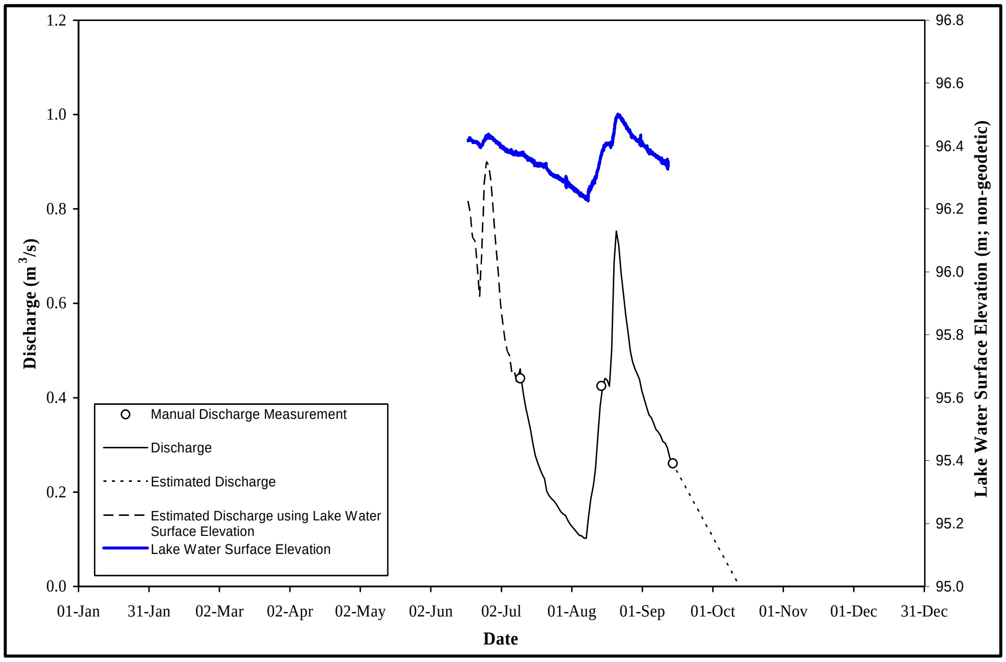


Figure 2.20 Hydrograph for P.O. Lake Outflow, 2007

2.4.5 H91 Windy Lake and Outflow

A factsheet describing the locations of the hydrometric station and equipment installed at Windy Lake and Outflow (Station H91) is provided in Appendix A. The appendix also contains stage-discharge data; the derived stage-discharge rating curve based on 2006 data; the derived stage-discharge rating curve based on 2007 data; mean daily discharge and water level data; and manual discharge measurement data and calculation sheets.

The station was visited five times during the 2006 field program and six times during the 2007 field program (Table 2.11). Continuous data are not available for 2006 because the data logger appeared to be providing realistic readings when downloaded but at the completion of the open water program, it was found to have been malfunctioning. Manual water surface elevation are available for 3 July and 12 August 2006, and discharge measurements are available for 3 July, 19 July, 12 August and 8 September 2006 (Figure 2.21). Continuous data collected between 22 June and 4 August 2007 were used to derive a hydrograph (Figure 2.22). The data logger was providing appropriate readings when downloaded but at the completion of the open-water program, it was found to be malfunctioning and so continuous data are not available after 4 August 2007. Manual water surface elevation and discharge measurements are available for 13 August and 14 September 2007.

Table 2.11 Station Visits to Windy Lake and Outflow Hydrometric Station, 2006 – 2007

Date	Activities	Lake	Water Level (non-geodetic)	Outflow	Discharge
29-May-06	Installed transducer and logger. Ice-covered conditions with no outflow.				
3-Jul-06	Surveyed water level and measured discharge at outflow. Downloaded data logger.	✓	98.435 m	✓	0.135 m^3/s
19-Jul-06	Measured discharge at outflow.			✓	0.059 m^3/s
12-Aug-06	Surveyed water level and measured discharge. Downloaded data logger.	✓	98.405 m	✓	0.052 m^3/s
8-Sep-06	Measured discharge. Removed transducer and for winter.			✓	0.042 m^3/s
24-May-07	Installed pressure transducer.				
22-Jun-07	Measured discharge under ice.			✓	0.003 m^3/s
3-Jul-07	Measured water surface elevation.	✓	Very low levels.		
20-Jul-07	Measured discharge and water surface elevation and downloaded data logger.	✓	98.379 m	✓	0.051 m^3/s
13-Aug-07	Measured discharge and water surface elevation and downloaded data logger.	✓	98.432 m	✓	0.078 m^3/s
15-Sep-07	Measured discharge, water surface elevation and downloaded data logger. Removed data logger for winter.	✓	98.409 m	✓	0.061 m^3/s

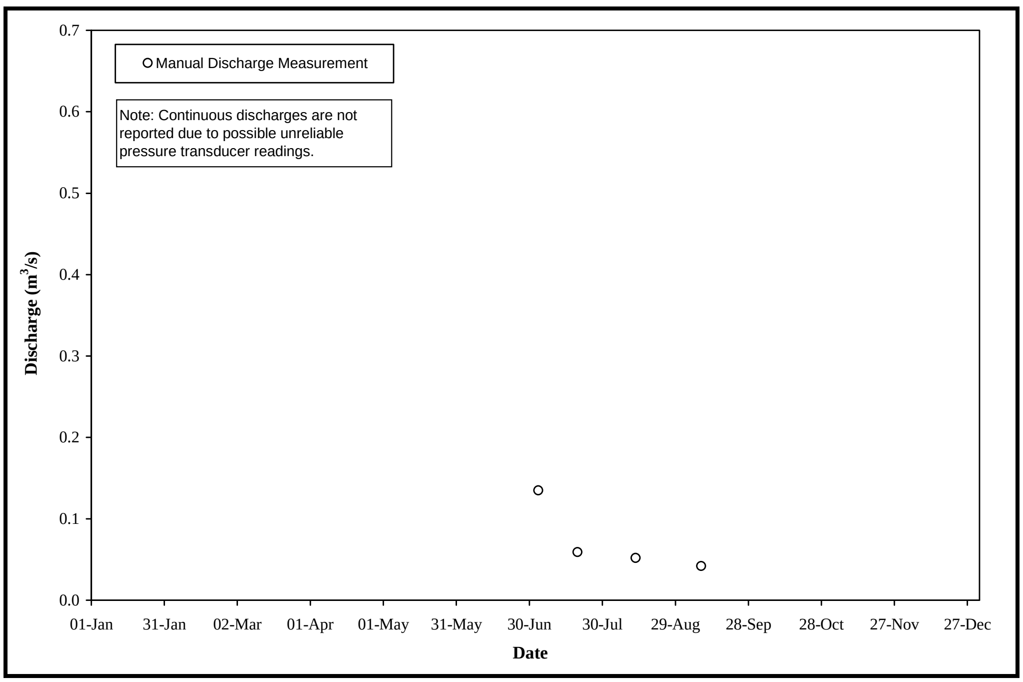


Figure 2.21 Hydrograph for Windy Lake and Outflow, 2006

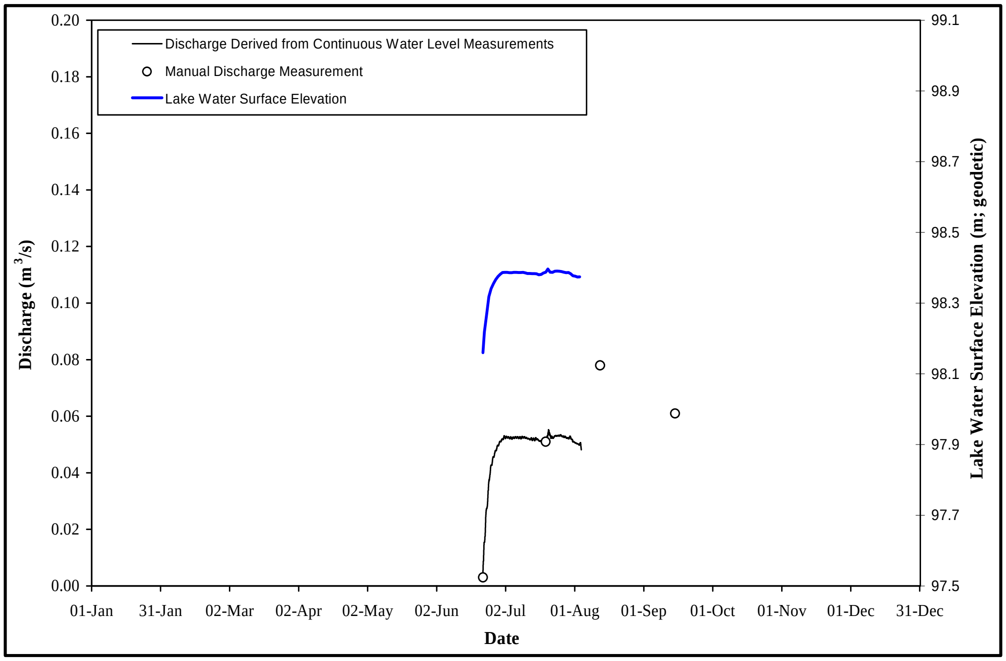


Figure 2.22 Hydrograph for Windy Lake and Outflow, 2007

2.4.6 Wolverine Lake

A factsheet describing the locations of the hydrometric station and equipment installed at Wolverine Lake (Station H91) is located in Appendix A. The appendix also contains stage data and mean daily water level data.

The Wolverine Lake hydrometric station was visited five times during the 2006 field program and four times during the 2007 field program (Table 2.12). Continuous hydrographs were derived for the period from 1 June to 8 September (Figure 2.23) and 13 June to 14 August 2007 (Figure 2.24). No discharge was observed at the outflow in 2006 or 2007 suggesting discharge only occurs during periods of high water.

Table 2.12 Station visits to Wolverine Lake Hydrometric Station, 2006 – 2007

Date	Activities	Lake	Water Level (non-geodetic)	Outflow	Discharge
1-Jun-06	Installed transducer and logger. Ice-covered conditions with no outflow.			n/a	
3-Jul-06	Measured water surface elevation and downloaded data logger.	✓	98.349 m		
23-Jul-06	Downloaded data logger at.				
12-Aug-06	Measured water surface elevation and downloaded data logger.	✓	98.273 m		
8-Sep-06	Measured water surface elevation and downloaded data logger. Removed transducer and logger for winter.	✓	98.204 m		
23-May-07	Installed pressure transducer, surveyed water level/ice surface.	✓	96.113 m	n/a	
7-Jul-07	Measured water surface elevation.	✓	96.143 m		
19-Jul-07	Downloaded data logger.				
14-Aug-07	Measured water surface elevation and downloaded data logger.	✓	96.042 m		

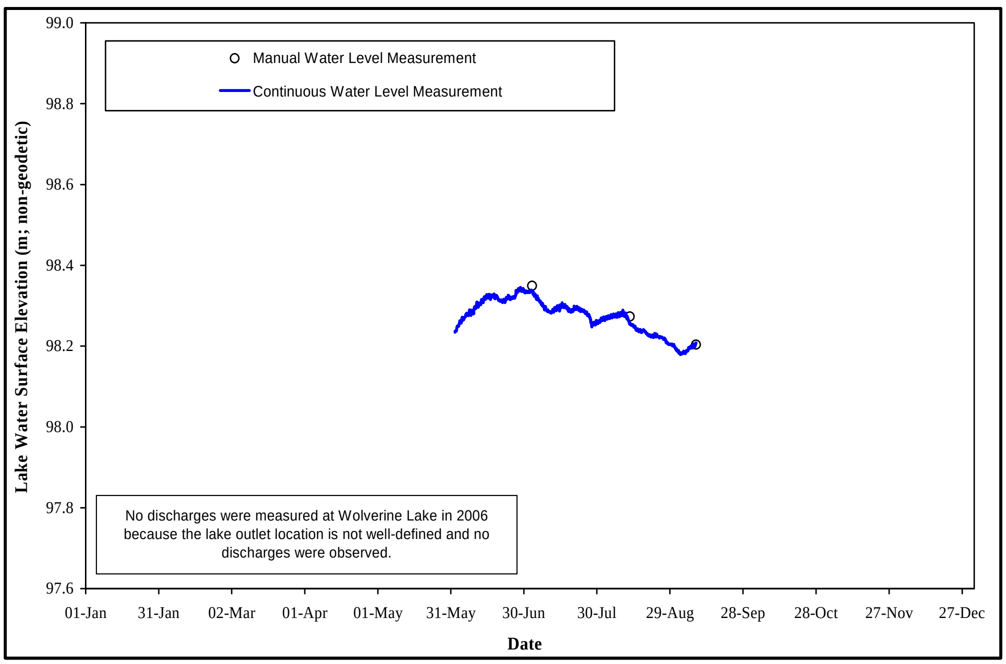


Figure 2.23 Hydrograph for Wolverine Lake, 2006

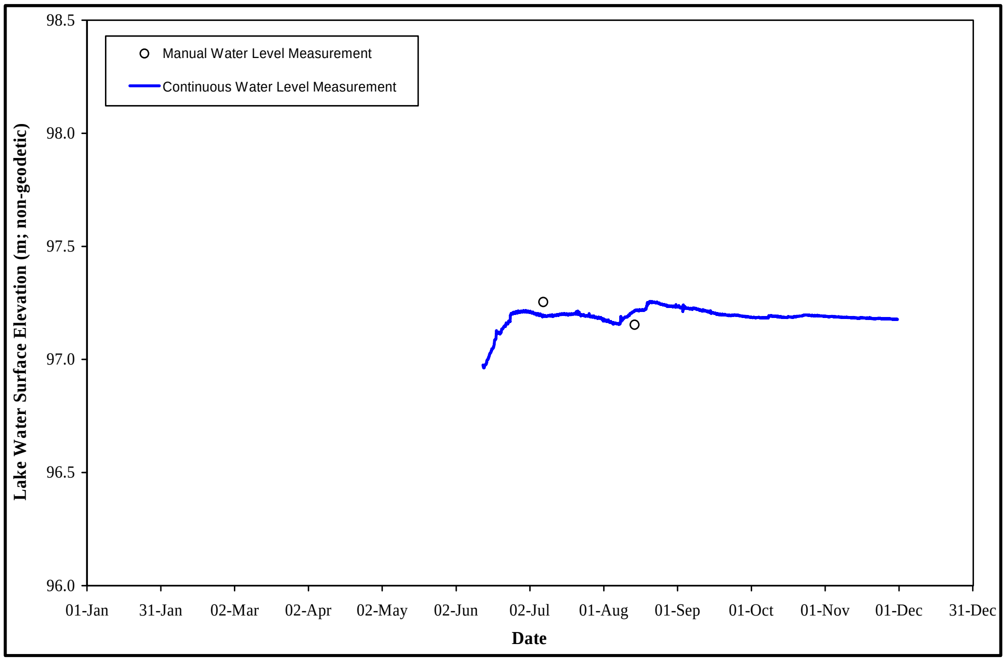


Figure 2.24 Hydrograph for Wolverine Lake, 2007

2.5 BOSTON AND MADRID PROJECT DISCUSSION

The 2006 and 2007 hydrometry programs marked the first and second year of hydrological data collection by Golder for the Boston and Madrid Project areas. Water surface elevation and discharge data were collected during the 2006 and 2007 open-water season for the Aimaokatalok River and Outflow, Koignuk River, Fickle Duck, Stickleback, Aimaokatalok, Glenn, Ogama, Patch, and Windy outflows. Water surface elevation and discharge data were also collected for P.O. Lake Outflow in 2007. Calculated annual water yields for Patch, Glenn, Ogama, and Stickleback lakes are presented in Table 2.13. The remaining stations do not have hydrographs estimated before or after the monitoring period.

Water surface elevation data were collected during the open-water season in 2006 for the Hope Bay tidal gauge, and in 2006 and 2007 for Wolverine Lake; Wolverine Lake appears to discharge only at extreme high water. Discharge data were collected for the north-east Aimaokatalok Inflow in 2006 and 2007.

Water yields for the lakes listed in Table 2.13 appear consistent with data from the monitoring program for the Doris North Project area. By comparison, Doris Lake Outflow had an annual water yield of 72.9 mm compared to 71.6 mm at Roberts Lake in 2006 (Golder 2007). Tail and Stickleback lakes have similar watershed areas and the annual water yields are similar: 53.1 mm for Tail Lake and 55.4 mm for Stickleback Lake (Golder 2008a). Patch Lake watershed has a greater ratio of lake surface area to watershed area than Tail Lake, and so would be expected to have lower water yields. The measured water yields for Glenn and Ogama lakes are consistent with lower ratios of lake water surface area to watershed area.

Table 2.13 Calculated Water Yields for Glenn, Ogama, Patch, and Stickleback Lakes, 2006 – 2007

Watershed	Total Annual Discharge in 2006[a] (m^3)	Total Annual Discharge in 2007[a] (m^3)	Watershed Area (km^2)	2006 Annual Water Yield (mm)	2007 Annual Water Yield (mm)
Patch Lake	1,432 000		35.5	40.3	
Ogama Lake	5,615 000	6983 169	71.9	78.1	97.1
Stickleback Lake	79 200	155 331	2.8	28.3	55.4
Glenn Lake	1,977 000		31.6	62.6	

[a] Hydrograph estimated before and after monitoring period.

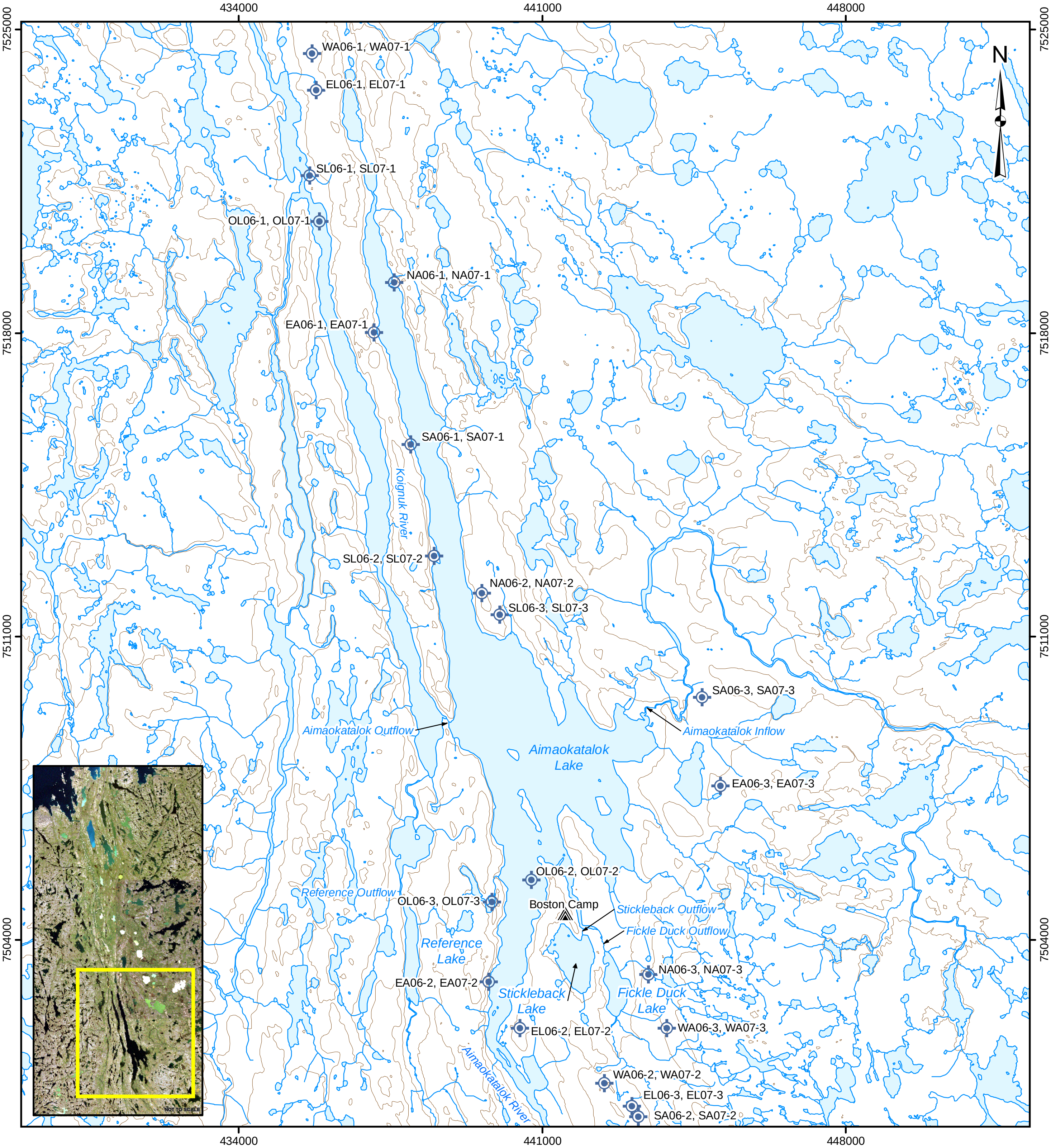
Though no baseline analysis currently exists to estimate mean annual water yields for lakes in this program, the consistency with Doris North Project area values indicate that these water yields represent conditions drier than the long-term mean.

Because sampling in 2006 at the Aimaokatalok Lake Inflow and Outflow and the Koignuk River served as reconnaissance, only partial annual data sets were collected. However, complete data sets were collected for the Koignuk River and Aimaokatalok Outflow in 2007. The Aimaokatalok Lake Outflow station was installed in deep water in September 2006 to allow continuous monitoring through the year.

2.6 SNOW COURSE SURVEYS

The water equivalent of a snowpack is a product of snow depth and density. Appendix A presents terrain type and snowpack measurement data collected in 2006 and 2007. Sampling locations for the 2006 and 2007 snow course survey program are shown in Figure 2.25.

Twenty-one stations over seven terrain types were examined during the snow course surveys in 2006 and 2007. Snow densities were similar across terrain types with the exception of the open lake and north aspect terrain types where values were higher. Snow depth for open lake terrain was 19.4 cm (mean) in 2006 and 22.2 cm (mean) in 2007. North aspect slope terrain had mean snow depths of 42.0 cm in 2006 and 51.8 cm in 2007.



LEGEND

- CAMP
- SNOW COURSE SURVEY LOCATION
- CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY

3500 0 3500

SCALE 1:125000 METRES

REFERENCE

Base data obtained from Government of Canada, Natural Resources Canada, Centre for Topographic Information (1:50 000). Landsat 7 imagery captured in 2007, obtained from CanImage. Field data collected by Golder Associates Ltd., 2008.
Projection: UTM Zone 13 Datum: NAD 83

PROJECT

NEWMONT The Gold Company

HOPE BAY MINING LTD.

TITLE

2006 AND 2007 SNOW COURSE SURVEY SITES, BOSTON PROJECT AREA

Golder Associates
Edmonton, Alberta

PROJECT NO. 07-1373-0019			SCALE AS SHOWN	REV. 0
DESIGN	DC	20 Nov. 2008	FIGURE: 2.25	
GIS	BR	30 Mar. 2009		
CHECK	AH	16 Mar. 2009		
REVIEW	GA	16 Mar. 2009		

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In 2006, snow water equivalents ranged from 59.4 mm of water for open lake terrain to 130.6 mm for north aspect slope terrain. In 2007, snow water equivalents ranged from 38.1 mm of water for exposed lowland terrain to 91.3 mm for south aspect terrain (Table 2.14, Figures 2.26 and 2.27,).

Table 2.14 Snow Course Survey Data for Boston Project Area, 2006 – 2007

Terrain Type	Survey Plot Number		Snow Density (g/cm^3)[a]		Snow Depth (cm)[b]		Snow Water Equivalent (mm)	
	2006	2007	2006	2007	2006	2007	2006	2007
Open Lake	OL-06-1	OL-07-1	0.298	0.216	24.3	22.0	72.2	47.4
	OL-06-2	OL-07-2	0.328	0.370	22.7	26.7	74.6	98.9
	OL-06-3	OL-07-3	0.278	0.112	11.3	17.9	31.4	20.0
	Mean		0.301	0.233	19.4	22.2	59.4	55.4
Exposed Lowland	EL-06-1	EL-07-1	0.185	0.171	38.8	40.1	71.6	68.4
	EL-06-2	EL-07-2	0.247	0.090	35.8	36.8	88.4	33.3
	EL-06-3	EL-07-3	0.309	0.058	24.3	21.5	75.2	12.5
	Mean		0.247	0.106	33.0	32.8	78.4	38.1
Sheltered Lowland	SL-06-1	SL-07-1	0.191	0.153	29.9	44.1	57.0	67.5
	SL-06-2	SL-07-2	0.254	0.126	30.9	41.2	78.4	52.1
	SL-06-3	SL-07-3	0.227	0.079	22.1	30.5	50.3	24.0
	Mean		0.224	0.119	27.6	38.6	61.9	47.9
North Aspect	NA-06-1	NA-07-1	0.294	0.191	40.9	25.4	120.3	48.6
	NA-06-2	NA-07-2	0.292	0.152	41.9	29.3	122.1	44.6
	NA-06-3	NA-07-3	0.346	0.267	43.2	40.4	149.6	107.9
	Mean		0.311	0.203	42.0	31.7	130.6	67.0
East Aspect	EA-06-1	EA-07-1	0.279	0.095	22.9	26.3	63.8	24.9
	EA-06-2	EA-07-2	0.214	0.146	31.1	57.0	66.6	83.5
	EA-06-3	EA-07-3	0.327	0.132	22.7	31.7	74.3	41.9
	Mean		0.273	0.124	25.6	38.3	68.2	50.1
South Aspect	SA-06-1	SA-07-1	0.254	0.119	28.9	35.0	73.3	41.7
	SA-06-2	SA-07-2	0.248	0.129	9.8	24.1	24.3	31.0
	SA-06-3	SA-07-3	0.295	0.183	31.6	28.2	93.3	51.6
	Mean		0.266	0.179	23.4	49.4	63.6	91.3
West Aspect	WA-06-1	WA-07-1	0.206	0.136	16.8	29.7	34.6	40.4
	WA-06-2	WA-07-2	0.314	0.174	45.8	45.0	143.9	78.3
	WA-06-3	WA-07-3	0.267	0.186	39.1	80.7	104.6	150.1
	Mean		0.263	0.165	33.9	51.8	94.4	89.6

[a] Mean based on three samples per plot.

[b] Mean based on 30 measurements per plot.

