Lake Chemistry and Physical Data For Selected North Slope, Alaska, Lakes: March 2009

Lake MO806, photo by D. Reichardt.

by

Kristie Holland, Dan Reichardt, Horacio Toniolo,

and Michael Lilly

March 2009

Cooperative North Slope Hydrology Projects

Report No. 09.01

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By:

Kristie Holland[1], Dan Reichardt[1], Horacio Toniolo[2], and Michael Lilly[1]

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Report Number 09.01

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Fairbanks, Alaska
March 2009

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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 (m)
mile (mi)	1.609	kilometer (km)
	Area	
Acre	43559.999	square feet (ft^2)
Acre	0.405	hectare (ha)
Square foot (ft^2)	3.587e-8	square mile (mi^2)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
gallon (gal)	3785.412	milliliter (mL)
Cubic foot (ft^3)	28.317	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.

Physical and Chemical Water-Quality Units:

Temperature:

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

$$°F = 1.8(°C) + 32$$

Specific electrical conductance (conductivity):

Conductivity of water is expressed in microsiemens per centimeter at 25°C (µS/cm). This unit is equivalent to microhms per centimeter at 25°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.

Vertical Datum:

In this report, "sea level" 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 North American Datum of 1927.

Abbreviations, Acronyms, and Symbols

AC	Actual conductivity
ADF&G	Alaska Department of Fish and Game
ADOT&PF	Alaska Department of Transportation and Public Facilities
ADNR	Alaska Department of Natural Resources
ASTM	American Society for Testing and Materials
atm	atmospheres
BLM	Bureau of Land Management
C	Celsius
CPA	ConocoPhillips Alaska, Inc.
DO	Dissolved oxygen
DOE	U.S. Department of Energy
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, equivalent to ppm
µg/L	micrograms per liter
mi^2	square miles
mm	millimeters
µS/cm	microsiemens per centimeter
mV	Millivolt
MMS	Minerals Management Service
NGVD	National Geodetic Vertical Datum
NSB	North Slope Borough
NTU	Nephelometric Turbidity Units
NWIS	National Water Information System
ORP	oxygen-reduction potential
ppm	parts per million, equivalent to mg/L
SC25	specific conductance at 25^{o}C
SWE	Snow Water Equivalent
QA	quality assurance
QC	quality control
UAF	University of Alaska Fairbanks
USGS	U.S. Geological Survey
WWW	World Wide Web
YSI	Yellow Springs Instruments

PROJECT COOPERATORS

The Cooperative North Slope Hydrology Projects cover a large area of the North Slope and benefited from a number of positive partnerships, all contributing to the overall project objectives.

- Bureau of Land Management (BLM)
- ConocoPhillips Alaska, Inc. (CPA)
- Geo-Watersheds Scientific (GWS)
- University of Alaska Fairbanks (UAF)
- Alaska Department of Natural Resources (ADNR)
- Alaska Department of Transportation and Public Facilities (ADOT&PF)
- U.S. Department of Energy (DOE)
- Minerals Management Service (MMS)
- Alaska Department of Fish and Game (ADF&G)
- North Slope Borough (NSB)

ACKNOWLEDGEMENTS

Field data collection for this report was funded by the Bureau of Land Management. Field coordination and logistics support were provided by ConocoPhillips Alaska.

Lake Chemistry and Physical Data For Selected North Slope, Alaska, Lakes: March 2009

INTRODUCTION

Geo-Watersheds Scientific (GWS), together with project cooperators, collected physical measurements and water quality data in lakes associated with water use by the petroleum industry on the North Slope of Alaska. The purpose of collecting this water-quality data was to provide the Bureau of Land Management (BLM) and the Alaska Department of Fish and Game (ADFG) with data for testing the UAF Dissolved Oxygen (DO) model. This model was developed in 2008 as an outcome of the North Slope Lakes Project. Additionally, this field trip effort provided data for UAF regional hydrology studies. Water quality data were collected from a variety of lakes, some of which have been permitted and used during the 2008-09 ice road season, and others have been selected due to their use in initial development of the DO model.

Data collected includes physical parameters, water quality, snow accumulation, and water levels. The field data collection for this report was funded by BLM in cooperation with ADF&G and ConocoPhillips Alaska (CPA). Table 1 lists the GPS coordinates for the lake sampling locations and Figures 1-3 show site locations in relation to local reference points.

The field data collection efforts were coordinated with the cooperative hydrology project across the North Slope and the results will be used to help support and improve Arctic Transportation Networks. The purposes of this publication are to 1) report data collected during the month of March 2009, and 2) summarize accomplished field trip objectives.

Table 1. GPS coordinates for study lake/sampling site locations.

Lake/Sampling Site	Latitude (NAD 83)	Longitude (NAD 83)
L9312-B	N70° 15.552’	W150° 56.918’
L9322-CT	N70° 20.269’	W151° 01.913’
L9323-CT	N70° 17.915’	W151° 0.326’
MO802-CT	N70° 9.523’	W151° 15.092’
MO710-CT	N70° 8.7516’	W151° 17.0874’
L9811-CT	N70° 12.4182’	W151° 10.4952’
L9817-1	N70° 14.070’	W151° 20.121’
MO806-CT	N70° 8.186’	W151° 23.756’
R0066-CT	N70° 8.608’	W151° 45.740’

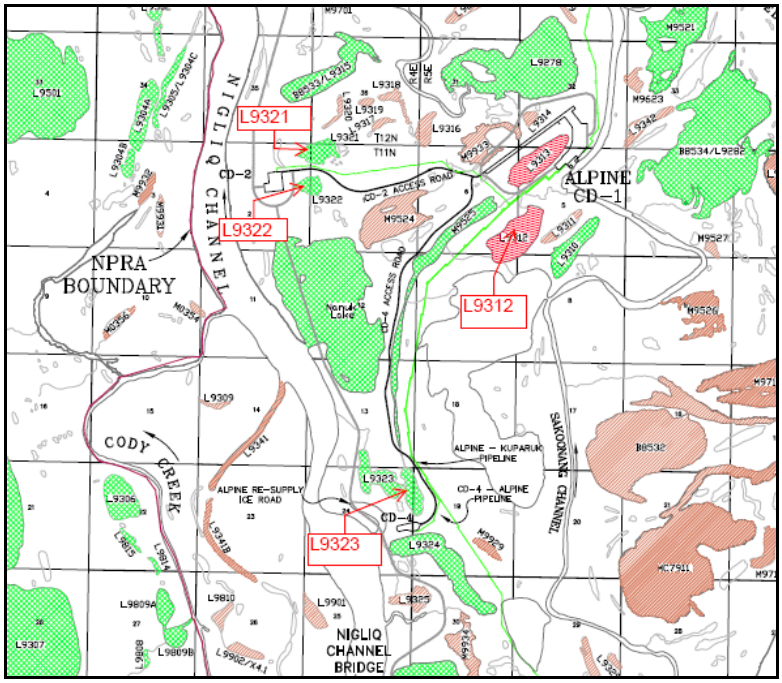

Figure 1. Locations of L9312, L9322, L9323 near Alpine (map source LCMF, 2009).

