Survey Data for Selected North Slope Lakes and Reservoirs from the Kuparuk River to Bullen Point: 2009

Greta Myerchin and Celine van Breukelen conducting a snow survey, photo by Robert Christensen.

by

Kristie Hilton, Greta Myerchin, Celine van Breukelen, William Schnabel, and Michael Lilly

January 2010

Kuparuk Foothills and Sagavanirktok River/Bullen Point Hydrology Projects

Report No. INE/WERC 09.05

Water and Environmental Research Center

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Kristie Hilton[1], Greta Myerchin[2], Celine van Breukelen[2], William Schnabel[2], Michael Lilly[1]

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DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the accuracy of the data presented herein. This research was funded by the Alaska Department of Transportation and Public Facilities (AKDOT&PF) and the Alaska Department of Natural Resources (ADNR). The contents of the report do not necessarily reflect the views of policies of the AKDOT&PF, ADNR or any local sponsor. This work does not constitute a standard, specification, or regulation.

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CONVERSION FACTORS, UNITS, WATER QUALITY UNITS, VERTICAL AND HORIZONTAL DATUM, ABBREVIATIONS AND SYMBOLS

Conversion Factors

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (mm)
mile (mi)	1.609	kilometer (km)
	Area	
Acre	43559.826	square feet (ft^2)
Acre	0.407	hectare (ha)
square foot (ft^2)	2.590	square mile (mi^2)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
gallon (gal)	3785	milliliter (mL)
cubic foot (ft^3)	23.317	liter (L)
Acre-ft	1233	cubic meter (m^3)
	Velocity and Discharge	
foot per day (ft/d)	0.3048	meter per day (m/d)
Square foot per day (ft^2/d)	.0929	square meter per day (m^2/d)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/sec)
	Hydraulic Conductivity	
foot per day (ft/d)	0.3048	meter per day (m/d)
foot per day (ft/d)	0.00035	centimeter per second (cm/sec)
meter per day (m/d)	0.00115	centimeter per second (cm/sec)
	Hydraulic Gradient	
foot per foot (ft/ft)	5280	foot per mile (ft/mi)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
	Pressure	
pound per square inch (lb/in^2)	6.895	kilopascal (kPa)

Units

For the purposes of this report, both English and Metric (SI) units were employed. The choice of "primary" units employed depended on common reporting standards for a particular property or parameter measured. Whenever possible, the approximate value in the "secondary" units was also provided in parentheses. Thus, for instance, stream flow was reported in cubic feet per second (cfs) followed by the value in cubic meters per second (m^3/s) in parentheses.

Physical and Chemical Water-Quality Units:

Temperature:

Water and air temperature is given in degrees Celsius (°C) and in degrees Fahrenheit (°F). Degrees Celsius can be converted to degrees Fahrenheit by use of the following equation:

°F = 1.8(°C) + 32

Electrical Conductance (Actual Conductivity and Specific Conductance):

In this report conductivity of water is expressed as Actual Conductivity [AC] in microSiemens per centimeter (µS/cm). This unit is equivalent to micromhos per centimeter. Elsewhere, conductivity is commonly expressed as Specific Conductance at 25°C [SC25] in µS/cm which is temperature corrected. To convert AC to SC25 the following equation can be used:

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$$SC25 = \frac{AC}{1 + r(T - 25)}$$

where:

SC25 = Specific Conductance at 25^{o}C, in µS/cm

AC = Actual Conductivity, in µS/cm

r = temperature correction coefficient for the sample, in ^{o}C

T = temperature of the sample, in ^{o}C

Milligrams per liter (mg/L) or micrograms per liter (µg/L):

Milligrams per liter is a unit of measurement indicating the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is the same as for concentrations in parts per million (ppm).

Vertical Datum:

"Sea level" in the following report refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929), a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called *Sea Level Datum of 1929*.

Horizontal Datum:

The horizontal datum for all locations in this report is the North American Datum of 1983 or World Geodetic System of 1984.

Abbreviations, Acronyms, and Symbols

AC	Actual conductivity
ADOT&PF	Alaska Department of Transportation and Public Facilities
ASTM	American Society for Testing and Materials
atm	Atmospheres
C	Celsius
DO	Dissolved oxygen
DVM	Digital voltage multi-meter
F	Fahrenheit (^{o}F).
ft	Feet
GWS	Geo-Watersheds Scientific
GWSI	USGS Ground-Water Site Inventory
km^2	Square kilometers
kPa	Kilopascal
lb/in^2	Pounds per square inch
m	Meters
mg/L	Milligrams per liter
µg/L	Micrograms per liter
mi^2	Square miles
mm	Millimeters
µS/cm	Microsiemens per centimeter
mV	Millivolt
NGVD	National Geodetic Vertical Datum
NWIS	National Water Information System
ppm	Parts per million
QA	Quality assurance
QC	Quality control
SAR	Synthetic aperture radar
SC25	Specific conductance at 25^{o}C
UAF	University of Alaska Fairbanks
USACE	U.S. Army Corps of Engineers, Alaska District
USGS	U.S. Geological Survey
WERC	Water and Environmental Research Center
WWW	World Wide Web
YSI	Yellow Springs Instruments

ABSTRACT

Water resources are limited in many areas of the North Slope, Alaska, particularly during mid-winter operations. Water is used for ice road construction and maintenance, drilling and facility operations, and potable water supplies. Identifying potential water sources for this region will help both industry and resource-management agencies.

Sampling conducted in the spring and summer of 2009 served as part of ongoing studies of watershed hydrology and lakes in the combined study areas for the Sagavanirktok River/Bullen Point, Kuparuk Foothills, and Umiat Corridor Hydrology projects. Field chemistry measurements, lake depth, ice thickness, and snow measurements were collected at each of the sites visited during spring ice cover conditions. Ten lakes anticipated to remain unfrozen at the bottom throughout the winter were pre-selected for field sampling. Four of these sites were former gravel pits, and six were natural lakes. Chemical profiles of the gravel pits demonstrated the potential of gravel pits and deeper lakes to provide significant water resources as well as over-wintering fish habitat. The natural lakes sampled were very shallow or frozen throughout the depth profile at the time of sampling, indicating that they would not likely serve as adequate late-winter water resources or fish habitat. Additional ice thickness and snow depth measurements on lakes were also collected to help with regional hydrologic analysis. Additional field work in July 2009 mapped bathymetry of three of the selected lake sites along the Dalton Highway for the purpose of ground truthing the synthetic aperture radar (SAR) data. Data from this project will also be used for analysis in the Arctic Transportation Networks project, sponsored by the US Department of Energy.

ACKNOWLEDGEMENTS

The data presented in this report was funded by grant ADN #2562122, Alaska Department of Transportation and Public Facilities, and by grant ADN #1099000, Department of Natural Resources, providing background data for lakes in the combined study areas. We also thank Northern Region ADOT&PF staff who provided information for water sources along the Dalton Highway.

Survey Data for Selected North Slope Lakes and Reservoirs from the Kuparuk River to Bullen Point: 2009

INTRODUCTION

Water resources are essential for construction and maintenance of gravel roads, and ice road / pad construction on the North Slope of Alaska. Yet many natural lakes are too shallow to provide significant freshwater resources throughout the winter operations period. Reservoirs, usually resulting from the construction of gravel mine sites, have historically been used as long-term water sources when adequate recharge exists. The Coastal Plain and Foothills regions between the Kuparuk River and Bullen Point, west of the Canning River, have hosted numerous oil and gas exploration activities over the past 25 years. Future development in many of these areas will require a network of natural lakes, or reservoirs, to provide adequate water supplies. In planning transportation networks, an opportunity for concurrent gravel resources and long-term water resource development exists. Physical and chemical measurements illustrate many natural lakes are insufficient for use as winter water resources or overwintering fish habitat. The larger rivers in the area (Kuparuk, Sagavanirktok, Kadleroshilik, Shaviovik, and Kavik Rivers) have low winter baseflows and are not generally considered potential sources for obtaining water during winter months.