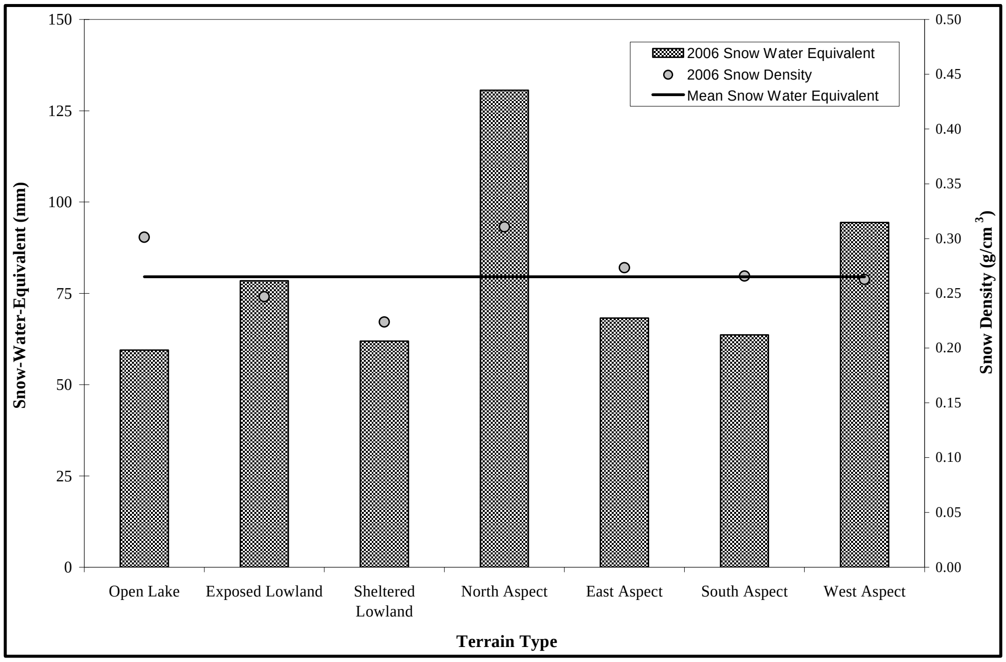


Figure 2.26 Snow Course Survey Data for Boston Project Area, 1 May 2006

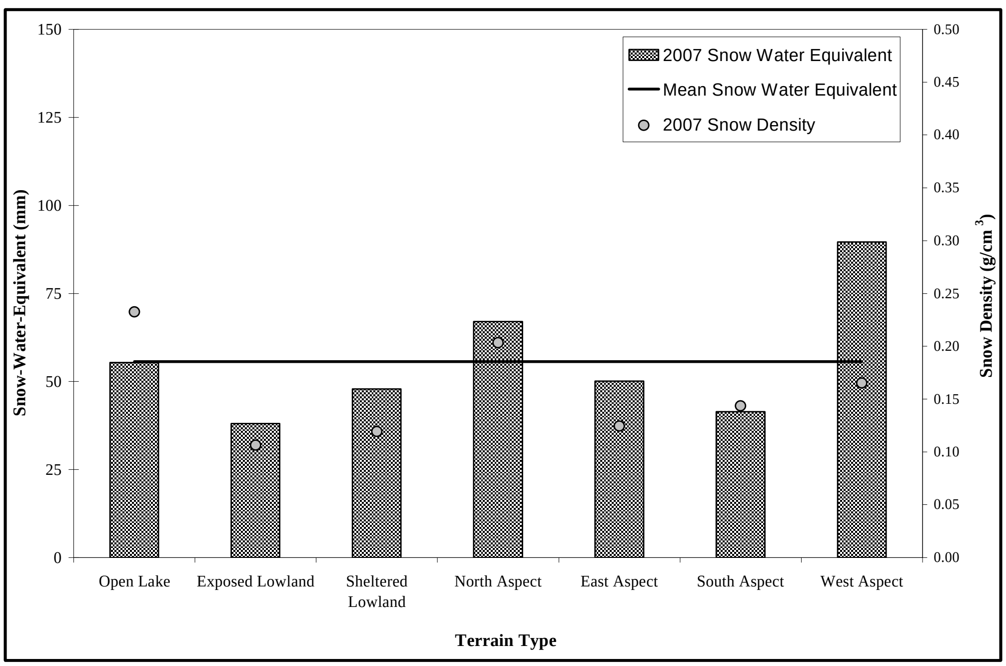


Figure 2.27 Snow Course Survey Data for Boston Project Area, 28 April - 5 May 2007

Wind redistributes snowfall over the course of a winter, and in general, less snow collects on exposed terrain, such as open lake areas, compared with sheltered lowlands. Similarly, prevailing winds redistribute snow unequally across slopes of differing aspect. These effects may result in substantial differences between terrain types. Our study involved a limited number of sampling stations in an area with little vegetation, and broad ranges of measured values were observed among terrain types. As such, detailed calculation of mean snow water equivalent, based on the relative proportion of each terrain type, is not recommended. An un-weighted mean snow water equivalent of 80 mm should be used in any water balance calculations in 2006 and 55.6 mm in 2007 (Figure 2.26 and 2.27)

2.7 RAINFALL

The Boston Camp meteorological station was installed on 2 July 2006 and operated continuously through 31 December 2006. Rainfall data were recorded at the station in months when air temperatures were above 0°C, which generally included May to September. It is possible that trace, or localized, rainfall events occurred during open water months in parts of the watershed distant from the meteorological station, and hence, were not recorded. Rainfall data for 2007 are not available due to malfunction of the tipping bucket rain gauge at the Boston climate station.

The Boston Camp meteorological station recorded 41.7 mm of rainfall between July and October 2006. The undercatch-adjusted depth of 49.6 mm is comparable to an estimated baseline mean of 67.6 mm for that period (Table 2.15). Daily and annual cumulative rainfall are plotted in Figure 2.28.

Table 2.15 Monthly Rainfall Measured at Boston Camp Meteorological Station, July – December 2006

Month	Measured Rainfall	Estimated Rainfall[a]	Baseline Mean Rainfall[b]
May[c]	n/a	n/a	3.2 mm
June[c]	n/a	n/a	13.7 mm
July[c]	20.1 mm	23.9 mm	24.2 mm
August	19.1 mm	22.7 mm	29.0 mm
September	1.8 mm	2.1 mm	14.4 mm
October	2.0 mm	2.4 mm	1.2 mm
Total[c]	**41.7 mm**	**49.6 mm**	**84.5 mm**

[a] Values incorporate an undercatch factor of 1.19.

[b] Source: Amec (2003). Values incorporate an undercatch factor of 1.19.

[c] Monitoring began when the meteorological station was installed on 2 July 2006. Baseline mean rainfall for the period July through September is 67.6 mm.

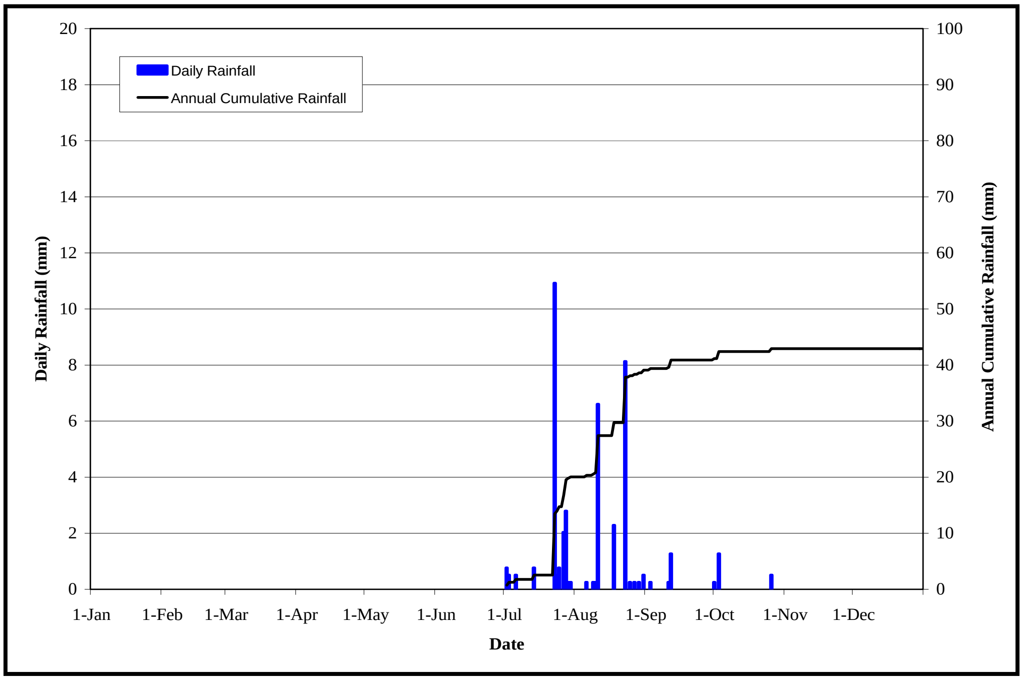


Figure 2.28 Rainfall Data from Boston Camp Meteorology Station, July - December 2006

3 PHYSICAL LIMNOLOGY AND WATER QUALITY

3.1 INTRODUCTION

The purpose of the 2006 and 2007 water quality programs was to collect sufficient information for an overall spatial and temporal characterization of the water quality within the Boston and Madrid Project areas.

3.2 METHODS

3.2.1 Field Sampling Stations and Timing

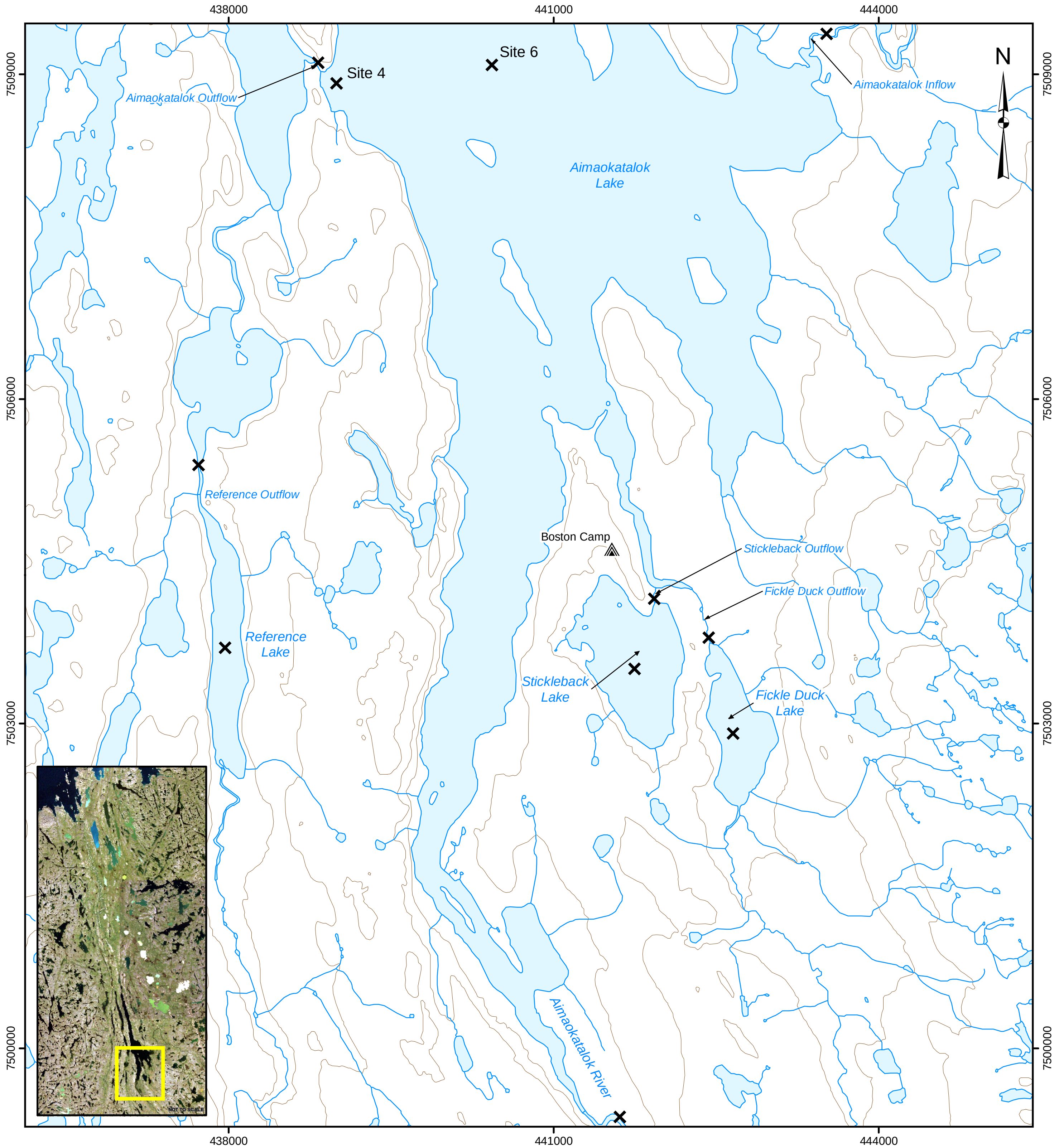
The majority of the water quality sampling stations in the Project Area were initially established in 2006, with the Hope Bay and Glenn Lake sampling locations established in 2007 (Figures 3.1 and 3.2).

Lakes and bays were sampled a minimum of three times between June and September 2006 and four times between May and September 2007. Generally stations were sampled in ice-covered conditions in May or June, with open water conditions occurring during the July to September sampling periods. Under-ice sampling was not conducted in all lakes due to logistic and accessibility constraints (i.e., limited availability of camp accommodations, and snow conditions to accommodate snowmachine access). Streams were sampled four times during open water conditions between June and September in both 2006 and 2007.

Sample stations were located using a Global Positioning System (GPS; hand-held Garmin GPS 76 with an accuracy of ± 5 m). Universal Transverse Mercator (UTM) coordinates were recorded for each sampling station; all UTM coordinates were recorded in North American Datum (NAD) 83, Zone 13.

3.2.1.1 Boston Project Area

The Boston Project Area includes Aimaokatalok, Fickle Duck, Stickleback, and Reference lakes, as well as the corresponding outflow streams and the Hope Bay marine station (Figures 3.1 and 3.2). In general, one sampling station was established in each lake, with the exception of Aimaokatalok Lake, where two stations (Stations 4 and 6) were located. There was one sampling station associated with the Aimaokatalok River, Aimaokatalok Inflow, and Koignuk River.



LEGEND

- CAMP
- WATER QUALITY SAMPLING STATION
- CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY

1500 0 1500

SCALE 1:50000 METRES

REFERENCE

Base data obtained from Government of Canada, Natural Resources Canada, Centre for Topographic Information (1:50 000). Landsat 7 imagery captured in 2007, obtained from CanImage. Field data collected by Golder Associates Ltd., 2008.
Projection: UTM Zone 13 Datum: NAD 83

PROJECT

NEWMONT The Gold Company

HOPE BAY MINING LTD.

TITLE

2006 AND 2007 WATER QUALITY SAMPLING STATIONS
BOSTON PROJECT AREA

Golder Associates
Edmonton, Alberta

PROJECT NO. 07-1373-0019			SCALE AS SHOWN	REV. 0
DESIGN	AH	23 Oct. 2008	FIGURE: 3.1	
GIS	RC	11 Mar. 2009		
CHECK	AH	16 Mar. 2009		
REVIEW	GA	16 Mar. 2009		

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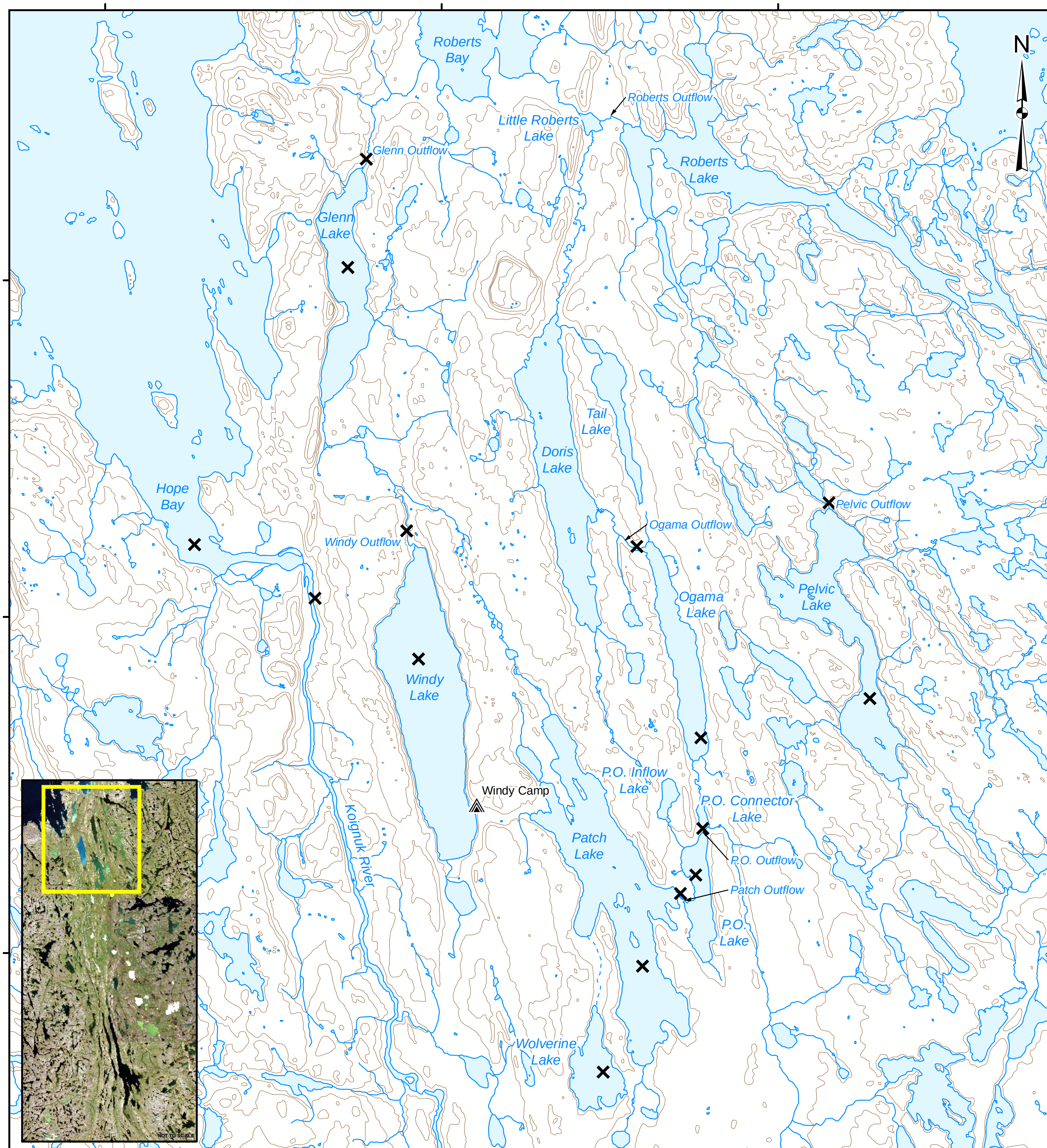

LEGEND

- CAMP
- WATER QUALITY SAMPLING STATION
- CONTOUR (20 m INTERVAL)
- INTERMITTENT STREAM
- WATERCOURSE
- WATERBODY

3000 0 3000

SCALE 1:100000 METRES

REFERENCE

Base data obtained from Government of Canada, Natural Resources Canada, Centre for Topographic Information (1:50 000). Landsat 7 imagery captured in 2007, obtained from CanImage. Field data collected by Golder Associates Ltd., 2008.

Projection: UTM Zone 13 Datum: NAD 83

PROJECT

NEWMONT The Gold Company

HOPE BAY MINING LTD.

TITLE

2006 AND 2007 WATER QUALITY SAMPLING STATIONS
BOSTON AND MADRID PROJECT AREAS

Golder Associates
Edmonton, Alberta

PROJECT NO. 07-1373-0019			SCALE AS SHOWN	REV. 0
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GIS	BR	30 Mar. 2009		
CHECK	AH	16 Mar. 2009		
REVIEW	GA	16 Mar. 2009		

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All Boston Project area lakes were sampled monthly during July, August, and September in 2006 and 2007. Under-ice samples were collected in Aimaokatalok and Stickleback lakes in June 2006. Three under-ice samples (top, middle, bottom) were collected in Aimaokatalok Lake Station 6. Each lake was sampled under-ice in 2007. In total, 56 lake water quality samples were collected between 2 June 2006 and 9 September 2007 (Table 3.1).

Table 3.1 Sampling Date and Number of Water Samples[a] Collected in the Boston Project Area Lakes, 2006 – 2007

Date	Aimaokatalok Lake		Fickle Duck Lake	Reference Lake	Stickleback Lake	Total No.
	Station 4	Station 6				
02-Jun-06	2[b]				1	**3**
03-Jun-06		3[c]		1		**4**
16-Jul-06	2	2				**4**
17-Jul-06					1	**1**
18-Jul-06			1	1		**2**
17-Aug-06	2	2	1	1	1	**7**
10-Sep-06	2	2	1		1	**6**
11-Sep-06				1		**1**
2006 Total	***8***	***9***	***3***	***4***	***4***	***28***
24-May-07	2	2	1		1	**6**
26-May-07				1		**1**
20-Jul-07		2				**2**
21-Jul-07	2			1	1	**4**
22-Jul-07			1			**1**
19-Aug-07	2	2				**4**
20-Aug-07			1	1	1	**3**
08-Sep-07	1	2				**3**
09-Sep-07	1[d]		1	1	1	**4**
2007 Total	***8***	***8***	***4***	***4***	***4***	***28***

Prepared by: EJJ Checked by: LR

[a] Excluding QA/QC samples – these are listed in Table 3.7.
[b] 2 = one top and one bottom sample; 1 = top sample unless indicated otherwise.
[c] Three samples were collected (top, middle, and bottom of water column) from Station 6.
[d] Bottom sample only.

All Boston Project area streams were sampled monthly during the open water season between June and September 2008 (Table 3.2). In total, 52 stream water quality samples were collected between 23 June 2006 and 16 September 2007.

One marine station in Hope Bay was included in the water quality program in 2007 because the Boston Project area waterbodies flow into Hope Bay *via* the Koignuk River and have the potential to influence water quality in the bay (Figure 3.2). Two water samples (top and bottom of the water column) were collected from the Hope

Bay station on each of the following dates: 27 May, 23 July, 17 August, and 15 September 2007.

Table 3.2 Sampling Date and Number of Water Samples[a] Collected in the Boston Project Area Streams, 2006 – 2007

Date	Aimaokatalok			Fickle Duck Outflow	Koignuk River	Reference Outflow	Stickleback Outflow	Total No.
	River	Inflow	Outflow					
23-Jun-06	1	1	1			1		**4**
24-Jun-06				1			1	**2**
16-Jul-06		1	1					**2**
17-Jul-06	1			1			1	**3**
18-Jul-06						1		**1**
13-Aug-06	1	1	1	1		1	1	**6**
10-Sep-06	1	1	1	1		1	1	**6**
2006 Total	***4***	***4***	***4***	***4***	***0***	***4***	***4***	***24***
23-Jun-07	1	1	1	1		1	1	**6**
02-Jul-07					1			**1**
19-Jul-07					1			**1**
20-Jul-07		1	1	1		1		**4**
21-Jul-07	1							**1**
22-Jul-07							1	**1**
18-Aug-07					1			**1**
19-Aug-07			1					**1**
20-Aug-07	1	1		1		1	1	**5**
09-Sep-07	1			1		1	1	**4**
10-Sep-07		1	1					**2**
16-Sep-07					1			**1**
2007 Total	***4***	***4***	***4***	***4***	***4***	***4***	***4***	***28***

[a] Excluding QA/QC samples – these are listed in Table 3.7.

Prepared by: EJJ Checked by: LR

3.2.1.2 Madrid Project Area

The Madrid Project area includes Glenn, Windy, Pelvic, Ogama, Wolverine, Patch, and P.O. lakes, as well as corresponding outflows for all lakes, except Wolverine Lake (Figure 3.2). One water quality sampling station was established in each of the lakes and outflow streams. Glenn Lake was not sampled in 2006, as this location was added to the sampling program in 2007.

All Madrid Project lakes were sampled monthly during July, August, and September 2006 and 2007. Each lake was sampled under-ice in June 2006 and May 2007, with the exception of P.O. Lake. In total, 84 lake water quality samples were collected between 1 June 2006 and 15 September 2007 (Table 3.3). Outflow streams were sampled monthly during the two open water seasons between June 2006 and September 2007. In total, 49 stream water quality samples were collected between 19 June 2006 and 17 September 2007 (Table 3.4).

Table 3.3 Sampling Date and Number of Water Samples[a] Collected in the Madrid Project Area Lakes, 2006 – 2007

Date	Glenn Lake[b]	Ogama Lake	Patch Lake	Pelvic Lake	P.O. Lake	Windy Lake	Wolverine Lake	Total No.
1-Jun-06		2[c]		2			1	**5**
2-Jun-06			1			2		**3**
21-Jul-06		2		2				**4**
22-Jul-06							2	**2**
23-Jul-06			2		1			**3**
24-Jul-06						2		**2**
12-Aug-06							1	**1**
15-Aug-06		2	1		1			**4**
16-Aug-06			1	2				**3**
18-Aug-06						2		**2**
8-Sep-06		2	2		1		1	**6**
9-Sep-06				2		2		**4**
2006 Total	***0***	***8***	***7***	***8***	***3***	***8***	***5***	***39***
22-May-07		1						**1**
23-May-07			2	2			1	**5**
24-May-07	2					2		**4**
16-Jul-07	2	1		2				**5**
17-Jul-07			2		1		1	**4**
18-Jul-07						2		**2**
15-Aug-07			2		1		1	**4**
16-Aug-07		2		2				**4**
17-Aug-07	2							**2**
20-Aug-07						2		**2**
11-Sep-07		1	2		1		1	**5**
12-Sep-07		1[d]						**1**
13-Sep-07				2				**2**
15-Sep-07	2					2		**4**
2007 Total	***8***	***6***	***8***	***8***	***3***	***8***	***4***	***45***

[a] Excluding QA/QC samples – these are listed in Table 3.8.
[b] Only sampled in 2007.
[c] 2 = one top and one bottom sample; 1= top sample unless indicated otherwise.
[d] Bottom sample only.

Prepared by: EJJ Checked by: LR

Table 3.4 Sampling Date and Number of Water Samples[a] Collected in the Madrid Project Area Streams, 2006 – 2007

Date	Glenn Outflow[b]	Ogama Outflow	Patch Outflow	Pelvic Outflow	P.O. Outflow	Windy Outflow	Total No.
19-Jun-06		1	1	1	1	1	**5**
21-Jul-06		1		1			**2**
22-Jul-06			1				**1**
23-Jul-06						1	**1**
24-Jul-06					1		**1**
12-Aug-06		1	1			1	**3**
15-Aug-06					1		**1**
16-Aug-06				1		1	**2**
9-Sep-06		1	1		1	1	**4**
2006 Total	***0***	***4***	***4***	***3***	***4***	***5***	***20***
22-Jun-07	1	1	1	1	1	1	**6**
2-Jul-07							**1**
17-Jul-07		1					**1**
19-Jul-07	1		1	1	1	1	**6**
12-Aug-07	1	1	1		1	1	**5**
18-Aug-07				1			**2**
15-Sep-07	1					1	**2**
16-Sep-07				1			**2**
17-Sep-07		1	1		1		**3**
2007 Total	***4***	***4***	***4***	***4***	***4***	***4***	***28***

Prepared by: EJJ Checked by: LR

[a] Excluding QA/QC samples – these are listed in Table 3.7.
[b] Only sampled in 2007.

3.2.2 Hope Bay

In 2007, one marine sampling station was established in Hope Bay as a component of the the water quality sampling program. This station was established because the Boston Project waterbodies flow into Hope Bay via the Koignuk River and have the potential to influence water quality. Eight water quality samples (four sets of surface and bottom samples) were collected between May and September 2007 (Table 3.5).

Table 3.5 Sampling Date and Number of Water Samples[a] Collected in Hope Bay, 2007

Date	Hope Bay	Total No.
27-May-07	2	**2**
23-Jul-07	2	**2**
17-Aug-07	2	**2**
15-Sep-07	2	**2**
2007 Total	**8**	**8**

Prepared by: EJJ
Checked by: LR

[a] Excluding QA/QC samples – these are listed in Table 3.7.

3.2.3 Field Sampling Procedures

All water quality sampling was completed according to the following Golder Technical Procedures (unpublished file information):

- 8.23-0: *Basic Limnology and Bathymetric Procedures*; and
- 8.3-1: *Surface Water Sampling Methods*.

3.2.3.1 Lakes and Bays

The water quality of the lakes and bays was characterized by measuring in situ physico-chemical water quality data and analyzing water quality samples for standard water quality parameters (e.g., total suspended solids [TSS]), major ionic composition, chlorophyll *a* (Chl *a*), nutrient, and trace metals concentrations.

