North Slope, Alaska, Snow-Course and Lake Survey Data: December 2009

T-probe next to vertical snow profile at L9312 snow-course site near Alpine, photo by Michael Lilly.

by

Jeff Derry, Kristie Hilton, Horacio Toniolo, and Michael Lilly

January 2010

Arctic Transportation Networks Project

Report GWS.TR.09.07

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Jeff Derry[1], Kristie Hilton[1], Horacio Toniolo[2], Michael Lilly[1]

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- U.S. Department of Energy
- National Energy Technology Laboratory
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January 2010

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DISCLAIMER

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. Common regulations related to tundra travel and water use on the North Slope, Alaska, use combinations of both English and SI units. 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, snow depth was reported in inches (in) followed by the value in centimeters (cm) 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

Snow Water Equivalent (SWE):

Water content of a given column of snow is determined by knowing the depth of the snowpack and density.

$$SWE = d_s * \rho_s \ / \ p_w$$

where:

d_s = snow depth

ρ_s = snow density

p_w = density of water.

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:

Error! Bookmark not defined. $SC25 = \dfrac{AC}{1 + r(T - 25)}$

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).

Millivolt (mV):
A unit of electromotive force equal to one thousandth of a volt.

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 North American Datum of 1927.

Abbreviations, Acronyms, and Symbols

AC	Actual conductivity
ADOT&PF	Alaska Department of Transportation and Public Facilities
ADNR	Alaska Department of Natural Resources
ASTM	American Society for Testing and Materials
atm	Atmospheres
ATN	Arctic Transportation Networks
C	Celsius (^oC)
cm	Centimeters
DO	Dissolved oxygen
DVM	Digital voltage multi-meter
F	Fahrenheit (^oF)
ft	Feet
GWS	Geo-Watersheds Scientific
in	Inches
kg	Kilograms
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
NRCS	Natural Resources Conservation Service
NWIS	National Water Information System
ORP	Oxygen-reduction potential
ppm	Parts per million
QA	Quality assurance
QC	Quality control
Sag	Sagavanirktok River
SC25	Specific conductance at 25^oC
SWE	Snow water equivalent
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

PROJECT COOPERATORS

The Arctic Transportation Network project covers a large area of the North Slope and benefits from a number of positive partnerships, all contributing to the overall project objectives.

- U.S. Department of Energy, National Energy Technology Laboratory (NETL)
- ConocoPhillips Alaska, Inc. (CPA)
- Bureau of Land Management
- Alaska Department of Natural Resources
- The Nature Conservancy
- Northern Alaska Environmental Center
- North Slope Borough
- National Weather Service
- Geo-Watersheds Scientific
- University of Alaska-Fairbanks
- Idaho National Laboratory

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This material is based upon work supported by the U.S. Department of Energy [National Energy and Technology Laboratory] under Award Number DE-FE0001240. Field coordination and logistics support were provided by ConocoPhillips Alaska. Additional support was provided by other project cooperators, North Slope Borough, Bureau of Land Management, National Weather Service, and Geo-Watersheds Scientific, in the form of financial and in-kind match. Department of Natural Resources provided data and supporting information for snow survey sites in the study area.

North Slope, Alaska, Snow-Course and Lake Survey Data: December 2009

INTRODUCTION

Geo-Watersheds Scientific (GWS), University of Alaska Fairbanks (UAF), and Idaho National Laboratory (INL), together with project cooperators, initiated a study in October 2009 to collect field data for the development of management tools for various aspects of Arctic Transportation Networks (ATN). Some of the variables collected include data from 10 meteorological and lake stations (such as snow-depth, air and soil temperatures, unfrozen soil moisture, precipitation, wind and radiation data). Data is also collected at selected lakes and reservoirs. Lake data may include snow depth and density data, water-quality and water-level measurements and general observations of watershed conditions.

Snow depth is considered an important variable by regulatory agencies, since tundra travel operations in the Coastal Tundra Area can only commence once a spatially consistent snow depth of 6 in (15 cm) in the coastal plain management areas, or 9 in (23 cm) in the Foothills management areas is maintained. Soil temperatures are also used to manage tundra travel. The soil temperature must reach 23° F (-5°C) at a depth of 12 in (30 cm) (Bader, 2004) to meet tundra travel management criteria. The intent of the soil temperature criteria is to ensure frozen soil strengths are adequate in terms of reaching maximum soil strength. Many meteorological factors determine when these conditions will be met. An established network of meteorological stations and increased manual snow measurements – both amount collected and number of sites visited – will improve the understanding of the timing and amount of snow distribution and will assist in the development of predictive and management tools.

TRIP OBJECTIVES

The December field effort was primarily focused on conducting snow-courses and verification of weather station snow-sensor operations. Snow sampling was performed at ATN project sampling sites as well as co-located with Alaska Department of Natural Resources (ADNR) sites (Figure 1 and Figure 2). Concurrent with these activities, 2L-Pad station installation continued, 2M station sensor upgrades began, and Kuparuk Network Base Station testing and upgrades were performed. A workplan was published prior to the December field campaign containing a site-by-site list of objectives (Derry et al. 2009a). Selected project objectives include the following:

1. 2L-Pad Station
   - Conduct snow-course.

2. Meltwater 19 (2P-Pad)
   - Conduct snow-course.

3. Betty Pingo
   - Station inspection; verification of snow-depth under NRCS Judd sensors.
   - Conduct snow-course.
   - Download NRCS station data, record Wyoming gauge level.

4. L9312
   - Collect lake ice information, survey water levels
   - Station inspection/maintenance.
   - Replace SR50 sensor.
   - Conduct snow-course on tundra and lake sites.

5. Toolik
   - NRCS-Soil snow-course.
   - ADOT Sag River Camp snow-course.

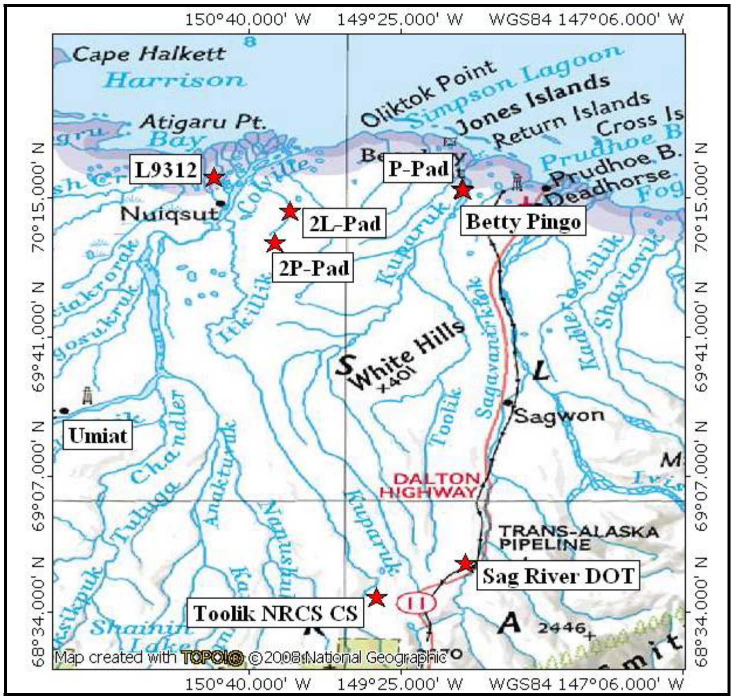

Figure 1. ATN Snow-course locations visited in December. Red stars indicate general locations. Some sites are close enough that symbols overlap.

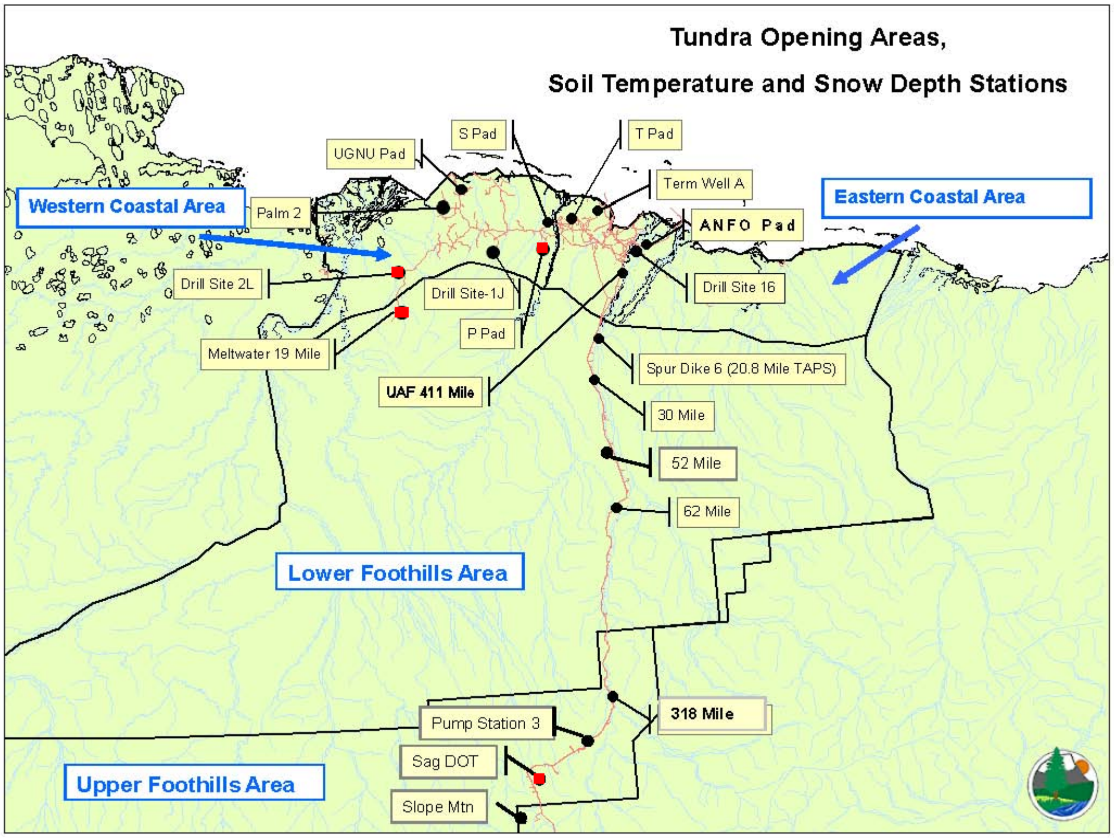

Figure 2. Map of ADNR snow and soil temperature sampling sites (ADNR, 2009). Sites marked in red were visited by ATN participants during the December field campaign to measure co-located snow-courses.

PROCEDURES

Snow-depth measurements were conducted in "L" shaped patterns on lake surfaces and/or tundra surfaces at predetermined locations according to ATN snow measurement methods (Derry et al. 2009b). Snow-depth measurements were taken approximately every 3.3 ft (1 m) for 82 ft (25 m), then turning 90 degrees, and continuing for another 82 ft (25 m). Snow samples were also collected for density measurements with an Adirondack snow sampler. Five densities were collected at each location and averaged to establish a representative density. A number of sampling sites are co-located with ADNR snow and soil sampling sites to compare sampling methods. The ADNR method involves collecting 20 depth measurements along a transect spaced at 1.5 ft (0.5 m) increments and two density measurements collected with a Federal Sampler (Derry et al. 2009b). The intent of co-located sites is to provide data for ADNR and ATN project staff to compare measurement methods at representative sites.

At Lake L9312, 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.

SELECTED RESULTS

Snow courses were conducted at eight different locations during the December trip. Four sites are co-located with ADNR sampling sites (Table 1).

Table 1. December snow sampling locations, locations in bold indicate site is co-located with ADNR snow and soil temperature sampling sites.