Three coordinated projects are studying the watershed hydrology and water resources in the central North Slope region: Sagavanirktok River/Bullen Point, Kuparuk Foothills, and Umiat Corridor Hydrology projects. The 2009 activities described in this report were funded by the Sagavanirktok/Bullen Point and Kuparuk Foothills projects, however the information provided may be useful for all of the projects. Lakes and reservoirs selected for sampling in 2009 fell between the Kuparuk River and Bullen Point, east of the Canning River (Figure 1). Some of these sites were located in the Foothills region near the Kuparuk and Sagavanirktok Rivers (Figure 2), while others were located within a few miles of the Arctic coast (Figure 3).

OBJECTIVES

The objective of this report is to provide lake and reservoir data collected in the early spring and summer of 2009. At the time of water chemistry sampling, spring snowmelt had not yet started and lake ice conditions were near a winter maximum. Bathymetric mapping took place in July, shortly after all the ice had melted. These data are intended to help resource developers and management agencies evaluate potential water resources in the region, and to help identify areas where water resources may be scarce.

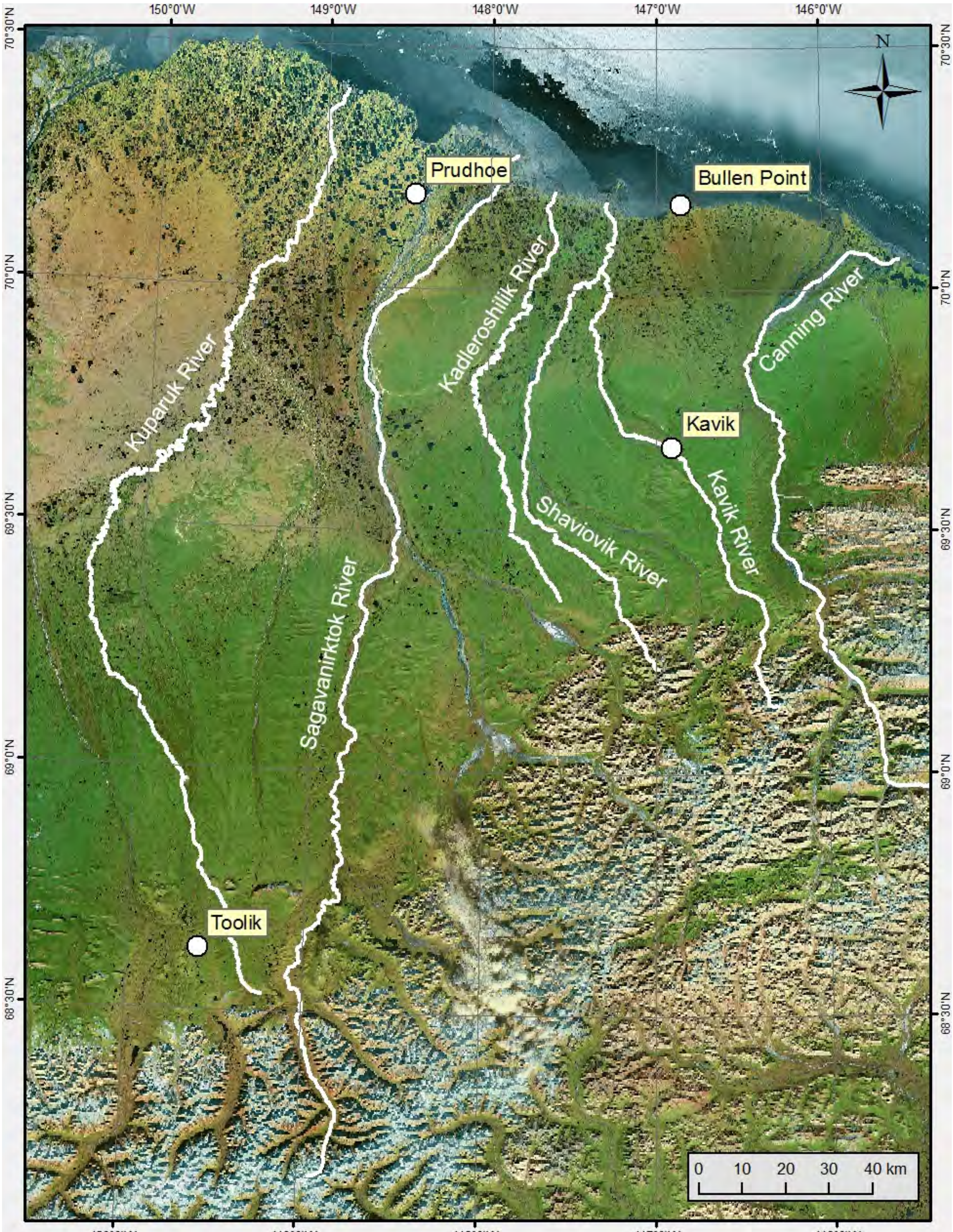

Figure 1. Map of the combined project study areas.

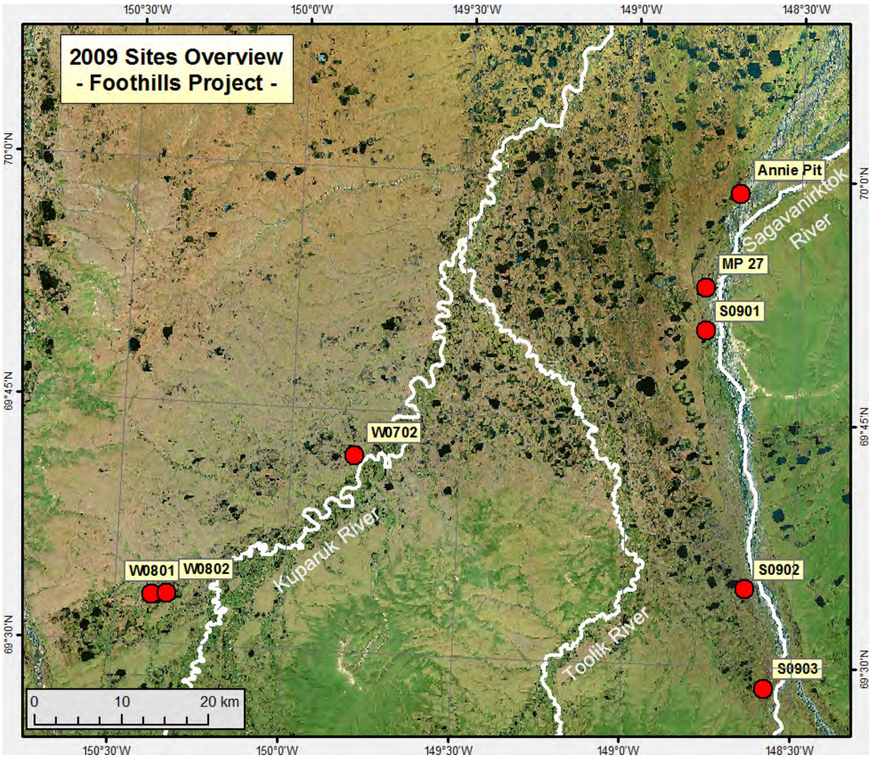

Figure 2. Study area and lake location map for the Sagavanirktok River/Kuparuk Foothills Region, North Slope.