Physico-Chemical Water Quality

Field measurements of physico-chemical water quality parameters (e.g., water temperature, dissolved oxygen [DO], conductivity, and pH) were recorded at each sampling station, except in Aimaokatalok Lake on 22 May 2008 because of equipment malfunction. When possible, DO and temperature profiles were measured monthly (at least three times during the 2006 sampling season and four times during 2007) using a field-calibrated Oxyguard™ Beta dissolved oxygen and temperature meter (accuracy: ± 0.1 mg/L DO and ± 0.1°C) in 2006, and a Horiba U-22 multi-parameter probe (precision ± 0.01 mg/L DO and ± 0.01°C) in 2007. DO and temperature were measured at 0.5 m intervals for lakes with water depth less than 10 m, and at 1.0 m intervals for lakes with water depth greater than 10 m. Measurements were taken along a vertical transect beginning at the water surface to 0.5 m above the bottom of the waterbody. The pH was measured approximately 0.2 m below the water surface using a field-calibrated Oakton WTW 340I in 2006 and a field-calibrated Horiba U-22 multi-parameter probe in 2007.

Water transparency, or clarity, was determined using a standard 20 cm diameter Secchi disk. Secchi depth is measured by calculating the average of the depth that the disk disappears when it is lowered into the water column and the depth that it re-appears when it is raised back through the water column. This depth was used to estimate the euphotic depth within the water column (i.e., approximate depth to which 1% of incident light penetrates), which coincides with approximately twice the Secchi depth (Mitchell and Prepas 1990).

Chemical Analysis

Water samples for chemical analysis were collected using a Trace Metals Acrylic Kemmerer water sampler, which was rinsed with ambient water prior to sample collection. Surface samples were collected 1.0 m below the water surface. Bottom samples were collected 1.0 m above the lake bed to prevent contamination from sediments through physical disturbance of the surface benthic sediment layer. Appropriate preservatives were added in the field according to laboratory specifications, when required. All water chemistry samples were stored and transported on ice to the applicable analytical laboratory.

One litre of water for Chl *a* samples was collected from the euphotic zone at the sampling location at each lake using a depth-integrated tube sampler. The euphotic zone was estimated as being approximately two times the Secchi depth or the extent of the water column to 0.5 m above the bottom, whichever depth was less. The 1 L water sample was split into three replicate samples consisting of 0.33 L. Each replicate sample was filtered through a Whatman GF/C glass-fibre filter (1.0 to 1.2 µm pore size) using a syringe and attached filter holder. Each filter was treated with 1.0 to 1.5 mL of a magnesium carbonate ($MgCO_3$) suspension (> 1 mg $MgCO_3$ per 100 mL deionized water) to reduce the potential for Chl *a* degradation prior to analysis. Each filter was then carefully rolled up, placed in an opaque vial, frozen, and transported in a dark, cold container to the analytical laboratory. Samples for Chl *a* analysis were kept frozen until analysis.

3.2.3.2 Streams

Field measurements of water temperature, DO, conductivity, and pH in streams were collected using the same procedures and instruments used at lake sampling stations. In addition, a water temperature data logger (HOBO Water Temp Pro v2) was installed at each stream sampling station to record continuous water temperature readings (i.e., measurement recorded every six minutes), generally between June and September in 2006 and 2007. Each data logger was secured to the bank of the watercourse and anchored to the substrate using a weight. If at any time the temperature data logger was exposed to air (e.g., disruption by an animal, fast moving current, drop in water level), readings were identified and excluded from further analysis.

Water samples for chemical analysis taken from streams were collected approximately 0.1 m below the water surface. Sample collection and handling followed the same protocols used for lake water samples.

3.2.4 Laboratory Analytical Procedures

All freshwater samples were analyzed by Alberta Research Council (ARC), Vegreville, Alberta. Marine samples were analyzed by Alberta Research Council (ARC), Vegreville, Alberta in 2006, by Maxxam Analytics Inc., Burnaby, British Columbia in May 2007, and by ALS Laboratory Group, Vancouver, BC from July to September 2007. Ultra-trace mercury in marine samples was analyzed by ARC in 2007.

All water samples for chemical analysis were analyzed for the following parameters:

- general water quality – included total alkalinity, laboratory pH and specific conductance, total dissolved solids (TDS), major cations and anions (i.e., bicarbonate, carbonate, calcium, chloride, magnesium, potassium, sodium, and sulphate), ionic balance, total hardness, true colour, and total suspended solids (TSS);
- nutrients – included total phosphorus, total Kjeldahl nitrogen, ammonia, nitrate, and nitrite;
- carbon species – particulate carbon, dissolved organic carbon, and total organic carbon;
- total and dissolved metals – included aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, tin, uranium, vanadium, and zinc; and
- other parameters – cyanide, fluoride, and sulphide.

Minimum Reported Values (MRVs) or Reported Detection Limits (RDLs) for each analytical laboratory are provided in Tables 3.6 and 3.7.

3.2.5 Data Analysis

Water quality data were summarized in tabular format, and a qualitative assessment (i.e., no statistical analysis) was completed as part of the characterization of existing baseline conditions in the Project area. The discussion of results are provided for each lake and stream station in the Boston and Madrid Project areas, with specific focus on physico-chemical condition and general water quality, including nutrient, and trace metals concentrations. In particular, the discussion of trace metals concentrations is limited to those that are higher than the applicable environmental guidelines.

Table 3.6 Water Quality Parameters and Corresponding Minimum Reported Values (MRV) from Laboratory Analyses of Freshwater Samples for the Boston and Madrid Project Areas, 2006 – 2007

Parameter	Unit	MRV	Parameter	Unit	MRV
Physical			***Metals - Total and Dissolved***		
Alkalinity, Total (as $CaCO_3$)	mg/L	1	Aluminum (Al)	µg/L	0.5 (0.2)[c]
Hardness, Total (as $CaCO_3$)	mg/L	0.01	Antimony (Sb)	µg/L	0.0005
Conductivity (EC)	µS/cm	0.1	Arsenic (As)	µg/L	0.002
Total Dissolved Solids	mg/L	0.1	Barium (Ba)	µg/L	0.004
Total Suspended Solids	mg/L	1	Beryllium (Be)	µg/L	0.003
Colour, True	TCU	1	Bismuth (Bi)	µg/L	0.001
			Boron (B)	µg/L	0.05 (0.03)[c]
Nutrients			Cadmium (Cd)	µg/L	0.002
Phosphorus, Total	mg/L	0.001	Chromium (Cr)	µg/L	0.03
Total Kjeldahl Nitrogen	mg/L	0.01	Cobalt (Co)	µg/L	0.001
Ammonia-N	mg/L	0.001	Copper (Cu)	µg/L	0.1 (0.05)[c]
Nitrate+Nitrite-N	mg/L	0.005	Cyanide	mg/L	0.001
Nitrite-N	mg/L	0.001	Iron (Fe)	µg/L	2
Nitrate-N[a]	mg/L	0.005	Lead (Pb)	µg/L	0.001
			Manganese (Mn)	µg/L	0.003
Organics			Mercury (Hg)	ng/L	0.6
Dissolved Organic Carbon	mg/L	0.2	Molybdenum (Mo)	µg/L	0.001
Total Organic Carbon[a]	mg/L	0.8	Nickel (Ni)	µg/L	0.005
Carbon, Particulate	mg/L	0.02	Selenium (Se)	µg/L	0.1
			Silver (Ag)	µg/L	0.0005
Major Ions			Strontium (Sr)	µg/L	0.004
Bicarbonate (HCO_3)	mg/L	1	Thallium (Tl)	µg/L	0.0003
Calcium (Ca)	mg/L	0.004	Tin (Sn)	µg/L	0.03
Chloride (Cl)	mg/L	0.3	Uranium (U)	µg/L	0.0001
Magnesium (Mg)	mg/L	0.0001	Vanadium (V)	µg/L	0.005
Potassium (K)	µg/L	0.002, 0.1[b]	Zinc (Zn)	µg/L	0.1 (0.05)
Sodium (Na)	µg/L	0.02, 0.5[b]	***Other***		
Sulphate (SO_4)	mg/L	3	Fluoride (F)	mg/L	0.01
			Sulphide (S^{2-})	mg/L	0.001
			Cyanide (CN^{2-})	mg/L	0.001

Prepared by: EJJ Checked by: SE

[a] Values are calculated.

[b] extractable Potassium and Sodium had higher MRVs.

[c] MRV values in brackets are for dissolved metals. Metals without values in brackets indicate that total and dissolved MRVs are the same

Table 3.7 Water Quality Parameters and Corresponding Minimum Reported Values (RDL and MRV) from Laboratory Analyses of Marine Samples for the Boston and Madrid Project Areas, 2007

Parameter	Unit	RDL	MRV		
		Maxxam	ALS		
Metals – Total		**May**	**Jul**	**Aug**	**Sep**
Aluminum (Al)	µg/L		100	10, 250	100, 150
Antimony (Sb)	µg/L		1, 10	5, 10	5, 10
Arsenic (As)[a]	µg/L	0.1	0.20	0.20	0.20
Barium (Ba)	µg/L		0.050	0.050	0.050
Beryllium (Be)	µg/L		5, 50	25, 50	25, 50
Bismuth (Bi)	mg/L		0.005, 0.050	0.025, 0.050	0.025, 0.050
Boron (B)	µg/L	500	10	10	10
Cadmium (Cd)[a]	µg/L	0.1	0.020	0.020	0.020
Calcium (Ca)	mg/L		0.050	0.050	0.050
Chromium (Cr)[a]	µg/L	0.5	5, 50	25, 50	25, 50
Cobalt (Co)	µg/L	0.1	0.050	0.050	0.050
Copper (Cu)	µg/L	0.1	0.050	0.050	0.050
Cyanide, Total	mg/L	0.0005	0.0050	0.0050	0.0050
Iron (Fe)	µg/L	1	10	10	10
Lead (Pb)	µg/L	0.1	0.050	0.050	0.050
Magnesium (Mg)	mg/L		0.10	0.10	0.10
Manganese (Mn)	µg/L	1	0.050	0.050	0.050
Mercury (Hg)[a]	ng/L	10	0.6[c]	0.6[c]	0.6[c]
Molybdenum (Mo)	µg/L		2.5	2.5	2.5
Nickel (Ni)	µg/L	0.5	0.050	0.050	0.050
Potassium (K)	µg/L		2.0	2.0	2.0
Selenium (Se)	µg/L		0.50	0.50	0.50
Silver (Ag)	µg/L	0.1	0.010, 0.10	0.50, 1.0	0.50, 1.0
Sodium (Na)	µg/L		2.0	2.0	2.0
Strontium (Sr)	µg/L	500	0.10	0.10	0.10
Thallium (Tl)	mg/L		0.0010, 0.010	0.0050, 0.010	0.0050, 0.010
Tin (Sn)	mg/L		0.0010, 0.010	0.0050, 0.010	0.0050, 0.010
Uranium (U)	µg/L		0.050	0.050	0.050
Vanadium (V)	µg/L		10, 100	50, 100	50, 100
Zinc (Zn)	µg/L	1.0	0.50	0.50	0.50

Parameter	Unit	RDL	MRV		
		Maxxam	ALS		
Nutrients		**May**	**Jul**	**Aug**	**Sep**
Ammonia-N	mg/L	0.005	0.020	0.020	0.020
Dissolved Organic Carbon	mg/L	0.5	0.50	0.50	0.50
Fluoride (F)	mg/L	0.01	0.20	2.0	0.20, 2.0
Phosphorus, Total	mg/L	0.005	1.5, 3.0	3.0	3.0
Sulphide	mg/L	0.005	0.020	0.020	0.020
Total Kjeldahl Nitrogen	mg/L	0.02	0.050	0.050	0.050
Total Organic Carbon	mg/L	0.5	0.50	0.50	0.50
Total Suspended Solids[a]	mg/L	4.0	3.0	3.0	3.0
Routine Water Analysis					
Chloride (Cl)	mg/L	50	0.50	0.50	0.50
Color, True	T.C.U.	5.0	5.0	5.0	5.0
Nitrate+Nitrite-N	mg/L	0.02	0.050[c]	0.10, 0.50[c]	0.10[c]
Nitrate-N[a]	mg/L	0.02	0.050	0.10, 0.50	0.10
Nitrite-N	mg/L	0.005	0.010	0.010	0.020
Sulphate (SO_4)	mg/L	50	0.50	0.50	0.50
Conductivity and Total Alkalinity					
Conductivity (EC)	µS/cm	1	2.0	2.0	2.0
Bicarbonate (HCO_3)	mg/L	0.5	-	-	-
Alkalinity, Total (as $CaCO_3$	mg/L	0.5	2.0	2.0	2.0
Total Dissolved Solids	mg/L	10	10	10	10

[a] Parameters included in CCME Guidelines (2007) for the protection of aquatic life in the marine system.

[b] Calculated.

Prepared by: LR Checked by: AH

3.2.5.1 Comparison to Water Quality Guidelines

All water chemistry results were compared to applicable federal Canadian Water Quality Guidelines (CWQG) for the Protection of Aquatic Life – Freshwater or Marine, as applicable (Canadian Council of Ministers for the Environment [CCME] 1987, 1999, 2007a, 2007b). The CWQG values are conservative as they err on the side of caution for the protection of aquatic life under daily exposure conditions. CWQGs are derived using data for the most sensitive test species, and are considered to protective of all receptors 100% of the time (CCME 1999). Therefore, any substances with concentrations below CWQG values are unlikely to pose a substantial risk to aquatic life. If there was either no applicable CWQG or the CWQG was considered dated, then other provincial/national guidelines were used (e.g., United States Environmental Protection Agency [U.S. EPA]).

The identification of a parameter whose concentration is higher than a particular guideline does not necessarily indicate impaired environmental conditions. The use of the guidelines for comparative purposes allows a better understanding of parameters that may be more important to evaluate during the environmental assessment. It also provides a better understanding of existing conditions to which resident biological community would be accustomed. There are often site-specific conditions related to geomorphology and geology that naturally result in locally elevated concentrations of various parameters within the aquatic environment (e.g., trace metals such as aluminium, copper, and selenium).

CWQGs for metals pertain to total metal concentrations, which consist of both the particulate and dissolved metal fractions (CCME 1999, 2007a). The bioavailability of most metals is affected by a number of environmental factors including pH, water hardness, oxidation-reduction conditions, and microbial degradation, as well as chemical speciation of specific metals (CCME 1987). Uncomplexed metal ions (e.g., Cd^{2+}, Cu^{2+}, Pb^{4+}, Ni^{2+}) are usually more bioavailable than complexed forms (i.e., particulate forms) (CCME 1987). The development of metal species-specific guidelines are problematic due to problems related to analytical methods, which may result in either overestimation or underestimation of the bioavailable fraction, as well as the relative toxicity of the different metal species. Therefore, comparisons using total concentrations of metals have been implemented as a protective measure (CCME 1987). In cases where the total metal concentration is higher than applicable CWQG, the dissolved concentration is also compared to determine if this concentration reports higher than the CWQG. This results in a conservative assessment of CWQG exceedences.

In some instances, guidelines are dependant on other environmental variables (e.g., water hardness, pH). A number of guidelines are based on a range of values rather than a single parameter concentration. Brief explanations of these parameters are provided in Appendix B1.

3.2.6 Quality Assurance/Quality Control

As part of the water quality QA/QC, field blanks, equipment blanks, and replicate samples were collected (Table 3.8). These samples were submitted to laboratories listed above for analysis. A detailed discussion of QA/QC methodology is presented in Appendix B2.

3.3 RESULTS AND DISCUSSION: LAKES

The following section provides a discussion of the water quality results in lakes within the Boston and Madrid Project areas. A detailed discussions of the water quality of each lake is provided under respective lake headings and focuses on general water quality characteristics and water quality parameters that have specific guidelines or assessment criteria (e.g., TSS, pH, DO, TP, dissolved inorganic nitrogen [ammonia, nitrate, and nitrite], and trace metals).

All field measurements, including water profiles of water temperature and DO, as well as pH, conductivity, and Secchi depth values are provided in Appendices B3 and B4. Water chemistry data, including Chl *a* concentrations, are provided in Appendix B5. Water quality QA/QC data are presented in Appendix B2.

3.3.1 Boston Project Area Lakes

3.3.1.1 Aimaokatalok Lake - Stations 4 & 6

The two sampling stations in Aimaokatalok Lake are situated in different water depths. Station 4 is located in a moderately shallow area, with a depth of approximately 6.5 m, and Station 6 is located in a deeper region of the lake, with a depth of approximately 27 m.

Aimaokatalok Lake is characterized as a clear freshwater lake, with soft water and a moderate to high acid sensitivity (Saffran and Trew 1996; Weiner 2000). The field pH ranged from slightly acidic to slightly alkaline (pH 6.0 to 7.8), with occasional pH values measured below the CWQG range of pH 6.5 to 9.0 (CCME 2007a) in August and September 2007 (Appendix B5).

Table 3.8 Summary of the QA/QC Samples Collected in the Boston and Madrid Project Areas, 2006 – 2007

Waterbody		QA/QC Sample Type	No. of Samples	Date
BOSTON PROJECT AREA	Fickle Duck Lake	Field blank	1	18-Jul-06
			1	17-Aug-06
			1	10-Sep-06
			1	21-Jul-07
			1	20-Aug-07
			1	9-Sep-07
	Reference Outflow	Equipment blank	1	18-Jul-06
			1	17-Aug-06
			1	11-Sep-06
			1	23-Jun-07
			1	21-Jul-07
			1	20-Aug-07
			1	9-Sep-07
	Stickleback Lake	Replicate	2	17-Jul-06
			2	17-Aug-06
			2	10-Sep-06
			1	24-May-07
			1	21-Jul-07
			1	20-Aug-07
			1	9-Sep-07
MADRID PROJECT AREA	Patch Outflow	Field blank	1	22-Jul-06
			1	22-Jun-07
	Patch Lake	Equipment blank	1	22-Jul-06
			1	15-Aug-06
			1	8-Sep-06
			1	24-May-07
			1	18-Jul-07
			1	18-Aug-07
			1	13-Sep-07
	Windy Outflow	Replicate	2	9-Sep-06
			1	19-Jul-07
	Pelvic Outflow		1	18-Aug-07
	Ogama Outflow		1	17-Sep-07

The range of laboratory conductivity values was similar at both stations, i.e., from 49 to 72 µS/cm, indicating low conductivity waters. Concentrations of major ions were typically low, and dominated by sodium and chloride (Appendix B5).

TSS concentrations ranged from <1 to 2 mg/L at Station 4, and < 1 to 3 mg/L at Station 6. The waters were slightly coloured at both stations (6 to 30 TCU), with higher colour evident during snow melt conditions. The Secchi depth ranged from 2.4 to 4.6 m (Figures 3.3 to 3.6; Appendix B3).

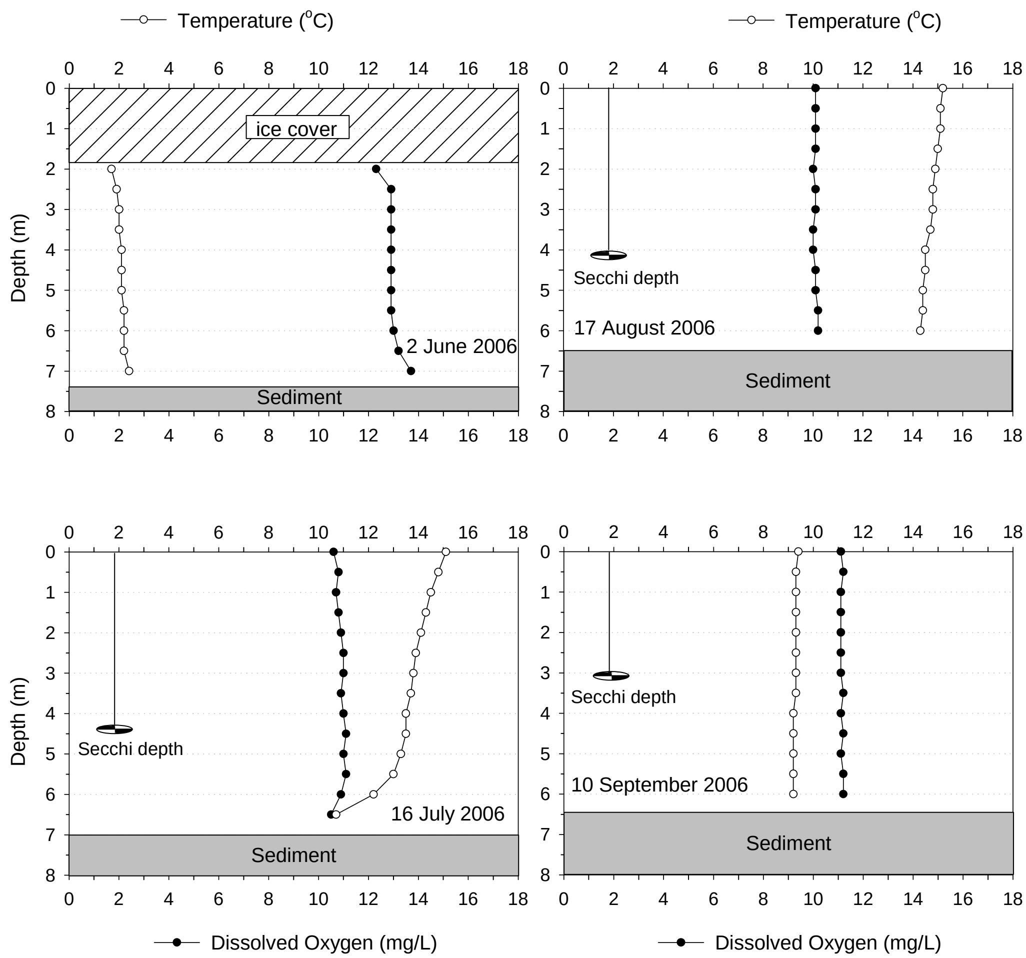

Figure 3.3 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Aimaokatalok Lake Station 4, 2006

Water column profiles of DO at Stations 4 and 6 indicated that the entire water column was generally well oxygenated throughout the monitoring periods in 2006 and 2007 (Figures 3.3 to 3.6). With the exception of Station 6 in May 2007, during ice-covered conditions, DO concentrations remained above the 9.5 mg/L CWQG for protection of early life stages of fish (CCME 2007a). In May 2007 at Station 6, the DO declined uniformly with depth, falling below 9.5 mg/L at 18 m, and below the 6.5 mg/L CWQG for the protection of aquatic life (CCME 2007a) at depths greater than 23 m (Figure 3.6). Decreases in DO at the bottom of the water column at Station 6 were evident in June and August

2006, with DO concentrations below the 6.5 mg/L CWQG for the protection of aquatic life in June, and below the 9.5 mg/L CWQG in August (Figure 3.5); as both of these low concentrations occurred at the bottom depth, they may have been the result of sediment disturbance by the probe during DO measurement.

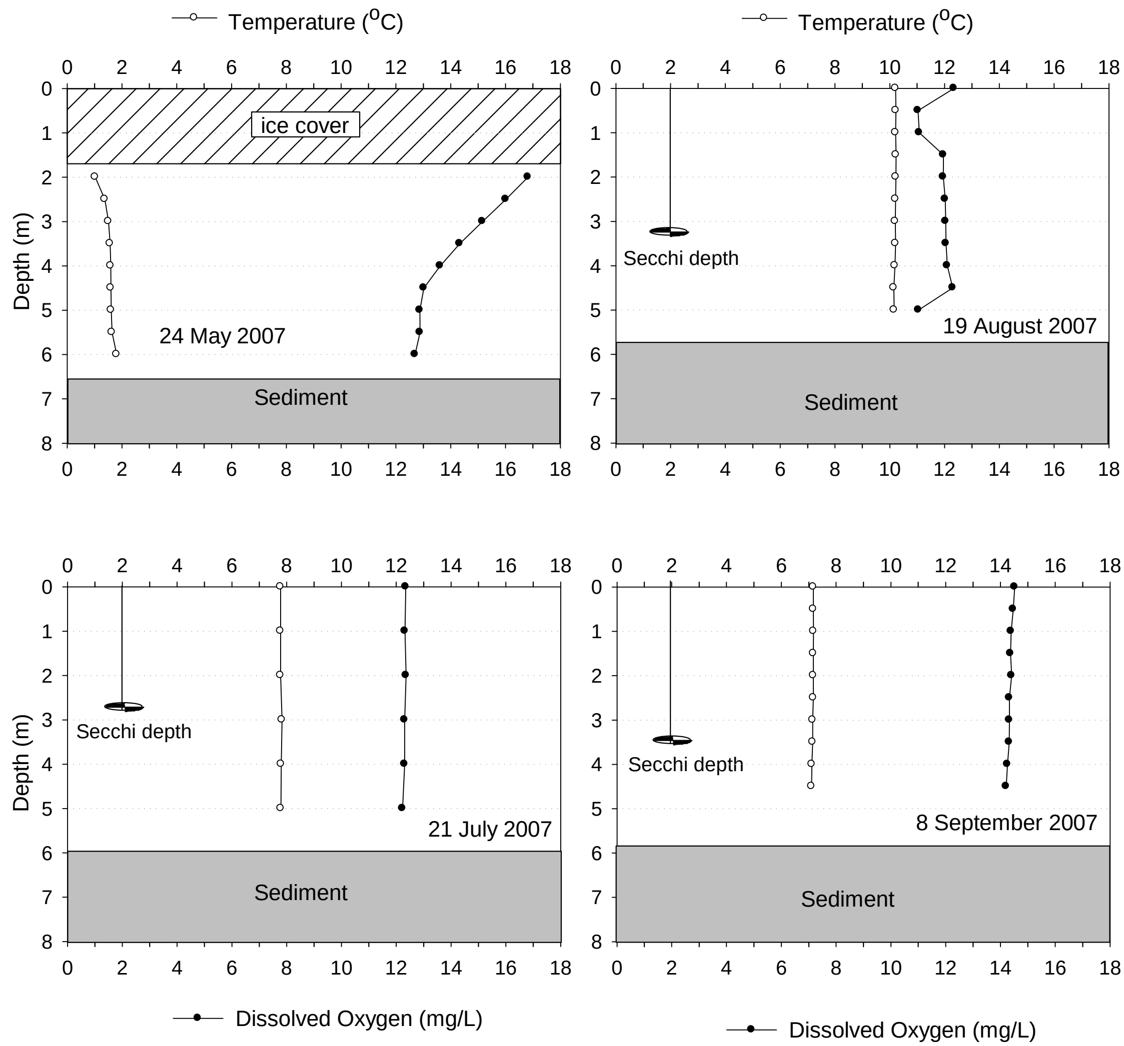

Figure 3.4 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Aimaokatalok Lake Station 4, 2007

Seasonal water column temperature trends were observed as expected, i.e., warmer water temperatures were measured in August, compared to July and September. Although the water column at Stations 4 and 6 was not obviously thermally stratified on any of the sampling dates in either 2006 or 2007 (Figures 3.3 to 3.6), a gradual decline in temperature with depth was evident in July at Station 6 in 2006 and 2007, and to a lesser extent in August 2006. Station 6 was cooler by 1 to 3°C (even at the surface) than Station 4 on both July and August 2006 sampling dates (Figures 3.3 and 3.5).