Station	Elevation Ft	North Latitude NAD 83	West Longitude NAD 83
Meltwater 19 (2P-Pad)	200	70° 03.853'	150° 26.779'
DS-2L (ASTAC)	112	70° 11.481'	150° 19.397'
P-Pad	10	70° 16.967'	148° 54.807'
Sag River DOT	1,630	68° 45.686'	148° 52.746'
Betty Pingo (NRCS Site)	10	70° 16.772'	148° 53.741'
L9312-Tundra Surface	7	70° 19.995'	150° 56.918'
L9312-Lake Surface	7	70° 20.008'	150° 57.083'
NRCS Soil Monitoring Site (Toolik Camp)	2,362	68° 37.366'	149° 36.598'

At the beginning of December more snow accumulation was seen at P-pad compared to Meltwater 19 and 2L-pad (Table 2, 3). More snow accumulation was seen at L9312 in the Alpine area to the west than at sample sites in the Kuparuk field area to the east (Table 2). Freezing sleet was observed in the Kuparuk field area with impacts on upper snow surface seen at P-Pad and Betty Pingo. No sign of desiccation at the bottom of the snowpack in Alpine or Kuparuk areas was observed, except in areas of shallow snow above tops of tussocks or polygon ridges.

Coinciding with observations of near freezing temperatures with drizzle on December 10 between Toolik Camp and Oil Spill Hill – which likely consolidated the snowpack – snow depths in the foothill region were reduced by approximately 1 in (2.5 cm) at Toolik Camp (Table 2), 2 in (5.1 cm) at Slope Mountain, and 1 in (2.5 cm) at Sag River DOT (Table 4) compared to depths collected 1-2 weeks earlier. The ADNR snow course average depth measurements for each site were averaged together for each region to compare the regional variation during November and December. ADNR does not use an average of the sites in a region to open tundra travel in any particular region. Effects of warmer temperatures in early December can be seen in the reduction of snow depths at all ADNR defined regions except the Lower Foothills (Figure 3). The dates used in the below figure are taken from the middle of each measurement period. The warm conditions in early December likely resulted in a significant delay in tundra travel opening in the coastal management regions.

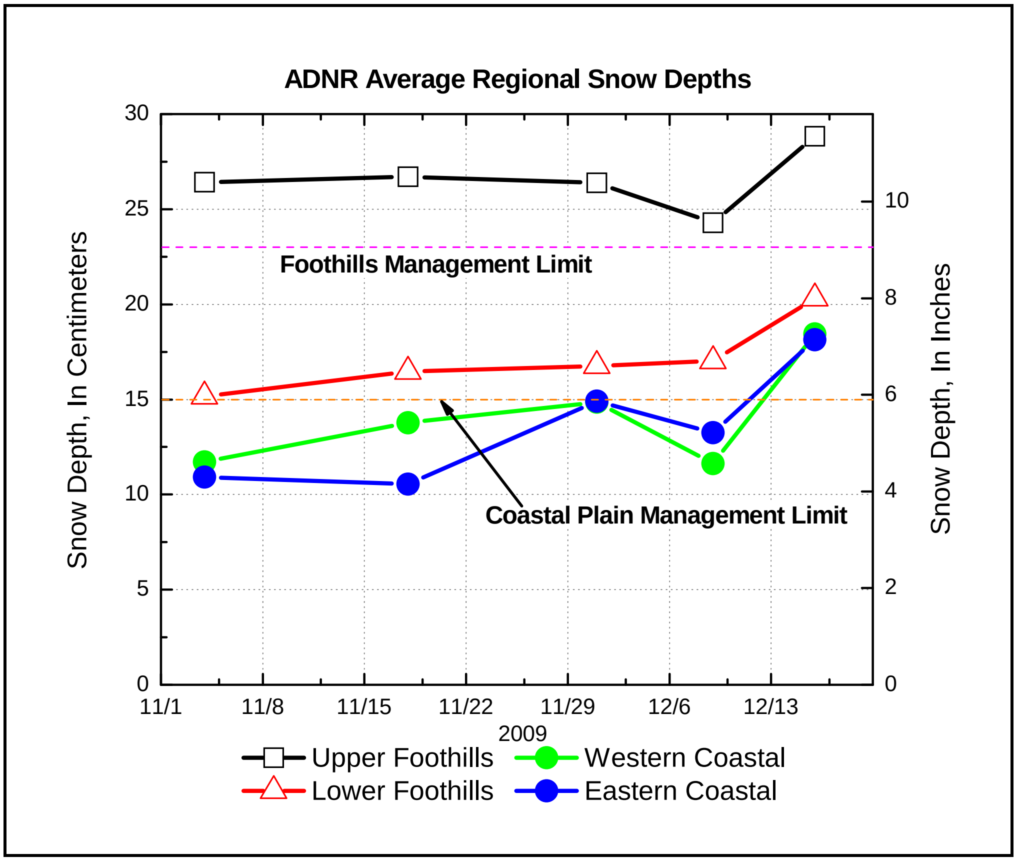

Figure 3. Regional average snow depth (snow-depth average of all sites in each region) for ADNR field collection campaigns November 4 – December 16, 2009.

Table 2. Average snow depth, density and SWE for all locations visited by ATN personnel in December.

	Sag River DOT		Meltwater19 (2P Pad)		P Pad		DS-2L (ASTAC)		Betty Pingo (NRCS Site)		L9312-Tundra Surface		L9312-Lake Surface		NRCS Climate Station (Toolik Camp)	
	in	cm	in	cm	in	cm	in	cm	in	cm	in	cm	in	cm	in	cm
Depth	10.3	26.2	6.3	15.9	7.9	20.0	6.5	16.4	7.2	18.2	10.6	27.0	3.6	9.2	9.6	24.3
Density	0.22		0.28		0.28		0.23		0.28		0.29		0.34		0.20	
SWE	2.2	5.7	1.7	4.4	2.2	5.5	1.5	3.7	2.0	5.1	3.0	7.7	1.2	3.2	1.9	4.7

Table 3. Summary of average depth, average density, and average SWE for measurements taken by ADNR at snow sampling sites from November 2-December 18, 2009.

	Nov 2 - 6			Nov 16 - 20			Nov 30 - Dec 4			Dec 7 - 11			Dec 14 - 18		
	Depth (in)	Density (g/cm^3)	SWE (in)	Depth (in)	Density (g/cm^3)	SWE (in)	Depth (in)	Density (g/cm^3)	SWE (in)	Depth (in)	Density (g/cm^3)	SWE (in)	Depth (in)	Density (g/cm^3)	SWE (in)
Eastern Coastal Area															
ANFO Pad	2.1			3.0	0.40	1.2	4.1	0.24	1.0	3.4	0.34	1.1	6.6	0.32	2.4
DS 16	5.7	0.35	2.1	5.4	0.45	3.3	6.9	0.34	2.4	5.9	0.31	2.0	8.7	0.32	3.2
UAF 411 mi	4.3	0.20	0.9	4.5	0.24	1.5	9.7	0.28	2.2	7.1	0.33	2.9	6.7	0.25	1.6
Term Well A	5.8	0.26	2.2	3.8	0.21	0.8	4.8	0.23	1.1	4.9	0.25	1.3	6.1	0.24	1.2
P Pad	4.1	0.19	0.9	4.3	0.23	0.9	4.9	0.13	0.6	6.1	0.28	1.8	9.5	0.30	2.8
T Pad	3.9	0.23	1.1	3.9	0.30	1.4	5.0	0.23	1.2	3.9	0.14	0.7	5.5	0.33	3.2
Area Averages	4.3	0.24	1.4	4.2	0.30	1.5	5.9	0.24	1.4	5.2	0.27	1.6	7.1	0.29	2.4
Western Coastal Area															
S Pad	4.1			5.5	0.39	2.3	5.3	0.19	0.9	4.0	0.19	0.9	6.3	0.24	1.3
DS-1J	3.6	0.19	0.8	7.5	0.29	2.3	6.6	0.45	4.4	4.1	0.28	1.2	9.6	0.35	3.7
UGNU Pad	4.3	0.29	1.3	4.1	0.28	1.3	4.9	0.37	2.6	4.1	0.20	0.9	6.5	0.36	2.7
Palm 2	5.4	0.25	1.5	4.9	0.21	1.1	7.2	0.32	2.0	5.8	0.28	1.6	6.6	0.22	1.4
DS-2L (ASTAC)	5.8	0.19	1.3	5.3	0.21	1.3	5.4	0.20	1.3	5.0	0.25	1.2	7.5	0.23	1.6
Area Averages	4.6	0.23	1.2	5.4	0.28	1.6	5.9	0.30	2.2	4.6	0.24	1.2	7.3	0.28	2.1
Lower Foothills Area															
SpurDike 6-20 Mi	4.0	0.23	1.0	7.1	0.29	1.7	5.3	0.25	1.4	3.9	0.24	1.5	5.5	0.26	1.7
30 Mile	2.8			3.5	0.15	0.6	4.6	0.18	1.1	4.5	0.22	0.9	4.8	0.27	1.0
52 Mile	9.3	0.20	1.8	8.8	0.15	1.4	9.6	0.18	1.8	11.9	0.24	3.1	13.2	0.22	3.2
62 Mile	9.1	0.20	1.8	8.6	0.19	1.5	8.8	0.21	1.3	7.8	0.24	2.1	9.0	0.21	1.6
Meltwater 19	4.9	0.13	0.8	4.5	0.19	1.0	4.8	0.30	2.3	5.6	0.27	1.5	7.7	0.24	1.2
Area Averages	6.0	0.19	1.4	6.5	0.20	1.2	6.6	0.22	1.6	6.7	0.24	1.8	8.0	0.24	1.7
Upper Foothills Area															
318 Mile	12.2	0.21	2.6	12.8	0.22	2.7	13.3	0.21	2.9	11.9	0.19	2.4	14.4	0.23	3.2
Pump 3	9.9	0.22	2.2	10.8	0.22	2.4	9.5	0.24	2.0	10.3	0.25	2.5	12.0	0.20	2.1
Sag R. DOT	10.3	0.24	2.4	10.1	0.23	2.0	10.1	0.25	1.6	9.3	0.22	2.8	10.9	0.26	2.8
Slope Mountain	9.3	0.14	1.2	8.5	0.21	1.3	8.7	0.21	1.5	6.9	0.21	1.7	8.2	0.13	1.0
Area Averages	10.4	0.20	2.1	10.5	0.22	2.1	10.4	0.23	2.0	9.6	0.22	2.3	11.4	0.20	2.3

Figures 4 through 7 show a comparison of snow depth measurements taken by both ADNR and the ATN project participants during the months of November and December. The dash symbols indicate individual snow depth measurements. Duplicate readings plot on top of each symbol. Of the four locations where both ATN and ADNR measure snow depth using different methods - 50 measurements at 3 ft (1 m) intervals along "L" shaped transect vs. 20 measurements at 1.5 ft (0.5 m) intervals along a straight transect - values compare well (Table 4). As expected, since the ATN method collects 30 more depth measurements, a greater range of values is seen compared to the ADNR range of depth values. Where a difference exists between average depth values, the ATN average depth is greater than the average DNR depth for all instances in December (Figure 8). The greatest difference between average depth values is approximately 1.6 in (4.0 cm) at 2L-pad and P-pad during the December 8 timeframe (Table 4, Figure 5 and Figure 6) as well as P-pad during the late November collection period (Figure 6). The average difference between ATN and ADNR depths during the late November 16 – 20 collection period is 0.7 in (1.8 cm) and 1.2 in (3.0 cm) during the December 7 – 11 collection period.

Table 4. Comparison of average snow depth, density, and SWE at 4 co-located ATN and ADNR snow sampling sites, December 7-11.