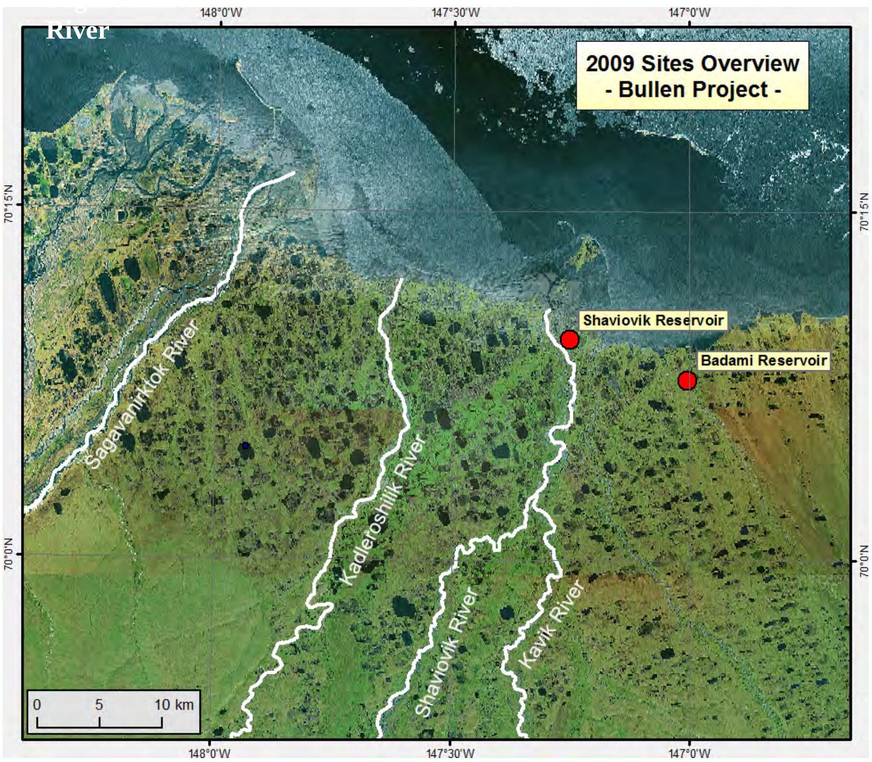

Figure 3. Study area and lake location map for Bullen Region, North Slope, Alaska.

PROCEDURES

Water Chemistry

Spring water chemistry measurements were conducted under lake and reservoir ice. A hole was drilled through the ice with a 2-inch diameter ice auger powered by a cordless drill. Physical measurements of depth (lake bottom to water surface), freeboard (water surface to top of ice), ice thickness (bottom of ice to top of ice), and snow depth (top of ice to top of snow, measured at the hole where snow was cleared to drill) were taken with a weighted flexible measuring tape and folding rule. The precision with which physical measurements are reported takes into account field conditions

Figure 4. Greta Myerchin and Celine van Breukelen drill a hole in the ice at Lake S0901 for physical and water-quality measurements, photo by Robert Christensen.

Temperature, pH, dissolved oxygen (DO), and electrical conductivity were measured with either a Yellow Springs Instruments (YSI) 556 multi-parameter meter, a YSI ProODO (Optical Dissolved Oxygen) meter, or a Hach LDO (Luminescent Dissolved Oxygen) meter. The calibration of each parameter was checked before and after each day of sampling, or as field conditions allowed. To pass the calibration check, parameters had to be within 10% of the calibration standard value. All parameters passed each pre- and post-calibration check, with the exception of a few conductivity measurements. Data tables for the calibration checks are available in Appendix A.

Bathymetry

Bathymetric surveys were conducted at three road-accessible lakes during Summer 2009 for the purpose of ground truthing depth predictions derived from satellite data. The survey results are considered to be approximate, and are not intended for regulatory use. Individual data points were collected from a canoe using a leadline. At each of the data points, the depth and position were saved into a Trimble GeoExolorer III DGPS. The path of the canoe was tracked in a separate GPS and was guided by a member of the team on shore to help ensure spatial distribution of measurements. To mark the perimeter, the GPS was set to automatically save its position every five seconds. The perimeter of the lake was marked by walking the shoreline and logging the position every five seconds.

The data were downloaded from the GPS using Trimble's PathFinder Office Version 3.10. The rover files were exported from PathFinder Office to shape files. The shape files were used to interpolate the bathymetric surface using the Geoastatistical Analyst package in the ArcMap from ESRI. All surface interpolation and statistical analysis of the data was performed using UTM Z6 WGS 84 coordinates. Maps of the bathymetric surface were generated using ordinary kriging. Surface statistics and contours were computed from the kriged surfaces.

RESULTS

Water Chemistry

Six lakes and four reservoirs were pre-selected for potential sampling. Three lakes, S0901, S0903 and MP29 contained little or no under-ice water at sample locations, therefore water-quality parameters were not obtained from these lakes. Physical and chemical measurements were collected for the remaining sites and are included in this report. Some conductivity measurements did not pass post-calibration standards and the results are not included in this report, see Appendix A for calibration information.

As illustrated in Table 1, the six natural lakes sampled were found to be relatively shallow or frozen to the bottom, while three of the man-made gravel pits, which now serve as reservoirs, were deep relative to other lakes in the area. One reservoir was sampled near the shoreline in shallow water, where the ice was frozen to the reservoir bottom, and no data was collected. Ice thicknesses were generally around 4 ft deep at the natural lakes and over 6 ft deep at the reservoirs. Three of the reservoirs were between 17 and 32 ft deep.

Table 1. Select sample locations and physical measurements.

Location	North Latitude (WGS84)	West Longitude (WGS84)	Date	Ice Thickness (ft)	Water Depth (ft)	Freeboard (ft)	Snow Depth (ft)
W0702	69 42.165’	149 48.538’	4/21/2009	4.17	8.66	0.15	0.95
W0801	69 32.995'	150 23.318'	4/21/2009	4.53	6.95	0.8	1.08
W0802	69 33.138’	150 20.733’	4/21/2009	3.90	5.25	0.00	0.72
S0901-1	69 50.693’	148 46.690’	4/23/2009	4.43	frozen	na	0.75
S0902-1	69 34.823’	148 38.498’	4/22/2009	4.33	5.05	0.03	0.72
S0903-1	69 28.593’	148 34.505’	4/22/2009	4.00	3.71	0.30	0.92
MP27 Pit	69 53.361’	148 46.928’	4/23/2009	2.26	frozen	na	1.61
Annie Pit	69 59.193’	148 41.056’	4/23/2009	6.49	23.45	0.36	0.56
Badami Pit	70 07.775’	146 59.980’	4/25/2009	6.9	17.11	0.6	0.2
Shaviovik Pit	70 09.458’	147 15.370’	4/29/2009	6.8	32.95	0.8	0.2

Table 2 presents the actual ice thickness measured for the Kuparuk region lakes compared to predicted ice thickness. This information is germane to the method currently under development whereby SAR data and ice thickness estimates are utilized to provide bathymetric information. This method will be described more fully in the project final report. The predicted ice thickness was calculated using modified Stefan’s equation for ice growth, as described in White (2004):

$$t = C * \sqrt{AFDD}$$, where

t = ice thickness in inches

C = coefficient ranging from 0.5 to 0.7 for an average lake with snow, and

AFDD = accumulated freezing degree days in °F days.

FDD were counted beginning September 25, 2008, the day the daily average air temperature dropped below freezing.

Table 2. Select predicted and measured ice thicknesses.

Location	Date	∑FDD[1] (°F)	Measured Ice Thickness (ft)	Predicted Ice Thickness[2] (ft) (C=.57)
W0702	4/21/2009	7795.1	4.17	4.19
W0801	4/21/2009	7795.1	4.53	4.19
W0802	4/21/2009	7795.1	3.90	4.19
S0901-1	4/23/2009	7846.0	4.43	4.21
S0902-1	4/22/2009	7818.5	4.33	4.20
S0903-1	4/22/2009	7818.5	4.00	4.20

[1] Temperature data were obtained from the National Climatic Data Center (NCDC) station at Prudhoe Bay.
[2] Ice thickness was calculated using modified Stefan's Equation.

At sample locations with sufficient under ice water, water chemistry characteristics were measured. These results are compiled in Tables 3, 4, 5, 6, 7, 8, and 9. Temperature and dissolved oxygen are plotted as a function of depth for lakes/reservoirs providing sufficient information in Figures 5 – 10.

Table 3. W0902-1 chemistry data.