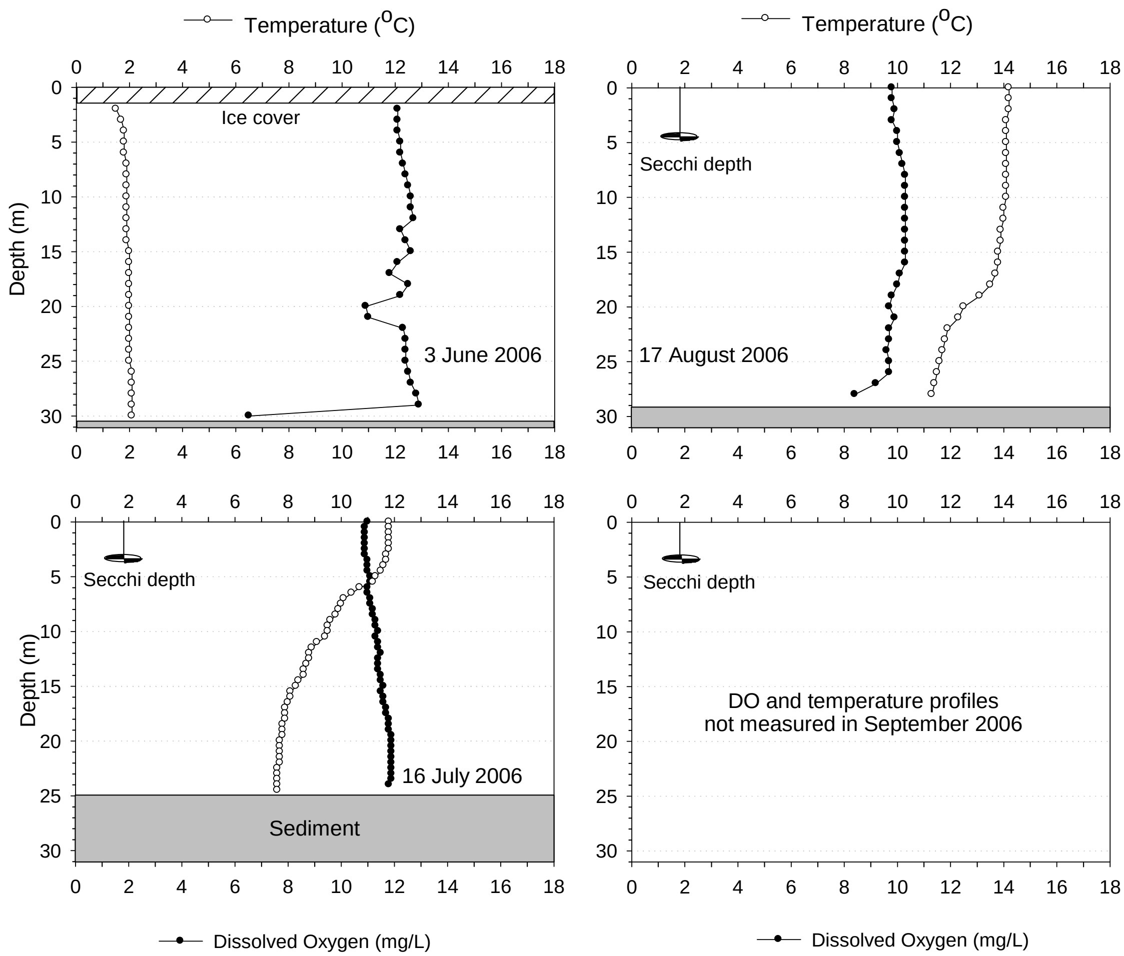

Figure 3.5 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Aimaokatalok Lake Station 6, 2006

Total phosphorus concentrations in Aimaokatalok Lake were similar at Stations 4 and 6, ranging from 6 to 28 µg/L over the course of the sampling periods (Appendix B5). Spot measurements of chlorophyll *a* collected in September 2006 and 2007 varied from 8.8 µg/L at Station 4 and 4.7 µg/L at Station 6 in 2006 and 1.1 to 2.3 µg/L in 2007. Based on the total phosphorus concentrations in 2006 and 2007, Aimaokatalok Lake could be conservatively classified as mesotrophic to meso-eutrophic (Appendix B1) (CCME 2004). Based on the concentrations of Chl *a*, Aimaokatalok Lake could be classified as oligo-mesotrophic (2006) and oligotrophic (2007) (Appendix B1) (Mitchell and Prepas 1990). In both years, concentrations of the dissolved inorganic forms of nitrogen (ammonia, nitrate, and nitrite) were well below CWQGs (CCME 2007a), representing <15% of the total nitrogen concentration (the TKN ranged from 0.23 to 1.49 mg/L at Station 4 and 0.23 to 0.37 mg/L).

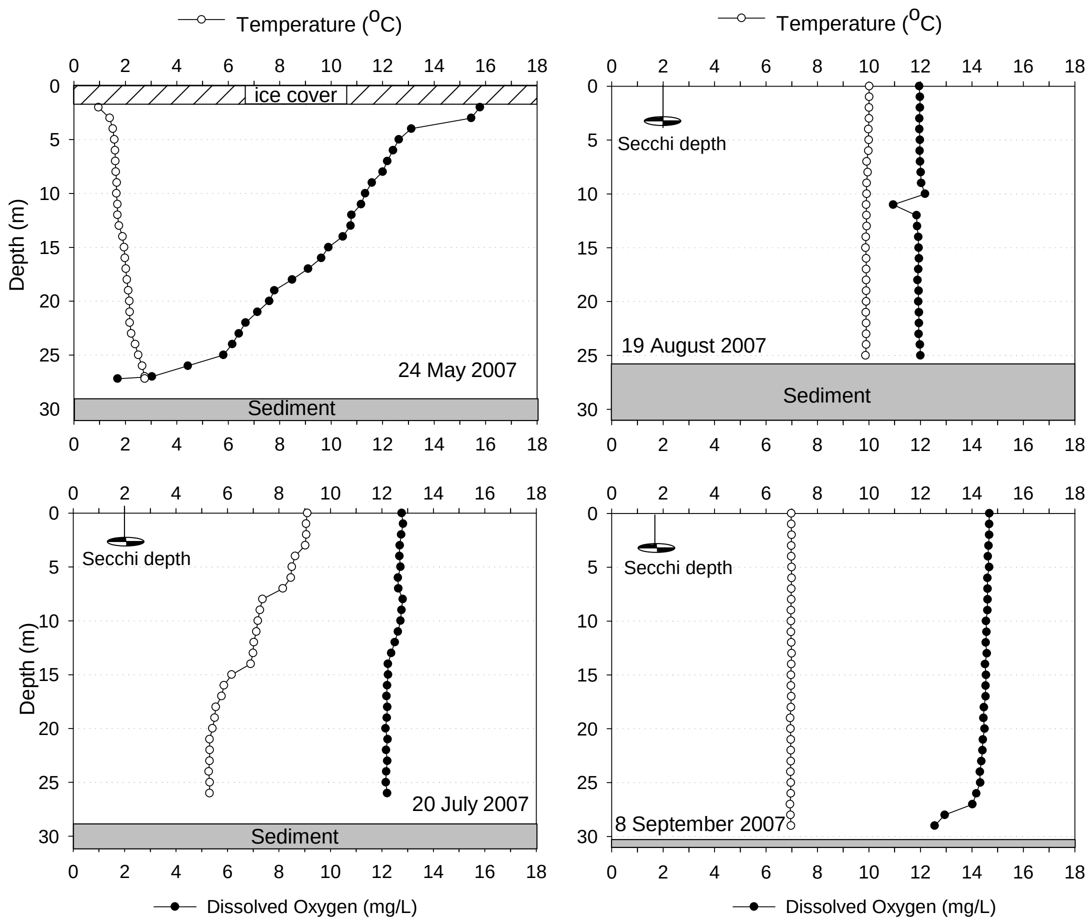

Figure 3.6 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Aimaokatalok Lake Station 6, 2007

Most baseline total metal concentrations were below the applicable CWQGs (CCME 2007a), with the exception of aluminum, cadmium, chromium, and copper. These exceptions are as follows:

- The total aluminum concentration was higher than the 100 µg/L CWQG (for pH ≥6.5) in the bottom sample collected at Station 6 in June 2006 (192 µg/L; Appendix B5). In 2007, total aluminum concentrations at Stations 4 and 6 were higher than the 5.0 µg/L CWQG (when pH <6.5) on every sampling date during the open-water season in slightly acidic surface waters, with concentrations ranging from 31.7 to 59.8 µg/L

(Appendix B5). The range of dissolved aluminium concentration in these cases was also higher than the CWQG (6.2 to 9.4 µg/L).

- Baseline total cadmium was above the site-adjusted CWQG in August 2006 (0.006 µg/L) and May 2007 (top: 0.024 µg/L; bottom: 0.009 µg/L).
- Total and dissolved chromium concentrations were naturally above the 1 µg/L CWQG sublethal toxicity of Cr (IV) in the bottom sample collected under-ice in May 2007 (1.2 µg/L). The surface sample had a total chromium concentration of 1 µg/L.
- Baseline total and dissolved copper concentrations were also above the 2 µg/L CWQG in the top sample collected under-ice in May 2007 with concentrations of 2.3 and 2.2 µg/L, respectively.

Elevated total mercury concentrations were measured in samples collected from Stations 4 and 6 in September 2006. These concentrations were at or just below the 26 ng/L CWQG concentration (Station 4 (top), 26 ng/L; and Station 6 (bottom), 22 ng/L) (Appendix B5). However, in the other two samples taken in September, and on all other occasions, the total mercury concentrations were well below the CWQG (CCME 2007a).

Total cyanide concentrations were consistently below the MRV (0.001 mg/L), with the exception of the August 2007 bottom sample (0.001 mg/L) and the May 2007 middle sample (0.001 mg/L).

3.3.1.2 Fickle Duck Lake

Fickle Duck Lake is a shallow (~4 m deep) freshwater lake. It is characterized by soft water, with a moderate to low sensitivity to acidification (Saffran and Trew 1996; Weiner 2000). Sampling was limited to open water conditions at this lake in 2006.

Field pH was slightly acidic to alkaline (6.6 to 8.0) and was within the CWQG range of pH 6.5 to 9.0 in 2006 and 2007 (CCME 2007a). The electrical conductivity of Fickle Duck Lake was typically low, ranging from 54 to 90 µS/cm. An atypically high conductivity of 332 µS/cm was recorded in the 2007 under-ice sample, which is consistent with salt exclusion processes often evident during ice-covered conditions. Typically, TDS concentrations in the water column increase during under-ice conditions (Pieters and Lawrence 2009; Hammer 1986), with the level of increases in TDS concentration directly related to the thickness of the ice and the water depth (e.g., TDS increases will likely be more pronounced in shallow lakes). Concentrations of major ions were typically low during open water conditions, and were dominated by calcium, sodium, and chloride (Appendix B5).

The TSS concentrations ranged from < 1 to 4 mg/L in 2006 and 2007. The Secchi depths ranged from 1.0 to 1.9 m, which was considered shallow in association with the relatively low TSS concentrations (Figures 3.7 and 3.8; Appendix B3). The waters were coloured (24 to 119 TCU), with the highest colour evident during under-ice conditions in May 2007.

The open-water DO profiles in 2006 and 2007 showed that Fickle Duck Lake was well oxygenated throughout the water column, with DO concentrations above the 9.5 mg/L CWQG for protection of early life stages of fish (Figures 3.7 and 3.8) (CCME 2007a). However, in May 2007, the shallow depth of water between the ice and sediments (0.5 m) was anoxic (0.0 mg/L; Figure 3.8).

Thermal stratification was not observed in Fickle Duck Lake, with isothermic conditions evident in 2006 and 2007 (Figures 3.7 and 3.8). Typical seasonal water column temperature trends were observed as expected, i.e., warmer water temperatures were measured in August, compared to July and September.

The total phosphorus concentrations in Fickle Duck Lake ranged from 16 to 39 µg/L in 2006 and 2007. Spot measurements of Chl *a* varied from 24.9 µg/L in September 2006 to a range of 3.4 to 5.6 µg/L in 2007 (Appendix B5). An algal bloom was evident during the August 2006 sampling; however, this was not clearly represented in the TSS and nutrient concentrations or the Secchi depth measurements, and Chl *a* samples were not collected. Based on the high total phosphorus concentrations, Fickle Duck Lake typically could be classified as mesotrophic to eutrophic (Appendix B1) (CCME 2004). However, based on Chl *a* concentrations, this lake could be classified as meso-eutrophic in 2006, and oligotrophic in 2007 (Appendix B1) (Mitchell and Prepas 1990).

All of the dissolved inorganic forms of nitrogen were well below the CWQGs (CCME 2007a) in both years, and represented 20% of total nitrogen concentration during one sampling period and < 5% during the remaining periods (the TKN ranged from 0.38 to 0.66 mg/L in 2006, and 0.36 to 1.28 mg/L in 2007). Elevated TKN and dissolved inorganic nitrogen were measured in the under-ice sample collected in May 2007.

Most total metal concentrations were below applicable CWQGs (CCME 2007a), with the exception of baseline total aluminum, chromium, copper, and iron. These exceptions are as follows:

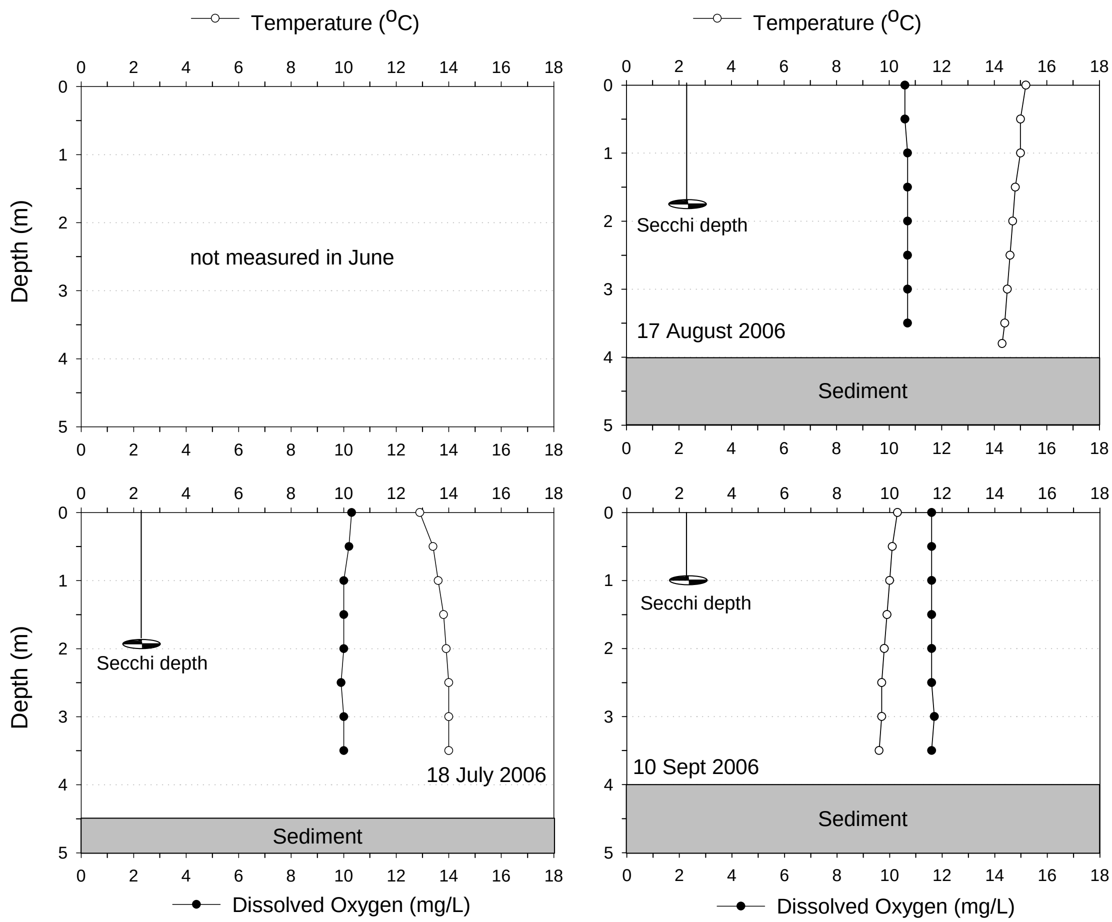

Figure 3.7 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Fickle Duck Lake, 2006

- Total aluminum baseline concentrations were above the 100 µg/L CWQG (for pH >6.5) in July 2006 (122 µg/L), September 2006 (172 µg/L), July 2007 (114 µg/L), August 2007 (155 µg/L), and September 2007 (112 µg/L) (Appendix B5).
- The total and dissolved chromium concentrations were above the 1 µg/L CWQG sublethal toxicity of Cr (IV) in anoxic, under-ice conditions in May 2007 (1.8 and 1.7 µg/L, respectively) (Appendix B5).
- The total and dissolved copper concentrations were above the 2 µg/L CWQG in anoxic, under-ice conditions in May 2007, and in September 2007 (2.6 and 2.4 µg/L, and 2.3 and 2.3 µg/L, respectively) (Appendix B5).
- Baseline total iron concentrations were at, or higher than, the 300 µg/L CWQG on each sampling occasion. The highest concentration was measured in the anoxic, under-ice conditions in May 2007 (2810 µg/L), in

which the dissolved iron concentration was also high (2130 µg/L) (Appendix B5).

Total cyanide concentrations were consistently below the MRV (0.001 mg/L).

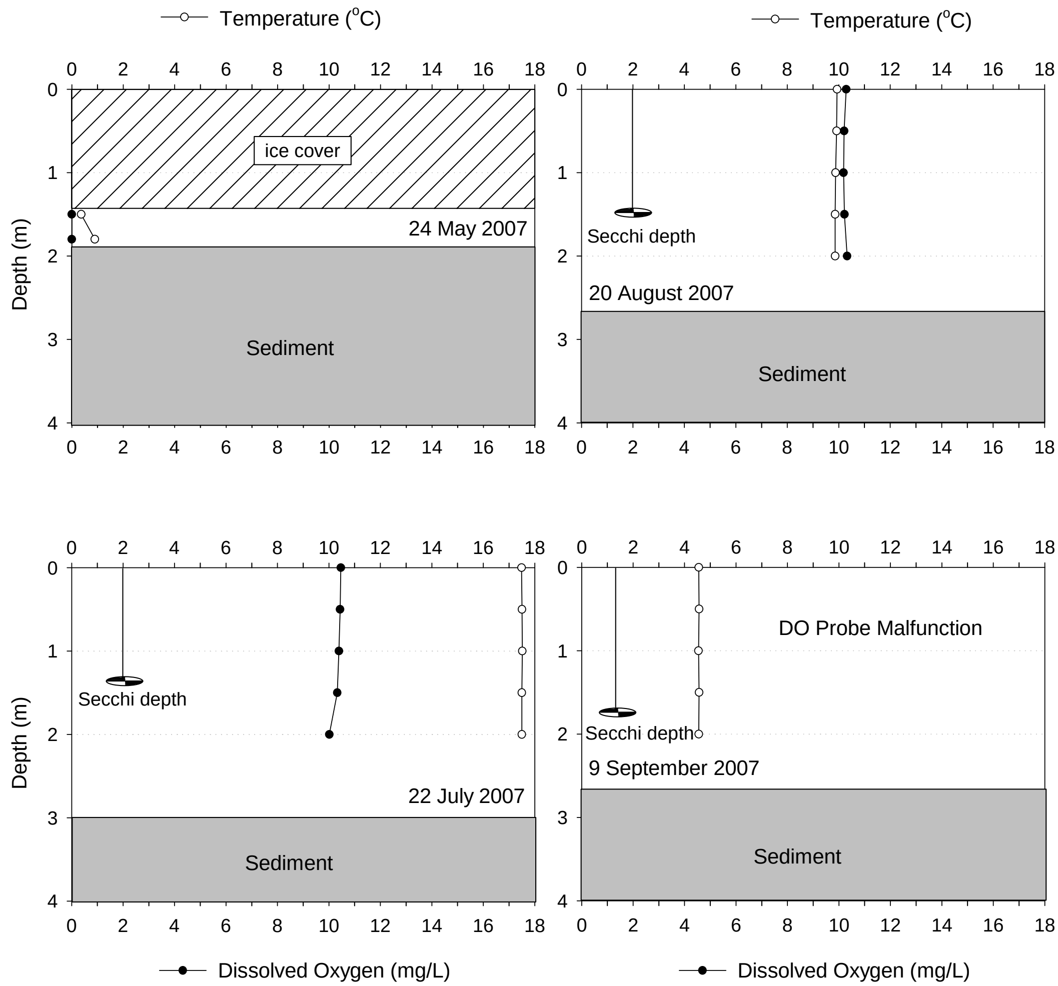

Figure 3.8 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Fickle Duck Lake, 2007

3.3.1.3 Reference Lake

Reference Lake is a clear, shallow (>4 m deep) freshwater lake. It is characterized by soft water, with a moderate sensitivity to acidification (Saffran and Trew 1996). Sampling was limited to open water conditions at this lake in 2006.

The field pH in Reference Lake in 2006 and 2007 was slightly acidic to slightly alkaline (6.4 to 7.7) and was generally within the CWQG range of pH 6.5 to 9.0 (CCME 2007a). A pH value of 6.4 in July 2006 was just below the minimum CWQG (Appendix B3).

The electrical conductivity of Reference Lake was typically low, with values ranging from 46 to 69 µS/cm during the open-water season in 2006 and 2007. An elevated conductivity of 270 µS/cm was measured in the 2007 under-ice sample (Appendix B5), consistent with higher TDS concentrations associated with salt exclusion processes during under ice conditions.

The TSS concentrations in Reference Lake were generally low, ranging from <1 to 4 mg/L in the 2006 and 2007 open-water seasons (Appendix B5). In the under-ice sample collected in May 2007, the higher TSS concentration (10 mg/L) may have been due to sediment disturbance while drilling the hole through the ice. The Secchi depths ranged from 1.0 to 2.5 m in 2006 and 2007 (Figures 3.9 and 3.10). The waters were coloured (14 to 58 TCU), with the highest colour measured in under-ice conditions in May 2007 (Appendix B5).

The water column remained well oxygenated during open-water conditions, with DO concentrations above the 9.5 mg/L CWQG for the protection of aquatic life (CCME 2007a) throughout the 2006 and 2007 open water period (Figures 3.9 and 3.10). During under-ice conditions in May 2007, the near-bottom DO was below the 6.5 mg/L CWQG for the protection of aquatic life (Appendix B4) (CCME 2007a).

Thermal stratification was not observed in Reference Lake, with a typically isothermic water column evident on all sampling occasions in 2006 and 2007. The water temperatures showed typical seasonal trends, with the warmest temperatures recorded in August 2006 and July 2007 (Figures 3.9 and 3.10).

The total phosphorus concentrations in Reference Lake ranged from 18 to 42 µg/L during the 2006 and 2007 open-water sampling periods, with a maximum concentration of 162 µg/L under-ice in May 2007. This high concentration was associated with high TSS (10 mg/L). The Chl *a* concentration was 7.1 µg/L in September 2006 and ranged from 1.9 to 4.2 µg/L in 2007 (Appendix B5). Based on the typical total phosphorus concentrations, Reference Lake could be classified as meso-eutrophic, although the high under-ice phosphorus concentration would indicate a hyper-eutrophic status (Appendix B1) (CCME 2004). Based on the the Chl *a* concentrations, Reference Lake could be classified as oligotrophic (Appendix B1) (Mitchell and Prepas 1990).

All of the dissolved inorganic forms of nitrogen were well below the CWQGs (CCME 2007a) in both years, and represented < 5% of the total nitrogen concentration (the TKN ranged from 0.38 to 0.49 mg/L in 2006, and 0.39 to 1.49 mg/L in 2007). Elevated TKN and dissolved inorganic nitrogen were measured in the under-ice sample collected in May 2007.

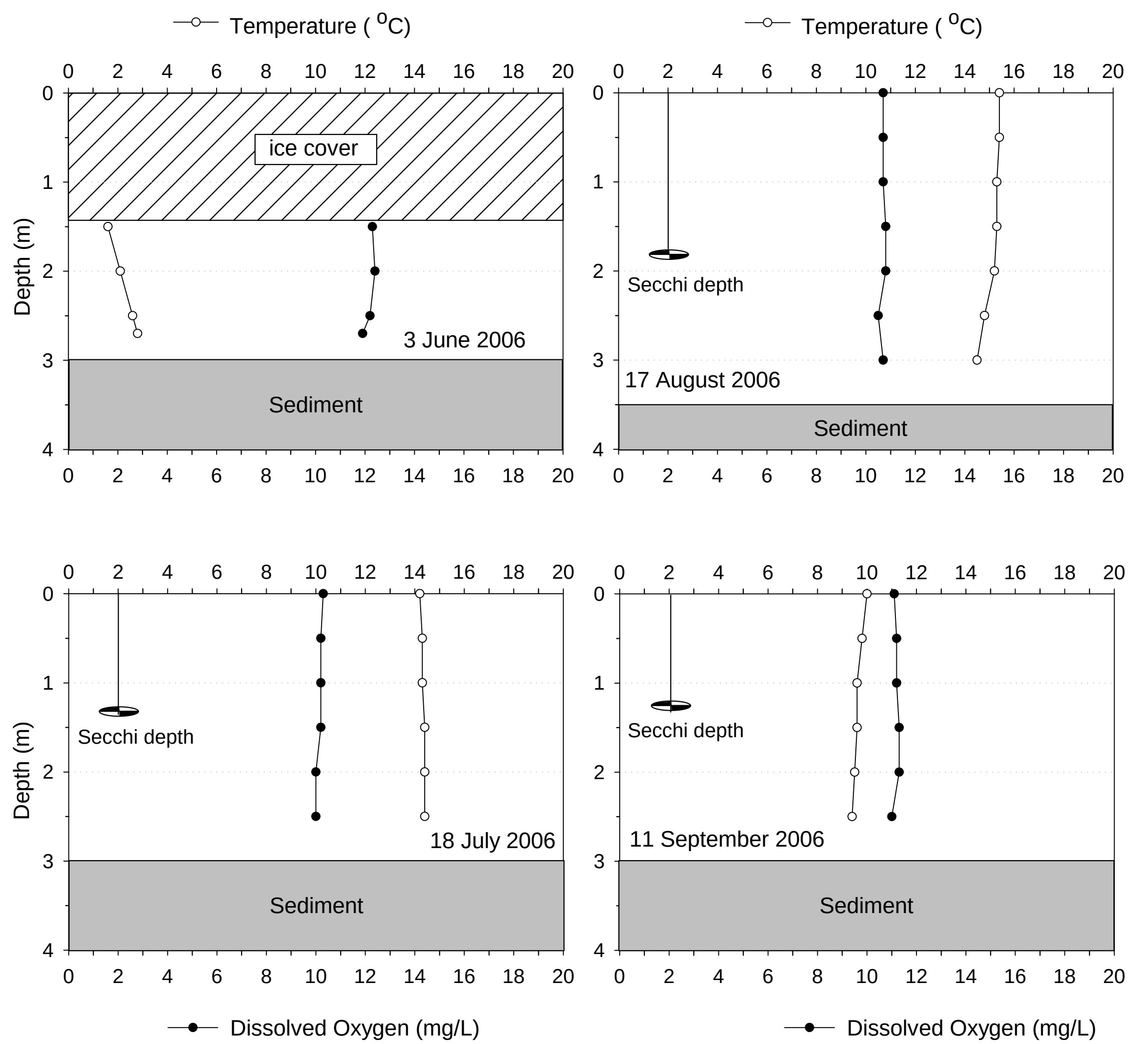

Figure 3.9 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Reference Lake, 2006

With the exception of baseline total aluminum, chromium, copper, and iron, most metals were below the applicable CWQGs (CCME 2007a). The exceptions are as follows:

- Total aluminum concentrations were above the 100 µg/L CWQG (for pH ≥ 6.5) on all four sampling occasions in 2006 and in the July 2007 sample (211 µg/L; Appendix B5). The 5.0 µg/L CWQG for total aluminum (for pH < 6.5) was substantially exceeded in July 2006 (173 mg/L) when the lake was at pH 6.4.