	Sag River DOT				Meltwater 19 (2P-Pad)				P-Pad				DS-2L (ASTAC)			
	GWS		ADNR		GWS		ADNR		GWS		ADNR		GWS		ADNR	
	in	cm	in	cm	in	cm	in	cm	in	cm	in	cm	in	cm	in	cm
Depth	10.3	26.2	9.3	23.6	6.3	15.9	5.6	14.2	7.9	20.0	6.1	15.4	6.5	16.4	5.0	12.7
Density (g/cm^3)	0.22		.22		0.28		0.27		0.28		0.28		0.23		0.25	
SWE	2.2	5.7	1.7	4.3	1.7	4.4	1.5	3.8	2.2	5.5	1.8	4.6	1.5	3.7	1.2	3.0

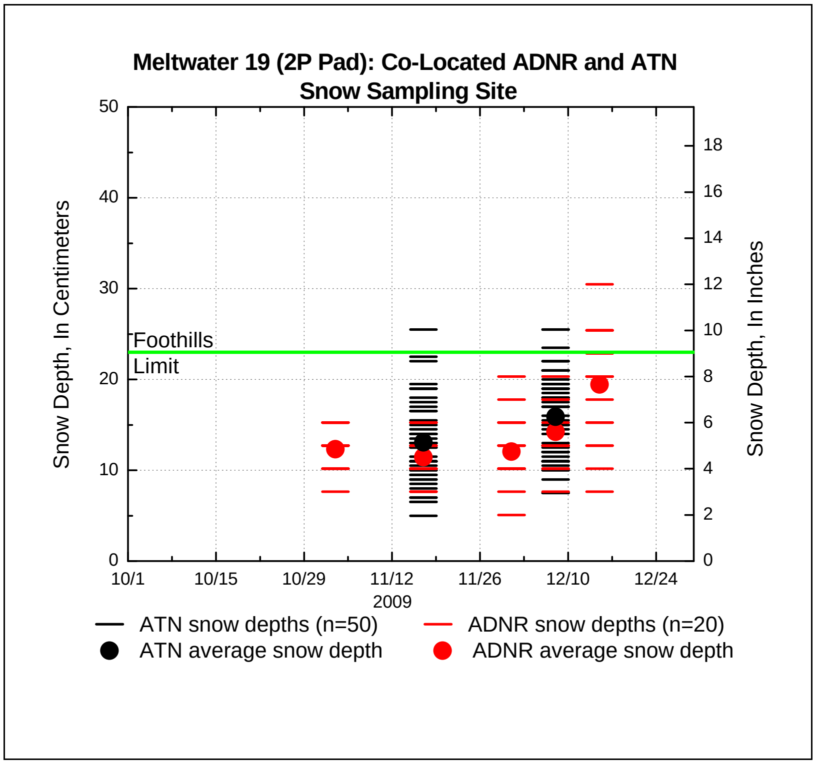

Figure 4. Snow depth comparison at Meltwater 19 (2P-Pad) located in the Lower Foothills Region, a co-located ADNR and ATN snow sampling site.

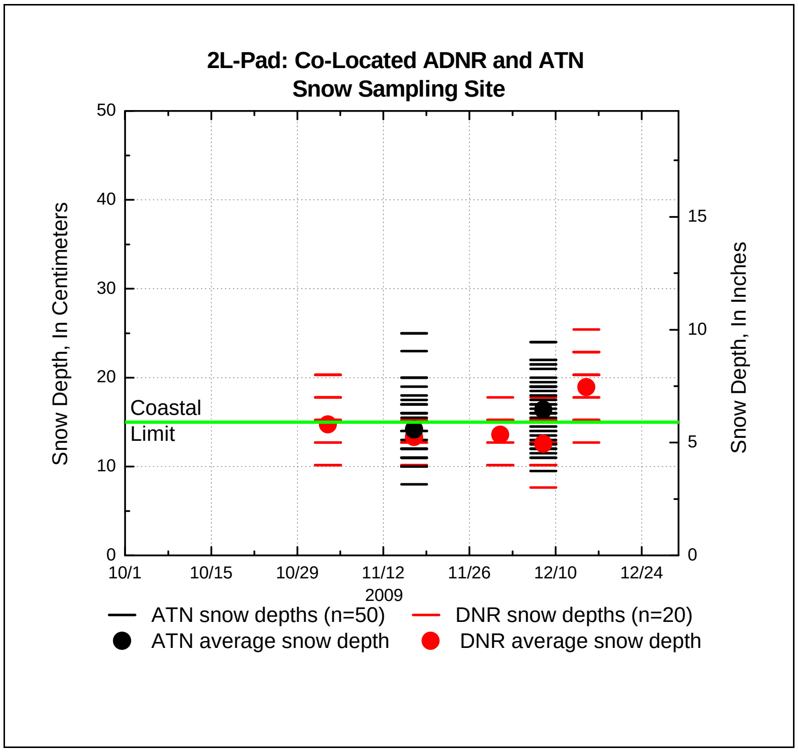

Figure 5. Snow depth comparison at 2L-Pad in the Western Coastal Region, a co-located ADNR and ATN snow sampling site.

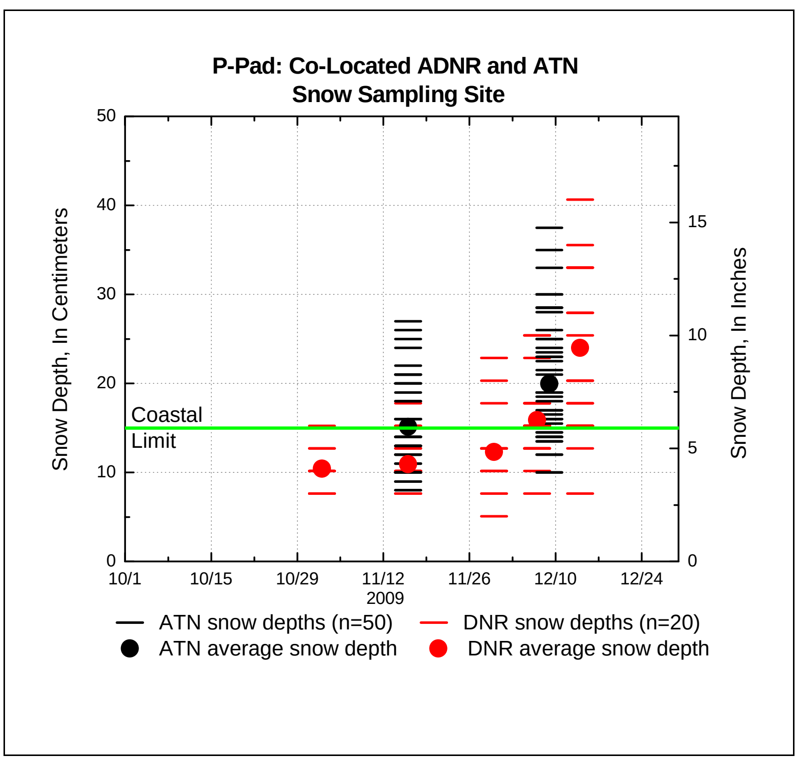

Figure 6. Snow depth comparison at P-Pad located in the Eastern Coastal Region, a co-located ADNR and ATN snow sampling site.

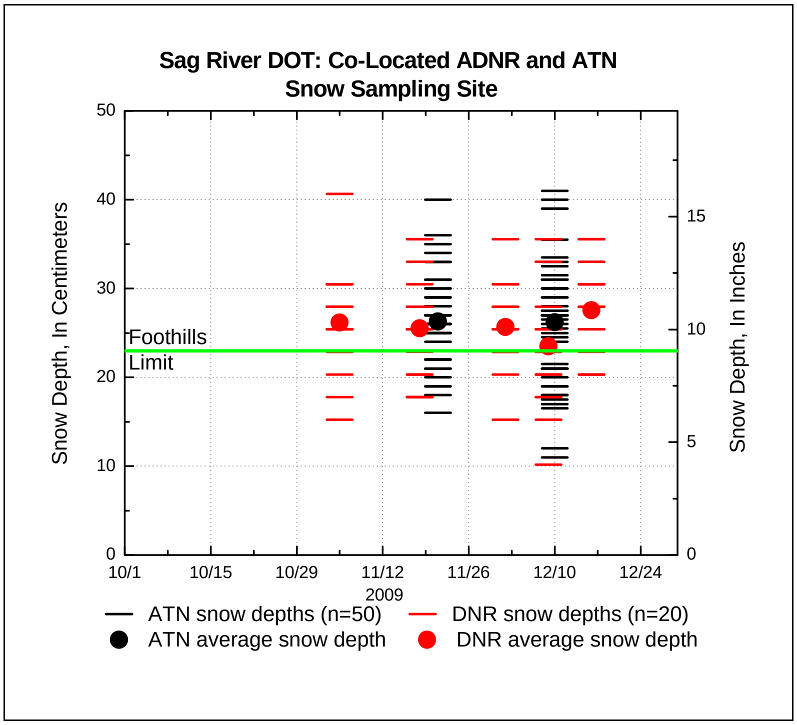

Figure 7. Snow depth comparison at Sag DOT located in the Upper Foothills Region, a co-located ADNR and ATN snow sampling site.

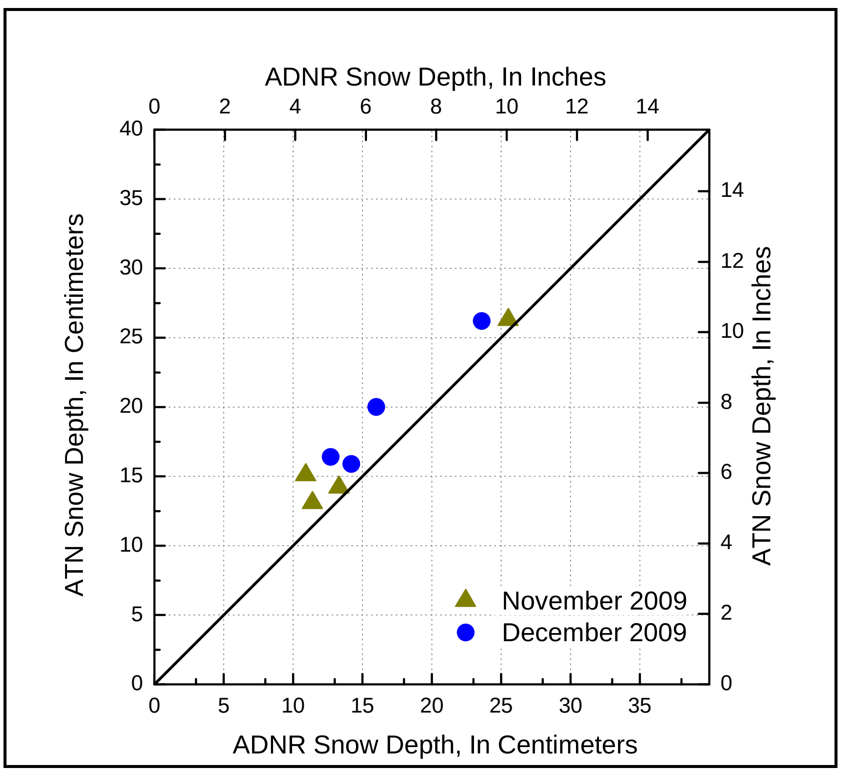

Figure 8. Comparison plot between paired measurements of snow courses. ATN data is consistently higher than ADNR data, though the difference is minor when considering the variation in surface vegetation.

On December 7, at Lake L9312, a water-level elevation survey was completed. Figure 9 shows the water level conditions for this site from 2004 to December 2009. Water levels were higher in December 2009 than in December 2008. This is likely due to the very dry summer in 2008 and related lake evaporation. The water levels are generally close to that of past years where the lake only received recharge from snowmelt and summer precipitation, and no overflow from the Colville River.