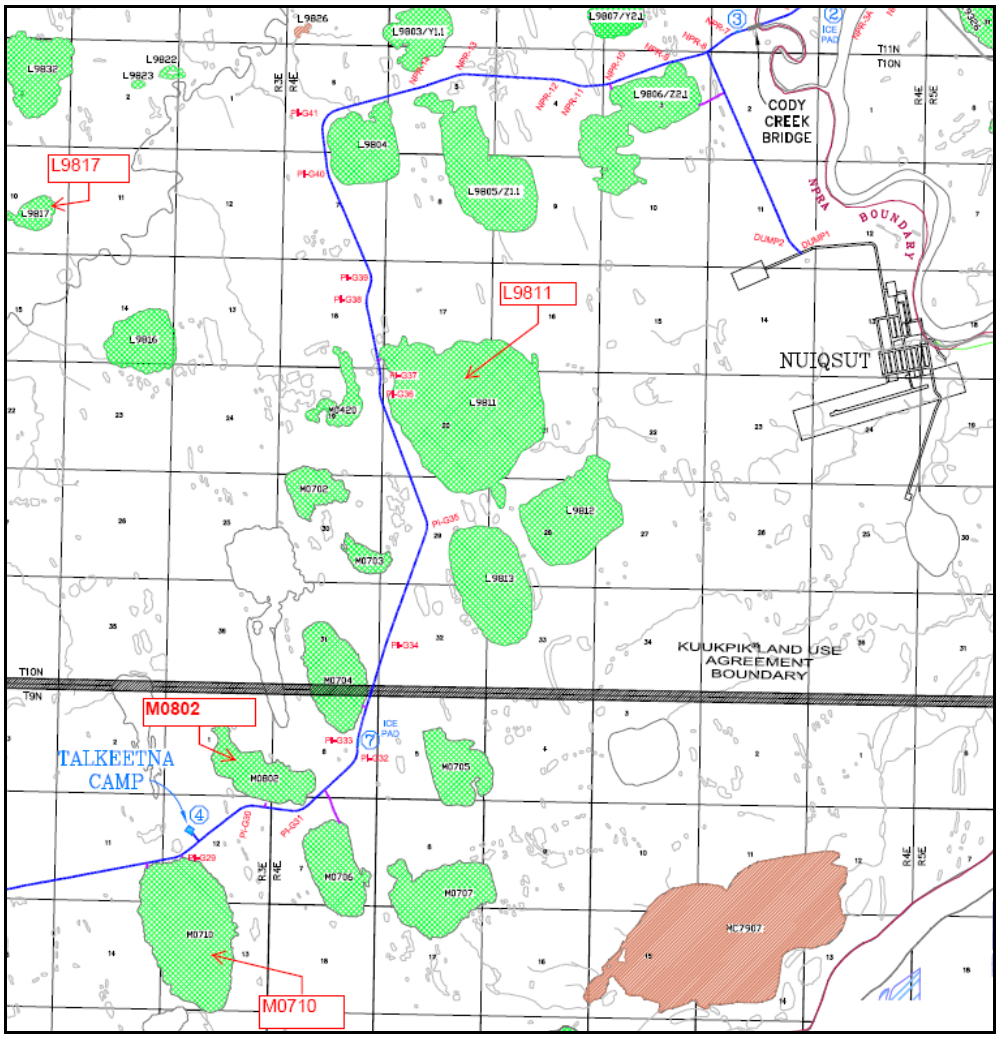

Figure 2. Locations of L9811, L9817, MO802 and M0710 near Nuiqsut (map source LCMF, 2009).

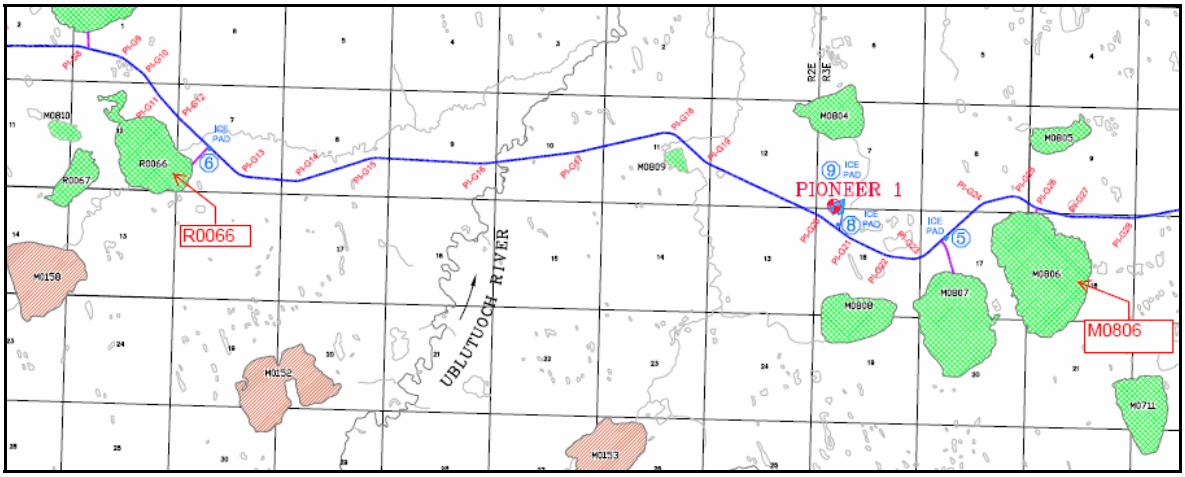

Figure 3. Locations of MO806 and R0066 near Ublutuoch River (map source LCMF, 2009).

TRIP OBJECTIVES

The goal of the March sampling trip was to collect physical and chemical data from each study lake. For each lake, a single hole was drilled at a designated sampling location in a deep portion of the lake, identified through available bathymetry, where physical and in situ water measurements were obtained. Logistical, personnel, and weather constraints, can limit the amount of time available in the field for sampling, but was not necessarily an issue on this trip. A project workplan was distributed before the trip outlining the sampling schedule (Reichardt et al, 2009). In March 2009, we focused on the following locations/tasks:

1. MO710, NPR-A
    - Measure field water-quality parameters at a pre-determined deep location.
2. MO802, NPR-A
    - Measure field water-quality parameters at a pre-determined deep location.
    - Conduct snow survey near sampling location on lake.
3. MO806, NPR-A
    - Measure field water-quality parameters at a pre-determined deep location.
    - Conduct snow survey near sampling location on lake.
4. R0066, NPR-A
    - Measure field water-quality parameters at a pre-determined deep location.
    - Conduct snow survey near sampling location on lake.
5. L9811, NPR-A
    - Measure field water-quality parameters at a pre-determined deep location.
    - Conduct snow survey near sampling location on lake.
6. L9817, NPR-A
    - Measure field water-quality parameters at L9817-1.
    - Conduct snow survey at previously studied tundra location.
    - Automated data collection and station maintenance.
7. L9323, NPR-A
    - Measure field water-quality parameters at a pre-determined deep location.
    - Conduct snow survey near sampling location on lake.

8. L9322, Alpine Facility
    - Measure field water-quality parameters at a pre-determined deep location.
9. L9312, Alpine Facility
    - Measure field water-quality parameters at L9312-B.
    - Obtain water level survey to local elevation control.
    - Conduct snow survey at previously studied tundra location.
    - Automated data collection and station maintenance.

Figure 4. Horacio Toniolo and Kristie Holland conducting a snow survey at L9312 (photo by D. Reichardt).

PROCEDURES

Water Chemistry Sampling

All field work followed the specified health, safety, and environmental guidelines outlined by CPA (White and Lilly, 2008). Physical measurements of water depth, snow depth, ice thickness, and freeboard (top of ice to water surface) were taken at each sampling location. Water-quality parameters such as temperature, pH, turbidity, conductivity, and dissolved oxygen (DO) were obtained by using an In-Situ Troll 9000 (submersible meter), at multiple depths throughout the water column. The precision with which physical measurements were reported

takes into account field conditions. The calibration of each parameter was checked before and after each day of sampling using the criteria in Table 2.

Table 2. In-Situ Troll 9000 calibration quality control criteria.

Parameter	Standards used	Acceptable deviation from calibration standard value
pH	4.01, 10.01	± 0.2
Conductivity	3900 (µs/cm)	within 10%
100% DO	100 % saturated	within 10%
0% DO	0 % saturated solution	within 0.3 mg/L

SELECTED RESULTS

Sampling occurred at 9 locations during the March field campaign (MO710, MO802, MO806, L9312, L9322, L9323, L9811, L9817, R0066). Table 3 summarizes some of the conditions at these sites. DO and conductivity are reported as a median, as opposed to an average of the measurements, for easier comparison between lakes. Some locations have more historical data than others, such as L9312 and L9817, which had been previously sampled by the team during past projects.

Table 3. Water depth, ice thickness, median DO concentration, and median conductivity.

Sampling Location	Water Depth [ft]	Ice Thickness [ft]	Median DO Concentration [mg/L]	Median Actual Conductivity [µS/cm]
MO710-CT	6.85	4.55	5.40	781.4
MO802-CT	7.45	3.75	2.21	291.9
MO806-CT	7.45	4.18	7.32	773.0
L9312-B	10.4	4.8	11.11	148.9
L9322-CT	10.45	4.3	6.96	304.5
L9323-CT	12.2	4.45	9.56	202.5
L9811-CT	6.6	3.6	1.59	856.7
L9817-1	8.2	5.28	2.29	903.9
R0066-CT	9.1	4.65	7.75	301.4

L9811, located near Nuiqsut in NPR-A, was the shallowest of the sites visited (6.6 ft) and had the lowest recorded median DO concentration (1.59 mg/L) and the second highest median conductivity reading (856.7 µS/cm) of all of the sites. L9817, also located near Nuiqsut in NPR-A, was of average depth (8.2 ft) with the second lowest DO concentration (2.29 mg/L) and the highest conductivity reading (903.9 µS/cm) of all of the sites. L9323, located near the Alpine facility, was the deepest sampling location (12.2 ft) with the second highest DO concentration (9.56 mg/L) and the second lowest median conductivity reading recorded (202.5 µS/cm). L9312, also located near the Alpine facility, was relatively deep (10.4 ft) and had the highest median DO concentration (11.11 mg/L) and the lowest conductivity measurement (148.9 µS/cm) of all the sites. Figure 5 shows the relationship between dissolved oxygen concentrations and depth at these sites, while Figure 6 shows the relationship between conductivity and dissolved oxygen concentrations.