Location	W0902-1					
Date	4/22/2009	**Depth BWS (ft)**	5.05			
Latitude	N 69 34.823'	**Freeboard (ft)**	0.72			
Longitude	W 148 38.498'	**Ice thickness (ft)**	4.33			
Datum	NAD 83	**Snow depth (ft)**	0.72			
YSI Pro ODO						
Time	**Depth (ft BWS)**	**Temp. °C**	**pH**	**Cond. (ųS/cm)**	**DO (mg/L)**	**DO (%)**
1616	4	0.4	---	---	0.64	4.5
YSI 556						
Time	**Depth (ft BWS)**	**Temp. °C**	**pH**	**Cond. (ųS/cm)**	**DO (mg/L)**	**DO (%)**
1625	4	0.11	7.21	1420	---	---
Sampled by: Myerchin, V. Breukelen						
Instruments: YSI 556 SN#04DE5945AC and YSI Pro ODO						
Pre-sampling calibration check: pass 4/22/09						
Post-sampling calibration check: pass 4/22/09						

Table 4. W0702 chemistry data.

Location	W0702					
Date	4/21/2009	**Depth BWS (ft)**		8.66		
Latitude	N 69 42.165'	**Freeboard (ft)**		0.15		
Longitude	W 149 48.538'	**Ice thickness (ft)**		4.17		
Datum	NAD 83	**Snow depth (ft)**		0.95		
YSI Pro ODO						
Time	**Depth (ft BWS)**	**Temp. °C**	**pH**	**Cond. (ųS/cm)**	**DO (mg/L)**	**DO (%)**
1109	4	0.80	---	---	***	***
1111	5	0.30	---	---	0.2	0.02
1112	6	0.30	---	---	0.0	0.00
1113	7	0.40	---	---	0.0	0.00
1115	8.5	0.90	---	---	0.0	0.00
YSI 556						
Time	**Depth (ft BWS)**	**Temp. °C**	**pH**	**Cond. (ųS/cm)**	**DO (mg/L)**	**DO (%)**
	5	0.98	7.72	---	---	---
	8	0.95	7.90	---	---	---
***invalid recorded measurement						
Sampled by: Myerchin, V. Breukelen						
Instruments: YSI 556 SN#04DE5945AC and YSI Pro ODO						
Pre-sampling calibration check: pass 4/20/09						
Post-sampling calibration check: pass 4/22/09, conductivity failed						

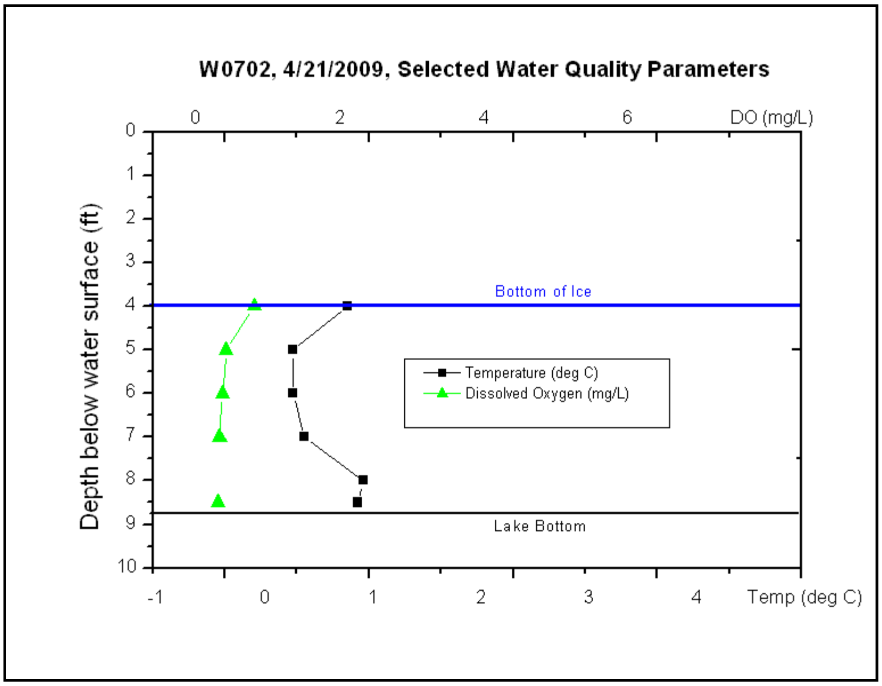

Figure 5. Temperature and dissolved oxygen in relation to depth below the water surface at W0702.

Table 5. W0801 chemistry data.

Location	W0801					
Date	4/21/2009	**Depth BWS (ft)**	6.95			
Latitude	N 69 32.995	**Freeboard (ft)**	0.8			
Longitude	W 150 23.318	**Ice thickness (ft)**	4.53			
Datum	NAD 83	**Snow depth (ft)**	1.08			
YSI Pro ODO						
Time	**Depth (ft BWS)**	**Temp. °C**	**pH**	**Cond. (ųS/cm)**	**DO (mg/L)**	**DO (%)**
1237	4	0.6	---	---	0.28	1.9
1239	5	.0.1	---	---	0.08	0.6
1240	6	0.4	---	---	0.03	0.2
1241	6.8	1.0	---	---	0.19	1.3
YSI 556						
Time	**Depth (ft BWS)**	**Temp. °C**	**pH**	**Cond. (ųS/cm)**	**DO (mg/L)**	**DO (%)**
1243	5		8.10	---	---	---
1245	6.8	1.28	7.83	---	---	---

Sampled by: Myerchin, C. van Breukelen
Instruments: YSI 556 SN#04DE5945AC and YSI Pro ODO
Pre-sampling calibration check: pass 4/20/09
Post-sampling calibration check: pass 4/22/09, conductivity failed

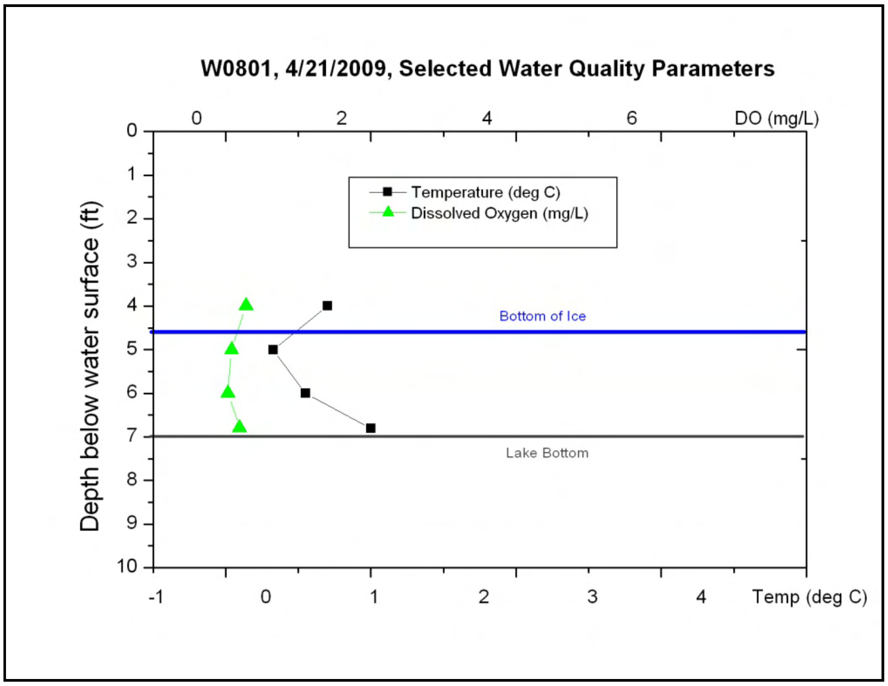

Figure 6. Temperature and dissolved oxygen in relation to depth below the water surface at W0801.

Table 6. W0802 chemistry data.