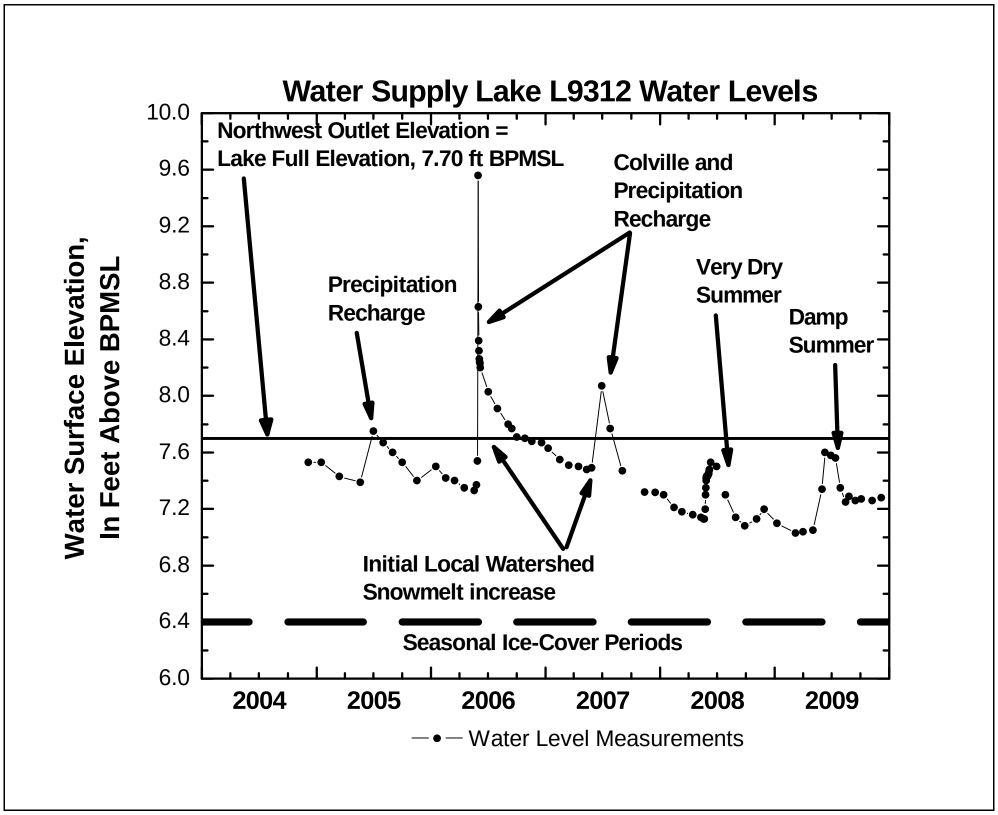

Figure 9. Plot of water level at L9312 through December 7, 2009.

SUMMARY

During the December ATN trip, we upgraded meteorological stations and the Kuparuk Network Base Station. Warm (near freezing) temperature conditions with sleet near Betty Pingo and drizzle at Toolik Camp were observed. Snow-depth values reflect this warm period with a reduction in average depth compared to previous field measurements. Snow depths were greater in the Alpine area than in the Kuparuk area. The paired snow course measurements compare well between the ATN project and ADNR. Water levels are higher this December at L9312 than the previous year. The collection of snow and lake information related to Arctic transportation networks will help the development of regulatory and user management tools and forecast modeling tools. These tools will help with the increasing development of resources and variation of natural conditions in these extreme Arctic climates.

REFERENCES

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APPENDIX A. SNOW SURVEY FORMS

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

Arctic Transportation Networks Project
Form F-012: Snow Survey Form

Project ID:	**ATN Project**	Site Location/Lake ID:	**ADNR 2L-Pad**
Survey Purpose:	**Determine Snow Depth and SWE**	Date: 12/8/2009	Time: 16:30

Location Description:	West of road between 2L-Pad and 2N-Pad, near soil thermistors. GWS measures to right (as looking at bore tube from road) and DNR measures to left.				
Survey objective:	Co-located snow survey site with DNR sampling site, tundra travel studies and management			Weather Observations:	mild weather conditions (10F), dark
Latitude:	N 70° 11.481'	Longitude:	W 150° 19.397'	Datum:	NAD83
Elevation:	112 ft	Elevation Datum:	NGVD29	Reference Markers:	Just northeast of weather station
Drainage Basin:	Miluveach River	Slope Direction:	Flat	Vegetation Type:	Lowland Wet Sedge Tundra
Slope Angle:	Flat	Access Notes:	Truck	Other:	Snow pack was fairly uniform some slabbing
Snow Depth Probe Type:		T-Handle Probe		Snow-Survey Team Names:	
Snow Tube Type:	Adirondack Snow Tube			Michael Lilly	

Snow Course Depths (cm)

	1	2	3	4	5
1	19.0	9.5	21.0	12.5	19.0
2	14.5	12.5	21.5	14.0	17.0
3	15.5	19.0	21.5	11.0	14.0
4	17.0	24.0	24.0	12.0	11.5
5	13.5	16.5	22.0	15.0	16.0
6	13.0	12.0	19.0	14.0	19.5
7	13.0	15.0	18.5	15.0	15.0
8	11.0	15.0	17.5	16.0	21.5
9	19.0	17.0	14.5	17.0	22.0
10	12.0	16.0	16.0	18.0	20.0

	(cm)
Average snow depth =	**16.4**
Maximum snow depth =	24.0
Minimum snow depth =	9.5
Standard variation =	3.6

	(inches)
Average snow depth =	**6.5**
Maximum snow depth =	**9.4**
Minimum snow depth =	**3.7**
Standard variation =	**1.4**

Snow Sample Depths and Weights

Bag #	Snow Depth (cm)	Weight (g)	Volume (cm^3)	Density (g/cm^3)	Organic Plug (cm)
20E3	15	55.5	535.5	0.10	
V4	16	129.9	571.2	0.23	
20E5	22	231.9	785.4	0.30	
Z4	13	132.1	464.1	0.28	
20E1	20	155.7	714.0	0.22	

Average Density = **0.226**

Average Snow Water Equivalent (SWE) = **3.7** cm H2O

Average Snow Water Equivalent = **1.46** inches H2O

Average Snow Water Equivalent = **0.12** feet H2O

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

Data entered by: Michael Lill Date: 12/8/09

Data QA/QC by: Jeff Derry Date: 12/14/09

Arctic Transportation Networks Project
Form F-012: Snow Survey Form

Project ID: **ATN Project** Site Location/Lake ID **ADNR 2P-Pad (Meltwater 19)**
Survey Purpose: **Determine Snow Depth and SWE** Date: 12/8/2009 Time: 14:50

Location Description:	West of road to 2P-Pad, North of 2P Pad, North of soil thermistors. GWS measures to right (as looking at bore tube from road) and DNR measures to left.				
Survey objective:	Co-located snow survey site with DNR sampling site, tundra travel studies and management			Weather Observations:	mild weather conditions (10F), dusk
Latitude:	N 70° 03.853'	Longitude:	W 150° 26.779'	Datum:	NAD83
Elevation:	200 ft	Elevation Datum:	NGVD29	Reference Markers:	none
Drainage Basin:	Kachemach River	Slope Direction:	Flat	Vegetation Type:	Lowland Wet Sedge Tundra
Slope Angle:	Flat	Access Notes:	Truck	Other:	Snowpack uniform to ground, some slabbing
Snow Depth Probe Type:		T-Handle Probe		Snow-Survey Team Names:	
Snow Tube Type:	Adirondack Snow Tube			Michael Lilly	

Snow Course Depths (cm)

	1	2	3	4	5
1	11.0	11.0	21.0	15.0	21.0
2	19.5	22.0	19.0	12.5	19.5
3	14.0	19.0	18.5	7.5	25.5
4	12.0	11.0	12.0	11.5	22.0
5	23.5	15.0	18.0	9.0	25.5
6	17.0	21.0	11.0	15.0	16.0
7	11.0	14.5	18.0	10.0	16.0
8	12.0	17.0	12.0	7.5	16.0
9	20.0	13.0	10.5	10.0	17.5
10	20.0	21.0	19.0	18.0	15.5

	(cm)
Average snow depth =	**15.9**
Maximum snow depth =	25.5
Minimum snow depth =	7.5
Standard variation =	4.6

	(inches)
Average snow depth =	**6.3**
Maximum snow depth =	**10.0**
Minimum snow depth =	**3.0**
Standard variation =	**1.8**

Snow Sample Depths and Weights

Bag #	Snow Depth (cm)	Weight (g)	Volume (cm^3)	Density (g/cm^3)	Organic Plug (cm)
E3	14	145.3	499.8	0.29	
E2	20	158.2	714.0	0.22	
E4	18	196.8	642.6	0.31	
E1	12	109.4	428.4	0.26	
E5	11	118.2	392.7	0.30	

Average Density = **0.275**
Average Snow Water Equivalent (SWE) = **4.4** cm H2O
Average Snow Water Equivalent = **1.72** inches H2O
Average Snow Water Equivalent = **0.14** feet H2O

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

Data entered by: Michael Lilly Date: 12/9/09
Data QA/QC by: Jeff Derry Date:12/14/09

Arctic Transportation Networks Project
Form F-012: Snow Survey Form

Project ID:	**ATN Project**	Site Location/Lake ID:	**Betty Pingo**
Survey Purpose:	**Determine Snow Depth and SWE**	Date: 12/9/2009	Time: 20:20

Location Description:	Near Wyoming gage. At staked snow site. Started east and then went north. Point of beginning is flagged rebar. Vertical snow gauge = no reading. Snow Depth under Judd sensor = 25.5, 28.5, 24, 20, 25. Wyoming Gauge = 31-1/2".				
Survey objective:	SWE and tundra travel studies and management			Weather Observations:	Dark, 10F, slight breeze
Latitude:	N 70° 16.772'	Longitude:	W 148° 53.741'	Datum:	NAD83
Elevation:	34 ft.	Elevation Datum:	NVGD27	Reference Markers:	Re-bar and lathe
Drainage Basin:	Kuparuk River	Slope Direction:	Flat	Vegetation Type:	Lowland Moist Sedge-Shrub Tundra
Slope Angle:	Flat	Access Notes:	Truck	Other:	Hard Crust on most of snowpack
Snow Depth Probe Type:		T-Handle Probe		Snow-Survey Team Names:	
Snow Tube Type:	Adirondack Snow Tube			Michael Lilly	

Snow Course Depths (cm)

	1	2	3	4	5
1	43.0	18.0	21.0	10.5	26.0
2	28.0	13.5	25.0	12.0	21.0
3	19.0	12.0	40.0	16.0	18.0
4	11.0	18.5	23.0	16.0	13.0
5	14.0	27.5	11.0	12.0	23.5
6	17.0	26.5	9.5	16.0	11.5
7	13.5	35.0	9.0	30.5	14.0
8	9.0	23.0	8.0	19.5	9.0
9	12.5	26.0	8.0	22.0	14.5
10	13.0	25.5	7.5	24.0	12.0

	(cm)
Average snow depth =	**18.2**
Maximum snow depth =	43.0
Minimum snow depth =	7.5
Standard variation =	8.3

	(inches)
Average snow depth =	**7.2**
Maximum snow depth =	**16.9**
Minimum snow depth =	**3.0**
Standard variation =	**3.3**

Snow Sample Depths and Weights

Bag #	Snow Depth (cm)	Weight (g)	Volume (cm^3)	Density (g/cm^3)	Organic Plug (cm)
Z1	38	429.9	1356.6	0.32	
Z2	17.5	215.0	624.8	0.34	
Z3	7	46.8	249.9	0.19	
Z4	20	223.6	714.0	0.31	
Z5	18	152.4	642.6	0.24	

Average Density = **0.280**

Average Snow Water Equivalent (SWE) = **5.1** cm H2O

Average Snow Water Equivalent = **2.00** inches H2O

Average Snow Water Equivalent = **0.17** feet H2O

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

Data entered by: Michael Lilly Date: 12/11/09

Data QA/QC by: Jeff Derry Date: 12/14/09

Arctic Transportation Networks Project
Form F-012: Snow Survey Form

Project ID:	**ATN**	Site Location/Lake ID:	**L9312 - Lake Surface**
Survey Purpose:	**Determine snow depth, SWE**	Date: 12/7/2009	Time: 13:05

Location Description:	On lake surface ~150 yards east from L9312 pumphouse.				
Survey objective:	Determine snow depth and density for application to lake recharge studies, and tundra travel management.			Weather Observations:	mild weather conditions (15F), hazy
Latitude:	N 70° 20.008'	Longitude:	W 150° 57.083'	Datum:	NAD 83
Elevation:	7 ft	Elevation Datum:	BPMSL	Reference Markers:	None, Ice surface
Drainage Basin:	Colville Basin	Slope Direction:	Flat	Vegetation Type:	None, Ice surface
Slope Angle:	Flat	Access Notes:	Haggland	Other:	Dense snow, drifting, patches of clear ice
Snow Depth Probe Type:		T- probe		Snow-Survey Team Names:	
Snow Tube Type:	Adirondack Snow Tube			Michael Lilly, Chris (LCMF)	

Snow Course Depths (cm)