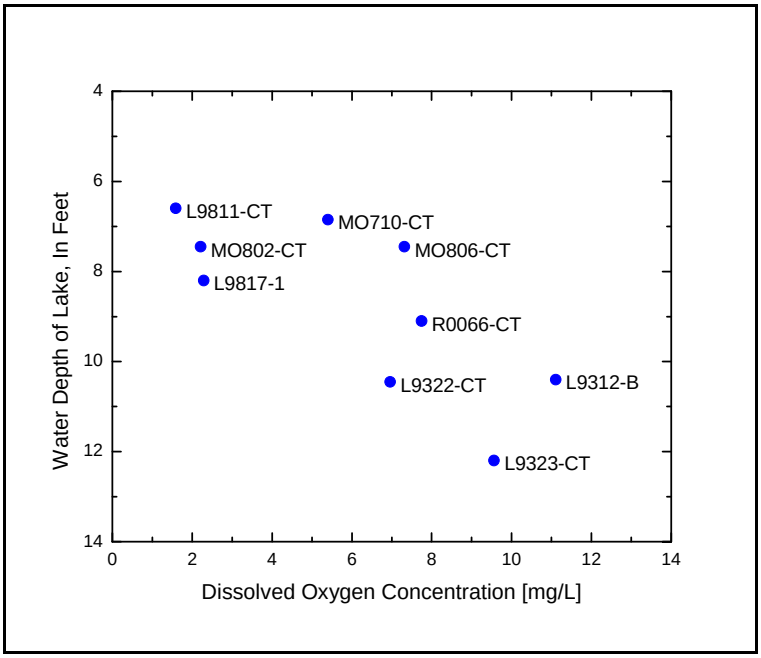

Figure 5. Plot of depth and dissolved oxygen concentrations at sample sites.

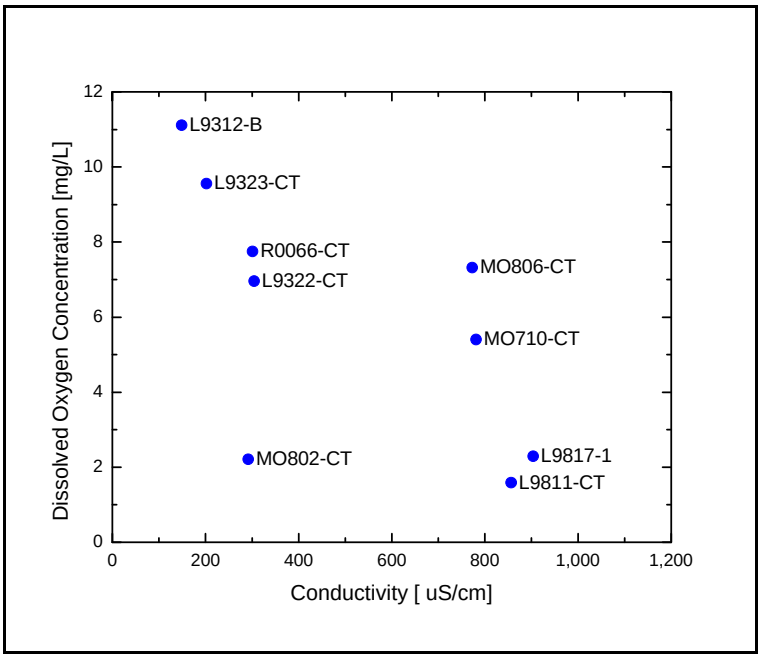

Figure 6. Plot of dissolved oxygen and conductivity concentrations at sample sites.

SUMMARY

The March field trip provided data on water depth, freeboard, ice thickness, DO, pH, conductivity, and temperature. Sampling location water depth varied from 6.6 - 12.2 ft, with the shallowest sampling point at L9811 and the deepest point at L9323. Ice thickness varied from 3.6 ft at L9811 to 5.28 ft at L9817. The median DO concentrations fell between 1.59 and 11.11 mg/L with the lowest recording at L9811 and the highest recording at L9312. The lowest conductivity reading was recorded at L9312 (148.9 μS/cm) and the highest reading was at L9817 (903.9 μS/cm).

Although some trends were observed, further studies would be necessary to determine if there are any correlations between these data. Continued monitoring of North Slope water-quality parameters will help in the understanding and usage of simulation tools utilized for water-resource management. This information is necessary for permitting agencies as well as industry professionals who depend on water resources for facility use and ice road/pad construction. Through field parameter assessments and the application of simulation models, we hope to

answer some of the many questions that surround allocation and usage of North Slope water resources.

REFERENCES

LCMF, Alpine Survey Office, ConocoPhillips Alaska, Inc. 2009. 2008-2009 Exploration Ice Road As-Built Alpine, Alaska. Drawing No. CE-APOO-1087.

Reichardt, D., Holland, K., Lilly, M.R. 2009. A Workplan for Lake Chemistry Sampling and Surveying at Select Lakes in NPR-A, Alpine, and Kuparuk Areas: March 2009. Geo-Watersheds Scientific. 5 pages.

White, D.M., and Lilly, M.R. 2008. ConocoPhillips Alaska, Inc.: Health, Safety, and Environmental Plan. Geo-Watersheds Scientific and the University of Alaska Fairbanks. 5 p.

APPENDIX A. WATER QUALITY FIELD SAMPLING FORMS

The following forms report the data collected with the water quality meters during field sampling.

Geo-Watersheds Scientific

Form F-004a: Water Quality Field-Sampling General

Project ID: **GWS09G** Site Location/Lake ID: MO802-CT

Sample Purpose: **Lake Water Quality** Date: 3/11/09 Time 11:02

FIELD MEASUREMENTS

GPS Coord. Northing: N70°9.523' Easting: W151°15.092' Datum: NAD83

Measurements By: KMH/DAR Time: 11:05

Water Depth (ft): 7.45 Ice Thickness (ft): 3.75

Freeboard (ft): 0.15 Snow Depth (ft): 1.0

Elev. (BPMSL): n/a Survey By: n/a Date: n/a Time: n/a

Water Sampling By: n/a Sample Depths BWS (ft): 1 n/a Date: n/a Time: n/a

2 n/a

WATER QUALITY METER INFORMATION 3 n/a

Calibration Information

Parameter (s)	Owner	Meter Make/Model	Serial No.	Pre-Sampling QAQC Check	Post-Sampling QAQC Check
MULTI	GWS	InSitu Troll 9000	33033	Pass	Pass

Parameters	**Field Measurements**									
Time:	11:11	11:15	11:19	11:23	11:27					
Depth BWS (ft):	4	5	6	7	BOT					
Temp (°C):	0.38	0.33	0.87	1.62	1.87					
pH:	7.40	7.28	7.18	7.35	7.98					
Barometeric (mmHg):	765.1	765.1	765.0	765.0	765.0					
Pressure (kPa):	10.518	13.251	16.384	19.544	21.336					
Conductivity (µS/cm):	290.8	288.8	291.9	366.9	442.5					
RDO (mg/L):	2.66	1.89	2.31	2.21	0.96					
RDO (%):	18.1	13.0	16.1	15.7	6.9					
Turbidity (NTU):	6.3	6.3	4.5	10.6	399.7					

Parameters	**Field Measurements**									
Time:										
Depth BWS (ft):										
Temp (°C):										
pH:										
Barometeric (mmHg):										
Pressure (kPa):										
Conductivity (µS/cm):										
RDO (mg/L):										
RDO (%):										
Turbidity (NTU):										

Remarks: Turbidity data was not verified by calibration check and is listed for informative purposes only.