Location	W0802					
Date	4/21/2009	**Depth BWS (ft)**	5.25			
Latitude	N 69 33.138'	**Freeboard (ft)**	0.0			
Longitude	W 150 23.318'	**Ice thickness (ft)**	3.9			
Datum	NAD 83	**Snow depth (ft)**	0.72			
YSI Pro ODO						
Time	**Depth (ft BWS)**	**Temp. °C**	**pH**	**Cond. (ųS/cm)**	**DO (mg/L)**	**DO (%)**
1405	3	0.0	---	---	0.17	1.2
1406	4	-1.0	---	---	0.04	0.3
1408	4.3	-1.0	---	---	0.00	0.0
YSI 556						
Time	**Depth (ft BWS)**	**Temp. °C**	**pH**	**Cond. (ųS/cm)**	**DO (mg/L)**	**DO (%)**
1410	4	0.02	7.20	---	---	---

Sampled by: Myerchin, C. van Breukelen

Instruments: YSI 556 SN#04DE5945AC and YSI Pro ODO

Pre-sampling calibration check: pass 4/20/09

Post-sampling calibration check: pass 4/22/09, conductivity failed

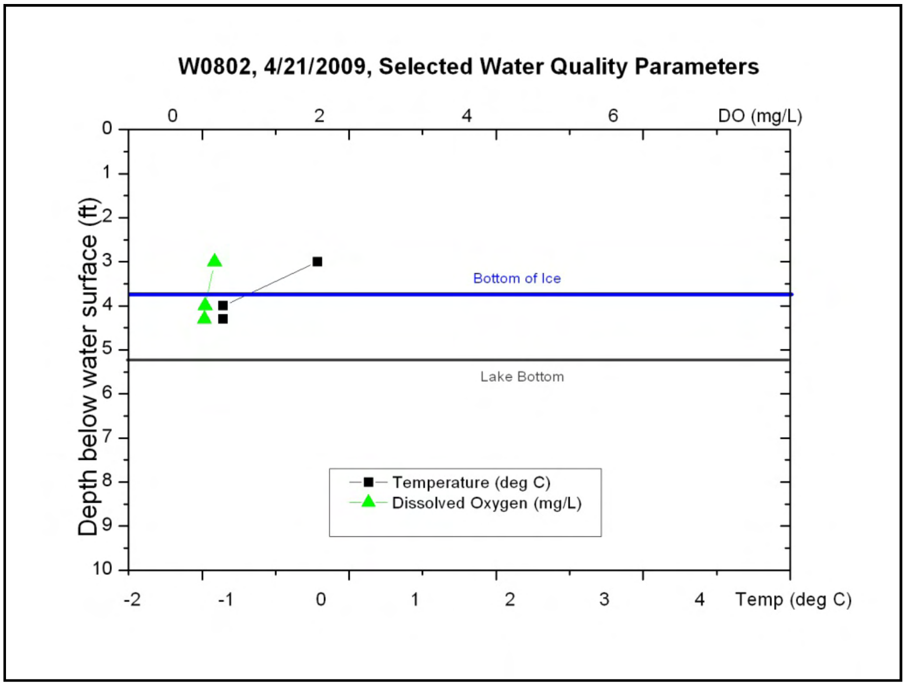

Figure 7. Temperature and dissolved oxygen in relation to depth below the water surface at W0802.

Table 7. Annie pit chemistry data.

Location	Annie Pit		
Date	4/25/2009	**Depth BWS (ft)**	23.45
Latitude	N 70 07.775	**Freeboard (ft)**	0.36
Longitude	W 146 59.980	**Ice thickness (ft)**	6.49
Datum	NAD 83	**Snow depth (ft)**	0.56

YSI Pro ODO

Time	Depth (ft BWS)	Temp. °C	pH	Cond. (ųS/cm)	DO (mg/L)	DO (%)
1151	6	0.4	---	---	10.35	71.6
1152	7	0.3	---	---	10.22	70.5
1152	9	0.2	---	---	10.20	70.2
1153	11	0.3	---	---	10.23	70.6
1155	13	0.5	---	---	10.21	70.9
1156	15	0.6	---	---	10.19	70.9
1157	17	0.8	---	---	10.11	70.7
1158	19	0.8	---	---	10.06	70.3
1200	20	0.9	---	---	9.98	70.2
1202	21.5	1.0	---	---	7.69	54.1

YSI 556

Time	Depth (ft BWS)	Temp. °C	pH	Cond. (ųS/cm)	DO (mg/L)	DO (%)
1209	7	---	7.54	---	---	---
1212	14	---	7.56	---	---	---

Sampled by: Myerchin, van Breukelen
Instruments: YSI 556 SN#04DE5945AC and YSI Pro ODO
Pre-sampling calibration check: pass 4/22/09
Post-sampling calibration check: pass 4/23/09, conductivity failed

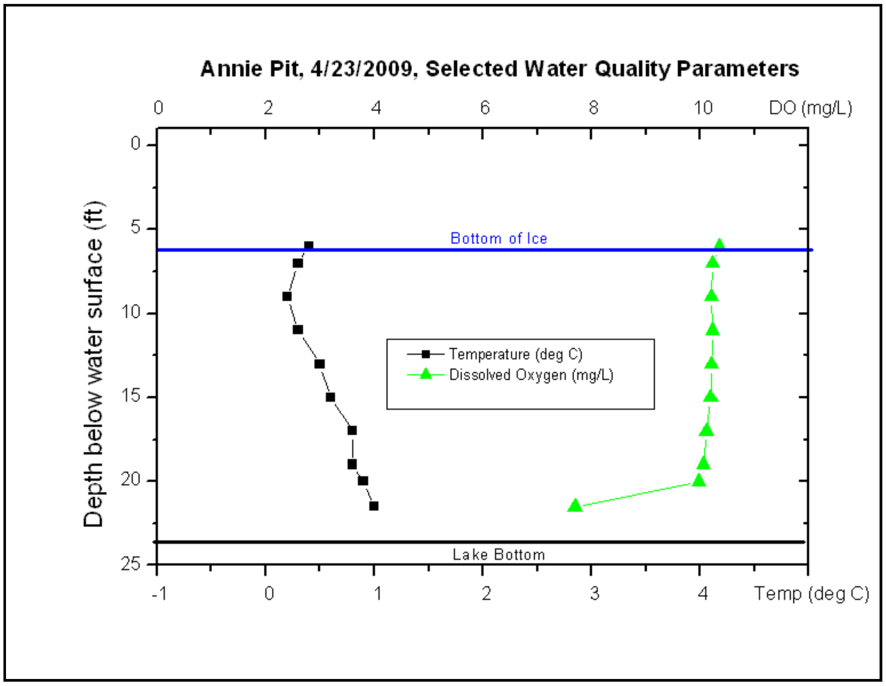

Figure 8. Temperature and dissolved oxygen in relation to depth below the water surface at Annie Pit.

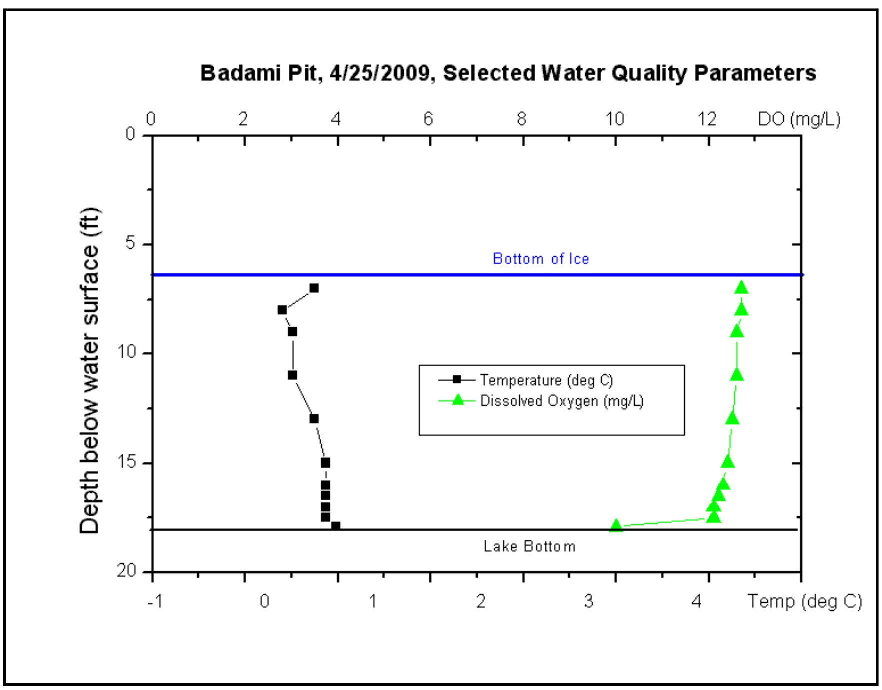

Figure 9. Temperature and dissolved oxygen in relation to depth below the water surface at Badami Pit.