	1	2	3	4	5
1	4.5	16.5	7.0	15.0	19.5
2	1.0	14.0	6.0	15.0	22.0
3	2.0	13.5	6.0	14.0	9.0
4	2.0	8.0	5.0	7.0	11.5
5	7.0	8.5	3.0	6.0	12.0
6	4.0	12.0	7.0	6.0	8.5
7	5.5	14.0	10.5	7.0	6.0
8	12.5	12.5	10.0	6.5	1.0
9	16.5	9.5	10.0	8.0	0.0
10	17.0	8.0	12.0	20.0	0.0

	(cm)
Average snow depth =	**9.2**
Maximum snow depth =	22.0
Minimum snow depth =	0.0
Standard variation =	5.3

	(inches)
Average snow depth =	**3.6**
Maximum snow depth =	**8.7**
Minimum snow depth =	**0.0**
Standard variation =	**2.1**

Snow Sample Depths and Weights

Bag #	Snow Depth (cm)	Weight (g)	Volume (cm^3)	Density (g/cm^3)	Organic Plug (cm)
Z2	5	69.8	178.5	0.39	
Z1	18	225.6	642.6	0.35	
V5	5	48.4	178.5	0.27	
Z3	16	217.6	571.2	0.38	
Z5	7	81.8	249.9	0.33	

Average Density = **0.344**
Average Snow Water Equivalent (SWE) = **3.2** cm H2O
Average Snow Water Equivalent = **1.24** inches H2O
Average Snow Water Equivalent = **0.10** feet H2O

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

Data entered by: Michael Lill — Date: 12/8/09
Data QA/QC by: Jeff Derry — Date: 12/14/09

Arctic Transportation Networks Project
Form F-012: Snow Survey Form

Project ID:	**ATN**	Site Location/Lake ID:	**L9312 - Tundra**	
Survey Purpose:	**Determine snow depth, SWE**	Date: 12/7/2009	Time:	13:39

Location Description:	On tundra on staked course, adjacent and north of L9312 weather station.				
Survey objective:	Determine snow depth and density for application to lake recharge studies, and tundra travel management.			Weather Observations:	mild weather conditions (15F), hazy
Latitude:	N 70° 19.995'	Longitude:	W 150° 56.918'	Datum:	NAD 83
Elevation:	7 ft	Elevation Datum:	BPMSL	Reference Markers:	Orange stakes
Drainage Basin:	Colville River	Slope Direction:	Flat	Vegetation Type:	Lowland Wet Sedge Tundra
Slope Angle:	Flat	Access Notes:	Haggland	Other:	Snow pack was fairly uniform, some slabbing
Snow Depth Probe Type:		T-probe		Snow-Survey Team Names:	
Snow Tube Type:	Adirondack Snow Tube			Michael Lilly, Chris (LCMF)	

Snow Course Depths (cm)

	1	2	3	4	5
1	25.0	27.5	25.5	45.0	38.0
2	23.5	19.0	27.0	43.0	35.0
3	29.0	18.0	25.5	41.0	33.0
4	23.0	18.0	31.5	33.0	25.5
5	60.0	14.5	26.5	31.0	11.5
6	31.5	15.0	15.0	20.0	22.0
7	25.0	8.0	17.5	18.0	26.5
8	30.0	13.0	12.0	23.5	26.5
9	22.0	29.0	11.5	38.5	33.0
10	28.0	37.0	40.0	39.0	40.0

	(cm)
Average snow depth =	**27.0**
Maximum snow depth =	60.0
Minimum snow depth =	8.0
Standard variation =	10.3

	(inches)
Average snow depth =	**10.6**
Maximum snow depth =	**23.6**
Minimum snow depth =	**3.1**
Standard variation =	**4.1**

Snow Sample Depths and Weights

Bag #	Snow Depth (cm)	Weight (g)	Volume (cm^3)	Density (g/cm^3)	Organic Plug (cm)
20E4	21	249.1	749.7	0.33	
20E2	20	188.3	714.0	0.26	
V2	21	218.2	749.7	0.29	
V1	27	255.5	963.9	0.27	
V3	30	292.9	1071.0	0.27	

Average Density = **0.285**

Average Snow Water Equivalent (SWE) = **7.7** cm H2O

Average Snow Water Equivalent = **3.03** inches H2O

Average Snow Water Equivalent = **0.25** feet H2O

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

Data entered by: Michael Lilly — Date: 12/8/09

Data QA/QC by: Jeff Derry — Date: 12/14/09

Arctic Transportation Networks Project
Form F-012: Snow Survey Form

Project ID:	**ATN Project**	Site Location/Lake ID:	**ADNR P-Pad**
Survey Purpose:	**Determine Snow Depth and SWE**	Date: 12/9/2009	Time: 19:07

Location Description:	On access road to P-Pad, north side, near Betty Pingo, near soil thermistors. GW-S measurements on right (as looking at sensor pipe from road) and DNR measurements on left.				
Survey objective:	Co-located snow survey site with DNR sampling site, tundra travel studies and management			Weather Observations:	Dark, mild temperature
Latitude:	N 70° 16.967'	Longitude:	W 148° 54.807'	Datum:	NAD83
Elevation:	33 ft.	Elevation Datum:	NGVD29	Reference Markers:	none
Drainage Basin:	Kuparuk River	Slope Direction:	Flat	Vegetation Type:	Lowland Moist Sedge-Shrub Tundra
Slope Angle:	Flat	Access Notes:	Truck	Other:	Top of snow was crusty
Snow Depth Probe Type:		T-Handle Probe		Snow-Survey Team Names:	
Snow Tube Type:	Adirondack Snow Tube			Michael Lilly	

Snow Course Depths (cm)

	1	2	3	4	5
1	14.0	23.5	28.0	16.0	10.0
2	15.5	25.0	23.0	23.0	19.0
3	13.5	21.5	22.5	19.0	15.0
4	28.5	21.5	17.0	16.0	14.0
5	14.0	15.0	12.0	28.5	10.0
6	14.5	17.0	28.5	16.0	10.0
7	25.0	18.0	35.0	13.5	12.0
8	14.5	16.5	30.0	26.0	15.0
9	14.0	19.0	21.0	37.5	30.0
10	24.0	18.5	15.0	30.0	33.0

	(cm)
Average snow depth =	**20.0**
Maximum snow depth =	37.5
Minimum snow depth =	10.0
Standard variation =	6.9

	(inches)
Average snow depth =	**7.9**
Maximum snow depth =	**14.8**
Minimum snow depth =	**3.9**
Standard variation =	**2.7**

Snow Sample Depths and Weights

Bag #	Snow Depth (cm)	Weight (g)	Volume (cm^3)	Density (g/cm^3)	Organic Plug (cm)
E1	14	94.7	499.8	0.19	
E2	18	195.3	642.6	0.30	
E3	20.5	182.4	731.9	0.25	
E4	22	286.3	785.4	0.36	
E5	28	281.1	999.6	0.28	

Average Density = **0.278**

Average Snow Water Equivalent (SWE) = **5.5** cm H2O

Average Snow Water Equivalent = **2.18** inches H2O

Average Snow Water Equivalent = **0.18** feet H2O

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

Data entered by: Michael Lilly Date: 12/9/09

Data QA/QC by: Jeff Derry Date: 12/14/09

Arctic Transportation Networks Project
Form F-012: Snow Survey Form

Project ID:	**ATN Project**	Site Location/Lake ID:	**Sag River DOT**
Survey Purpose:	**Determine Snow Depth and SWE**	Date: 12/10/2009	Time: 13:31

Location Description:	On Road to DOT garage. Near soil thermistor bore hole. GW-S stays to right (as looking at bore tube) and DNR stays left.				
Survey objective:	SWE and Tundra Travel (Co-located snow survey site with DNR sampling site)			Weather Observations:	Cold, Light, Calm
Latitude:	N 68° 45.686'	Longitude:	W 148° 52.746'	Datum:	NAD 83
Elevation:	1640 ft.	Elevation Datum:	NGVD29	Reference Markers:	Soil Thermistor bore hole
Drainage Basin:	Kuparuk	Slope Direction:	Flat	Vegetation Type:	Upland Tussock Tundra
Slope Angle:	Flat	Access Notes:	Truck	Other:	Surface was crusting, some signs of melting
Snow Depth Probe Type:		T-Handle Probe		Snow-Survey Team Names:	
Snow Tube Type:	Adirondack Snow Tube			Michael Lilly	

Snow Course Depths (cm)

	1	2	3	4	5
1	29.0	21.5	27.0	27.0	31.0
2	39.0	27.5	40.0	28.0	31.5
3	24.0	33.5	21.0	27.0	27.0
4	12.0	29.0	16.5	39.0	18.0
5	21.0	30.0	17.0	26.5	25.0
6	19.0	30.0	30.0	27.0	11.0
7	20.0	35.5	21.0	31.0	24.5
8	21.0	41.0	23.0	17.5	33.0
9	27.5	18.0	30.0	19.0	26.0
10	21.0	31.0	27.0	32.5	25.5

	(cm)
Average snow depth =	**26.2**
Maximum snow depth =	41.0
Minimum snow depth =	11.0
Standard variation =	6.8

	(inches)
Average snow depth =	**10.3**
Maximum snow depth =	**16.1**
Minimum snow depth =	**4.3**
Standard variation =	**2.7**

Snow Sample Depths and Weights

Bag #	Snow Depth (cm)	Weight (g)	Volume (cm^3)	Density (g/cm^3)	Organic Plug (cm)
20E1	28	230.4	999.6	0.23	
20E2	20	114.1	714.0	0.16	
20E3	30	241.9	1071.0	0.23	
20E4	18	157.7	642.6	0.25	
20E5	23	185.5	821.1	0.23	

Average Density = **0.217**
Average Snow Water Equivalent (SWE) = **5.7** cm H2O
Average Snow Water Equivalent = **2.24** inches H2O
Average Snow Water Equivalent = **0.19** feet H2O

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

Data entered by: Michael Lilly Date: 12/11/09
Data QA/QC by: Jeff Derry Date: 12/14/09

Arctic Transportation Networks Project
Form F-012: Snow Survey Form

Project ID: **ATN Project** Site Location/Lake ID: **Toolik NRCS Site**
Survey Purpose: **Determine Snow Depth and SWE** Date: 12/10/2009 Time: 11:22

Location Description:	Near Tollik Camp and Toolik Lake. Adjacent and south and west of NRCS long-term Climate Station				
Survey objective:	SWE and tundra travel studies and management			Weather Observations:	22F, freezing drizzle, slight breeze
Latitude:	N 68° 37.366'	Longitude:	W 149° 36.598'	Datum:	NAD 83
Elevation:	2500 ft.	Elevation Datum:	NGVD27	Reference Markers:	NRCS Station
Drainage Basin:	Toolik Lake	Slope Direction:	East	Vegetation Type:	Upland Shrubby Tussuck Tundra
Slope Angle:	~10 degrees	Access Notes:	Walk from Toolik	Other:	Signs of wind and thermal erosion of snowpack
Snow Depth Probe Type:		T-Handle Probe		Snow-Survey Team Names:	
Snow Tube Type:	Adirondack Snow Tube			Michael Lilly	

Snow Course Depths (cm)

	1	2	3	4	5
1	16.0	36.0	24.0	14.5	30.0
2	28.0	24.0	30.5	18.5	32.0
3	14.0	31.0	21.0	23.0	24.5
4	23.0	28.0	23.5	27.0	19.5
5	22.0	17.0	25.0	17.0	26.5
6	38.0	27.0	27.0	25.0	27.0
7	18.5	35.0	37.0	17.0	16.5
8	20.0	20.0	33.0	20.5	13.0
9	24.0	36.5	21.0	23.0	22.0
10	23.0	25.0	25.0	24.5	20.0

	(cm)
Average snow depth =	**24.3**
Maximum snow depth =	38.0
Minimum snow depth =	13.0
Standard variation =	6.2

	(inches)
Average snow depth =	**9.6**
Maximum snow depth =	**15.0**
Minimum snow depth =	**5.1**
Standard variation =	**2.4**

Snow Sample Depths and Weights

Bag #	Snow Depth (cm)	Weight (g)	Volume (cm^3)	Density (g/cm^3)	Organic Plug (cm)
B1	13	44.2	464.1	0.10	
B2	16	136.6	571.2	0.24	
B3	15	87.5	535.5	0.16	
B4	22	181.5	785.4	0.23	
B5	20	177.6	714.0	0.25	

Average Density = **0.196**
Average Snow Water Equivalent (SWE) = **4.7** cm H2O
Average Snow Water Equivalent = **1.87** inches H2O
Average Snow Water Equivalent = **0.16** feet H2O

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

Data entered by: Michael Lilly Date: 12/11/09
Data QA/QC by: Jeff Derry Date: 12/14/09

APPENDIX B. DNR SNOW DATA

The following table reports snow information obtained by DNR in November and December.