Field-Form Filled Out By: KMH Date: 3/13/09

QAQC Check By: DAR Date: 3/13/09

Geo-Watersheds Scientific

Form F-004a: Water Quality Field-Sampling General

Project ID: **GWS09G** Site Location/Lake ID: MO710-CT

Sample Purpose: **Lake Water Quality** Date: 3/11/09 Time 12:35

FIELD MEASUREMENTS

GPS Coord. Northing: N70°08.7516' Easting: W151°17.0874' Datum: NAD83

Measurements By: KMH Time: 12:40

Water Depth (ft): 6.85 Ice Thickness (ft): 4.55

Freeboard (ft): 0.49 Snow Depth (ft): 0.10

Elev. (BPMSL): n/a Survey By: n/a Date: n/a Time: n/a

Water Sampling By: n/a Sample Depths BWS (ft): 1 n/a Date: n/a Time: n/a

2 n/a

WATER QUALITY METER INFORMATION 3 n/a

Calibration Information

Parameter (s)	Owner	Meter Make/Model	Serial No.	Pre-Sampling QAQC Check	Post-Sampling QAQC Check
MULTI	GWS	InSitu Troll 9000	33033	Pass	Pass

Parameters	**Field Measurements**									
Time:	12:47	12:52	12:57	13:01	13:06					
Depth BWS (ft):	4	5	6	6.5	BOT					
Temp (°C):	0.40	0.21	0.18	0.48	0.50					
pH:	7.52	7.52	7.50	7.48	7.44					
Barometeric (mmHg):	764.7	764.7	764.7	764.8	764.8					
Pressure (kPa):	10.174	13.181	16.248	18.910	19.215					
Conductivity (µS/cm):	791.9	786.4	781.4	777.3	776.5					
RDO (mg/L):	6.37	5.66	5.40	5.20	4.42					
RDO (%):	44.0	38.9	37.0	36.0	30.5					
Turbidity (NTU):	20.3	15.6	3.8	6.2	46.6					

Parameters	**Field Measurements**									
Time:										
Depth BWS (ft):										
Temp (°C):										
pH:										
Barometeric (mmHg):										
Pressure (kPa):										
Conductivity (µS/cm):										
RDO (mg/L):										
RDO (%):										
Turbidity (NTU):										

Remarks: Turbidity data was not verified by calibration check and is listed for informative purposes only.

Field-Form Filled Out By: KMH Date: 3/13/09

QAQC Check By: DAR Date: 3/13/09

Geo-Watersheds Scientific

Form F-004a: Water Quality Field-Sampling General

Project ID: **GWS09G** Site Location/Lake ID: MO806-CT

Sample Purpose: **Lake Water Quality** Date: 3/11/09 Time 14:10

FIELD MEASUREMENTS

GPS Coord. Northing: N70°8.186' Easting: W151°23.756' Datum: NAD83

Measurements By: KMH/DAR Time: 14:12

Water Depth (ft): 7.45 Ice Thickness (ft): 4.18

Freeboard (ft): 0.32 Snow Depth (ft): 0.45

Elev. (BPMSL): n/a Survey By: n/a Date: n/a Time: n/a

Water Sampling By: n/a Sample Depths BWS (ft): 1 n/a Date: n/a Time: n/a

2 n/a

WATER QUALITY METER INFORMATION 3 n/a

Calibration Information

Parameter (s)	Owner	Meter Make/Model	Serial No.	Pre-Sampling QAQC Check	Post-Sampling QAQC Check
MULTI	GWS	InSitu Troll 9000	33033	Pass	Pass

Parameters	**Field Measurements**									
Time:	14:21	14:25	14:29	14:32	14:38					
Depth BWS (ft):	4	5	6	7	BOT					
Temp (°C):	0.06	0.12	0.83	1.20	1.64					
pH:	7.61	7.60	7.56	7.52	7.42					
Barometeric (mmHg):	764.9	764.9	764.9	764.9	764.9					
Pressure (kPa):	10.277	13.237	16.280	19.182	21.458					
Conductivity (µS/cm):	671.8	785.6	773.4	769.8	773.0					
RDO (mg/L):	9.82	8.42	7.32	6.89	4.39					
RDO (%):	67.0	57.6	51.4	48.6	31.1					
Turbidity (NTU):	7.8	5.0	4.9	5.4	30.3					

Parameters	**Field Measurements**									
Time:										
Depth BWS (ft):										
Temp (°C):										
pH:										
Barometeric (mmHg):										
Pressure (kPa):										
Conductivity (µS/cm):										
RDO (mg/L):										
RDO (%):										
Turbidity (NTU):										

Remarks: Turbidity data was not verified by calibration check and is listed for informative purposes only.

Field-Form Filled Out By: KMH Date: 3/13/09

QAQC Check By: DAR Date: 3/13/09

Geo-Watersheds Scientific

Form F-004a: Water Quality Field-Sampling General

Project ID: **GWS09G** Site Location/Lake ID: L9323-CT

Sample Purpose: **Lake Water Quality** Date: 3/11/09 Time 16:20

FIELD MEASUREMENTS

GPS Coord. Northing: N70°17.915' Easting: W151°00.326' Datum: NAD83

Measurements By: KMH Time: 16:30

Water Depth (ft): 12.20 Ice Thickness (ft): 4.45

Freeboard (ft): 0.40 Snow Depth (ft): 0.35

Elev. (BPMSL): n/a Survey By: n/a Date: n/a Time: n/a

Water Sampling By: n/a Sample Depths BWS (ft): 1 n/a Date: n/a Time: n/a

2 n/a

WATER QUALITY METER INFORMATION 3 n/a

Calibration Information

Parameter (s)	Owner	Meter Make/Model	Serial No.	Pre-Sampling QAQC Check	Post-Sampling QAQC Check
MULTI	GWS	InSitu Troll 9000	33033	Pass	Pass

Parameters	**Field Measurements**									
Time:	16:35	16:38	16:40	16:43	16:45	16:48	16:53	16:56	16:59	17:03
Depth BWS (ft):	3	4	5	6	7	8	9	10	11	12
Temp (°C):	0.43	0.25	0.27	0.62	0.94	1.26	1.50	1.72	2.10	2.26
pH:	7.98	7.77	7.62	7.41	7.36	7.30	7.20	7.10	7.23	7.35
Barometeric (mmHg):	768.5	768.5	768.5	768.4	768.4	768.5	768.5	768.6	768.6	768.6
Pressure (kPa):	7.599	10.273	13.872	16.372	19.121	22.162	25.296	28.274	31.236	34.204
Conductivity (µS/cm):	204.0	202.8	201.1	198.8	197.2	195.9	202.1	203.6	221.8	224.9
RDO (mg/L):	10.55	10.02	9.79	9.68	9.57	9.55	8.75	6.41	4.58	3.09
RDO (%):	72.1	68.3	67.0	66.5	66.5	66.9	61.7	45.6	32.7	22.4
Turbidity (NTU):	0.6	0.6	0.6	0.6	0.7	0.8	1.9	3.8	2.3	1.9

Parameters	**Field Measurements**									
Time:										
Depth BWS (ft):										
Temp (°C):										
pH:										
Barometeric (mmHg):										
Pressure (kPa):										
Conductivity (µS/cm):										
RDO (mg/L):										
RDO (%):										
Turbidity (NTU):										

Remarks: Turbidity data was not verified by calibration check and is listed for informative purposes only.

Field-Form Filled Out By: KMH Date: 3/13/09

QAQC Check By: DAR Date: 3/13/09

Geo-Watersheds Scientific

Form F-004a: Water Quality Field-Sampling General

Project ID: **GWS09G** Site Location/Lake ID: R0066-CT

Sample Purpose: **Lake Water Quality** Date: 3/12/09 Time 10:15

FIELD MEASUREMENTS

GPS Coord. Northing: N70°8.608' Easting: W151°45.740' Datum: NAD83

Measurements By: KMH/DAR Time: 10:20

Water Depth (ft): 9.10 Ice Thickness (ft): 4.65

Freeboard (ft): 0.05 Snow Depth (ft): 0.65

Elev. (BPMSL): n/a Survey By: n/a Date: n/a Time: n/a

Water Sampling By: n/a Sample Depths BWS (ft): 1 n/a Date: n/a Time: n/a

2 n/a

WATER QUALITY METER INFORMATION 3 n/a

Calibration Information

Parameter (s)	Owner	Meter Make/Model	Serial No.	Pre-Sampling QAQC Check	Post-Sampling QAQC Check
MULTI	GWS	InSitu Troll 9000	33033	Pass	Pass

Parameters	**Field Measurements**									
Time:	10:31	10:33	10:35	10:39	10:45	10:48				
Depth BWS (ft):	5	6	7	8	9	BOT				
Temp (°C):	0.46	0.77	1.29	1.84	2.08	2.15				
pH:	7.66	7.58	7.51	7.39	7.29	7.25				
Barometeric (mmHg):	765.6	765.5	765.5	765.5	765.6	765.7				
Pressure (kPa):	13.339	16.239	19.229	22.083	25.060	26.371				
Conductivity (µS/cm):	295.8	294.5	294.8	308.0	315.1	317.8				
RDO (mg/L):	8.33	8.32	8.34	7.15	5.67	5.52				
RDO (%):	57.4	57.7	58.9	51.2	40.9	39.9				
Turbidity (NTU):										

Parameters	**Field Measurements**									
Time:										
Depth BWS (ft):										
Temp (°C):										
pH:										
Barometeric (mmHg):										
Pressure (kPa):										
Conductivity (µS/cm):										
RDO (mg/L):										
RDO (%):										
Turbidity (NTU):										