Table 8. Badami gravel pit chemistry data.

Location	Badami Pit					
Date	4/25/2009	**Depth BWS (ft)**	17.11			
Latitude	N 70 07.775	**Freeboard (ft)**	0.6			
Longitude	W 146 59.980	**Ice thickness (ft)**	6.9			
Datum	NAD 83	**Snow depth (ft)**	0.2			
Hach LDO						
Time	**Depth (ft BWS)**	**Temp. °C**	**pH**	**Cond. (ųS/cm)**	**DO (mg/L)**	**DO (%)**
16:53	7	0.58	---	---	12.7	87.7
16:59	8	0.91	---	---	12.7	87.1
17:02	9	1.65	---	---	12.6	86.9
17:04	11	2.00	---	---	12.6	86.8
17:08	13	2.26	---	---	12.5	86.8
17:12	15	2.40	---	---	12.4	86.4
17:18	16	2.47	---	---	12.3	85.6
17:25	17	2.43	---	---	12.1	83.9
17:31	17.92	2.43	---	---	10.0	69.9
YSI 556						
Time	**Depth (ft BWS)**	**Temp. °C**	**pH**	**Cond. (ųS/cm)**	**DO (mg/L)**	**DO (%)**
17:40	12	0.64	6.96	218.0	18.1	128.0

Sampled by: Derry, Gieck
Instruments: YSI 556 SN#04D5945AC and Hach LDO
Hach Pre-sampling calibration check: pass 4/27/09
YSI Pre-sampling calibration check: pass 4/23/09
YSI Post-sampling calibration check: pass 4/26/09

Table 9. Shaviovik gravel pit chemistry data.

Location	Shaviovik Pit		
Date	4/29/2009	**Depth BWS (ft)**	32.95
Latitude	N 70 09.458	**Freeboard (ft)**	0.8
Longitude	W 147 15.370	**Ice thickness (ft)**	6.8
Datum	NAD 83	**Snow depth (ft)**	0.2

Hach LDO

Time	Depth (ft BWS)	Temp. (°C)	pH	Cond. (ųS/cm)	DO (mg/L)	DO (%)
0330	7	0.00	---	---	14.2	97.6
0335	9	0.10	---	---	14.4	97.9
0338	11	0.10	---	---	14.5	97.9
0342	13	0.00	---	---	14.5	97.9
0345	15	0.00	---	---	14.5	97.9
0349	17	0.10	---	---	14.3	97.2
0353	19	0.10	---	---	14.2	96.3
0357	21	0.20	---	---	14.0	95.3
0402	23	0.30	---	---	13.8	94.2
0407	25	0.30	---	---	13.7	93.7
0412	27	0.40	---	---	13.7	93.4
0418	29	0.40	---	---	13.6	92.6
0423	30	0.40	---	---	13.5	92.4
0426	31	0.40	---	---	13.5	92.2
0429	32	0.40	---	---	13.5	92.1
0435	32.79	0.50	---	---	5.1	34.8

YSI 556

Time	Depth (ft BWS)	Temp. °C	pH	Cond. ųS/cm	DO (mg/L)	DO (%)
19:20 (4/25/09)	12	.26	7.75	199	21.54	152.8

Sampled by: Derry, Gieck
Instrument: YSI 556 SN#04D5945AC and Hach LDO
Hach Pre-sampling calibration check: pass 4/27/09
YSI Post-sampling calibration check: pass 4/23/09
YSI Post-sampling calibration check: pass 4/26/09

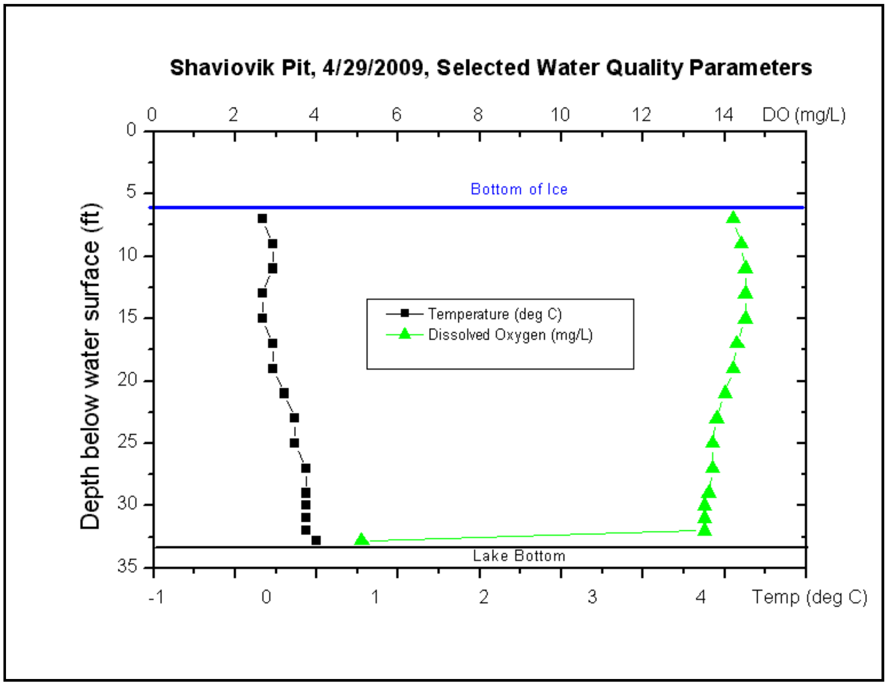

Figure 10. Temperature and dissolved oxygen in relation to depth below the water surface at Shaviovik Pit.

Bathymetry

The three lakes where bathymetric surveys were conducted were all shallow thaw lakes. Summary bathymetric information is provided in Table 10, and the bathymetric sounding and contour maps are shown in Figure 11 and Figure 12. The bathymetry results indicated that these lakes are typical of shallow thaw lakes and would not be good candidates for over winter water use.

Table 10. Summary of bathymetry results

Lake	Date Visited	Area (m^2)	Average depth (m)	Max Depth (m)	Number of Depths Collected[3]
S0901	10-Jul-09	387,212	1.08	1.95	111
S0902	9-Jul-09	357,965	1.04	1.90	145
S0903	8-Jul-09	486,289	0.90	2.10	111

[3] "Number of Depths Collected" is the number of data points collected using the lead line method, and does not include those points used to mark the perimeter of the lake.