Upper Foothills

Slope Mountain																							average	
Date																						g/cm^3	in	cm
11/5/2009	depth (in)	8	9	10	9	9	8	10	10	6	8	9	9	9	11	10	11	10	11	9	10		9.30	23.62
	density (g/cm^3)	0.16	0.12																			0.14		
	SWE (in)	1.40	0.96																				1.18	2.99
11/18/2009	depth (in)	11	12	9	8	7	8	12	9	6	8	7	10	9	6	9	9	8	8	6	7		8.45	21.46
	density (g/cm^3)	0.24	0.18																			0.21		
	SWE (in)	1.30	1.23																				1.26	3.21
12/2/2009	depth (in)	8	10	11	9	10	9	7	7	6	7	8	7	7	6	8	13	9	8	13	11		8.70	22.10
	density (g/cm^3)	0.2282	0.1986																			0.21		
	SWE (in)	2.0542	0.9928																				1.52	3.87
12/9/2009	depth (in)	9	7	7	0	2	10	9	7	7	2	8	8	7	9	5	8	8	7	10	7		6.85	17.40
	density (g/cm^3)	0.2578	0.1576																			0.21		
	SWE (in)	2.1916	1.2607																				1.73	4.38
12/16/2009	depth (in)	7	6	6	11	7	9	7	4	8	10	6	9	10	12	13	11	7	6	7	8		8.20	20.83
	density (g/cm^3)	0.1221	0.1324																			0.13		
	SWE (in)	0.7935	1.192																				0.99	2.52
average																					depth		**8.30**	**21.08**
																					density	**0.18**		
																					SWE		**1.34**	**3.40**

Upper Foothills

Sag River DOT																						average		
Date																						g/cm^3	in	cm
11/5/2009	depth (in)	9	12	11	12	9	10	11	10	11	7	9	12	10	12	6	10	16	11	10	8		10.30	26.16
	density (g/cm^3)	0.24	0.23																			0.24		
	SWE (in)	2.64	2.11																				2.38	6.03
11/18/2009	depth (in)	7	11	10	10	9	10	13	12	7	8	10	10	14	7	14	11	10	10	8	10		10.05	25.53
	density (g/cm^3)	0.25	0.22																			0.23		
	SWE (in)	2.50	1.42																				1.96	4.98
12/2/2009	depth (in)	10	9	11	11	10	12	10	11	11	12	9	9	14	10	11	9	10	8	9	6		10.10	25.65
	density (g/cm^3)	0.2442	0.251																			0.25		
	SWE (in)	1.5871	1.6317																				1.61	4.09
12/9/2009	depth (in)	8	10	10	6	10	9	13	4	7	11	10	10	8	8	13	9	9	7	9	14		9.25	23.50
	density (g/cm^3)	0.1724	0.2733																			0.22		
	SWE (in)	1.7245	3.8268																				2.78	7.05
12/16/2009	depth (in)	9	10	14	10	8	8	8	11	11	8	13	12	11	14	12	14	12	11	9	12		10.85	27.56
	density (g/cm^3)	0.2244	0.298																			0.26		
	SWE (in)	2.0199	3.576																				2.80	7.11
average																					depth		**10.11**	**25.68**
																					density	**0.24**		
																					SWE		**2.30**	**5.85**

Upper Foothills

Pump Station 3

Date																						average	
																					g/cm^3	in	cm
11/5/2009	depth (in)	9	10	9	10	10	11	9	10	10	10	10	9	9	10	9	11	9	10	11	11		9.85	25.02
	density (g/cm^3)	0.23	0.20																			0.22		
	SWE (in)	2.33	2.04																				2.18	5.54
11/18/2009	depth (in)	10	9	11	10	13	11	10	10	12	10	11	12	10	13	10	10	11	11	12	9		10.75	27.31
	density (g/cm^3)	0.22	0.23																			0.22		
	SWE (in)	2.27	2.56																				2.41	6.13
12/2/2009	depth (in)	7	9	9	10	10	11	10	12	10	9	11	7	11	10	7	9	10	9	10	8		9.45	24.00
	density (g/cm^3)	0.2052	0.2653																			0.24		
	SWE (in)	1.539	2.3874																				1.96	4.99
12/9/2009	depth (in)	11	10	10	10	12	11	10	8	11	11	10	11	10	10	10	10	9	10	11	10		10.25	26.04
	density (g/cm^3)	0.2398	0.2542																			0.25		
	SWE (in)	2.3978	2.542																				2.47	6.27
12/16/2009	depth (in)	9	11	10	12	13	12	12	14	13	13	11	12	13	10	12	11	14	13	12	12		11.95	30.35
	density (g/cm^3)	0.1921	0.2045																			0.20		
	SWE (in)	2.1126	2.147																				2.13	5.41
average																			depth			**10.45**	**26.54**
																			density	**0.22**		
																			SWE		**2.23**	**5.67**

Upper Foothills

318 Mile																							average	
Date																						g/cm^3	in	cm
11/5/2009	depth (in)	9	12	11	11	12	13	12	9	12	12	13	15	13	12	11	13	13	15	11	14		12.15	30.86
	density (g/cm^3)	0.22	0.20																			0.21		
	SWE (in)	2.68	2.46																				2.57	6.53
11/18/2009	depth (in)	14	13	11	13	12	8	13	14	14	13	13	13	14	13	14	13	11	15	12	13		12.80	32.51
	density (g/cm^3)	0.23	0.21																			0.22		
	SWE (in)	2.79	2.68																				2.73	6.95
12/2/2009	depth (in)	10	11	10	13	15	16	17	15	14	14	12	15	14	15	14	14	11	13	13	10		13.30	33.78
	density (g/cm^3)	0.2083	0.2151																			0.21		
	SWE (in)	2.6039	3.1191																				2.86	7.27
12/9/2009	depth (in)	12	12	10	11	14	11	13	11	14	12	9	11	12	12	12	13	10	12	15	12		11.90	30.23
	density (g/cm^3)	0.1477	0.2326																			0.19		
	SWE (in)	1.4771	3.2565																				2.37	6.01
12/16/2009	depth (in)	16	17	17	15	15	17	16	16	13	14	10	14	16	16	15	7	9	13	15	17		14.40	36.58
	density (g/cm^3)	0.2508	0.2091																			0.23		
	SWE (in)	3.26	3.1363																				3.20	8.12
average																					depth		**12.91**	**32.79**
																					density	**0.21**		
																					SWE		**2.75**	**6.98**

Lower Foothills

62 Mile

Date																						average g/cm^3	average in	average cm
11/5/2009	depth (in)	5	9	8	10	9	10	9	9	8	10	11	10	11	6	10	8	9	10	9	10		9.05	22.99
	density (g/cm^3)	0.20	0.21																			0.20		
	SWE (in)	1.62	2.07																				1.85	4.69
11/18/2009	depth (in)	8	9	9	6	13	10	7	9	5	12	5	7	11	11	10	7	7	7	11	7		8.55	21.72
	density (g/cm^3)	0.20	0.18																			0.19		
	SWE (in)	1.68	1.38																				1.53	3.89
12/2/2009	depth (in)	12	11	12	9	11	10	8	8	9	10	9	8	7	9	6	6	9	7	8	6		8.75	22.23
	density (g/cm^3)	0.1861	0.2336																			0.21		
	SWE (in)	1.1164	1.4016																				1.26	3.20
12/9/2009	depth (in)	5	9	9	5	8	8	6	10	7	10	10	5	6	9	9	6	7	9	8	9		7.75	19.69
	density (g/cm^3)	0.2617	0.2278																			0.24		
	SWE (in)	2.7481	1.4806																				2.11	5.37
12/16/2009	depth (in)	6	9	10	6	9	11	11	9	9	10	10	6	8	9	8	10	12	7	9	10		8.95	22.73
	density (g/cm^3)	0.2149	0.2029																			0.21		
	SWE (in)	1.1817	1.9271																				1.55	3.95
average																					depth		**8.61**	**21.87**
																					density	**0.21**		
																					SWE		**1.66**	**4.22**

Lower Foothills

52 Mile																						average		
Date																						g/cm^3	in	cm
11/6/2009	depth (in)	9	12	7	11	6	9	8	9	10	10	9	9	5	8	11	9	11	11	9	12		9.25	23.50
	density (g/cm^3)	0.20	0.21																			0.20		
	SWE (in)	1.62	2.07																				1.85	4.69
11/18/2009	depth (in)	8	7	10	12	7	12	6	8	12	10	5	5	5	10	8	14	7	9	11	10		8.80	22.35
	density (g/cm^3)	0.14	0.16																			0.15		
	SWE (in)	1.61	1.24																				1.43	3.63
12/2/2009	depth (in)	12	10	9	9	9	11	8	9	12	7	13	7	11	13	7	8	7	12	7	11		9.60	24.38
	density (g/cm^3)	0.168	0.1821																			0.18		
	SWE (in)	1.6798	2.0027																				1.84	4.68
12/9/2009	depth (in)	13	13	11	6	13	12	13	11	14	13	13	12	10	10	13	13	13	11	11	12		11.85	30.10
	density (g/cm^3)	0.2172	0.2621																			0.24		
	SWE (in)	2.8237	3.4077																				3.12	7.91
12/16/2009	depth (in)	10	14	14	10	9	10	13	9	15	16	14	8	14	12	16	16	13	16	17	17		13.15	33.40
	density (g/cm^3)	0.2375	0.2073																			0.22		
	SWE (in)	3.3252	3.1088																				3.22	8.17
average																					depth		**10.53**	**26.75**
																					density	**0.20**		
																					SWE		**2.29**	**5.82**

Lower Foothills

30 Mile																						average		
Date																						g/cm^3	in	cm
11/6/2009	depth (in)	3	4	3	2	2	3	4	3	2	3	4	3	2	3	2	3	3	2	2	2		2.75	6.99
	density (g/cm^3)																							
	SWE (in)																							
11/18/2009	depth (in)	3	3	4	3	3	2	4	4	4	3	3	3	4	3	4	4	4	5	4	2		3.45	8.76
	density (g/cm^3)	0.18	0.13																			0.15		
	SWE (in)	0.62	0.52																				0.57	1.45
12/2/2009	depth (in)	3	4	4	4	4	5	4	4	4	4	3	4	4	4	4	4	6	6	8	9		4.60	11.68
	density (g/cm^3)	0.1832	0.1702																			0.18		
	SWE (in)	1.0993	1.1061																				1.10	2.80
12/9/2009	depth (in)	3	5	4	4	4	4	4	4	4	6	4	5	4	4	6	5	5	4	4	6		4.45	11.30
	density (g/cm^3)	0.2241	0.2061																			0.22		
	SWE (in)	0.8966	0.9275																				0.91	2.32
12/16/2009	depth (in)	5	4	4	6	6	5	4	6	3	4	4	5	5	6	7	4	5	5	4	4		4.80	12.19
	density (g/cm^3)	0.2817	0.2527																			0.27		
	SWE (in)	0.8451	1.137																				0.99	2.52
average																					depth		**4.01**	**10.19**
																					density	**0.20**		
																					SWE		**0.89**	**2.27**