Remarks:

Field-Form Filled Out By: KMH Date: 3/13/09

QAQC Check By: DAR Date: 3/13/09

Geo-Watersheds Scientific

Form F-004a: Water Quality Field-Sampling General

Project ID: **GWS09G** Site Location/Lake ID: L9811-CT

Sample Purpose: **Lake Water Quality** Date: 3/12/09 Time 11:35

FIELD MEASUREMENTS

GPS Coord. Northing: N70°12.4182' Easting: W151°10.4952' Datum: NAD83

Measurements By: KMH Time: 11:45

Water Depth (ft): 6.60 Ice Thickness (ft): 3.60

Freeboard (ft): 0.05 Snow Depth (ft): 0.80

Elev. (BPMSL): n/a Survey By: n/a Date: n/a Time: n/a

Water Sampling By: n/a Sample Depths BWS (ft): 1 n/a Date: n/a Time: n/a

2 n/a

WATER QUALITY METER INFORMATION 3 n/a

Calibration Information

Parameter (s)	Owner	Meter Make/Model	Serial No.	Pre-Sampling QAQC Check	Post-Sampling QAQC Check
MULTI	GWS	InSitu Troll 9000	33033	Pass	Pass

Parameters	**Field Measurements**									
Time:	12:04	12:07	12:10	12:12						
Depth BWS (ft):	4	5	6	BOT						
Temp (°C):	0.17	0.24	0.65	0.78						
pH:	7.47	7.47	7.46	7.43						
Barometeric (mmHg):	765.3	765.5	765.4	765.4						
Pressure (kPa):	10.281	13.371	16.164	18.954						
Conductivity (µS/cm):	859.7	858.3	855.1	855.5						
RDO (mg/L):	2.29	1.84	1.34	1.25						
RDO (%):	16.1	12.6	9.3	8.7						
Turbidity (NTU):										

Parameters	**Field Measurements**									
Time:										
Depth BWS (ft):										
Temp (°C):										
pH:										
Barometeric (mmHg):										
Pressure (kPa):										
Conductivity (µS/cm):										
RDO (mg/L):										
RDO (%):										
Turbidity (NTU):										

Remarks:

Field-Form Filled Out By: KMH Date: 3/13/09

QAQC Check By: DAR Date: 3/13/09

Geo-Watersheds Scientific

Form F-004a: Water Quality Field-Sampling General

Project ID: **GWS09G** Site Location/Lake ID: L9817-1

Sample Purpose: **Lake Water Quality** Date: 3/12/09 Time 13:00

FIELD MEASUREMENTS

GPS Coord. Northing: N70°14.070' Easting: W151°20.121' Datum: NAD83

Measurements By: KMH Time: 13:10

Water Depth (ft): 8.20 Ice Thickness (ft): 5.28

Freeboard (ft): 0.10 Snow Depth (ft): 0.12

Elev. (BPMSL): n/a Survey By: n/a Date: n/a Time: n/a

Water Sampling By: n/a Sample Depths BWS (ft): 1 n/a Date: n/a Time: n/a

2 n/a

WATER QUALITY METER INFORMATION 3 n/a

Calibration Information

Parameter (s)	Owner	Meter Make/Model	Serial No.	Pre-Sampling QAQC Check	Post-Sampling QAQC Check
MULTI	GWS	InSitu Troll 9000	33033	Pass	Pass

Parameters	**Field Measurements**									
Time:	13:21	13:25	13:28	13:33						
Depth BWS (ft):	6	7	8	BOT						
Temp (°C):	0.08	0.14	1.17	1.39						
pH:	8.51	8.03	7.44	7.44						
Barometeric (mmHg):	765.8	766.0	765.9	765.9						
Pressure (kPa):	16.721	19.237	22.216	23.609						
Conductivity (µS/cm):	749.1	803.8	1004.0	1011.0						
RDO (mg/L):	4.51	3.31	1.27	0.87						
RDO (%):	30.5	23.2	8.9	6.2						
Turbidity (NTU):										

Parameters	**Field Measurements**									
Time:										
Depth BWS (ft):										
Temp (°C):										
pH:										
Barometeric (mmHg):										
Pressure (kPa):										
Conductivity (µS/cm):										
RDO (mg/L):										
RDO (%):										
Turbidity (NTU):										

Remarks:

Field-Form Filled Out By: KMH Date: 3/13/09

QAQC Check By: DAR Date: 3/13/09

Geo-Watersheds Scientific

Form F-004a: Water Quality Field-Sampling General

Project ID: **GWS09G** Site Location/Lake ID: L9312-Raft B

Sample Purpose: **Lake Water Quality** Date: 3/12/09 Time 16:30

FIELD MEASUREMENTS

GPS Coord. Northing: N70°19.995' Easting: W150°56.918' Datum: NAD83

Measurements By: KMH/DAR Time: 16:45

Water Depth (ft): 10.40 Ice Thickness (ft): 4.80

Freeboard (ft): 0.10 Snow Depth (ft): 0.45

Elev. (BPMSL): 7.03 Survey By: LCMF Date: 3/8/09 Time: n/a

Water Sampling By: n/a Sample Depths BWS (ft): 1 n/a Date: n/a Time: n/a

2 n/a

WATER QUALITY METER INFORMATION 3 n/a

Calibration Information

Parameter (s)	Owner	Meter Make/Model	Serial No.	Pre-Sampling QAQC Check	Post-Sampling QAQC Check
MULTI	GWS	InSitu Troll 9000	33033	Pass	Pass

Parameters	**Field Measurements**									
Time:	17:01	17:06	17:09	17:11	17:18	17:23	17:26			
Depth BWS (ft):	5	6	7	8	9	10	BOT			
Temp (°C):	0.32	0.45	1.08	1.30	1.68	2.02	2.11			
pH:	8.05	7.95	7.89	7.82	7.74	7.35	7.19			
Barometeric (mmHg):	767.0	767.0	767.1	767.1	767.1	767.1	767.1			
Pressure (kPa):	13.393	16.287	19.284	22.193	25.181	28.342	30.672			
Conductivity (µS/cm):	150.7	148.9	146.5	145.8	144.6	154.0	166.9			
RDO (mg/L):	11.16	11.11	11.26	11.39	9.96	7.86	6.12			
RDO (%):	76.2	76.3	78.6	-	71.1	-	44.0			
Turbidity (NTU):										

Parameters	**Field Measurements**									
Time:										
Depth BWS (ft):										
Temp (°C):										
pH:										
Barometeric (mmHg):										
Pressure (kPa):										
Conductivity (µS/cm):										
RDO (mg/L):										
RDO (%):										
Turbidity (NTU):										

Remarks: Before sampling, small bubbles were observed rising up to the surface.

Field-Form Filled Out By: KMH Date: 3/13/09

QAQC Check By: DAR Date: 3/13/09

Geo-Watersheds Scientific

Form F-004a: Water Quality Field-Sampling General

Project ID: **GWS09G** Site Location/Lake ID: L9322-CT

Sample Purpose: **Lake Water Quality** Date: 3/13/09 Time 10:20

FIELD MEASUREMENTS

GPS Coord. Northing: N70°20.269' Easting: W151°01.913 Datum: NAD83

Measurements By: KMH Time: 10:25

Water Depth (ft): 10.45 Ice Thickness (ft): 4.30

Freeboard (ft): 0.25 Snow Depth (ft): 0.65

Elev. (BPMSL): 6.64 Survey By: LCMF Date: 3/8/09 Time: n/a

Water Sampling By: n/a Sample Depths BWS (ft): 1 n/a Date: n/a Time: n/a

2 n/a

WATER QUALITY METER INFORMATION 3 n/a

Calibration Information

Parameter (s)	Owner	Meter Make/Model	Serial No.	Pre-Sampling QAQC Check	Post-Sampling QAQC Check
MULTI	GWS	InSitu Troll 9000	33033	Pass	Pass

Parameters	**Field Measurements**									
Time:	10:39	10:45	10:48	10:51	10:53	10:59	11:03			
Depth BWS (ft):	5	6	7	8	9	10	BOT			
Temp (°C):	0.95	0.63	0.97	1.16	1.55	1.84	1.93			
pH:	6.92	6.97	6.96	6.96	6.95	6.91	6.83			
Barometeric (mmHg):	768.3	768.3	768.3	768.3	768.3	768.3	768.4			
Pressure (kPa):	13.373	16.216	20.014	22.291	25.261	28.242	30.532			
Conductivity (µS/cm):	316.5	311.8	306.7	304.5	300.1	300.2	312.3			
RDO (mg/L):	8.54	7.39	7.04	6.96	6.44	4.91	3.91			
RDO (%):	59.6	50.9	48.8	48.7	45.5	35.0	27.9			
Turbidity (NTU):										