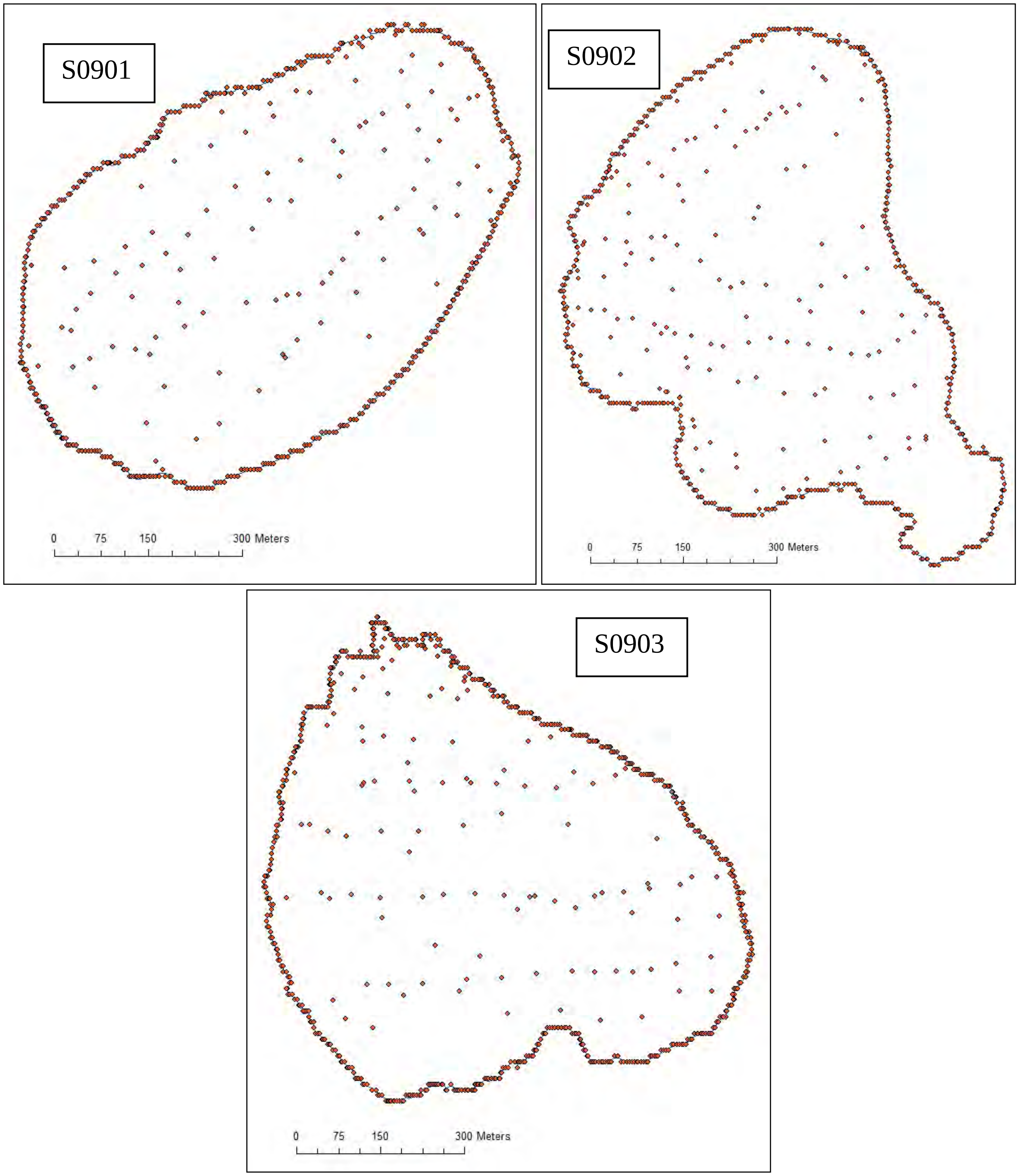

Figure 11: Sounding locations for lakes S0901, S0902, S0903

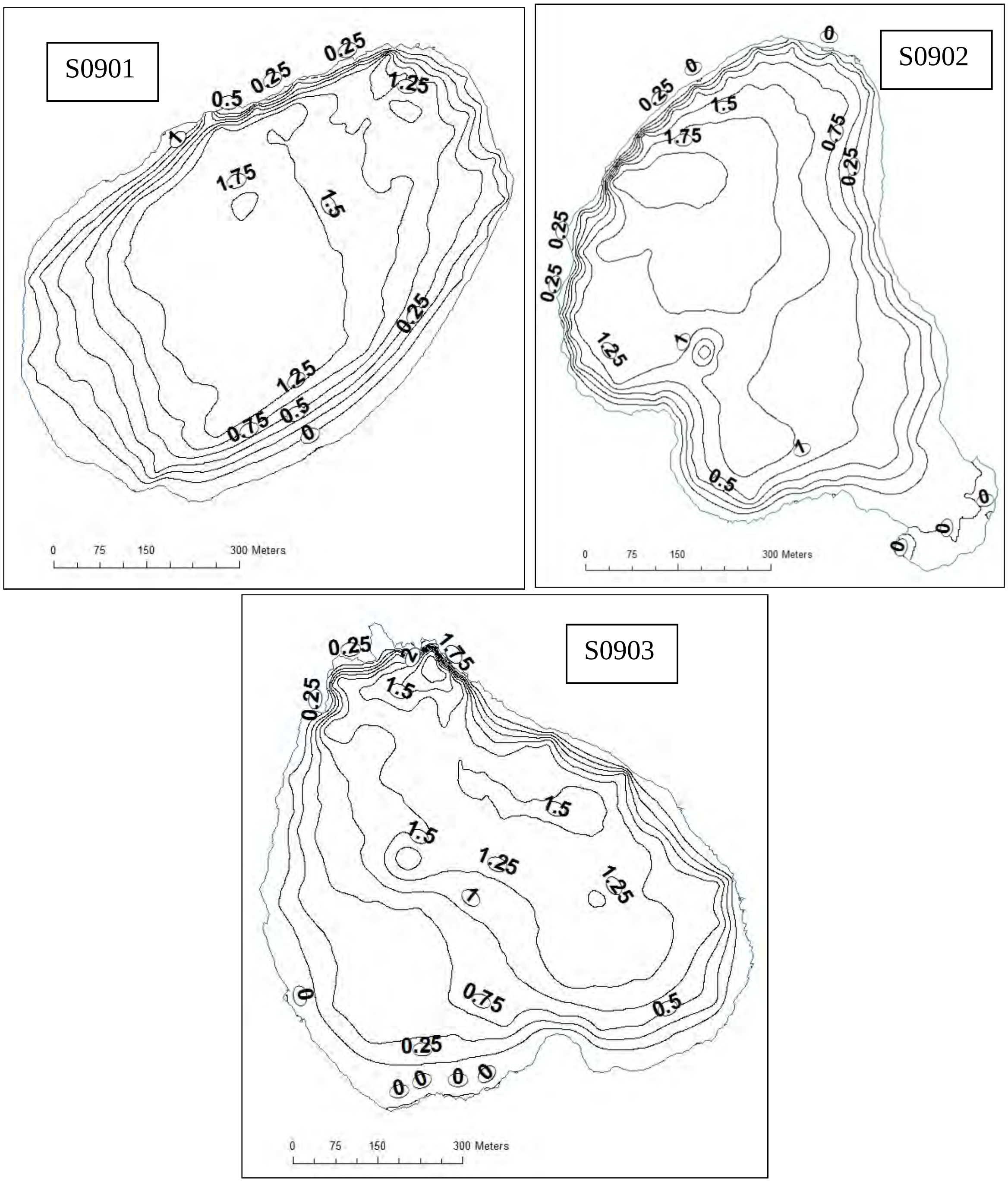

Figure 12: Contour lines (meters) for lakes S0901, S0902, S0903

SUMMARY

Lake chemistry and physical data were collected during spring (before snowmelt) and summer conditions in the region between the Canning River and Kuparuk River, North Slope, Alaska. These data were collected to help support winter water use planning and management.

The collected data indicate three of the gravel mine site reservoirs had high DO levels. Two of these sites, Shaviovik and Badami Pits, served as active water sources during the winter of 2008-09. This information is consistent with data retrieved from other reservoirs that receive adequate recharge and are also used as winter water sources. Locating gravel mine sites in areas with adequate recharge characteristics will help improve the future distribution and volume of winter water availability. The data collected at Kuparuk Foothills lakes W0802, S0901, S0902 and S0903 this season indicated these natural lakes froze nearly or fully to the bottom and would not serve as an adequate late winter water sources. Lakes W0702 and W0801 had more unfrozen water at the lake bottom at winter's end (4.5 ft and 2.4 ft, respectively). DO levels in these lakes were found to be close to zero, thus indicating that the lakes do not likely support overwintering fish species highly sensitive to low DO conditions. Estimates of ice thickness via the modified Stefan's Equation were generally consistent with physical measurements collected at six lake sites, thus indicating that the modified Stefan's Equation will be applicable in the derivation of bathymetric information from SAR data.