Lower Foothills																								
Spur Dike 6 - 20 Mile																						average		
Date																						g/cm^3	in	cm
11/6/2009	depth (in)	3	2	2	5	3	4	4	6	4	4	4	4	5	6	4	4	3	4	4	4		3.95	10.03
	density (g/cm^3)	0.20	0.26																			0.23		
	SWE (in)	0.79	1.31																				1.05	2.66
11/18/2009	depth (in)	6	8	4	8	8	10	6	8	10	8	6	5	7	7	7	9	5	6	8	6		7.10	18.03
	density (g/cm^3)	0.28	0.30																			0.29		
	SWE (in)	1.98	1.50																				1.74	4.42
12/2/2009	depth (in)	8	7	7	8	6	5	3	4	4	3	2	5	4	6	6	5	4	6	6	7		5.30	13.46
	density (g/cm^3)	0.2667	0.238																			0.25		
	SWE (in)	1.4668	1.3088																				1.39	3.53
12/9/2009	depth (in)	2	4	4	3	3	3	3	5	3	3	8	5	4	2	3	5	3	3	6	5		3.85	9.78
	density (g/cm^3)	0.2095	0.2716																			0.24		
	SWE (in)	1.0477	2.0371																				1.54	3.92
12/16/2009	depth (in)	7	5	7	8	6	5	5	4	5	5	4	7	5	4	4	3	5	7	8	5		5.45	13.84
	density (g/cm^3)	0.2915	0.2336																			0.26		
	SWE (in)	2.0405	1.4016																				1.72	4.37
average																					depth		**5.13**	**13.03**
																					density	**0.26**		
																					SWE		**1.49**	**3.78**

Lower Foothills																								
Meltwater 19																							average	
Date																						g/cm^3	in	cm
11/3/2009	depth (in)	5	4	4	5	6	5	5	4	4	5	4	6	3	6	5	6	5	5	5	5		4.85	12.32
	density (g/cm^3)	0.12	0.15																			0.13		
	SWE (in)	0.72	0.87																				0.80	2.02
11/17/2009	depth (in)	3	4	4	5	5	5	6	4	4	4	4	6	3	6	5	3	6	4	5	4		4.50	11.43
	density (g/cm^3)	0.15	0.24																			0.19		
	SWE (in)	0.75	1.20																				0.97	2.47
12/1/2009	depth (in)	5	5	8	6	6	4	7	5	4	4	3	3	2	2	4	6	5	6	6	4		4.75	12.07
	density (g/cm^3)	0.3243	0.2787																			0.30		
	SWE (in)	1.6214	2.9268																				2.27	5.78
12/8/2009	depth (in)	8	4	3	7	5	7	7	7	5	6	4	5	7	5	5	8	5	5	5	4		5.60	14.22
	density (g/cm^3)	0.2494	0.2992																			0.27		
	SWE (in)	1.6214	1.3466																				1.48	3.77
12/15/2009	depth (in)	8	10	12	12	10	9	6	5	5	4	3	6	5	8	7	7	9	9	10	8		7.65	19.43
	density (g/cm^3)	0.2482	0.2279																			0.24		
	SWE (in)	0.9928	1.3672																				1.18	3.00
average																					depth		**5.47**	**13.89**
																					density	**0.23**		
																					SWE		**1.34**	**3.41**

Eastern Coastal Area

UAF 411 Mile

																							average	
Date																						g/cm^3	in	cm
11/4/2009	depth (in)	5	5	4	5	4	5	5	5	2	4	5	5	5	4	4	3	4	5	3	4		4.30	10.92
	density (g/cm^3)	0.27	0.12																			0.20		
	SWE (in)	1.35	0.49																				0.92	2.33
11/18/2009	depth (in)	4	3	4	5	4	5	4	3	6	3	4	4	5	5	6	5	4	4	6	6		4.50	11.43
	density (g/cm^3)	0.25	0.23																			0.24		
	SWE (in)	1.50	1.53																				1.51	3.84
12/2/2009	depth (in)	10	8	11	10	11	15	15	14	9	10	9	9	9	9	7	7	7	9	9	5		9.65	24.51
	density (g/cm^3)	0.2679	0.2873																			0.28		
	SWE (in)	1.8756	2.4424																				2.16	5.48
12/10/2009	depth (in)	9	6	7	8	7	7	6	8	6	8	3	6	8	6	9	6	6	9	7	9		7.05	17.91
	density (g/cm^3)	0.3259	1.7313																			1.03		
	SWE (in)	2.281	3.4627																				2.87	7.29
12/16/2009	depth (in)	3	5	5	7	7	7	7	7	6	7	8	7	7	7	7	8	7	7	7	7		6.65	16.89
	density (g/cm^3)	0.1894	0.3035																			0.25		
	SWE (in)	1.5149	1.6695																				1.59	4.04
average																					depth		**6.43**	**16.33**
																					density	**0.40**		
																					SWE		**1.81**	**4.60**

Eastern Coastal Area

P Pad

Date																						average g/cm^3	average in	average cm
11/2/2009	depth (in)	3	4	4	4	4	4	4	4	3	5	5	5	4	3	4	5	4	6	3	4		4.10	10.41
	density (g/cm^3)	0.12	0.27																			0.19		
	SWE (in)	0.47	1.34																				0.91	2.30
11/16/2009	depth (in)	3	4	4	4	4	3	5	4	4	7	4	4	3	4	6	4	4	4	5	6		4.30	10.92
	density (g/cm^3)	0.20	0.26																			0.23		
	SWE (in)	1.00	0.79																				0.89	2.27
11/30/2009	depth (in)	9	9	8	4	4	4	3	3	3	3	2	5	5	4	5	5	5	7	5	4		4.85	12.32
	density (g/cm^3)	0.123	0.1391																			0.13		
	SWE (in)	0.6767	0.5565																				0.62	1.57
12/7/2009	depth (in)	6	7	5	6	4	3	9	5	6	6	7	10	6	6	5	7	10	6	6	5		6.25	15.88
	density (g/cm^3)	0.3062	0.2519																			0.28		
	SWE (in)	2.1435	1.5115																				1.83	4.64
12/14/2009	depth (in)	3	7	6	7	13	13	11	6	8	6	5	11	10	6	8	13	13	14	13	16		9.45	24.00
	density (g/cm^3)	0.3023	0.2948																			0.30		
	SWE (in)	2.2672	3.3905																				2.83	7.19
average																					depth		**5.79**	**14.71**
																					density	**0.23**		
																					SWE		**1.41**	**3.59**

Eastern Coastal Area

T Pad

Date																						average g/cm^3	average in	average cm
11/2/2009	depth (in)	4	4	5	4	3	5	4	4	3	3	4	4	4	3	4	4	4	4	4	4		3.90	9.91
	density (g/cm^3)	0.30	0.15																			0.23		
	SWE (in)	1.50	0.60																				1.05	2.68
11/16/2009	depth (in)	4	2	4	2	3	5	4	5	4	4	4	5	4	5	5	3	5	1	5	4		3.90	9.91
	density (g/cm^3)	0.19	0.40																			0.30		
	SWE (in)	0.94	1.81																				1.38	3.49
11/30/2009	depth (in)	4	8	6	4	6	5	4	4	5	5	4	4	4	7	4	4	7	6	5	4		5.00	12.70
	density (g/cm^3)	0.3263	0.1331																			0.23		
	SWE (in)	1.958	0.5325																				1.25	3.16
12/7/2009	depth (in)	3	4	3	5	5	4	3	3	4	5	2	3	4	4	7	3	4	4	4	4		3.90	9.91
	density (g/cm^3)	0.0593	0.2142																			0.14		
	SWE (in)	0.237	1.1783																				0.71	1.80
12/14/2009	depth (in)	4	6	5	5	7	5	5	5	5	6	5	6	5	6	6	6	6	6	4	7		5.50	13.97
	density (g/cm^3)	0.3037	0.3641																			0.33		
	SWE (in)	2.2775	4.1875																				3.23	8.21
average																					depth		**4.44**	**11.28**
																					density	**0.24**		
																					SWE		**1.52**	**3.87**

Eastern Coastal Area

Term Well A																							average	
Date																						g/cm^3	in	cm
11/2/2009	depth (in)	4	5	4	6	8	5	6	3	6	7	7	4	7	7	6	6	5	7	5	7		5.75	14.61
	density (g/cm^3)	0.14	0.38																			0.26		
	SWE (in)	0.84	3.46																				2.15	5.46
11/16/2009	depth (in)	4	5	3	5	3	2	4	5	4	4	3	4	4	3	4	4	3	3	3	6		3.80	9.65
	density (g/cm^3)	0.23	0.19																			0.21		
	SWE (in)	0.92	0.74																				0.83	2.11
11/30/2009	depth (in)	5	5	5	5	5	7	5	5	5	4	5	5	4	5	3	4	4	5	5	5		4.80	12.19
	density (g/cm^3)	0.2473	0.2205																			0.23		
	SWE (in)	0.9893	1.2126																				1.10	2.80
12/7/2009	depth (in)	5	4	2	3	4	5	3	5	8	5	8	5	2	8	4	5	7	4	5	6		4.90	12.45
	density (g/cm^3)	0.2343	0.2693																			0.25		
	SWE (in)	1.1714	1.3466																				1.26	3.20
12/14/2009	depth (in)	6	6	5	7	5	4	5	8	7	7	6	5	4	6	6	7	8	7	5	7		6.05	15.37
	density (g/cm^3)	0.2782	0.1965																			0.24		
	SWE (in)	1.3912	0.9825																				1.19	3.01
average																					depth		**5.06**	**12.85**
																					density	**0.24**		
																					SWE		**1.31**	**3.32**

Eastern Coastal Area

DS 16																							average	
Date																						g/cm^3	in	cm
11/2/2009	depth (in)	7	7	4	6	6	6	6	6	6	6	4	6	6	5	5	6	6	6	6	4		5.70	14.48
	density (g/cm^3)	0.31	0.38																			0.35		
	SWE (in)	1.85	2.31																				2.08	5.28
11/16/2009	depth (in)	7	7	7	6	5	7	2	7	8	4	7	3	6	6	3	6	4	5	5	3		5.40	13.72
	density (g/cm^3)	0.50	0.40																			0.45		
	SWE (in)	4.03	2.57																				3.30	8.39
11/30/2009	depth (in)	7	6	3	5	6	4	5	7	7	7	5	7	5	7	6	8	9	10	11	12		6.85	17.40
	density (g/cm^3)	0.3626	0.3237																			0.34		
	SWE (in)	3.2634	1.4565																				2.36	5.99
12/7/2009	depth (in)	6	3	6	6	7	5	6	6	7	9	4	5	7	6	5	6	6	6	6	5		5.85	14.86
	density (g/cm^3)	0.3203	0.2933																			0.31		
	SWE (in)	2.0817	1.9065																				1.99	5.07
12/14/2009	depth (in)	9	10	7	11	9	9	9	8	10	6	7	7	8	8	9	10	8	10	9	9		8.65	21.97
	density (g/cm^3)	0.3187	0.3298																			0.32		
	SWE (in)	2.8684	3.4627																				3.17	8.04
average																					depth		**6.49**	**16.48**
																					density	**0.35**		
																					SWE		**2.58**	**6.55**

Eastern Coastal Area

ANFO Pad																							average	
Date																						g/cm^3	in	cm
11/2/2009	depth (in)	2	3	2	2	3	1	2	1	2	2	2	2	2	2	2	3	2	2	2	2		2.05	5.21
	density (g/cm^3)																							
	SWE (in)																							
11/16/2009	depth (in)	4	3	3	3	2	4	3	3	2	2	4	2	4	3	3	3	3	3	3	3		3.00	7.62
	density (g/cm^3)	0.47	0.34																			0.40		
	SWE (in)	1.40	1.01																				1.21	3.06
11/30/2009	depth (in)	5	4	4	4	3	3	4	3	4	5	5	5	6	4	4	3	3	5	4	3		4.05	10.29
	density (g/cm^3)	0.3135	0.1709																			0.24		
	SWE (in)	1.2538	0.6836																				0.97	2.46
12/7/2009	depth (in)	2	4	3	3	4	3	4	3	4	4	2	4	3	4	3	4	2	3	5	3		3.35	8.51
	density (g/cm^3)	0.3355	0.3445																			0.34		
	SWE (in)	1.0065	1.2057																				1.11	2.81
12/14/2009	depth (in)	6	7	5	7	6	6	6	6	6	5	7	8	7	8	7	8	8	8	5	5		6.55	16.64
	density (g/cm^3)	0.3092	0.3362																			0.32		
	SWE (in)	2.1642	2.6897																				2.43	6.16
average																					depth		**3.80**	**9.65**
																					density	**0.33**		
																					SWE		**1.43**	**3.62**