Parameters	**Field Measurements**									
Time:										
Depth BWS (ft):										
Temp (°C):										
pH:										
Barometeric (mmHg):										
Pressure (kPa):										
Conductivity (µS/cm):										
RDO (mg/L):										
RDO (%):										
Turbidity (NTU):										

Remarks:

Field-Form Filled Out By: KMH Date: 3/13/09

QAQC Check By: DAR Date: 3/13/09

APPENDIX B. WATER QUALITY METER CALIBRATION FORMS

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

Geo-Watersheds Scientific

Form F-004e: Water Quality Meter Calibration Form

Project ID: **GWS09G** Site Location/Lake ID: MO710, MO802, MO806, L9323

Sample Purpose: **Lake Water Quality**

WATER QUALITY METER INFORMATION

Meter Make: In-Situ Model: Troll 9000

Owner: GWS S/N: 33033

CALIBRATION AND QUALITY ASSURANCE INFORMATION

Pre-Sampling QA

Parameter	Date	Time	Standard	Lot No.	Exp.	Meter Reading	Pass/Fail
pH	3/10/09	18:30	Hach 4.01	#A6230	Aug-07	4.05	Pass
pH	3/10/09	18:30	Hach 10.01	#A8235	Aug-12	10.10	Pass
Conductivity	3/10/09	18:30	Myron Co. 3900 uS	4AC03CB	Nov-07	3930	Pass
RDO - Zero DO	3/10/09	18:30	HANNA HI7040	G1012	Feb-11	nr	na
RDO - 100% DO	3/10/09	18:30	Bubbled Nanopure	na	na	102.3%(10.44 mg/l @ 13.88C/ 767.1 mmHg)	Pass

Post-Sampling QA

Parameter	Date	Time	Standard	Lot No.	Exp.	Meter Reading	Pass/Fail
pH	3/11/09	19:00	Hach 4.01	#A6230	Aug-07	4.00	Pass
pH	3/11/09	19:00	Hach 10.01	#A8235	Aug-12	9.96	Pass
Conductivity	3/11/09	19:00	Myron Co. 3900 uS	4AC03CB	Nov-07	3899	Pass
RDO - Zero DO	3/11/09	19:00	HANNA HI7040	G1012	Feb-11	0.4% (0.05 mg/l @ 10.44C/ 768.3 mmHg)	Pass
RDO - 100% DO	3/11/09	19:00	Bubbled Nanopure	na	na	97.9% (9.94 mg/l @ 15.11C/ 768.3 mmHg)	Pass

Remarks:

Field-Form Filled Out By: Holland Date: 3/14/2009

QAQC Check By: Reichardt Date: 3/14/2009

Geo-Watersheds Scientific

Form F-004e: Water Quality Meter Calibration Form

Project ID: **GWS09G** Site Location/Lake ID: R0066, L9811, L9817, L9312

Sample Purpose: **Lake Water Quality**

WATER QUALITY METER INFORMATION

Meter Make: In-Situ Model: Troll 9000

Owner: GWS S/N: 33033

CALIBRATION AND QUALITY ASSURANCE INFORMATION

Pre-Sampling QA

Parameter	Date	Time	Standard	Lot No.	Exp.	Meter Reading	Pass/Fail
pH	3/11/09	19:00	Hach 4.01	#A6230	Aug-07	4.00	Pass
pH	3/11/09	19:00	Hach 10.01	#A8235	Aug-12	9.96	Pass
Conductivity	3/11/09	19:00	Myron Co. 3900 uS	4AC03CB	Nov-07	3899	Pass
RDO - Zero DO	3/11/09	19:00	HANNA HI7040	G1012	Feb-11	0.4% (0.05 mg/l @ 10.44C/ 768.3 mmHg)	Pass
RDO - 100% DO	3/11/09	19:00	Bubbled Nanopure	na	na	97.9% (9.94 mg/l @ 15.11C/ 768.3 mmHg)	Pass

Post-Sampling QA

Parameter	Date	Time	Standard	Lot No.	Exp.	Meter Reading	Pass/Fail
pH	3/13/09	7:30	Hach 4.01	#A6230	Aug-07	4.02	Pass
pH	3/13/09	7:30	Hach 10.01	#A8235	Aug-12	9.98	Pass
Conductivity	3/13/09	7:30	Myron Co. 3900 uS	4AC03CB	Nov-07	3713	Pass
RDO - Zero DO	3/13/09	7:30	HANNA HI7040	G1012	Feb-11	0.4% (0.05 mg/l @ 8.41C/ 767.5 mmHg)	Pass
RDO - 100% DO	3/13/09	7:30	Bubbled Nanopure	na	na	100% (10.44 mg/l @ 13.88C/ 767.1 mmHg)	Pass

Remarks:

Field-Form Filled Out By: Holland Date: 3/14/2009

QAQC Check By: Reichardt Date: 3/14/2009

Geo-Watersheds Scientific

Form F-004e: Water Quality Meter Calibration Form

Project ID: **GWS09G** Site Location/Lake ID: MO710, MO802, MO806, L9323

Sample Purpose: **Lake Water Quality**

WATER QUALITY METER INFORMATION

Meter Make: In-Situ Model: Troll 9000

Owner: GWS S/N: 33033

CALIBRATION AND QUALITY ASSURANCE INFORMATION

Pre-Sampling QA

Parameter	Date	Time	Standard	Lot No.	Exp.	Meter Reading	Pass/Fail
pH	3/13/09	7:30	Hach 4.01	#A6230	Aug-07	4.02	Pass
pH	3/13/09	7:30	Hach 10.01	#A8235	Aug-12	9.98	Pass
Conductivity	3/13/09	7:30	Myron Co. 3900 uS	4AC03CB	Nov-07	3713	Pass
RDO - Zero DO	3/13/09	7:30	HANNA HI7040	G1012	Feb-11	0.4% (0.05 mg/l @ 8.41C/ 767.5 mmHg)	Pass
RDO - 100% DO	3/13/09	7:30	Bubbled Nanopure	na	na	100% (10.44 mg/l @ 13.88C/ 767.1 mmHg)	Pass

Post-Sampling QA

Parameter	Date	Time	Standard	Lot No.	Exp.	Meter Reading	Pass/Fail
pH	3/13/09	12:20	Hach 4.01	#A6230	Aug-07	4.08	Pass
pH	3/13/09	12:20	Hach 10.01	#A8235	Aug-12	10.08	Pass
Conductivity	3/13/09	12:20	Myron Co. 3900 uS	4AC03CB	Nov-07	3604	Pass
RDO - Zero DO	3/13/09	12:20	HANNA HI7040	G1012	Feb-11	0.7% (0.08 mg/l @ 10.50C/ 767.3 mmHg)	Pass
RDO - 100% DO	3/13/09	12:20	Bubbled Nanopure	na	na	104.6% (11.05 mg/l @ 13.25C/ 767.3 mmHg)	Pass

Remarks:

Field-Form Filled Out By: Holland Date: 3/14/2009

QAQC Check By: Reichardt Date: 3/14/2009

Geo-Watersheds Scientific

Form F-004e: Water Quality Meter Calibration Form

Project ID: **GWS09G** Site Location/Lake ID: standard verification (final check)

Sample Purpose: **Lake Water Quality**

WATER QUALITY METER INFORMATION

Meter Make: In-Situ Model: Troll 9000

Owner: GWS S/N: 33033

CALIBRATION AND QUALITY ASSURANCE INFORMATION

Pre-Sampling QA

Parameter	Date	Time	Standard	Lot No.	Exp.	Meter Reading	Pass/Fail
pH	3/18/09	13:30	Oakton 4.01	2403214	Mar-06	4.06 @ 17.9C	Pass
pH	3/18/09	13:30	Oakton 10.01	2402122	Aug-05	10.21@ 18.7C	Pass

Post-Sampling QA

Parameter	Date	Time	Standard	Lot No.	Exp.	Meter Reading	Pass/Fail
pH	3/18/09	13:30	Oakton 4.01	2809533	Sep-10	4.04 @ 20C	Pass
pH	3/18/09	13:30	Oakton 7.00	2810392	Oct-10	7.08 @ 20C	Pass
pH	3/18/09	13:30	Oakton 10.01	2805007	Oct-09	10.20 @ 20C	Pass
Conductivity	3/18/09	13:30	Oakton 447 uS	2811332	Nov-09	450.4	Pass

Remarks: Compared individual expired standards used on field trip with non-expired standards. pH readings pass/fail based on temperature. 4.01 at 10C or 20C should read 4.00. 7.00 at 20C should read 7.01. 10.01 at 10C should read 10.18 and at 20C should read 10.06. Based on these criteria, all standards pass the QAQC standards set by the project and all pH data collected should be considered validated.