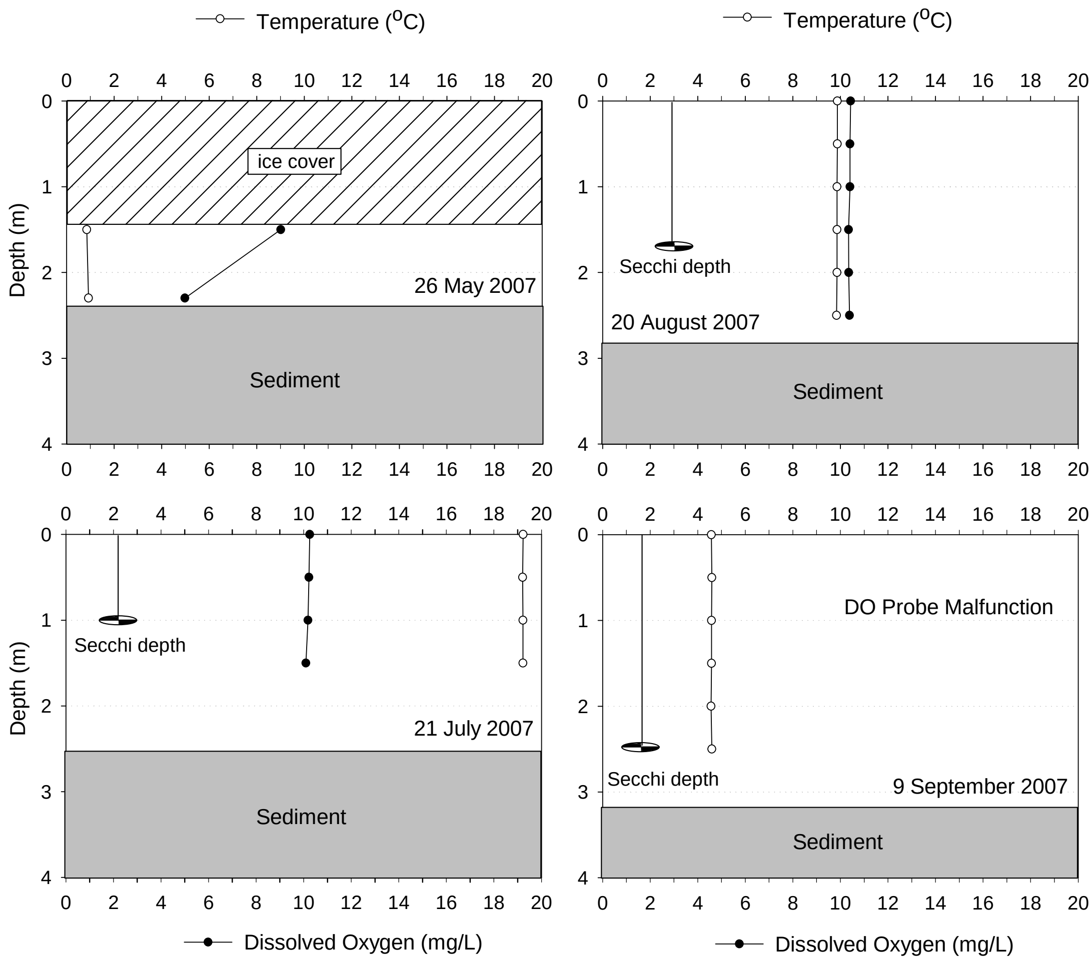

Figure 3.10 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Reference Lake, 2007

- The total and dissolved chromium concentrations were above the 1 µg/L CWQG sublethal toxicity of Cr (IV) in under-ice conditions in May 2007 (both at 1.2 µg/L) (Appendix B5).
- The total and dissolved copper concentrations were above the 2 µg/L CWQG in anoxic, under-ice conditions in May 2007 and in August 2007 (2.5 and 2.2 µg/L, and 3.1 and 2.6 µg/L, respectively) (Appendix B5).
- Baseline total iron concentrations were at, or higher than, the 300 µg/L CWQG in August 2006 (301 µg/L) and May (1790 µg/L) and July

2007 (340 µg/L). The highest concentration was measured in the low oxygen under-ice conditions in May 2007, in which the dissolved iron concentration was also high (1030 µg/L) (Appendix B5).

Total cyanide concentrations were consistently below the MRV (0.001 mg/L), with the exception of the August 2007 sample (0.001 mg/L).

3.3.1.4 Stickleback Lake

Stickleback Lake is a very clear, shallow (approximately 3.5 m deep) freshwater lake. It is characterized by soft water, with a low sensitivity to acidification (Saffran and Trew 1996; Weiner 2000).

In 2006 and 2007, the field pH measurements were slightly acidic to alkaline (pH 6.5 to 8.2) and within the CWQGs (pH 6.5 to 9.0) (CCME 2007a). During open water conditions, electrical conductivity values ranged from 167 to 252 µS/cm in 2006 and 246 to 248 µS/cm in 2007, which was approximately three times higher than other lakes within the Boston Project area (Appendix B5). The major ions were dominated by calcium and chloride. Consistent with the elevated conductivity measured during under-ice conditions in the shallow Fickle Duck and Reference lakes, elevated conductivity was also measured in Stickleback Lake during the under-ice conditions in May 2007 (643 µS/cm).

Total suspended solids concentrations were low, ranging between < 1 and 2 mg/L in 2006 and 2007. The Secchi depth ranged from 2.4 to 2.8 m in 2006 and to the bottom in 2007 (Figures 3.11 and 3.12). The waters were slightly coloured (< 1 to 8 TCU), with the highest colour typically observed during under-ice or snowmelt conditions.

The water column remained well oxygenated (10 to 12 mg/L) throughout the water column during open-water conditions (Figure 3.11 and 3.12). During under-ice conditions, the free water exhibited low DO concentrations. In June 2006, DO concentrations declined gradually with depth from below the minimum CWQG for protection of early life stages of fish (9.5 mg/L) at 1.5 m depth, to 4.7 mg/L at the bottom, which was below the 6.5 mg/L CWQG for the protection of aquatic life (Figure 3.11) (CCME 2007a). In May 2007, the 1 m of free water below the ice was near anoxic (between 0 and 0.5 mg/L; Figure 3.12).

No distinct thermal stratification was observed in Stickleback Lake in 2006 and 2007, although a slight positive temperature gradient with depth from 2 to 4°C was present in the ice-covered water column in May 2006. Typical seasonal trends were evident, with the warmest temperatures measured in July or August (Figures 3.11 and 3.12).

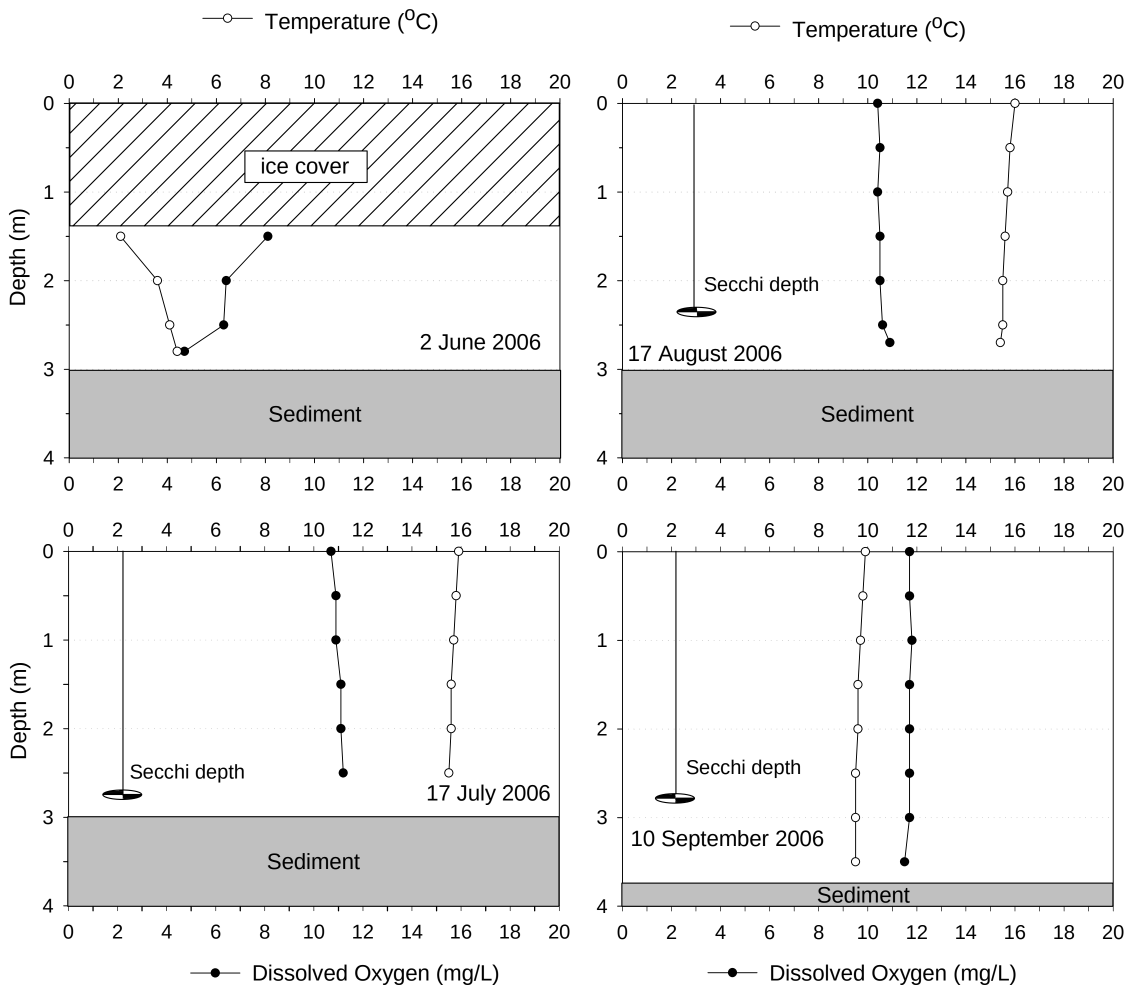

Figure 3.11 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Stickleback Lake, 2006

Total phosphorus concentrations in Stickleback Lake ranged from 11 to 28 µg/L. The September 2006 Chl *a* concentration was 4.2 µg/L, and ranged from 1.4 to 2.0 µg/L in 2007 (Appendix B5). Based on the total phosphorus concentrations, the lake would be classified as mesotrophic to meso-eutrophic (Appendix B1) (CCME 2004); however, the Chl *a* concentrations were indicative of oligotrophic lakes (Appendix B1) (Mitchell and Prepas 1990).

All of the dissolved inorganic forms of nitrogen were well below the CWQGs (CCME 2007a) in both years, and represented < 13% of the total nitrogen concentration (the TKN ranged from 0.36 to 0.40 mg/L in 2006, and 0.36 to 0.77 mg/L in 2007). As observed in the shallow Fickle Duck and Reference lakes, an elevated TKN concentration was measured in May 2007 under-ice conditions.

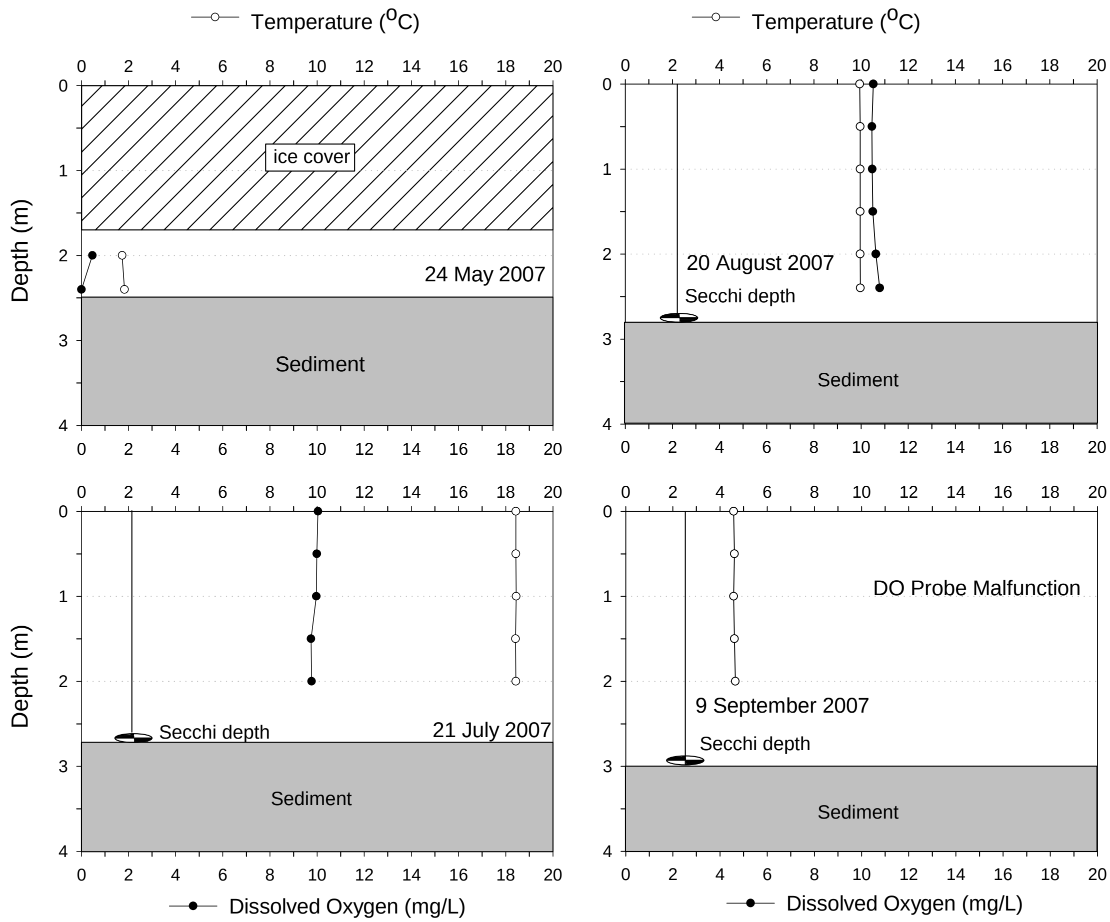

Figure 3.12 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Stickleback Lake, 2007

Baseline total metal concentrations remained below applicable CWQGs (CCME 2007a), with the exception of total iron and selenium that were associated with the May 2007 under-ice conditions. These exceptions are as follows:

- The total iron concentration (574 µg/L) was higher than the 300 µg/L CWQG (Appendix B5).
- The total selenium concentration (2.0 µg/L) was higher than the 1.0 µg/L CWQG (Appendix B5).

Total cyanide concentrations were generally below the MRV (0.001 mg/L), with exceptions during under-ice conditions in June 2006 (0.001 mg/L) and May 2007 (0.002 mg/L).

3.3.1.5 Boston Project Area Lakes Summary

The lakes within the Boston Project area were typically clear, with soft water, low TDS concentrations, and a moderate to high sensitivity to acidification. The exception to this generalization was Stickleback Lake, which had higher TDS concentrations and corresponding higher alkalinity and hardness values, and therefore a lower sensitivity to acidification. TDS concentrations in Stickleback Lake were approximately three times the concentrations measured in the other Boston Project area lakes, which suggests that the watershed may drain through slightly different geology or that there is a distinct groundwater input to this lake. Sodium, calcium, and chloride were the dominant major ions. The range of pH values was slightly acidic to alkaline for all lakes in the Boston Project area (Appendix B5).

Thermal stratification was not evident during the open water season. The water column of each lake remained well oxygenated throughout open water conditions. Under-ice DO concentrations fell below the CWQG for protection of all life stages of fish in the shallow lakes, namely Fickle Duck, Reference, and Stickleback lakes, with anoxic DO conditions measured in Fickle Duck Lake in May 2007.

Based on total phosphorus concentrations measured in 2006 and 2007, the Boston Project area lakes ranged from mesotrophic (Aimaokatalok, Fickle Duck, and Stickleback lakes) to hyper-eutrophic (Fickle Duck Lake). Based on Chl *a* concentrations, the Boston Project area lakes ranged from oligotrophic (Reference and Stickleback lakes) to meso-eutrophic (Fickle Duck Lake). All of the lakes in the Boston Project area were considered to be phosphorus-limited.

Baseline total metal concentrations were rarely higher than CWQGs (CCME 2007a) in the Boston Project area lakes, with the exception of occurrences of elevated total aluminum, cadmium, chromium, copper, iron, and selenium concentrations. Total aluminum and iron concentrations were higher than relevant CWQGs on one or more sampling occasions in all lakes except Aimaokatalok Lake. Total copper and cadmium concentrations were higher than applicable CWQGs on at least one sampling occasion in all lakes. Selenium was only above the CWQG on one sampling event in Stickleback Lake (Tables 3.9 and 3.10). For most metals, the proportion of the dissolved fraction was moderate to high, accounting for 50 to 100% of the total concentration.

Table 3.9 Summary of Aimaokatalok Lake (Stations 4 and 6) Water Samples that were Above Guidelines for the Protection of Aquatic Life in Freshwater, 2006 – 2007

Station	Strata	Date	TSS	Field pH	Al (Total)		Cd (Total)	Cr (Total)	Cu (Total)
				CWQG 6.5-9.0	CWQG 100 µg/L for pH≥6.5	CWQG 5.0 µg/L for pH<6.5	CWQG 0.010 µg/L[a]	CWQG 1.0 µg/L or USEPA 16 µg/L[b]	CWQG 2-4 µg/L[a]
Aimaokatalok Lake Station 4	Top*	2-Jun-06	<1	6.7					
	Top	10-Sep-06	1	7.3					
	Top*	24-May-07	<1	7.0			**0.024**		**2.3**
	Bottom*	24-May-07	<1	7.0				**1.2**	
	Top	21-Jul-07	<1	**6.0**		**31.7**			
	Top	19-Aug-07	<1	**6.2**		**43.7**			
	Top	8-Sep-07	<1	**6.0**		**42.9**			
Aimaokatalok Lake Station 6	Bottom*	3-Jun-06	2	6.9	**192**				
	Top	20-Jul-07	<1	**6.0**		**36.2**			
	Top	19-Aug-07	2	**6.1**		**48.1**			
	Top	8-Sep-07	<1	**6.1**		**59.8**			

Total suspended solids (TSS) and field pH values are provided to help in interpretation of the values exceeding guidelines.

[a] CWQG was adjusted for hardness (See Appendix B1).

[b] For Cr sublethal toxicity, the CWQG is 1.0 µg/L; for acute toxicity, the USEPA guideline is 16 µg/L (See Appendix B1).

* Samples were taken under ice.

Values exceeding CWQGs are **bold.**

Prepared by: EJJ Checked by: JM

Table 3.10 Summary of Fickle Duck, Reference, and Stickleback Lake Water Samples that were Above Guidelines for the Protection of Aquatic Life in Freshwater, 2006 – 2007

Station	Strata	Date	TSS	Field pH	Al (Total)		Cr (Total)	Cu (Total)	Iron (Total)	Se (Total)
				CWQG 6.5-9.0	CWQG 100 µg/L for pH≥6.5	CWQG 5.0 µg/L for pH<6.5	CWQG 1.0 µg/L or USEPA 16 µg/L[b]	CWQG 2-4 µg/L[a]	CWQG 300 µg/L	CWQG 1.0 µg/L
Fickle Duck Lake	Top	18-Jul-06	2	7.0	**122**				**364**	
	Top	17-Aug-06	3	8.0					**501**	
	Top	10-Sep-06	4	7.7	**172**				**532**	
	Top*	24-May-07	1	6.9			**1.8**	**2.6**	**2810**	
	Top	22-Jul-07	2	7.3	**114**				**357**	
	Top	20-Aug-07	<1	6.8	**155**				**317**	
	Top	9-Sep-07	1	6.6	**112**			**2.3**		
Reference Lake	Bottom*	3-Jun-06	1	6.9	**191**				**402**	
	Top	18-Jul-06	3	**6.4**		**173**				
	Top	17-Aug-06	2	7.4	**101**				**301**	
	Top	11-Sep-06	2	7.7	**156**					
	Top*	26-May-07	10	6.7			**1.2**	**2.5**	**1790**	
	Top	21-Jul-07	4	6.8	**211**				**340**	
	Top	20-Aug-07	<1	6.5				**3.1**		
Stickleback Lake	Top	17-Aug-06	<1	8.2				**2.0**		
	Top*	24-May-07	2	7.3					**574**	**2.0**

Total suspended solids (TSS) and field pH values are provided to help in interpretation of the values exceeding guidelines.
[a] CWQG was adjusted for hardness (See Appendix B1).
[b] For Cr sublethal toxicity, the CWQG is 1.0 µg/L; for acute toxicity, the USEPA guideline is 16 µg/L (See Appendix B1).
* Samples were taken under ice.
Values exceeding CWQGs are **bold.**

3.3.2 Madrid Project Area

3.3.2.1 Glenn Lake

Glenn Lake is a deep (approximately 20 m deep) freshwater lake. It is characterized by soft water, with a negligible sensitivity to acidification (Saffran and Trew 1996; Weiner 2000).

The lake pH values were very consistent and near-neutral (7.2 to 7.4) and were within the CWQG range of pH 6.5 to 9.0 (CCME 2007a).

Glenn Lake exhibited moderate electrical conductivity ranging from 331 µS/cm to 464 µS/cm, which was also the water column differential in July 2007; this profile gradient was attributed to the expression of low conductivity surface flows from melting ice at the time of sampling. Conductivity was typically between 373 and 457 µS/cm in all other samples, reflecting the marine origins of sediments in the basin. The major ions were dominated by sodium and chloride (Appendix B5).

Total suspended solids concentrations ranged from < 1 to 4 mg/L, and the Secchi depth ranged from 1.0 to 3.0 m (Figure 3.13). The waters were slightly coloured (6 to 22 TCU), with the highest colour values measured in September 2007 (Appendix B5).

The water column remained well oxygenated throughout the 2007 sampling season, which included under-ice conditions. Glenn Lake DO concentrations were above the 9.5 mg/L CWQG for protection of early life stages of fish (CCME 2007a) throughout the water column (Figure 3.13).

Slight thermal stratification was evident in July; the water temperature declined from 8.9°C near water surface to 2.9°C near bottom sediments, with slight stratification observed at 5 and 12 m (Figure 3.13). Typically isothermic conditions were evident in the remaining sampling periods in 2007. Typical seasonal trends were evident, with the warmest temperatures measured in August (Figure 3.13). The differences in Glenn Lake water depth between sampling dates was due to the sharp relief in the lake bottom around the sampling station, and the marginal error associated with locating sampling stations using GPS devices.

Total phosphorus concentrations in Glenn Lake ranged from 5 to 18 µg/L. The Chl *a* concentrations in Glenn Lake were very low in 2007, ranging from 0.8 to 1.0 µg/L (Appendix B5). Based on the TP and Chl *a* concentrations, Glenn Lake could be classified as oligo-mesotrophic (Appendix B1) (Mitchell and Prepas 1990; CCME 2004).

All of the dissolved inorganic forms of nitrogen (ammonia, nitrate, and nitrite) were well below the CWQGs, representing < 14% of the total nitrogen concentrations (the TKN ranged from 0.20 to 0.25 mg/L).

Most metal concentrations were below the applicable CWQGs (CCME 2007a), with the exception of baseline total aluminum, chromium, copper, iron, and selenium. These exceptions are as follows:

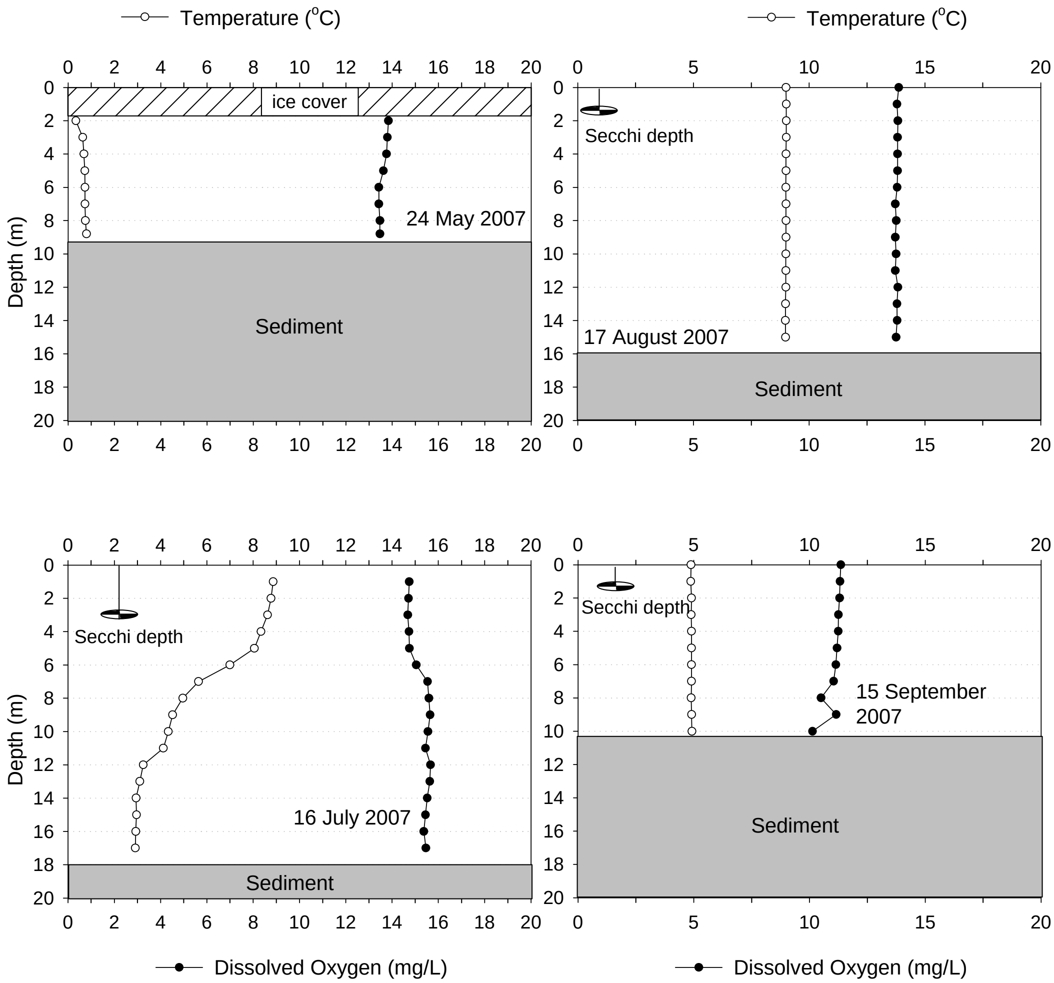

Figure 3.13 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Glenn Lake, 2007

- Baseline total aluminum concentrations were above the 100 µg/L CWQG (for pH ≥ 6.5) for top and bottom samples collected on all three open-water sampling dates in 2007, with concentrations ranging from 112 to 650 µg/L (Appendix B5).
- Background total chromium was above the 1.0 µg/L CWQG for sublethal toxicity of Cr (IV), with a concentration of 1.1 µg/L in the top sample in September 2007.
- Total and dissolved copper concentrations in Glenn Lake were naturally at, or above, the 2 µg/L CWQG in all water quality samples collected in 2007 (Appendix B5). The total copper concentrations ranged from 2.2 to 3.8 µg/L, and the dissolved copper concentrations ranged from 1.9 to 2.8 µg/L.

- Baseline total iron concentrations were above the 300 µg/L CWQG in the surface and bottom samples collected in August and September, with concentrations ranging from 325 to 436 µg/L.
- Baseline total selenium exceeded the 1.0 µg/L CWQG in the surface and bottom samples collected in May (under-ice), July, and August, with concentrations ranging from 1.1 to 2.0 µg/L (Appendix B5). Dissolved selenium concentrations were higher than the CWQG in the surface and bottom sample in May (1.3 and 1.6 µg/L, respectively), and the bottom sample in July (1.5 µg/L).

Total cyanide concentrations were below the MRV (0.001mg/L) in all but the July 2007 top sample (0.002 mg/L) (Appendix B5).