Western Coastal Area

DS-2L (ASTAC)																							average	
Date																						g/cm^3	in	cm
11/3/2009	depth (in)	7	4	5	7	4	8	7	4	6	5	5	6	4	8	6	6	5	8	5	6		5.80	14.73
	density (g/cm^3)	0.18	0.21																			0.19		
	SWE (in)	1.06	1.46																				1.26	3.21
11/17/2009	depth (in)	5	5	5	4	5	4	5	5	5	6	6	5	6	6	6	6	6	5	5	5		5.25	13.34
	density (g/cm^3)	0.29	0.13																			0.21		
	SWE (in)	1.75	0.78																				1.26	3.21
12/1/2009	depth (in)	4	6	6	6	6	6	5	5	5	5	6	6	4	5	4	7	6	5	4	6		5.35	13.59
	density (g/cm^3)	0.2503	0.1434																			0.20		
	SWE (in)	2.0027	0.5737																				1.29	3.27
12/8/2009	depth (in)	4	4	6	5	5	4	3	6	4	7	5	6	6	6	4	5	5	5	5	4		4.95	12.57
	density (g/cm^3)	0.3061	0.1961																			0.25		
	SWE (in)	1.3775	1.0786																				1.23	3.12
12/15/2009	depth (in)	8	6	9	6	5	6	10	9	7	9	8	6	7	7	7	8	8	6	9	8		7.45	18.92
	density (g/cm^3)	0.217	0.238																			0.23		
	SWE (in)	1.8447	1.3088																				1.58	4.00
average																					depth		**5.76**	**14.63**
																					density	**0.22**		
																					SWE		**1.32**	**3.36**

Western Coastal Area

Palm 2																							average	
Date																						g/cm^3	in	cm
11/3/2009	depth (in)	5	5	5	5	7	6	3	5	6	6	6	4	5	6	6	5	5	6	7	4		5.35	13.59
	density (g/cm^3)	0.25	0.25																			0.25		
	SWE (in)	1.25	1.76																				1.50	3.82
11/17/2009	depth (in)	5	5	4	5	5	6	5	5	5	5	3	5	5	5	5	5	7	4	4	4		4.85	12.32
	density (g/cm^3)	0.20	0.22																			0.21		
	SWE (in)	0.79	1.32																				1.06	2.68
12/1/2009	depth (in)	6	5	4	5	6	6	6	7	8	7	8	8	9	7	9	9	7	7	10	10		7.20	18.29
	density (g/cm^3)	0.3394	0.2968																			0.32		
	SWE (in)	1.697	2.226																				1.96	4.98
12/10/2009	depth (in)	6	6	6	5	6	6	7	5	6	6	8	5	3	6	5	8	5	6	5	6		5.80	14.73
	density (g/cm^3)	0.1903	0.3676																			0.28		
	SWE (in)	0.9515	2.2054																				1.58	4.01
12/15/2009	depth (in)	7	7	7	7	7	8	6	6	7	6	7	6	7	5	5	6	7	7	6	7		6.55	16.64
	density (g/cm^3)	0.2724	0.1643																			0.22		
	SWE (in)	1.9065	0.9859																				1.45	3.67
average																					depth		**5.95**	**15.11**
																					density	**0.26**		
																					SWE		**1.51**	**3.83**

Western Coastal Area

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Date																						average g/cm^3	average in	average cm
11/3/2009	depth (in)	4	9	3	5	5	3	8	3	4	2	3	4	4	4	3	5	5	4	4	3		4.25	10.80
	density (g/cm^3)	0.29	0.29																			0.29		
	SWE (in)	1.45	1.16																				1.31	3.32
11/17/2009	depth (in)	6	4	3	5	3	5	6	6	5	3	4	4	3	3	4	3	5	3	3	3		4.05	10.29
	density (g/cm^3)	0.38	0.17																			0.28		
	SWE (in)	1.90	0.69																				1.29	3.28
12/1/2009	depth (in)	8	10	11	8	6	5	6	3	3	4	3	2	3	4	3	3	4	3	4	4		4.85	12.32
	density (g/cm^3)	0.4024	0.3401																			0.37		
	SWE (in)	4.2253	1.0202																				2.62	6.66
12/10/2009	depth (in)	7	4	5	5	5	4	4	5	3	3	3	4	4	5	3	3	4	3	3	5		4.10	10.41
	density (g/cm^3)	0.1659	0.2425																			0.20		
	SWE (in)	0.5805	1.2126																				0.90	2.28
12/15/2009	depth (in)	7	6	5	3	3	6	11	6	6	3	5	9	6	11	6	5	9	6	11	6		6.50	16.51
	density (g/cm^3)	0.3504	0.3734																			0.36		
	SWE (in)	2.2775	3.1741																				2.73	6.92
average																					depth		**4.75**	**12.07**
																					density	**0.30**		
																					SWE		**1.77**	**4.49**

Western Coastal Area

DS-1J																						average		
Date																						g/cm^3	in	cm
11/3/2009	depth (in)	3	3	5	4	3	4	2	3	3	5	5	2	3	2	5	4	4	4	3	4		3.55	9.02
	density (g/cm^3)	0.21	0.17																			0.19		
	SWE (in)	1.05	0.52																				0.78	1.99
11/17/2009	depth (in)	10	9	5	6	7	9	13	6	6	5	11	7	8	10	5	9	3	5	9	6		7.45	18.92
	density (g/cm^3)	0.26	0.32																			0.29		
	SWE (in)	1.81	2.69																				2.25	5.72
12/1/2009	depth (in)	5	5	3	4	6	4	5	4	6	8	8	9	10	7	8	7	7	9	8	9		6.60	16.76
	density (g/cm^3)	0.353	0.5377																			0.45		
	SWE (in)	3.7066	5.1081																				4.41	11.19
12/10/2009	depth (in)	4	3	4	3	3	3	4	4	5	4	4	3	5	2	6	4	7	5	5	4		4.10	10.41
	density (g/cm^3)	0.1649	0.3944																			0.28		
	SWE (in)	0.4947	1.9718																				1.23	3.13
12/15/2009	depth (in)	9	7	7	10	10	10	10	9	11	9	13	10	11	10	10	6	8	11	11	9		9.55	24.26
	density (g/cm^3)	0.3176	0.3756																			0.35		
	SWE (in)	3.4936	3.9436																				3.72	9.45
average																					depth		**6.25**	**9.60**
																					density	**0.31**		
																					SWE		**2.48**	**6.30**

Western Coastal Area

S Pad																							average	
Date																						g/cm^3	in	cm
11/3/2009	depth (in)	5	2	3	6	4	3	3	4	6	7	4	2	4	4	3	4	3	6	4	5		4.10	10.41
	density (g/cm^3)																							
	SWE (in)																							
11/17/2009	depth (in)	4	5	5	6	7	3	5	6	6	6	3	5	6	8	7	4	5	6	7	6		5.50	13.97
	density (g/cm^3)	0.58	0.21																			0.39		
	SWE (in)	3.76	0.92																				2.34	5.95
12/1/2009	depth (in)	3	4	4	4	5	5	5	6	6	5	6	8	6	6	6	7	5	7	4	3		5.25	13.34
	density (g/cm^3)	0.1518	0.2191																			0.19		
	SWE (in)	0.8347	0.9859																				0.91	2.31
12/8/2009	depth (in)	5	4	4	3	3	4	4	3	3	4	3	5	3	3	5	7	4	4	4	4		3.95	10.03
	density (g/cm^3)	0.1718	0.2061																			0.19		
	SWE (in)	0.8588	1.0306																				0.94	2.40
12/14/2009	depth (in)	6	7	6	6	7	8	8	6	5	7	6	7	6	6	6	5	5	6	5	7		6.25	15.88
	density (g/cm^3)	0.3456	0.1345																			0.24		
	SWE (in)	1.7279	0.8073																				1.27	3.22
average																					depth		**5.01**	**12.73**
																					density	**0.25**		
																					SWE		**1.37**	**3.47**

APPENDIX C. L9312 ELEVATION SURVEY FORM

The following form reports the elevation survey information obtained during field sampling.

Arctic Transportation Networks

Form F-011: Elevation Survey Form

Project ID: **ATN** Site Location/Lake ID: L9312

Survey Purpose: **Water-Level Elevations** Date: 12/7/2009 Time: 12:35

Location:	Lake L9312, located southeast of Alpine pad, survey by pump house benchmarks				
Survey objective:	Determine FWS Elevation.				Weather Observations: 15°F, hazey
Instrument Type:	Leica NA720	Instrument ID:	5482372 (GWS owned)		
Rod Type:	Fiberglass	Rod ID:	Crane Fiber Glass		
Bench Mark Information:					Survey Team Names
Name	Agency Responsible	Elevation (ft)	Latitude (dd-mm.mmm)	Longitude (ddd-mm.mmm)	Lilly, Chris (LCMF)
L9312"P"	CP	11.73	na	na	

Station	BS (ft)	HI (ft)	FS (ft)	Elevation (fasl)	Distance (ft)	Horizontal Angle	Vertical Angle	Remarks
TBM "P"	2.65	14.38		11.73				Top of inlet pipe support
TBM "O"		14.38	2.91	11.47				Top of inlet pipe support. BM Elev=11.46'
99-32-59		14.38	-0.19	14.57				Top of Pumphouse SE VSM. BM Elev = 14.55
L9312 Ice		14.38	7.10	**7.28**				**Freeboard = 0.00**
Turn on L9312 Ice								
L9312 WL	6.77	14.05		7.28				**WL = 7.28**
99-32-59		14.05	-0.57	14.61				
TBM"O"		14.05	2.59	11.46				
TBM"P"		14.05	2.32	11.73				close survey to 0.00'

Abbreviations: backsight, BS; degrees, dd; feet, ft; feet above mean sea level, fasml; foresight, FS; height of instrument, HI; minute mm; seconds, ss; BP Mean Sea Level, BPMSL

APPENDIX D. LAKE ICE PHYSICAL MEASURMENTS

The following form reports physical measurements pertaining to lake ice obtained during field sampling.

Arctic Transportation Networks Project

FORM F-005: WATER-LEVEL MEASUREMENT FORM

Lake or Site ID: **L9312**

Local Number: Survey ID

All measurements in feet, unless noted

	NAD83	
Elevation (ft)	Latitude (dd-mm.mmm)	Longitude (dd-mm.mmm)
7.00	N 70 19.995	W 150 56.918

ABBREVIATIONS

BOI, bottom of ice

Calib, used to calibrate PT

IS, ice surface

LB, lake bottom

LS, land surface

MP, measuring point

N/A, not available

WS, water surface

Vertical-Datum Corrections, reference survey notes in site folders

Date	MP ID	MP Elevation (feet above BP Sea Level)
3/26/2004	"P"	11.61
1/16/2006	"P"	11.73 (BM elevation adjusted)

Date	Time	Method	Snow Depth	Total Depth IS to LB	Estimated Error	Ice Thickness (IS to BOI)	Freeboard (IS to WS)	WS Elevation	IS Elevation	Remarks
11/18/09	17:27	Levels	0.04	6.95	+/- 0.01	1.58	0.04	7.26		
12/7/09	13:00	Levels	0.2	10.55	+/- 0.01	2.26	0.00	7.28		

Collected Data Values

Lake-Full Elevation = measured at staff gage or near vertical benchmark after lake outflow ceased following spring snowmelt

Freeboard (FB) = Height of ice level over water level in open hole

Ice Thickness (IT) = Measured distance between top and bottom of ice

Total Depth (TD) = Measured distance from water surface to lake bottom

Estimated Error = Field estimate of water level measurement error

Calculated Values

Ice Surface (IS) Elevation = Water Elevation + Freeboard

Ice Bottom (IB) Elevation = Ice Surface Elevation - Ice Thickness