Field-Form Filled Out By: Holland Date: 3/18/2009

QAQC Check By: Reichardt Date: 3/19/2009

APPENDIX C. SNOW SURVEY FORMS

The following forms report the snow survey information obtained during field sampling.

Geo-Watersheds Scientific

Form F-012: Snow Depth and Water Content Survey Form

Project ID:	**GWS09G**	Site Location/Lake ID:	**MO806-CT**
Survey Purpose:	**Determine snow water equivalent**	Date: 3/11/2009	Time: 14:30

Location Description:	Snow course is from center of the lake, 25 meters West x 25 meters South				
Survey objective:	Determine Snow Water Equivalent			Weather Observations:	-5°F, 15mph East Wind, Sunny
Latitude:	N70°8.186'	Longitude:	W151°23.756'	Datum:	NAD83
Elevation:	Approximately 109	Elevation Datum:	BPMSL	Reference Markers:	Orange snow poles
Drainage Basin:	Lake MO806	Slope Direction:	Flat	Vegetation Type:	Ice
Slope Angle:	0°	Access Notes:		Other:	
Snow Depth Probe Type:		T-handle probe		Snow-Survey Team Names	
Snow Tube Type:	Arinodack snow tube			Toniolo, Reichardt	

Snow Course Depths, in cm.

	1	2	3	4	5
1	19.0	13.0	21.5	26.0	22.0
2	21.0	15.0	27.0	26.0	15.5
3	21.0	19.5	29.5	29.0	14.0
4	23.5	16.0	34.0	24.0	18.5
5	25.0	14.0	32.0	21.5	21.0
6	28.0	16.0	29.0	27.0	25.0
7	23.0	18.5	25.0	31.5	26.0
8	21.0	24.0	23.5	32.0	28.0
9	23.5	21.0	24.0	32.0	26.0
10	19.0	39.5	23.5	27.0	25.5

	(cm)
Average snow depth =	**23.7**
Maximum snow depth =	39.5
Minimum snow depth =	13.0
Standard variation =	5.6

Snow Sample Depths and Weights

Bag #	Depth (cm)	Weight (gr)	Volume (cm^3)	Density (gr/cm^3)
B1	16	210.0	571.2	0.37
B2	15	222.3	535.5	0.42
B3	30	440.3	1071.0	0.41
B4	21	255.4	749.7	0.34
B5	14	192.9	499.8	0.39

Average Density =	**0.38**	
Average Snow Water Equivalent (SWE) =	**9.1**	cm H2O
Average Snow Water Equivalent =	**3.59**	inches H2O
Average Snow Water Equivalent =	**0.30**	feet H2O

SWE = avg. snow depth*(density snow/density water)

Geo-Watersheds Scientific

Form F-012: Snow Depth and Water Content Survey Form

Project ID:	**GWS09G**	Site Location/Lake ID:	**MO802-CT**
Survey Purpose:	**Determine snow water equivalent**	Date: 3/11/2009	Time: 11:20

Location Description:	Snow course is from center of the lake, 25 meters West x 25 meters South				
Survey objective:	Determine Snow Water Equivalent			Weather Observations:	-18°F, 20mph East Wind, Sunny
Latitude:	N70°9.523'	Longitude:	W151°15.092'	Datum:	NAD83
Elevation:	Approximately 98 ft	Elevation Datum:	BPMSL	Reference Markers:	Orange snow poles
Drainage Basin:	Lake MO802	Slope Direction:	Flat	Vegetation Type:	Ice
Slope Angle:	0°	Access Notes:		Other:	
Snow Depth Probe Type:		T-handle probe		Snow-Survey Team Names	
Snow Tube Type:	Arinodack snow tube			Toniolo, Reichardt	

Snow Course Depths, in cm.

	1	2	3	4	5
1	28.0	38.0	24.0	29.0	42.0
2	23.5	32.0	19.0	33.0	38.0
3	23.0	30.0	18.5	34.0	31.0
4	25.0	33.0	26.0	33.0	23.0
5	36.0	27.0	17.0	35.5	26.0
6	36.5	26.5	17.0	35.0	33.0
7	36.0	24.5	25.0	36.0	29.0
8	40.0	28.0	20.0	32.5	30.5
9	40.0	21.0	27.5	51.0	39.0
10	39.0	22.5	32.0	46.0	46.0

	(cm)
Average snow depth =	**30.8**
Maximum snow depth =	51.0
Minimum snow depth =	17.0
Standard variation =	7.8

Snow Sample Depths and Weights

Bag #	Depth (cm)	Weight (gr)	Volume (cm^3)	Density (gr/cm^3)
A1	22	368.1	785.4	0.47
A2	31	480.3	1106.7	0.43
A3	35	455.3	1249.5	0.36
A4	32	418.4	1142.4	0.37
A5	23	282.7	821.1	0.34

Average Density =	**0.40**	
Average Snow Water Equivalent (SWE) =	**12.2**	cm H2O
Average Snow Water Equivalent =	**4.79**	inches H2O
Average Snow Water Equivalent =	**0.40**	feet H2O

SWE = avg. snow depth*(density snow/density water)

Geo-Watersheds Scientific
Form F-012: Snow Depth and Water Content Survey Form

Project ID: **GWS09G** Site Location/Lake ID: **L9817**
Survey Purpose: **Determine snow water equivalent** Date: 3/12/2009 Time: 13:00

Location Description:	Started near L9817 water sampling location. Travelled 25 paces, turned left 90° and travelled 25 paces to end point.				
Survey objective:	Determine Snow Water Equivalent			Weather Observations:	Very Windy, -18F, Wind Chill -46F
Latitude:	N 70° 14.070'	Longitude:	W 151° 20.121'	Datum:	NAD 83
Elevation:	94 ft (approximately)	Elevation Datum:	BPMSL	Reference Markers:	
Drainage Basin:	Lake L9817	Slope Direction:	Flat	Vegetation Type:	Ice
Slope Angle:	Flat	Access Notes:	Haglund	Other:	
Snow Depth Probe Type:		T-handle probe		Snow-Survey Team Names	
Snow Tube Type:	Arinodack snow tube			Dan Reichardt and Horacio Toniolo	

Snow Course Depths, in cm.

	1	2	3	4	5
1	0.0	0.0	5.0	9.0	5.0
2	0.0	0.0	3.0	8.0	7.0
3	0.0	0.0	6.0	7.0	9.0
4	0.0	2.0	10.0	7.0	3.0
5	0.0	6.0	6.0	8.0	6.0
6	0.0	10.0	8.0	5.0	4.0
7	0.0	4.0	11.0	4.0	11.0
8	0.0	0.0	13.0	3.0	10.0
9	0.0	0.0	11.0	10.0	10.0
10	0.0	1.0	7.0	11.0	10.0

	(cm)
Average snow depth =	**5.0**
Maximum snow depth =	13.0
Minimum snow depth =	0.0
Standard variation =	4.2

Snow Sample Depths and Weights

Bag #	Depth (cm)	Weight (gr)	Volume (cm^3)	Density (gr/cm^3)
E-1	9	125.9	321.3	0.39
E-2	2	32.8	71.4	0.46
E-3	3	48.9	107.1	0.46
E-4	10	112.4	357.0	0.31
E-5	8	96.4	285.6	0.34

Average Density = **0.39**
Average Snow Water Equivalent (SWE) = **2.0** cm H2O
Average Snow Water Equivalent = **0.77** inches H2O
Average Snow Water Equivalent = **0.06** feet H2O

SWE = avg. snow depth*(density snow/density water)

Geo-Watersheds Scientific
Form F-012: Snow Depth and Water Content Survey Form

Project ID: **GWS09G** Site Location/Lake ID: **L9811-CT**
Survey Purpose: **Determine snow water equivalent** Date: 3/12/2009 Time: 12:00

Location Description:	At center of lake, proceed West 25 meters x South 25 meters.				
Survey objective:	Determine Snow Water Equivalent			Weather Observations:	-15°F, 20mph East Wind, Sunny
Latitude:	N70°12.4182'	Longitude:	W151°10.4952'	Datum:	NAD83
Elevation:	approximately 100'	Elevation Datum:	BPMSL	Reference Markers:	n/a
Drainage Basin:	Lake L9811	Slope Direction:	flat	Vegetation Type:	ice
Slope Angle:	0°	Access Notes:		Other:	
Snow Depth Probe Type:		T-handle probe		Snow-Survey Team Names	
Snow Tube Type:	Arinodack snow tube			Reichardt, Toniolo	

Snow Course Depths, in cm.