3.3.2.2 Ogama Lake

Ogama Lake is a shallow (approximately 7 m deep) freshwater lake. It is characterized by soft water, typically with a low sensitivity to acidification (Saffran and Trew 1996; Weiner 2000).

Field measured pH was slightly acidic to alkaline (6.5 to 8.3) and within the CWQG range of pH 6.5 to 9.0 (CCME 2007a). The acidic pH was associated with the under-ice conditions in June 2006.

Ogama Lake had moderate electrical conductivity values during open-water conditions, which ranged from 252 to 298 µS/cm in 2006 and 2007. The under-ice conductivity was considerably greater in the deep sample in June 2006 (701 µS/cm) and May 2007 (602 µS/cm), reflecting the elevated TDS conditions that are often associated with ice-covered lakes. The dominant major ions were sodium and chloride.

Total suspended solids concentrations ranged from 1 to 7 mg/L in 2006 and 2007 (Appendix B5). The corresponding Secchi depth measurements ranged from 0.9 m to 1.7 m in 2006 and 2007 (Figures 3.14 and 3.15). The waters were coloured, ranging between < 1 to 58 TCU, with the highest colour values in 2006 associated with under-ice conditions, and the highest colour values in 2007 associated with late summer/early fall conditions.

During under ice conditions, water column DO concentrations exhibited a negative gradient with depth. DO concentrations during under-ice conditions in June 2006 declined from >12 mg/L in the upper water column to < 0.5 mg/L near the bottom (Figure 3.14). In 2007 the under-ice DO concentrations declined from 5.9 mg/L in the upper water column, which was below the 6.5 mg/L CWQG for the protection of aquatic life (CCME 2007a), to anoxic conditions at the bottom (Figure 3.15). In July 2006 and 2007, the top 4.5 to 5.0 m of water column was well oxygenated (> 10 mg/L), but DO declined to concentrations just below the 9.5 mg/L CWQG for protection of early life stages of fish (CCME 2007a) below 5.0 m depth (July 2006), and below the 6.5 mg/L CWQG for protection of aquatic life below 6.0 m (July 2007) (Figure 3.15). The DO concentrations remained high and near-uniform throughout the water column in August and September of 2006 and 2007.

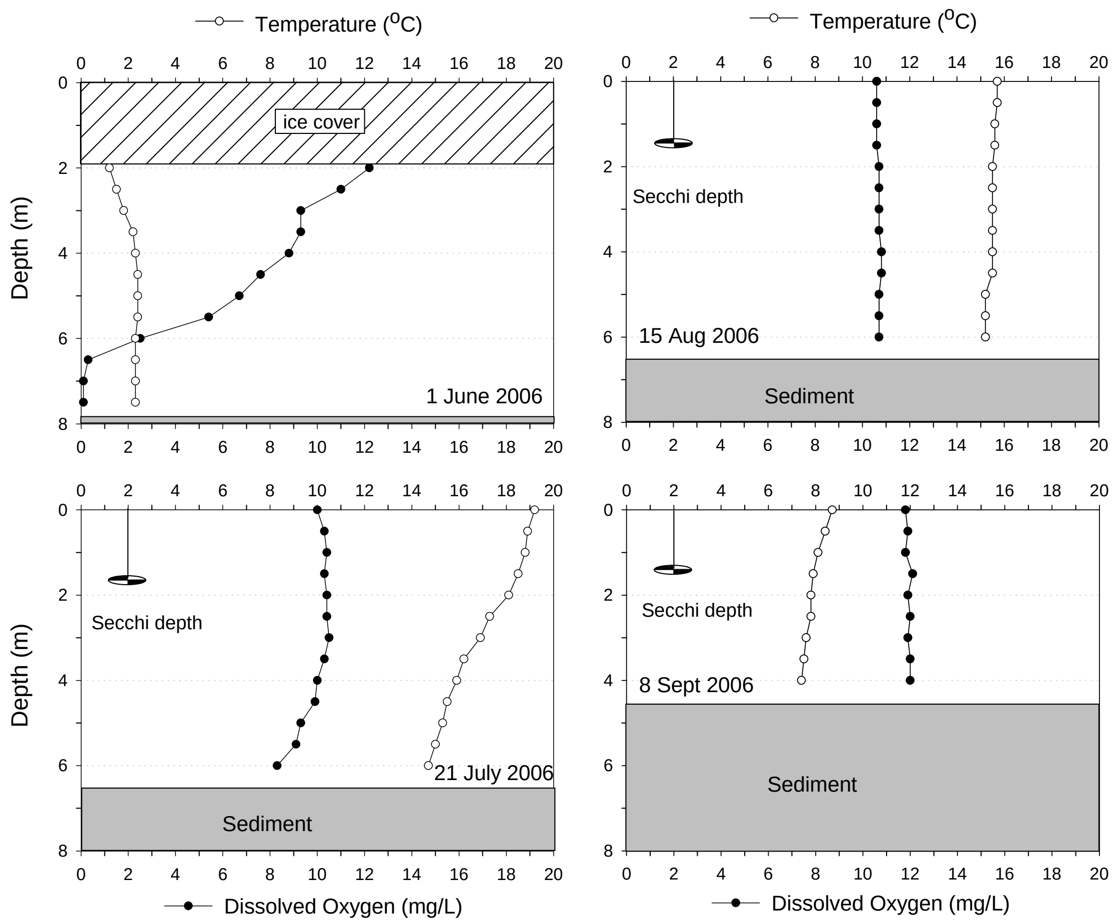

Figure 3.14 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Ogama Lake, 2006

The water column in Ogama Lake was not thermally stratified during any of the sampling events in 2006 (Figure 3.14) or during May, August, and September 2007. Ogama Lake was thermally stratified in July 2007; water temperature dropped from 17.7°C at 2 m to 11.2°C at 3 m depth (Figure 3.15). Typical seasonal temperature trends were observed in the water column, with warmer water column temperatures in July and August compared to September in 2006 and 2007.

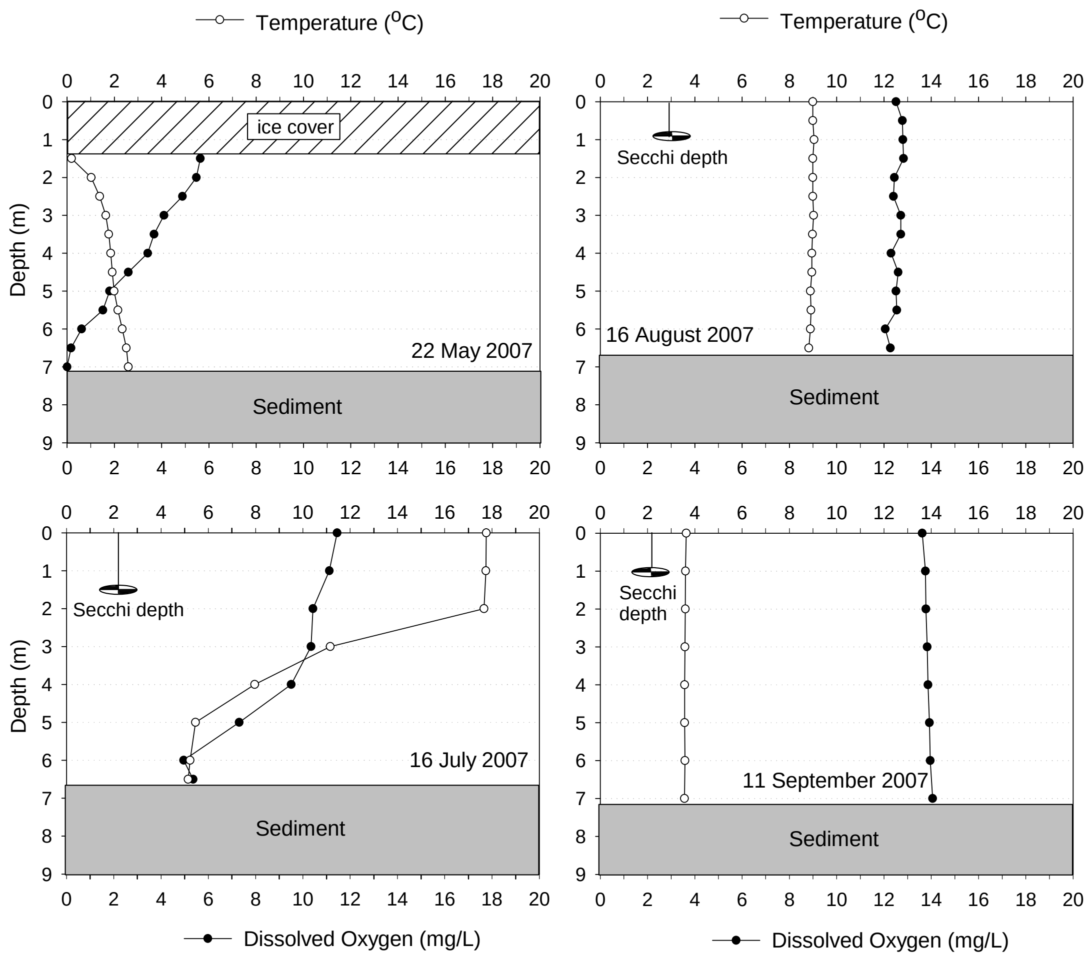

Figure 3.15 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Ogama Lake, 2007

During the 2006 and 2007 sampling periods, the total phosphorus concentrations ranged from 21 to 49 µg/L (Appendix B5). The Chl *a* concentration was 6.8 µg/L in September 2006 and ranged from 3.4 to 5.5 µg/L in 2007. Based on total phosphorus concentrations, Ogama Lake could be classified as meso-eutrophic to eutrophic (Appendix B1) (CCME 2004); however, the range of Chl *a* concentrations indicated an oligotrophic productivity status (Appendix B1) (Mitchell and Prepas 1990).

All of the dissolved inorganic forms of nitrogen were well below the CWQGs (CCME 2007a) in both years, and generally represented < 4% of the total nitrogen concentrations (the TKN ranged from 0.40 to 0.63 mg/L in 2006, and 0.42 to 0.63 mg/L in 2007); however, in the June 2006 bottom sample, dissolved inorganic nitrogen represented 26% of the total nitrogen concetration due to elevated concentrations of ammonia (108 µg N/L) and nitrate (74 µg N/L).

With the exception of baseline total aluminium, copper, iron, and selenium, most total metal concentrations were below the applicable CWQGs (CCME 2007a). The exceptions are as follows:

- Total aluminum concentrations were naturally above the 100 µg/L CWQG for total aluminum (for pH ≥ 6.5) on all sampling occasions in top and bottom samples in 2006 and 2007 with one exception, with concentrations above the CWQG ranging from 117 to 495 µg/L (Appendix B5). The one exception was an aluminum concentration of 63.4 in the top sample collected under ice on 22 May 2007.
- Baseline total copper concentrations were above the 2 µg/L CWQG in June 2006 (top and bottom), and May (top), August (bottom), and September (bottom) 2007, with concentrations ranging from 2.2 to 3.0 µg/L (Appendix B5). In the majority of these cases, the dissolved copper concetrations were also above CWQGs, ranging from 2.0 to 2.6 µg/L.
- Background total iron concentrations were above the 300 µg/L CWQG in the June 2006 (top and bottom), and July (top) and August 2007 (bottom), with concentrations ranging from 319 to 823 µg/L (Appendix B5). The dissolved iron concentration in June 2006 was also above the CWQG (320 µg/L).
- Baseline total selenium concentrations were at, or above, the 1.0 µg/L CWQG in top and bottom samples on June, August, and September 2006, and May, August and September (bottom only) 2007, ranging from from 1.0 to 3.6 µg/L (Appendix B5). In the majority of these cases, the dissolved selenium concentrations were also above CWQGs, ranging from 1.0 to 3.3 µg/L.

Total cyanide concentrations were generally below the MRV (0.001 mg/L); however, values at or higher than the MRV were measured in June 2006 (0.001 and 0.002 mg/L for top and bottom samples, respectively), August 2006 (0.001 mg/L for top and bottom samples), September 2006 (0.001 mg/L for the top sample), and in May 2007 (0.001 mg/L) and August 2007 (0.002 mg/L for the bottom sample (Appendix B5).

3.3.2.3 Patch Lake

Patch Lake is a moderately deep (approximately 16 m) freshwater lake. It is characterized by soft water, with a low sensitivity to acidification (Saffran and Trew 1996; Weiner 2000).

Field pH measurements were slightly acidic to alkaline (6.8 to 8.1) and within the CWQG of pH 6.5 to 9.0 (CCME 2007a) on all sampling occasions in 2006 and 2007. Patch Lake exhibited moderate conductivity, ranging from 325 to 458 µS/cm in 2006, and 336 to 531 µS/cm in 2007. The major ions were dominated by sodium and chloride (Appendix B5).

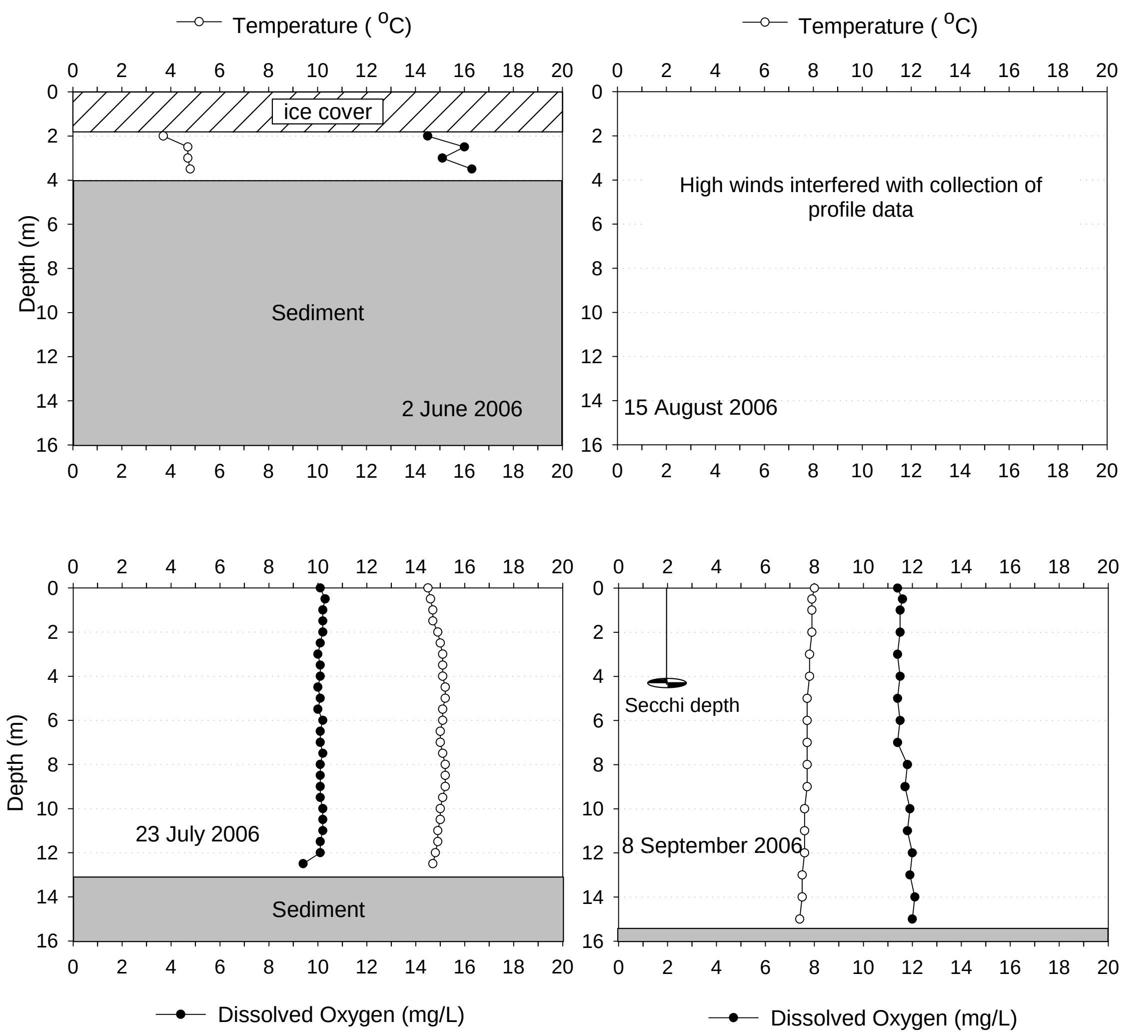

Figure 3.16 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Patch Lake, 2006

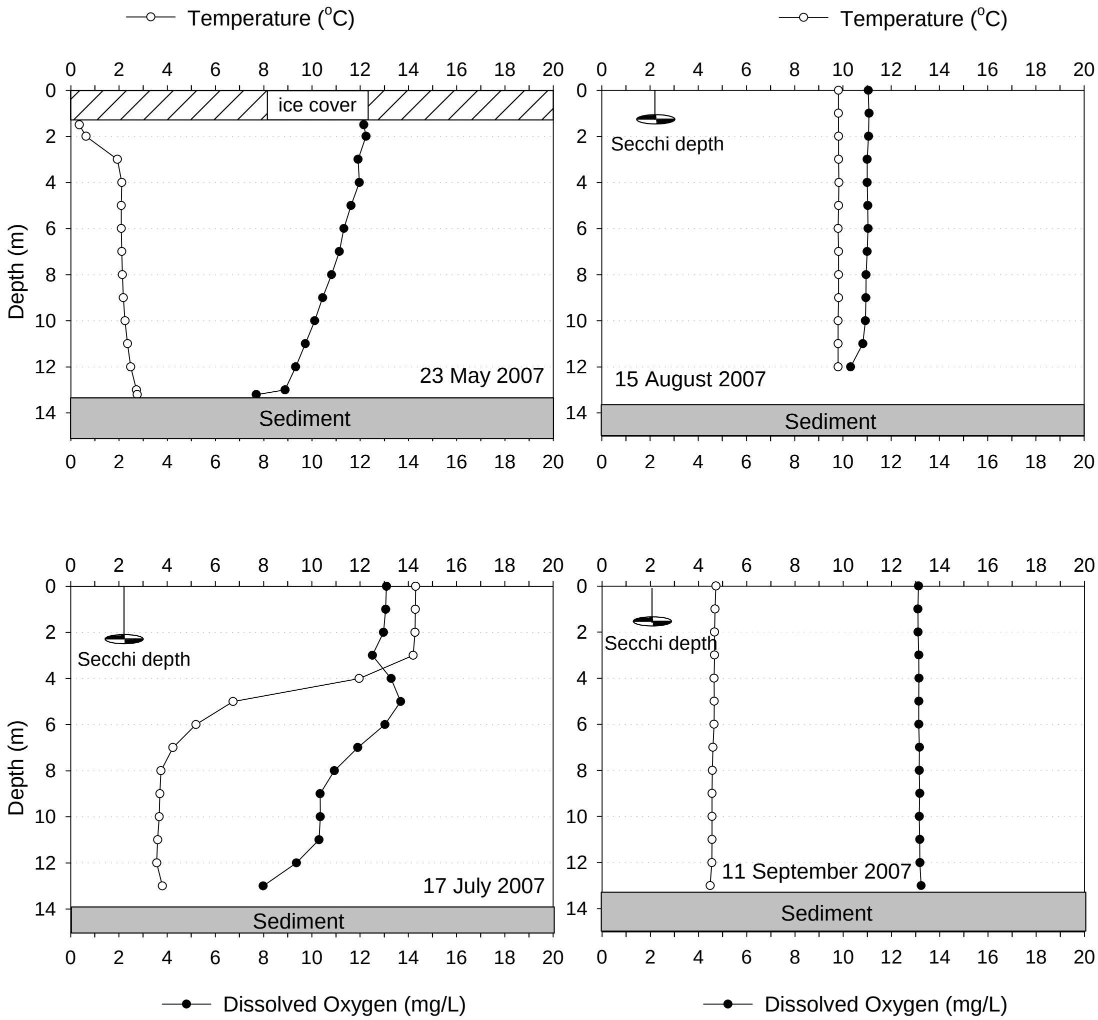

Figure 3.17 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Patch Lake, 2007

Patch Lake was relatively clear, with TSS concentrations typically around 1 µg/L in 2006, and ranging from < 1 to 4 mg/L in 2007. The Secchi depth in September 2006 was 4.25 m (it was recorded only once in 2006) (Figure 3.16), and ranged from 1.25 to 2.2 m in 2007 (Figure 3.17). The waters were slightly coloured ranging from < 1 to 8 TCU (Appendix B5).

Patch Lake was well oxygenated throughout 2006 and 2007, and remained above the CWQG of 9.5 mg/L (CCME 2007a) even during under-ice conditions (however, the June 2006 sampling station was not consistent with the location used for the other seven sampling dates in 2006 and 2007) (Figures 3.16 and 3.17). In July 2007, the DO was weakly stratified around 5 m depth, declining from 13.7 to 8 mg/L at 13 m. Occassionaly the bottom DO readings fell below the 9.5 mg/L CWQG for protection of early life stages of fish (July 2006 and May 2007) (Figure 3.16).

Thermal stratification was not generally evident thoughout the sampling in 2006 and 2007, with the exception of July 2007. A pronounced thermocline was observed at 4 m depth, when the water temperature declined from 12.0°C (at 4.0 m) to 6.7°C (at 5.0 m; Figure 3.17). The lower water column maintained a temperature of 4°C from 8 to 13 m. As expected, during under-ice conditions, a colder upper water layer was obvious down to 3 m depth.

Baseline total phosphorus concentrations ranged from 9 to 23 µg/L in 2006, and from 4 to 12 µg/L in 2007, with one elevated TP concentration measured in August 2007 (60 µg/L, bottom sample). The Chl *a* concentrations were consistently low in 2006 and 2007, and ranged from 0.6 to 1.0 µg/L (Appendix B5). The typical total phosphorus concentrations indicated that Patch Lake could be classified as oligo-mesotrophic (Appendix B1) (CCME 2004). The low Chl *a* concentrations indicated that the phytoplankton productivity in this lake was very low, typical of an oligotrophic system (Appendix B1) (Mitchell and Prepas 1990).

All of the dissolved inorganic forms of nitrogen were well below the CWQGs (CCME 2007a) in 2006 and 2007, and generally represented < 11% of the total nitrogen concentration. The TKN ranged from 0.18 to 0.31 mg/L in 2006, and 0.18 to 0.29 mg/L in 2007.

Most baseline total metal concentrations were below the applicable CWQGs (CCME 2007a), with the exception of total aluminum, copper, mercury, and selenium. These exceptions are as follows:

- Baseline total aluminum concentrations were higher than the 100 µg/L CWQG (for pH ≥ 6.5) in the July 2006 (top sample), and August and September 2007 top and bottom samples, with concentrations ranging from 138 to 351 µg/L (Appendix B5).

- Baseline total copper concentrations were above the 2.0 µg/L CWQG in June 2006 bottom, and August 2007 top and bottom samples, ranging from 2.2 and 3.8 µg/L (Appendix B5). The dissolved copper concentration in the August 2007 bottom sample was also above the CWQG (2.2 µg/L).
- The background total mercury concentration was above the 26 ng/L CWQG in the August 2006 top water sample (44 ng/L) (Appendix B5).
- Total selenium concentrations were above the 1.0 µg/L CWQG in most 2006 and 2007 samples (ranging from 1.2 to 2.1 µg/L), with the

exception of July 2006 and September 2007. (Appendix B5). In many of these cases, the dissolved selenium concentrations were also higher than the CWQGs.

Total cyanide concentrations were generally below the MRV (0.001 mg/L); however, values at or higher than the MRV were measured in June 2006 (0.001 mg/L), August 2006 (0.002 and 0.001 mg/L for top and bottom samples, respectively), and September 2006 (0.001 mg/L for the top sample) (Appendix B5).

3.3.2.4 Pelvic Lake

Pelvic Lake is a deep (approximately 16 m deep) freshwater lake. Its background conditions are characterized by soft water, with a moderate to low sensitivity to acidification (Saffran and Trew 1996; Weiner 2000).

The pH was slightly acidic to alkaline (6.5 to 8.6) in 2006 and 2007 and within the CWQG range of pH 6.5 to 9.0 (CCME 2007a). In 2006, the lake was slightly acidic during under-ice conditions, and alkaline during open water conditions. In 2007, the field pH of ranged from 6.7 to 7.7. Electrical conductivity was consistent in 2006 and 2007, ranging from 226 to 360 µS/cm. The major ions were dominated by sodium and chloride (Appendix B5).

Total suspended solids ranged from 1 to 11 mg/L in 2006 and 2007. The corresponding Secchi depths were shallow, varying between 0.8 and 1.1 m in both years (Figures 3.18 and 3.19) The waters were coloured ranging from < 1 to 49 TCU, with the highest values measured during under-ice and snow melt conditions (Appendix B5).

Oxic stratification or oxic gradients through the water column were evident during under-ice or early summer conditions in 2006 and 2007. In June 2006 (under-ice), Pelvic Lake was well oxygenated down to 10.5 m, below which DO declined to < 1.0 mg/L at the bottom (Figure 3.18). In May 2007 (under-ice), the top 1.0 m of water was well oxygenated but gradually declined to anoxic conditions at the bottom of the water column (Figure 3.19). A similar gradient was evident in July 2007. Pelvic Lake remained well oxygenated throughout the water column during open-water conditions in 2006, and August and September 2007. In July 2006, only the bottom of the water column was slightly below the 9.5 mg/L CWQG for protection of early life stages of fish (9.2 mg/L; Figure 3.18) (CCME 2007a).

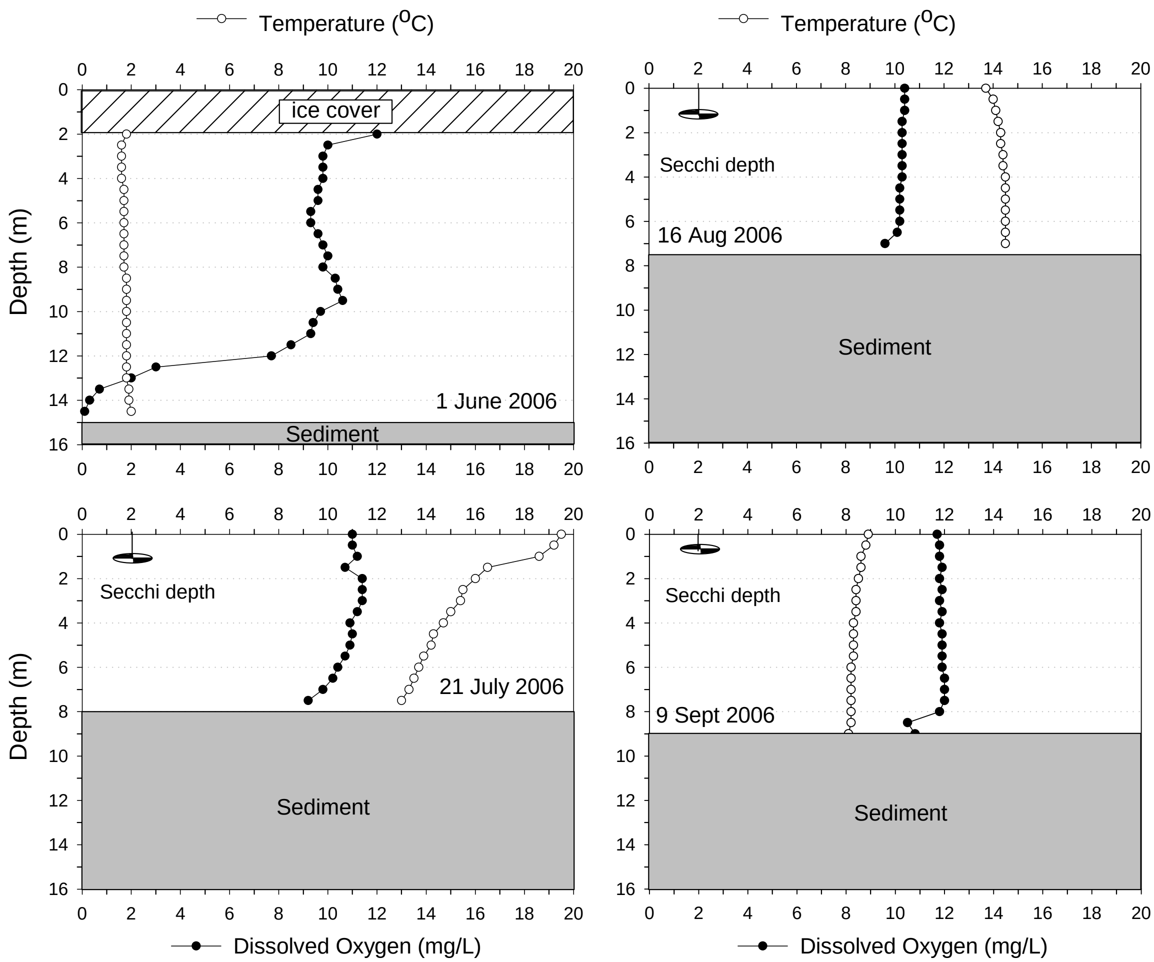

Figure 3.18 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Pelvic Lake, 2006

Thermal stratification was evident in July 2006 and July 2007. In July 2006, a 2°C decline was present from 1.0 to 1.5 m (Figure 3.18). Above the thermocline, the water temperature reached 19.5°C, which was the warmest temperature recorded for all Boston and Madrid Project area stations in 2006. In July 2007, the temperature declined from 16.8°C at the surface of the water column to 6.4°C at 4.0 m depth (Figure 3.19). Temperature profiles were isothermal in August and September of 2006 and 2007 (Figures 3.18 and 3.19). Typical seasonal trends were evident with the warmer surface temperatures prevalent in July (Figures 3.18 and 3.19).