REFERENCES

White, K. (2004) *Ice Engineering*: “Method to Estimate River Ice Thickness Based on Meteorological Data.” US Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire. CRREL Report TN-0403.

APPENDIX A. WATER QUALITY ASSURANCE DATA

The following tables report the pre- and post-calibration checks for water quality meters used during field sampling.

QAQC Information for Sites W0702, W0801, W0802.

Calibration and Quality Assurance Information

Meter: YSI 556 MPS, S/N 04D5945 AC – pH, Conductivity

YSI Pro ODO, TTT Environmental – Dissolved Oxygen

Site Location: W0702, 0801, W0802

PRE-SAMPLING QA

Parameter	Date	Time	Standard	Lot No.	Exp.	Reading	P/ F
pH 4.01	4/20/09	1919	Oakton	2806445	Jun-10	3.98 @ 17.85 C	Pass
pH 7.00	4/20/09	1923	Oakton	2803537	Mar-10	7.15 @ 17.76C	Pass
pH 10.00	4/20/09	1927	Oakton	2804418	Oct-09	10.18 @ 17.92 C	Pass
Conductivity (μS/cm)	4/20/09	1934	Oakton 447 μS/cm	2807297	Jul-09	385 @ 17.76 C	Pass
DO 100 (%)	4/20/09	1940	Nanopure Water	----	----	94.2 @ 17.4 C	Pass

POST-SAMPLING QA

Parameter	Date	Time	Standard	Lot No.	Exp.	Reading	P/ F
pH 4.01	4/22/09	0820	Oakton	2806445	Jun-10	4.05 @ 10.97 C	Pass
pH 7.00	4/22/09	0822	Oakton	2803537	Mar-10	7.19 @ 11.06 C	Pass
pH 10.00	4/22/09	0824	Oakton	2804418	Oct-09	10.24 @ 10.99 C	Pass
Conductivity (μS/cm)	4/22/09	0815	Oakton 447 μS/cm	2807297	Jul-09	397 @ 11.02 C	Fail
DO 100 (%)	4/22/09	0820	Nanopure Water	----	----	94.0 @ 11.0 C	Pass

QAQC Information for Sites S0903, S0902

Calibration and Quality Assurance Information

Meter: YSI 556 MPS, S/N 04D5945 AC – pH, Conductivity

YSI Pro ODO, TTT Environmental – Dissolved Oxygen

Site Location: S0903-1, -2, -3, -4 and S0902-1, -2, -3.

PRE-SAMPLING QA

Parameter	Date	Time	Standard	Lot No.	Exp.	Reading	P/ F
pH 4.01	4/22/09	0820	Oakton	2806445	Jun-10	4.05 @ 10.97 C	Pass
pH 7.00	4/22/09	0822	Oakton	2803537	Mar-10	7.19 @ 11.06 C	Pass
pH 10.00	4/22/09	0824	Oakton	2804418	Oct-09	10.24 @ 10.99 C	Pass
Conductivity (µS/cm)	4/22/09	0815	Oakton 447 µS/cm	2807297	Jul-09	329 @ 10.95 C	Pass
DO 100 (%)	4/22/09	0820	Nanopure Water	----	----	94.0 @ 11.0 C	Pass

POST-SAMPLING QA

Parameter	Date	Time	Standard	Lot No.	Exp.	Reading	P/ F
pH 4.01	4/22/09	2034	Oakton	2806445	Jun-10	4.01 @ 12.90 C	Pass
pH 7.00	4/22/09	2039	Oakton	2803537	Mar-10	7.06 @ 12.90 C	Pass
pH 10.00	4/22/09	2044	Oakton	2804418	Oct-09	10.15 @ 13.07 C	Pass
Conductivity (µS/cm)	4/22/09	2018	Oakton 447 µS/cm	2807297	Jul-09	365 @ 12.73 C	Pass
DO 100 (%)	4/22/09	2019	Nanopure Water	----	----	94.6 @ 13.9 C	Pass

QAQC Information for Sites Annie Pit, MP27, S0901.

Calibration and Quality Assurance Information

Meter: YSI 556 MPS, S/N 04D5945 AC – pH, Conductivity

YSI Pro ODO, TTT Environmental – Dissolved Oxygen

Site Location: Annie Pit, MP27, S0901-1 and S0901-2

PRE-SAMPLING QA

Parameter	Date	Time	Standard	Lot No.	Exp.	Reading	P/ F
pH 4.01	4/22/09	2034	Oakton	2806445	Jun-10	4.01 @ 12.90 C	Pass
pH 7.00	4/22/09	2039	Oakton	2803537	Mar-10	7.06 @ 12.90 C	Pass
pH 10.00	4/22/09	2044	Oakton	2804418	Oct-09	10.15 @ 13.07 C	Pass
Conductivity (µS/cm)	4/22/09	2018	Oakton 447 µS/cm	2807297	Jul-09	365 @ 12.73 C	Pass
DO 100 (%)	4/22/09	2019	Nanopure Water	----	----	94.6 @ 13.9 C	Pass

POST-SAMPLING QA

Parameter	Date	Time	Standard	Lot No.	Exp.	Reading	P/ F
pH 4.01	4/23/09	1910	Oakton	2806445	Jun-10	4.10 @ 14.98 C	Pass
pH 7.00	4/23/09	1910	Oakton	2803537	Mar-10	6.99 @ 15.27 C	Pass
pH 10.00	4/23/09	1910	Oakton	2804418	Oct-09	10.11 @ 15.43 C	Pass
Conductivity (µS/cm)	4/23/09	1910	Oakton 447 µS/cm	2807297	Jul-09	768 @ 15.00 C	Fail
DO 100 (%)	4/23/09	1910	Nanopure Water	----	----	92.7 @ 13.1 C	Pass

QAQC Information for Sites Badami and Shaviovik.

Calibration and Quality Assurance Information

Meter: YSI 556 MPS, S/N 04D5945 AC – pH, Conductivity

Hach LDO, BLM – Dissolved Oxygen

Site Location: Badami and Shaviovik

PRE-SAMPLING QA

Parameter	**Date**	**Time**	**Standard**	**Lot No.**	**Exp.**	**Reading**	**P/ F**
pH 4.01	4/23/09	1605	Oakton	2807297	Jun-10	4.00 @ 19.71 C	Pass
pH 7.00	4/23/09	1610	Oakton	2801686	Mar-10	7.07 @ 19.49 C	Pass
pH 10.00	4/23/09	1615	Oakton	2806445	Oct-09	10.05 @ 19.77 C	Pass
Conductivity (µS/cm)	4/23/09	1555	Oakton 447 µS/cm	2803537	Jul-09	426 @ 122.46 C	Pass
DO 100 (%)	4/23/09	1625	Nanopure Water	----	----	102.1 @ 21.41 C	Pass
Hach LDO – DO 100 (%)	4/27/09	1925	Nanopure Water	----	----	99.8 @ 21.41	Pass

POST-SAMPLING QA

pH 4.01	4/26/09	1830	Oakton	2807297	Jun-10	4.02 @ 20.43 C	Pass
pH 7.00	4/26/09	1835	Oakton	2801686	Mar-10	7.04 @ 20.20 C	Pass
pH 10.00	4/26/09	1840	Oakton	2806445	Oct-09	10.06 @ 20.90 C	Pass
Conductivity (µS/cm)	4/26/09	1820	Oakton 447 µS/cm	2803537	Jul-09	435 @ 21.10 C	Pass
DO 100 (%)	4/26/09	1850	Nanopure Water	----	----	6.7 @ 19.34 C	Pass