	1	2	3	4	5
1	24.0	14.0	14.0	17.0	16.0
2	26.0	6.0	13.0	23.0	13.0
3	27.0	21.0	11.0	18.0	12.0
4	27.0	21.0	10.0	21.0	18.0
5	21.0	19.0	13.0	21.0	21.0
6	10.0	17.0	12.0	21.0	20.0
7	10.0	13.0	9.0	19.0	23.0
8	11.0	13.0	10.0	15.0	17.0
9	19.0	17.0	12.0	18.0	18.0
10	10.0	13.0	4.0	15.0	24.0

	(cm)
Average snow depth =	**16.3**
Maximum snow depth =	27.0
Minimum snow depth =	4.0
Standard variation =	5.4

Snow Sample Depths and Weights

Bag #	Depth (cm)	Weight (gr)	Volume (cm^3)	Density (gr/cm^3)
A1	22	188.6	785.4	0.24
A2	31	314.6	1106.7	0.28
A3	24	267.5	856.8	0.31
A4	15	147.0	535.5	0.27
A5	18	199.2	642.6	0.31

Average Density = **0.28**
Average Snow Water Equivalent (SWE) = **4.6** cm H2O
Average Snow Water Equivalent = **1.83** inches H2O
Average Snow Water Equivalent = **0.15** feet H2O

SWE = avg. snow depth*(density snow/density water)

Geo-Watersheds Scientific
Form F-012: Snow Depth and Water Content Survey Form

Project ID: **GWS09G** Site Location/Lake ID: **L9322-CT**
Survey Purpose: **Determine snow water equivalent** Date: 3/13/2009 Time: 10:30

Location Description:	At center of lake, proceed West 25 meters x South 25 meters.				
Survey objective:	Determine Snow Water Equivalent			Weather Observations:	-20°F, 5mph East Wind, Sunny
Latitude:	N70°20.269'	Longitude:	W151°01.913'	Datum:	NAD83
Elevation:	approximately 7'	Elevation Datum:	BPMSL	Reference Markers:	n/a
Drainage Basin:	LakeL9322	Slope Direction:	flat	Vegetation Type:	ice
Slope Angle:	0°	Access Notes:		Other:	
Snow Depth Probe Type:		T-handle probe		Snow-Survey Team Names	
Snow Tube Type:	Arinodack snow tube			Reichardt, Toniolo	

Snow Course Depths, in cm.

	1	2	3	4	5
1	32.0	35.5	12.0	34.0	29.0
2	33.0	33.0	13.0	26.0	24.0
3	34.5	26.0	8.5	29.0	18.5
4	35.0	19.0	16.0	28.0	15.0
5	36.0	18.0	16.0	24.5	15.5
6	31.5	22.0	13.5	27.0	22.0
7	23.0	23.0	9.0	25.0	36.5
8	31.0	24.0	26.5	25.5	36.5
9	32.0	19.0	34.0	39.0	33.0
10	35.0	11.0	40.0	34.0	26.0

	(cm)
Average snow depth =	**25.8**
Maximum snow depth =	40.0
Minimum snow depth =	8.5
Standard variation =	8.5

Snow Sample Depths and Weights

Bag #	Depth (cm)	Weight (gr)	Volume (cm^3)	Density (gr/cm^3)
F1	36	424.4	1285.2	0.33
F2	31	352.1	1106.7	0.32
F3	20	232.0	714.0	0.32
F4	45	390.0	1606.5	0.24
F5	12	139.7	428.4	0.33

Average Density =	**0.31**	
Average Snow Water Equivalent (SWE) =	**8.0**	cm H2O
Average Snow Water Equivalent =	**3.13**	inches H2O
Average Snow Water Equivalent =	**0.26**	feet H2O

SWE = avg. snow depth*(density snow/density water)

Geo-Watersheds Scientific
Form F-012: Snow Depth and Water Content Survey Form

Project ID: **GWS09G** Site Location/Lake ID: **L9312-WxStation**
Survey Purpose: **Determine snow water equivalent** Date: 3/12/2009 Time: 17:00

Location Description:	North of weather station at L9312. Start at east snow pole, transect goes 25 m west x 25 m North. See L9312 WxSta Snow 070922.JPG for layout.				
Survey objective:	Determine Snow Water Equivalent			Weather Observations:	-18°F, 20mph East Wind, Sunny
Latitude:	N70°20.019'	Longitude:	W150°57.134'	Datum:	NAD83
Elevation:	Approximately 10 ft	Elevation Datum:	BPMSL	Reference Markers:	Orange snow poles
Drainage Basin:	Lake L9312	Slope Direction:	East	Vegetation Type:	Tussuck tundra
Slope Angle:	2°	Access Notes:		Other:	
Snow Depth Probe Type:		T-handle probe		Snow-Survey Team Names	
Snow Tube Type:	Arinodack snow tube			Reichardt, Toniolo, Holland	

Snow Course Depths, in cm.

	1	2	3	4	5
1	74.0	51.0	20.0	41.0	44.0
2	65.0	53.0	27.0	51.0	37.0
3	54.0	55.0	55.0	41.0	35.0
4	46.0	60.0	68.0	34.0	35.0
5	41.0	59.0	24.0	25.0	36.0
6	41.5	63.0	45.0	23.0	44.0
7	23.0	59.0	45.5	36.0	68.0
8	26.0	47.0	43.0	34.0	43.0
9	37.0	35.0	45.5	46.0	37.0
10	45.0	23.0	42.0	43.0	39.5

	(cm)
Average snow depth =	**43.3**
Maximum snow depth =	74.0
Minimum snow depth =	20.0
Standard variation =	12.9

Snow Sample Depths and Weights

Bag #	Depth (cm)	Weight (gr)	Volume (cm^3)	Density (gr/cm^3)
F1	42	495.4	1499.4	0.33
F2	58	715.8	2070.6	0.35
F3	38	441.3	1356.6	0.33
F4	22	184.0	785.4	0.23
F5	31	336.4	1106.7	0.30

Average Density = **0.31**
Average Snow Water Equivalent (SWE) = **13.3** cm H2O
Average Snow Water Equivalent = **5.25** inches H2O
Average Snow Water Equivalent = **0.44** feet H2O

SWE = avg. snow depth*(density snow/density water)

Geo-Watersheds Scientific
Form F-012: Snow Depth and Water Content Survey Form

Project ID: **GWS09G** Site Location/Lake ID: **R0066-CT**
Survey Purpose: **Determine snow water equivalent** Date: 3/12/2009 Time: 10:40

Location Description:	Snow course is from center of the lake, 25 meters West x 25 meters South				
Survey objective:	Determine Snow Water Equivalent			Weather Observations:	-18°F, 20mph East Wind, Sunny
Latitude:	N70°08.608'	Longitude:	W151°45.740'	Datum:	NAD83
Elevation:	Approximately 94 ft	Elevation Datum:	BPMSL	Reference Markers:	Orange snow poles
Drainage Basin:	Lake R0066	Slope Direction:	Flat	Vegetation Type:	Ice
Slope Angle:	0°	Access Notes:		Other:	
Snow Depth Probe Type:		T-handle probe		Snow-Survey Team Names	
Snow Tube Type:	Arinodack snow tube			Toniolo, Reichardt	

Snow Course Depths, in cm.

	1	2	3	4	5
1	16.0	15.0	14.0	17.0	24.0
2	21.0	17.0	17.0	12.0	25.0
3	29.0	14.0	21.0	14.0	27.0
4	26.0	10.0	19.0	17.0	25.0
5	15.0	15.0	18.0	17.0	17.0
6	11.0	14.0	20.0	12.0	21.0
7	15.0	20.0	17.0	16.0	17.0
8	18.0	26.0	13.0	19.0	18.0
9	16.0	27.0	13.0	20.0	16.0
10	14.0	23.0	29.0	23.0	20.0

	(cm)
Average snow depth =	**18.4**
Maximum snow depth =	29.0
Minimum snow depth =	10.0
Standard variation =	4.8

Snow Sample Depths and Weights

Bag #	Depth (cm)	Weight (gr)	Volume (cm^3)	Density (gr/cm^3)
D1	24	330.0	856.8	0.39
D2	12	143.9	428.4	0.34
D3	22	290.7	785.4	0.37
D4	25	323.6	892.5	0.36
D5	18	234.2	642.6	0.36

Average Density = **0.36**
Average Snow Water Equivalent (SWE) = **6.7** cm H2O
Average Snow Water Equivalent = **2.63** inches H2O
Average Snow Water Equivalent = **0.22** feet H2O

SWE = avg. snow depth*(density snow/density water)