Total phosphorus concentrations in Pelvic Lake ranged from 34 to 62 µg/L in 2006 and from 27 to 62 µg/L in 2007, with the exception of 128 µg/L in the July 2007 bottom sample. The Chl *a* concentration in September 2006 was 19.1 µg/L, and the concentration range in 2007 was 6.5 to 14.4 µg/L. The total phosphorus concentrations indicated that Pelvic Lake could be classified with a meso-eutrophic to eutrophic status (Appendix B1) (CCME 2004). The range of Chl *a* concentrations indicated that phytoplankton productivity was high, consistent with a mesotrophic classification (Appendix B1) (Mitchell and Prepas 1990).

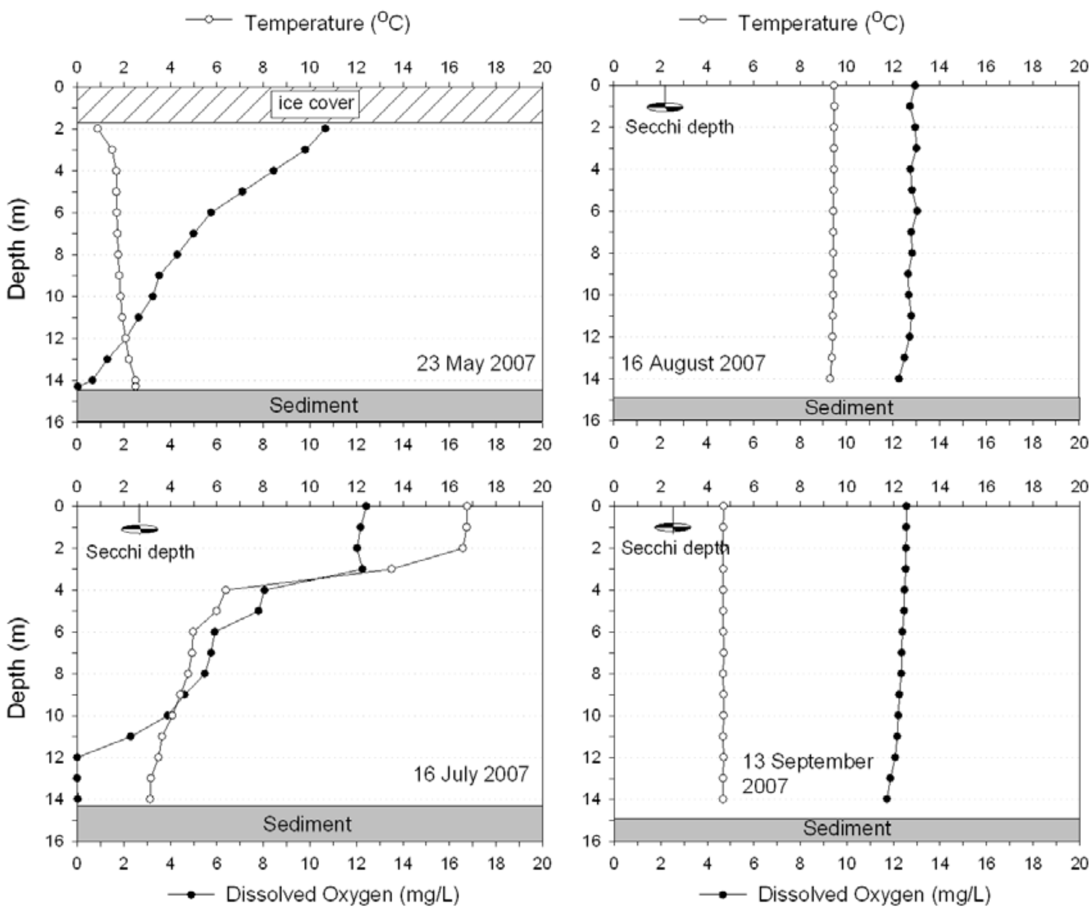

Figure 3.19 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Pelvic Lake, 2007

All of the dissolved inorganic forms of nitrogen (ammonia, nitrate, and nitrite) were well below the CWQGs (CCME 2007a) in 2006 and 2007, and generally represented < 5% of the total nitrogen concentration during open water conditions. A substantially higher proportion of dissolved inorganic nitrogen was evident during under-ice conditions, particularly in the deeper, anoxic regions of the water column, with the dissolved inorganic nitrogen representing 45 to 58% of the total nitrogen concentration (Appendix B5). The TKN ranged from 0.52 to 0.84 mg/L in 2006, and 0.49 to 1.05 mg/L in 2007.

Baseline total metal concentrations were below the applicable CWQGs (CCME 2007a) for most metals, with the exception of total aluminum, copper, iron, and selenium. The exceptions are as follows:

- Baseline total aluminum concentrations were above the 100 µg/L CWQG (for pH ≥ 6.5) in September 2006 and in open water conditions in 2007. The elevated concentrations ranged from 103 to 262 µg/L.
- Total copper concentrations were higher than the 2 µg/L CWQG during under-ice conditions in June 2006, and in the bottom samples collected in July and September 2006, and August 2007. The range of elevated concentrations was 2.3 to 3.0 µg/L (Appendix B5). The dissolved copper concentration in the August 2007 bottom sample was also above the CWQG (2.9 µg/L).
- Background total iron concentrations were above the 300 µg/L CWQG during under-ice conditions in June 2006 and May 2007 (under-ice), and in July and August 2007, with elevated concentrations ranging fron 407 to 2 760 µg/L. The highest iron concentrations were associated with low DO or anoxic conditions in the lower region of the water column, with the dissolved iron concentrations in May and July 2007 samples also higher than guideline concentrations (May: 515 µg/L; July: 1670 µg/L) (Appendix B5).
- Total selenium concentrations exceeded the 1.0 µg/L CWQG throughout 2006, with the exception of the July sampling event, and in the May and July 2007 samples. The elevated concentrations ranged from 1.1 to 2.1 µg/L (Appendix B5).

Total cyanide concentrations were measured at, or below, the MRV (0.001 mg/L) in top and bottom samples collected throughout 2006, and 2007, with the exception of the May 2007 top sample that had a concentration of 0.0002 mg/L (Appendix B5).

3.3.2.5 P.O. Lake

P.O Lake is a shallow (approximately 3 m deep) freshwater lake situated between Patch and Ogama lakes. Its background condition is characterized by soft water, with a low acid sensitivity (Saffran and Trew 1996; Weiner 2000). Sampling was limited to open water conditions in 2006 and 2007.

The pH was slightly alkaline (7.4 to 8.3) in 2006 and neutral to slightly alkaline (7.0 to 7.4) in 2007 and within the CWQG range of pH 6.5 to 9.0 (CCME 2007a).

The range of electrical conductivity values was relatively consistent in 2006 and 2007 (306 to 350 µS/cm in 2006, and 322 to 356 µS/cm in 2007). The major ions were dominated by sodium and chloride (Appendix B5).

The TSS concentrations in P.O. Lake ranged from < 1 to 4 mg/L in 2006 and 2007. The corresponding Secchi depths ranged from 2.2 to 2.5 m in 2006 (Figure 3.20) and from 1.0 to 2.0 m in 2007 (Figure 3.21). The waters were slightly coloured, ranging from < 1 to 13 TCU, with the highest value measured in September 2007 (Appendix B5).

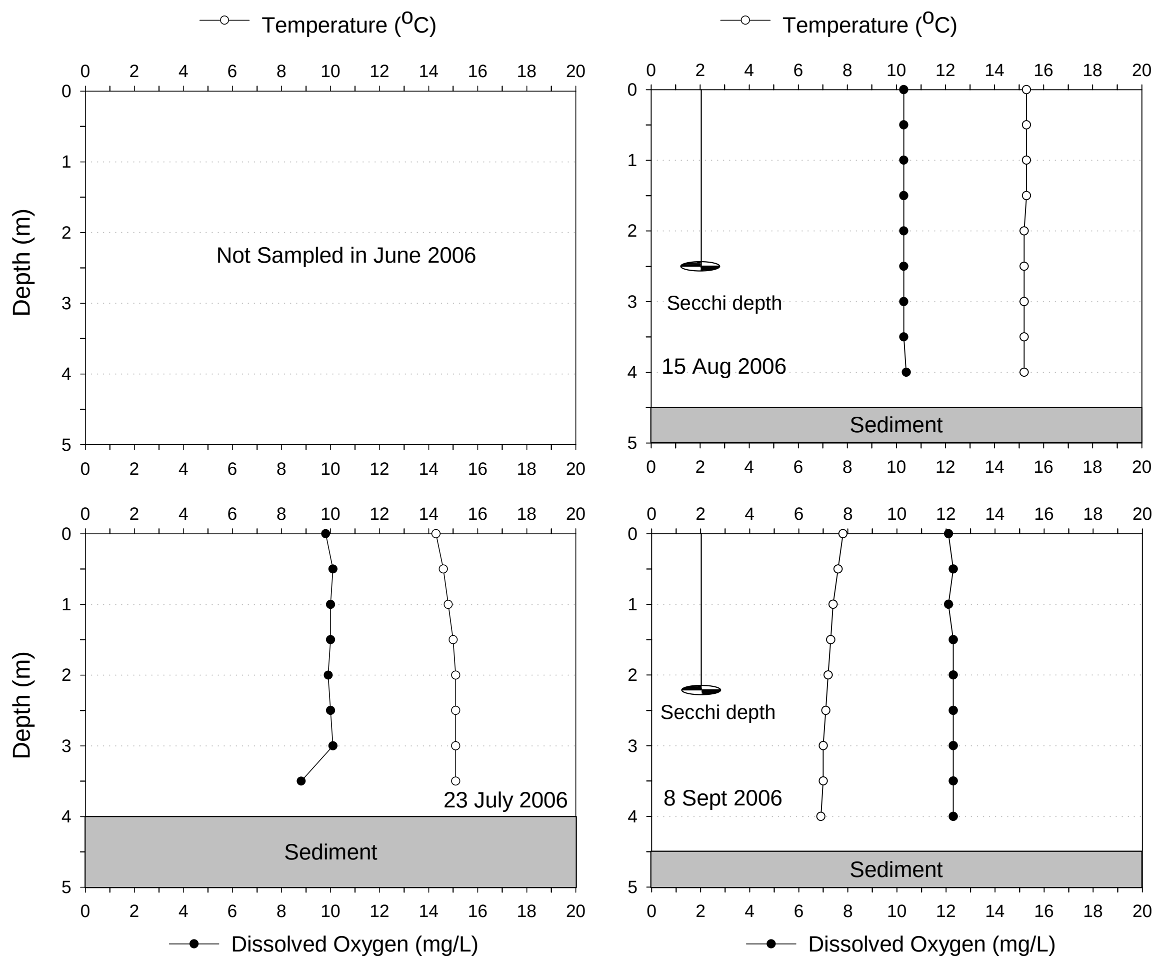

Figure 3.20 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for P.O. Lake, 2006

DO profiles in both 2006 and 2007 showed that during open water conditions P.O. Lake was well oxygenated and near uniform throughout the water column (Figures 3.20 and 3.21). DO was above the 9.5 mg/L CWQG for protection of early life stages of fish (CCME 2007a) in all but one measurement (8.8 mg/L), taken at lake bottom in July 2006 (Figure 3.20). Variation in maximum depth between sampling dates is likely due to sampling at a different location due to the error associated with using GPS devices.

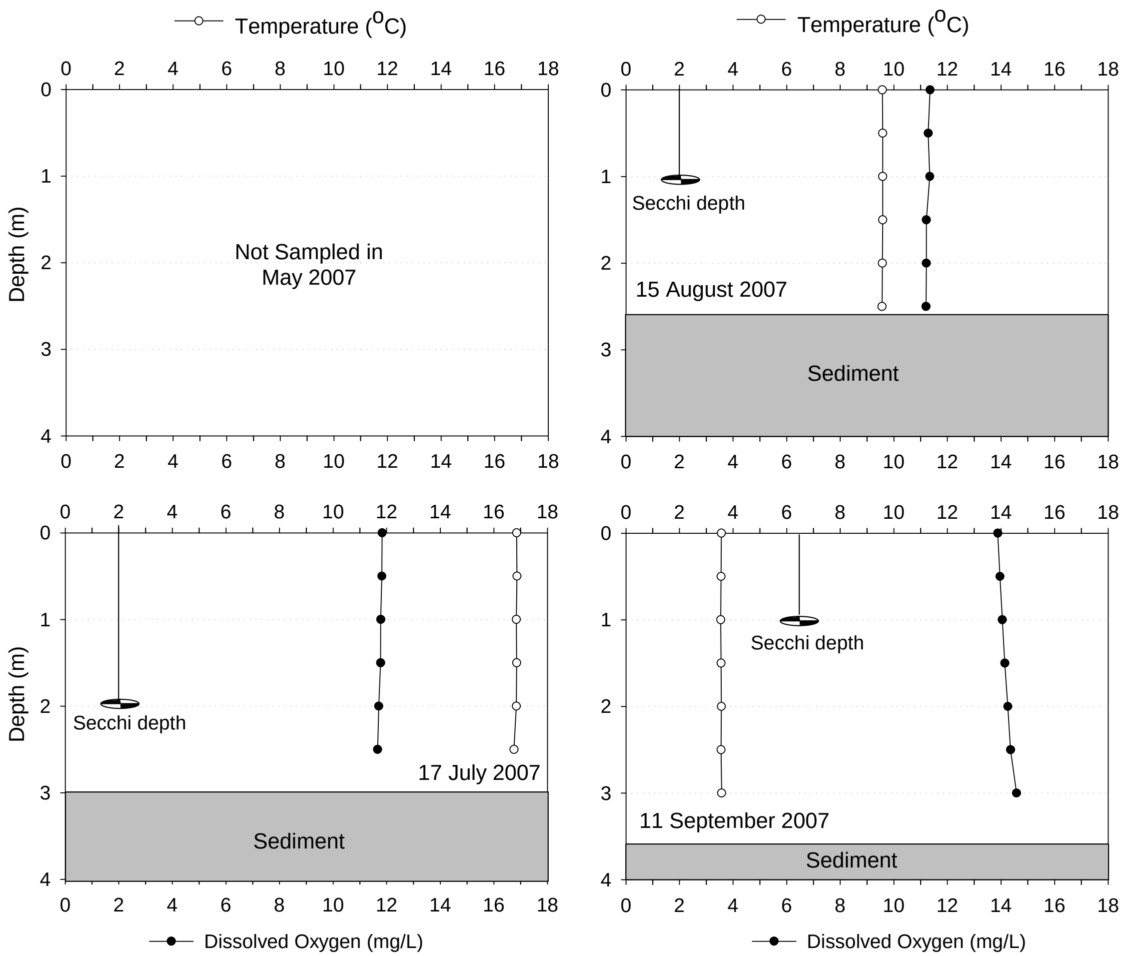

Figure 3.21 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for P.O. Lake, 2007

The water column was isothermic during all sampling events in 2006 and 2007 and showed typical seasonal trends with warmer temperatures prevalent in July and August (Figures 3.20 and 3.21).

TP concentrations in P.O. Lake ranged from 8 to 20 µg/L in 2006, and 10 to 14 µg/L in 2007. An anomalously high TP concentration was measured in September (188 µg/L), which is most likely attributed to analytical error or sample contamination. In September 2006, the Chl *a* concentration was 1.3 µg/L and in 2007, it ranged from 1.2 to 2.5 µg/L (Appendix B5). The TP concentrations indicated that P.O. Lake could be classified as mesotrophic (Appendix B1)

(CCME 2004); however, the range of Chl *a* concentrations indicated low phytoplankton productivity, which is typical of an oligotrophic status (Appendix B1) (Mitchell and Prepas 1990).

All of the dissolved inorganic forms of nitrogen (ammonia, nitrate, and nitrite) were well below the CWQGs for both years, and generally represented < 9% of the total nitrogen concentration during open water conditions. The TKN ranged from 0.19 to 0.35 mg/L in 2006, and 0.21 to 0.27 mg/L in 2007.

With the exception of baseline total aluminum, selenium, and iron, most metal concentrations were below the CWQGs (CCME 2007a). The exceptions are as follows:

- Baseline total aluminum concentrations were above the 100 µg/L CWQG (for pH ≥ 6.5) in all 2006 and 2007 samples. The concentrations ranged from 106 to 527 µg/L (Appendix B5).
- Total selenium concentrations were above the 1.0 µg/L CWQG in August 2006, September 2006, and all 2007 samples, with elevated concentrations ranging from 1.2 to 2.2 g/L (Appendix B5). Dissolved selenium concentrations in August and September 2006, and July 2007 were also above guidelines (concentrations ranging from 1.0 to 1.2 µg/L).
- The total iron concentration measured in September 2007 (314 µg/L) was above the 300 µg/L CWQG.

Total cyanide concentrations ranged from below the MRV (0.001 mg/L) to 0.002 mg/L (August) in 2006. The total cyanide concentrations in 2007 samples were below an the 0.001 mg/L MRV (Appendix B5).

3.3.2.6 Windy Lake

Windy Lake is a clear, deep (approximately 18 m deep) freshwater lake. The background condition is characterized by soft water, with a negligible sensitivity to acidification (Saffran and Trew 1996; Weiner 2000).

The field pH ranged from slightly acidic to alkaline (6.4 to 8.2) in 2006 and 2007, with most of measured pH values within the CWQG range of pH 6.5 to 9.0 (Appendix B5) (CCME 2007a). A surface and bottom pH measurement (6.4) in Augsut 2007 was slightly below the lower limit of the CWQGs.

The range of electrical conductivity measurements were consistent in 2006 and 2007, ranging from 416 to 508 µS/cm. The close proximity of Windy Lake to

Hope Bay and the marine origin of the sediments in which the lake is situated account for the higher conductivity of Windy Lake. The major ions were dominated by sodium and chloride (Appendix B5).

Windy Lake was generally very clear, with TSS concentrations ranging from < 1 to 1 mg/L in all but one sample during 2006 and 2007. The surface sample collected in September 2007 had a TSS concentration of 5 mg/L; however, the bottom sample had only 1 mg/L TSS. The high degree of clarity in Windy Lake was evident in the deep Secchi depths; the maximum Secchi depth in 2006 was 6.3 m recorded in September (Figure 3.22), and in 2007, a maximum Secchi depth of 4.9 m was recorded in July (Figure 3.23). The waters were slightly coloured ranging from <1 to 11 TCU, with the highest value measured in July 2006 (Appendix B5).

The turquoise colour feature of Windy Lake, which is unique within the lakes of the Hope Bay region, is considered due to a combination of very low suspended sediment concentrations, low dissolved organic carbon, and the backscattering of light from calcium carbonate floc (consistently higher concentrations than other Boston and Madrid Project lakes) suspended in the water.

Windy Lake was well oxygenated throughout the water column in 2006 (Figure 3.22) and 2007 (Figure 3.23). The DO profile readings were above the 9.5 mg/L CWQG for protection of early life stages of fish (CCME 2007a), with the exception of below a distinct oxycline at 14.5 m depth in June 2006, where the near-bottom concentration dropped to 3.5 mg/L at 17.5 m depth. A more gradual reduction of DO with depth was evident in May 2007 (Figure 3.23), with the oxygen concentration in the bottom region of the water column reduced to 8 mg/L. Slight DO aberrations were evident in July 2006 and 2007, with DO discontinuities below the thermocline at 12 m depth in July 2006, and a positive oxycline with depth resulting in a DO increase from 14 to 16 mg/L at 7 m depth in July 2007.

Slight thermal stratification was present in July 2006; the thermocline was at 12 to 13 m where the temperature dropped from 11.0 to 9.5°C (Figure 3.22). Windy Lake was not thermally stratified on the remaining 2006 sampling dates, or on any of the 2007 sampling dates (Figures 3.22 and 3.23). Typical seasonal trends were evident with warmer temperatures prevalent in July and August.

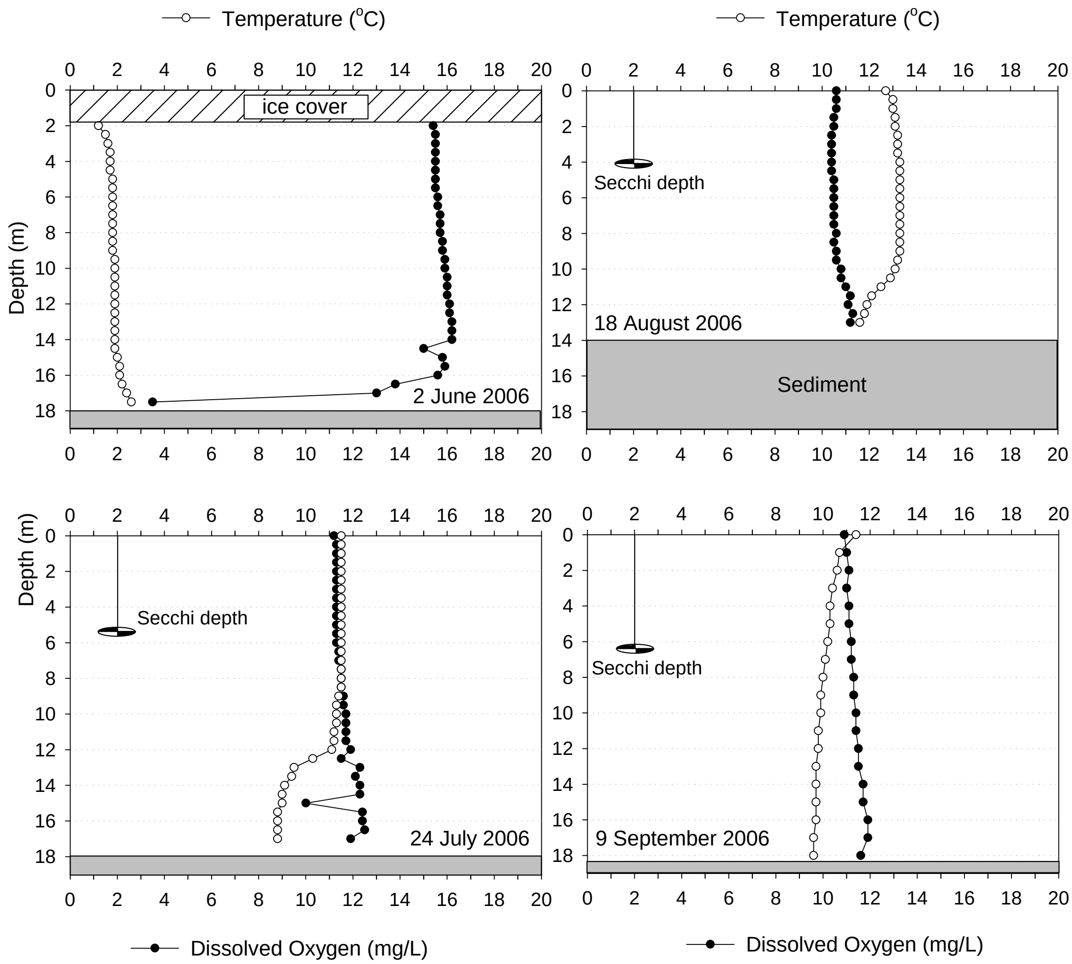

Figure 3.22 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Windy Lake, 2006

TP ranged from 6 to 22 µg/L in 2006 and from 3 to 7 µg/L in 2007, with the 2007 range of TP concentrations being the lowest compared to other lakes in the Boston and Madrid Project areas. Based on the TP concentrations, Windy Lake would be classified conservatively as a mesotrophic system in 2006, but oligotrophic in 2007 (Appendis B1) (CCME 2004). The Chl *a* concentration ranged from 0.3 to 1.1 µg/L in the 2006 to 2007 sampling program (Appendix B5). The low concentrations of Chl *a* indicated that the phytoplankton productivity was typical of an oligotrophic system (Appendix B1) (Mitchell and Prepas 1990).

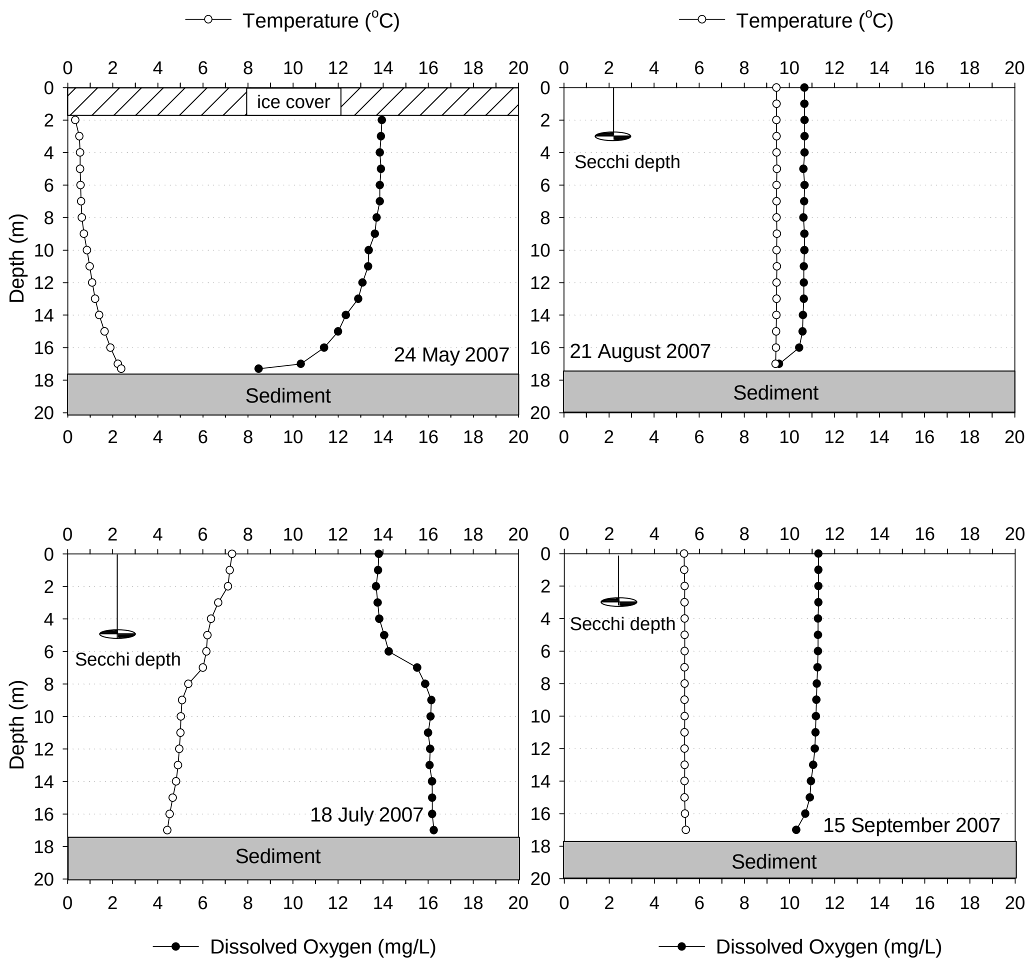

Figure 3.23 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Windy Lake, 2007

All of the dissolved inorganic forms of nitrogen (ammonia, nitrate, and nitrite) were also well below the CWQGs (CCME 2007a) in 2006 and 2007, and generally represented < 10% of the total nitrogen concentration during open water conditions, although elevated ammonia in June and July 2006 resulted in dissolved inorganic nitrogen (ammonia concentrations ranged from 0.018 to 0.025 mg/L) representing approximately 20% of the total nitrogen. The TKN ranged from 0.09 to 0.16 mg/L in 2006, and 0.07 to 0.12 mg/L in 2007, which were low compared to other lakes in the Boston and Madrid Project areas.

Most metal concentrations were below the applicable CWQGs (CCME 2007a), with the exception of baseline total aluminum and selenium. These exceptions are as follows:

- Baseline total aluminum was above the 5.0 µg/L CWQG (for pH < 6.5) in August 2007 (top: 89.7 µg/L; bottom: 93.3 µg/L) and the 100 µg/L CWQG (for pH ≥ 6.5) in September 2007 (top: 110 µg/L; bottom: 146 µg/L) (Appendix B5).
- Background total selenium concentrations were above the 1.0 µg/L CWQG in every sample collected from Windy Lake in 2006 and at least one water column sample collected in May, July, and August 2007. The elevated concentrations ranged from 1.1 to 2.3 µg/L (Appendix B5).

Total cyanide concentrations were generally measured at, or below, the MRV (0.001 mg/L) in 2006. The total cyanide concentrations in 2007 samples were reported below the MRV (0.001 mg/L), with the exception of the top sample collected in August 2007 which was measured at 0.001 mg/L (Appendix B5).

3.3.2.7 Wolverine Lake

Wolverine Lake is a shallow (approximately 4.7 m deep) freshwater lake. Its background conditon is characterized by soft water, with a low sensitivity to acidification during open water conditions, and negligible acid sensitivity under ice-covered conditions (Saffran and Trew 1996; Weiner 2000).

In 2006 and 2007, field pH in Wolverine Lake was slightly acidic to slightly alkaline, ranging from pH 6.6 to 8.3, which was within the CWQG range of pH 6.5 to 9.0 (CCME 2007a).

The electrical conductivity of Wolverine Lake ranged from 215 to 375 µS/cm in 2006, and from 340 to 378 µS/cm during the open-water season in 2007. The higher under-ice conductivity observed in 2007 (880 µS/cm) was consistent with elevated TDS concentrations resulting from salt exclusion processes, which occur during under-ice conditions. Sodium and chloride were the dominant ions in Wolverine Lake.

Wolverine Lake waters were clear, with TSS concentrations ranging from < 1 to 2 mg/L in 2006 and 2007. The greatest Secchi depth recorded for Wolverine Lake in 2006 was 3.7 m in July (Figure 3.24), and to the bottom (> 3.4 m) in September 2007 (Figure 3.25). The waters were slightly coloured (1 to 31 TCU), with the highest colour evident during under-ice conditions.

During open water conditions in 2006 and 2007, Wolverine Lake was generally well oxygenated and above the 9.5 mg/L CWQG for protection of early life stages of fish (CCME 2007a) in all but one profile measurement (Figures 3.24

and 3.25). In August 2007, the DO concentration (6.6 mg/L) near the bottom of the lake was below the 9.5 mg/L CWQG for protection of early life stages of fish. During under-ice conditions, DO conditions within the water column were varied, with well oxygenated conditions in May 2006 (11.3 to 14.4 mg/L), but hypoxic DO conditions evident in the 1 m of free water beneath the ice in May 2007 (1.4 to 1.5 mg/L) (Figure 3.25).

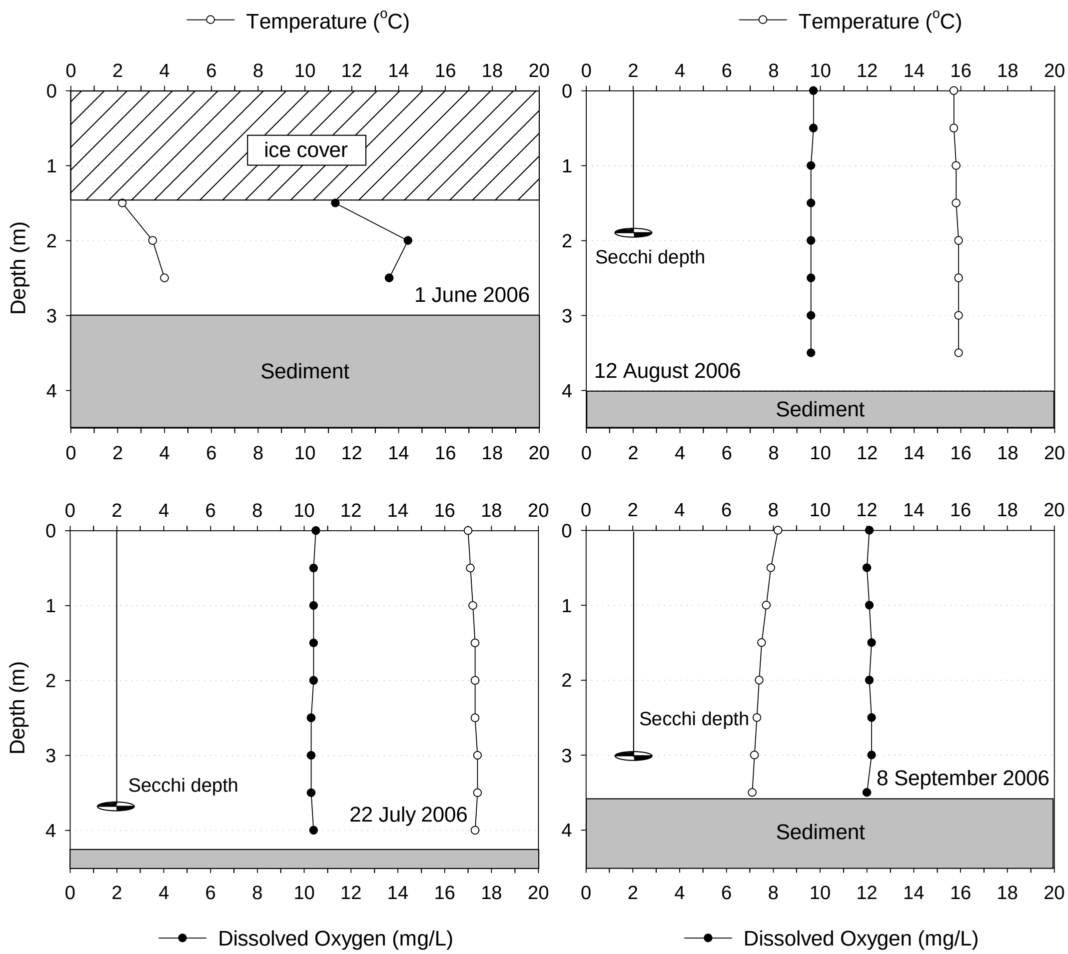

Figure 3.24 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Wolverine Lake, 2006

Wolverine Lake did not thermally stratify in 2006 or 2007, and showed typical seasonal temperature trends (Figures 3.24 and 3.25).

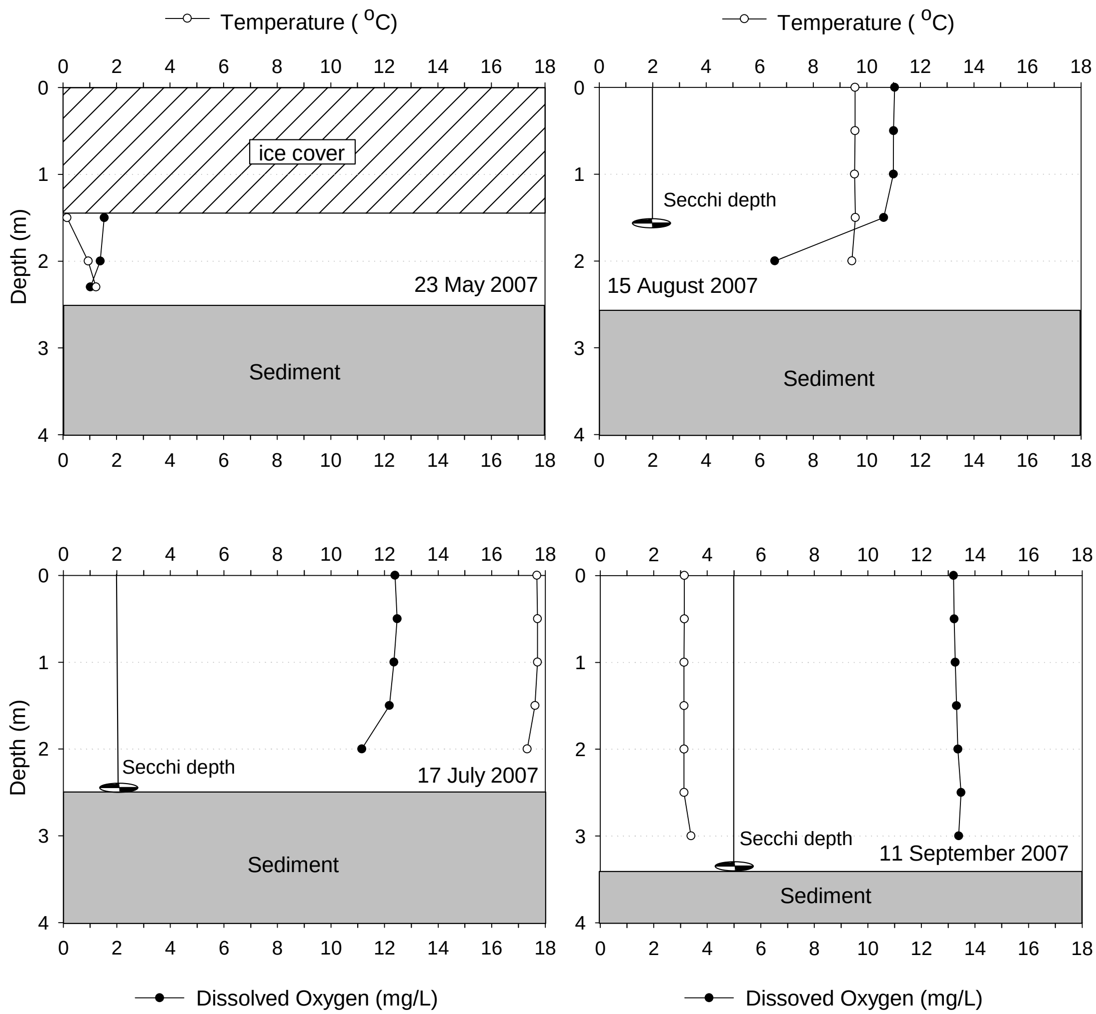

Figure 3.25 Secchi Depths, Temperature, and Dissolved Oxygen Profiles for Wolverine Lake, 2007

TP concentrations generally ranged from 11 to 27 µg/L in 2006 and 2007, with the exception of an elevated TP concentration measured in the May 2007 under-ice sample (48 µg/L). The Chl *a* concentration was 4.5 µg/L in September 2006, and ranged from 1.5 to 1.8 µg/L in 2007. The typical TP concentrations indicated that Wolverine Lake would be classified with a mesotrophic to meso-eutrophic status (Appendix B1) (CCME 2004); however, the Chl *a* concentrations indicated an oligotrophic status (Appendix B1) (Mitchell and Prepas 1990).

All of the dissolved inorganic forms of nitrogen (ammonia, nitrate, and nitrite) were also well below the CWQGs (CCME 2007a) in 2006 and 2007, and generally represented < 5% of the total nitrogen concentration, although elevated nitrate (0.19 mg/L) in May 2007, during hypoxic under-ice conditions resulted in dissolved inorganic nitrogen representing approximately 20% of the total nitrogen. The TKN concentrations ranged from 0.35 to 0.40 mg/L in 2006, and 0.31 to 0.82 mg/L in 2007, which were low compared to most other lakes in the Boston and Madrid Project areas.

Most of the baseline metal concentrations were below the applicable CWQGs (CCME 2007a), with the exception of total aluminum, cadmium and selenium. These exceptions are as follows:

- The total aluminum concentration measured in August 2007 (168 µg/L) was above the 100 µg/L CWQG (for pH > 6.5).
- The total cadmium concentration measured in June 2006 (0.016 µg/L) was above the 0.014 µg/L CWQG (adjusted for hardness).
- Baseline total selenium concentrations were higher than or at the 1.0 µg/L CWQG in all samples, with the exception of the June 2006 under-ice sample. The elevated total selenium concentrations ranged from 1.0 to 4.4 µg/L (Appendix B5). The dissolved selenium concentrations in July 2006, and May and July 2007 were also at or above the guideline concentrations (ranging from 1.0 to 3.1 µg/L).

Total cyanide concentrations ranged from below the MRV (0.001 mg/L) to 0.002 mg/L (August) in 2006. The total cyanide concentrations in 2007 samples were reported below the MRV (0.001 mg/L), with the exception of the May 2007 under-ice sample (0.002 mg/L) (Appendix B5).

3.3.2.8 Madrid Project Area Lakes Summary

Background conditions within the Madrid Project area characterized lakes as having fresh, soft water, with low to negligible sensitivity to acidification. Shallow lakes, such as Ogama and Wolverine, showed elevated TDS concentrations, and associated hardness and alkalinity during under-ice conditions, which reduced the sensitivity of these lakes to acidification. Glenn and Windy lakes had a negligible sensitivity to acidification due to generally higher TDS concentrations throughout the monitoring period.

The pH values indicated near neutral to slightly alkaline waters during under-ice and open water conditions. The field pH was measured below the CWQG range on one occasion in the Madrid Project area (Windy Lake: pH 6.4 in August 2007) (CCME 2007a).

The range of conductivity values in the Madrid Project lakes was 153 to 701 µS/cm in 2006 and 2007 (Appendix B5). The proximity of the Madrid Project area to the marine environment and the marine origin of sediments compared to the Boston

Project area would account for the higher conductivity of the Madrid Project area lakes. The major ions were dominated by sodium and chloride.

All lakes were generally clear, with TSS between < 1 and 7 mg/L in 2006 and between < 1 and 11 mg/L in 2007 (Appendix B5). Glenn, Patch, P.O., Windy, and Wolverine lakes had maximum TSS concentrations below 5 mg/L and Secchi depths ranged up to a maximum of 6.3 m. Pelvic Lake was the least transparent lake with TSS concentrations up to 11 mg/L and correspondingly low Secchi depths (1 m or less). The waters were slightly to moderately coloured (< 1 to 58 TCU), with elevated colour associated with a variety of seasonal conditions: during under-ice (e.g., Ogama Lake), snow melt (e.g., Pelvic Lake) and late summer conditions (e.g., Glenn Lake). The least coloured lakes (< 1 to 13 TCU) were Patch, P.O., and Windy lakes.

The water column of all lakes were generally well oxygenated throughout open water conditions, with DO reductions in the deeper water column associated with thermocline development in several lakes in July 2007 (e.g., Glenn, Ogama, Patch, Pelvic, and Windy lakes). During these conditions, and during ice-covered conditions in the shallow lakes, DO concentrations were below the lower CWQG of 6.5 mg/L (CCME 2007a).

Thermal stratification was evident in several lakes during the open water season, particularly in July 2007 (i.e., the shallow Glenn[1], Patch, Ogama and Pelvic lakes, and the deeper Windy Lake). Normal seasonal temperature trends were observed in most lakes, with warmer water column temperatures in late July and August.

With reference to the range of annual TP concentrations in 2006 and 2007, the trophic classification of the Madrid Project area lakes ranged from oligo-mesotrophic (i.e., Glenn, Patch, and Windy lakes) to eutrophic (i.e., Ogama and Pelvic lakes). Based on the range of Chl *a* concentrations, the phytoplankton production based on the Organisation for Economic Co-operation and Development (OECD) productivity classification (Appendix B1) was typical of oligotrophic systems in all but Glenn and Pelvic lakes, which were typical of oligo-mesotrophic and mesotrophic systems, respectively.

Most of the baseline metal concentrations were below applicable CWQGs (CCME 2007a); however, total aluminum, cadmium, chromium, copper, iron, mercury, and selenium were measured above the CWQGs in one or more

[1] Note that although Glenn Lake is considered a deep lake, this sampling event was conducted in a water depth of approximately 18 m. The sharp relief in the lake bottom around this sampling station resulted in a large variance in water depth throughout the 2007 sampling period.

samples in 2006 and 2007 (Tables 3.11 to 3.13). For most metals, the proportion of the dissolved fraction was moderate to high, accounting for 50 to 100% of the total concentrations in the lakes. Cyanide was typically below the MRV, though all but P.O. Lake had at least one sample measured at or slightly above the MRV.

Table 3.11 Summary of Glenn and Ogama Lake Water Samples that Were Above Guidelines for the Protection of Aquatic Life in Freshwater, 2006 – 2007

Station	Strata	Date	TSS	Field pH	Al (Total)	Cr (Total)	Cu (Total)	Iron (Total)	Se (Total)
				CWQG 6.5-9.0	CWQG 100 µg/L for pH≥6.5	CWQG 1.0 µg/L	CWQG 2.0 µg/L	CWQG 300 µg/L	CWQG 1.0 µg/L
Glenn Lake	Top*	24-May-07	2	7.4			***3***		***1.7***
	Bottom*	24-May-07	<1	7.4			***2.9***		***2***
	Top	16-Jul-07	2	7.3	***112***		***2.2***		***1.1***
	Bottom	16-Jul-07	<1	7.3	***125***		***2.8***		***1.9***
	Top	17-Aug-07	3	7.2	***457***		***3.1***	***327***	***1.1***
	Bottom	17-Aug-07	3	7.2	***458***		***2.8***	***325***	***1.2***
	Top	15-Sep-07	4	-	***650***	***1.1***	***3.8***	***436***	
	Bottom	15-Sep-07	2	-	***593***		***3.7***	***391***	
Ogama Lake	Top*	1-Jun-06	3	6.5	***495***		***2.2***	***728***	***1.7***
	Bottom*	1-Jun-06	4	**6.5**	***120***		***3***	***823***	***3.6***
	Top	21-Jul-06	3	7.3	***186***				
	Bottom	21-Jul-06	5	**7.3**	***263***				
	Top	15-Aug-06	4	8.3	***117***				***1.9***
	Bottom	15-Aug-06	3	**8.3**	***139***				***1.7***
	Top	8-Sep-06	4	8	***172***				***1.4***
	Bottom	8-Sep-06	4	**8**	***184***				***1.4***
	Top*	22-May-07	1	7.1			***2.5***		***3.1***
	Top	16-Jul-07	3	7	***200***			***319***	
	Top	16-Aug-07	7	7.1	***336***				
	Bottom	16-Aug-07	7	7	***375***		***2.2***	***320***	
	Top	11-Sep-07	5	7.1	***306***				
	Bottom	11-Sep-07	5	7.1	***305***		***2.6***		

Total suspended solids (TSS) and field pH values are provided to help in interpretation of the values exceeding guidelines.
Values exceeding guidelines are ***italicized and bold***.
[*] Samples collected under ice.

Prepared by: EJJ Checked by: JM

Table 3.12 Summary of Patch and Pelvic Lake Water Samples that Were Above Guidelines for the Protection of Aquatic Life in Freshwater, 2006 – 2007

Station	Strata	Date	TSS	Field pH	Al (Total)	Cu (Total)	Iron (Total)	Hg (Total)	Se (Total)
				CWQG 6.5-9.0	CWQG 100 µg/L for pH≥6.5	CWQG 2.0 µg/L	CWQG 300 µg/L	CWQG 26 ng/L	CWQG 1.0 µg/L
Patch Lake	Bottom*	2-Jun-06	<1	6.8		***2.2***			***1.8***
	Top	23-Jul-06	2	7.0	***138***				
	Top	15-Aug-06	1	-				***44***	***1.6***
	Bottom	16-Aug-06	<1	-					***1.8***
	Top	8-Sep-06	<1	8.1					***1.3***
	Bottom	8-Sep-06	<1	8.1					***1.8***
	Top*	23-May-07	<1	7.4					***1.9***
	Bottom*	23-May-07	<1	7.4					***2.1***
	Top	17-Jul-07	<1	7.1					***1.4***
	Bottom	17-Jul-07	<1	7.1					***1.6***
	Top	15-Aug-07	3	7.0	***306***	***2.2***			***1.2***
	Bottom	15-Aug-07	4	7.0	***351***	***3.8***			***1.3***
	Top	11-Sep-07	3	-	***195***				
	Bottom	11-Sep-07	2	-	***179***				
Pelvic Lake	Top*	1-Jun-06	3	6.5		***2.7***			***1.5***
	Bottom*	1-Jun-06	1	6.5			***407***		***2.0***
	Top	21-Jul-06	5	8.6					
	Bottom	21-Jul-06	4	8.6		***2.4***			
	Top	16-Aug-06	7	8.2					***1.5***
	Bottom	16-Aug-06	7	8.2					***1.5***
	Top	9-Sep-06	7	8.2	***103***				***1.9***
	Bottom	9-Sep-06	7	6.8	***133***	***2.3***			***1.6***
	Top*	23-May-07	11	7.7					***2.1***
	Bottom*	23-May-07	5	7.7			***1100***		***1.9***
	Top	16-Jul-07	2	6.9	***186***				***1.1***
	Bottom	16-Jul-07	9	6.9	***111***		***2760***		***1.1***
	Top	16-Aug-07	6	6.7	***201***				
	Bottom	16-Aug-07	6	6.7	***178***	***3.0***	***429***		
	Top	13-Sep-07	8	-	***258***				
	Bottom	13-Sep-07	7	-	***262***				

Total suspended solids (TSS) and field pH values are provided to help in interpretation of the values exceeding guidelines.
Values exceeding guidelines are ***italicized and bold***.
* Samples collected under ice.

Prepared by: EJJ Checked by: JM

Table 3.13 Summary of P.O., Windy, and Wolverine Lake Water Samples that Were Above Guidelines for the Protection of Aquatic Life in Freshwater, 2006 – 2007

Station	Strata	Date	TSS	Field pH	Al (Total)		Cd (Total)	Iron (Total)	Se (Total)
				CWQG 6.5-9.0	CWQG 100 µg/L for pH≥6.5	CWQG 5.0 µg/L for pH<6.5	CWQG 0.014[d] µg/L	CWQG 300 µg/L	CWQG 1.0 µg/L
P.O. Lake	Top	23-Jul-06	<1	7.4	***106***				
	Top	15-Aug-06	1	8.3	***115***				***1.5***
	Top	8-Sep-06	<1	8.3	***176***				***2.2***
	Top	17-Jul-07	<1	7.4	***121***				***1.3***
	Top	15-Aug-07	3	7.0	***369***				***1.3***
	Top	11-Sep-07	4	7.1	***527***			***314***	***1.2***
Windy Lake	Top*	2-Jun-06	<1	6.7					***1.7***
	Bottom*	2-Jun-06	<1						***1.6***
	Top	24-Jul-06	1	6.9					***1.1***
	Bottom	24-Jul-06	<1						***1.3***
	Top	18-Aug-06	1	8.2					***1.5***
	Bottom	18-Aug-06	<1						***1.7***
	Top	9-Sep-06	<1	8.1					***2.1***
	Bottom	9-Sep-06	<1						***2.3***
	Top	20-Aug-07	1	***6.4***		***89.7***			***1.1***
	Bottom	20-Aug-07	1	***6.4***		***93.3***			***1.1***
	Bottom	15-Sep-07	1		***146***				
	Top	15-Sep-07	5		***110***				
Wolverine Lake	Bottom*	1-Jun-06	1	6.6			***0.015***		
	Top	22-Jul-06	2	8.1					***1.1***
	Bottom	22-Jul-06	2						***1.3***
	Top	12-Aug-06	<1	7.7					***1.5***
	Top	8-Sep-06	<1	8.3					***1.4***
	Top	23-May-07	2	7.3					***4.4***
	Top	17-Jul-07	<1	7.8					***1.3***
	Top	15-Aug-07	2	6.8	***168***				***1.1***
	Top	11-Sep-07	<1						

Total suspended solids (TSS) and field pH values are provided to help in interpretation of the values exceeding guidelines.

Values exceeding guidelines are ***italicized and bold.***

* Samples collected under ice.

Prepared by: EJJ Checked by: JM

3.4 RESULTS AND DISCUSSION: STREAMS AND RIVERS

The following section provides a discussion of the water quality results in streams within the Boston and Madrid Project areas. Detailed discussions for each stream are provided under respective stream headings and focus on general water quality characteristics, and water quality parameters that have specific guidelines or assessment criteria (e.g., TSS, pH, DO, TP, dissolved inorganic nitrogen [ammonia, nitrate, and nitrite], and trace metals).

All field spot measurements of pH, conductivity, DO, and water temperature are provided in Appendix B3. Laboratory results of water quality analyses for the sampling programs are presented in Appendices B5.

3.4.1 Boston Project Area

3.4.1.1 Aimaokatalok Inflow

Aimaokatalok Inflow is a coloured (15 to 52 TCU), freshwater stream, characterized by naturally soft water with low alkalinity and low conductivity. This stream enters Aimaokatalok Lake from the east.

Field pH was near neutral (7.1 to 7.4) in 2006, but was slightly acidic (6.1 to 6.5) in 2007, which fell below the CWQG range of pH 6.5 to 9.0 in early July (pH 6.3) and September (pH 6.1) (CCME 2007a).

The electrical conductivity was similar in both years, ranging from 64 to 109 µS/cm. Sodium and chloride were the dominant major ions in 2006 (Appendix B5); chloride data were not available for 2007, but similar concentrations of the other ions indicated that chloride concentrations in 2007 would have been consistent with those measured in 2006.

Baseline TSS concentrations in Aimaokatalok Inflow in 2006 and 2007 typically were low (2 to 4 mg/L); however, the exception of an elevated TSS concentration measured in June 2007 (23 mg/L) was likely associated with ice-melt conditions and elevated watershed runoff.

Aimaokatalok Inflow was well oxygenated throughout both sampling seasons during open water conditions, with all DO measurements above the 9.5 mg/L CWQG for protection of early life stages of fish (Appendix B3) (CCME 2007a). Logged temperature data showed typical seasonal trends, with warmest temperatures in mid-July and early August, and the coolest temperatures at the time of logger removal in early September (Figure 3.26).

TP concentrations in Aimaokatalok Inflow ranged from 19 to 60 µg/L in 2006 and from 27 to 40 µg/L in 2007. The TP concentrations in the inflow were high compared to Aimaokatalok Lake, where the maximum concentration was 29 µg/L (Appendix B5). Based on these baseline total phosphorus concentrations, the stream would be classified as mesotrophic to eutrophic (Appendix B1) (CCME 2004).

All of the dissolved inorganic forms of nitrogen (ammonia, nitrite and nitrate) were well below the CWQGs (CCME 2007a) in both 2006 and 2007, and represented