2011 ALPINE ICE ROAD RECHARGE STUDIES

Submitted to

ConocoPhillips Alaska, Inc.

Submitted by

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Acronyms, Abbreviations and Definitions

ADNR – Alaska Department of Natural Resources

Baker – Michael Baker Jr., Inc.

Bankfull - the water level, or stage, at which a stream, river or lake is at the top of its banks and any further rise would result in water moving into the flood plain

BPMSL – British Petroleum Mean Sea Level

CPAI – ConocoPhillips Alaska, Inc.

CRD – Colville River Delta

LCMF - Umiaq/LCMF, LLC

HWM – High Water Mark

mgal – million gallons

SWE – Snow Water Equivalent

TBM – Temporary Benchmark

WSE - Water Surface Elevation

1.0 INTRODUCTION

Maintenance and operations at Alpine oil field necessitate the use of ice roads and pads during the winter months. The temporary infrastructure supports overland transportation of resources which would otherwise not be possible for this remote location. Winter seasonal construction of ice roads and pads requires millions of gallons of fresh water, which is withdrawn from nearby lakes in the form of both liquid and ice chips. Water is typically withdrawn during the months of December through May for the purposes of ice road construction and maintenance.

ConocoPhillips Alaska, Inc., (CPAI) withdraws water and ice from lakes in compliance with various permits related to fish habitat and temporary water use granted by the State of Alaska. CPAI is requesting additional ice chip withdrawal at nine ice road resupply lakes in the Alpine area. Permitting requirements include recharge studies at all nine water withdrawal lakes, including obtaining and documenting recharge levels. Two of the nine lakes, M9602 and M9605, required additional data collection and analysis due to a request by CPAI to remove additional ice chips. Additional studies at these two particular lakes included late-season snow surveys and calculation of available recharge volumes. In the early spring 2011, CPAI requested Michael Baker Jr., Inc. (Baker) to conduct the Alpine Ice Road Recharge Studies before and during spring breakup 2011 at nine ice road resupply lakes in support of CPAI's request for additional ice chip removal. This report summarizes the hydrologic observations, measurements, and analyses undertaken for this project.

Baker sincerely appreciates the support provided by CPAI, Alpine Environmental Coordinators, Umiaq/LCMF and Bristow Helicopters, which was essential for safe and productive field monitoring.

1.1 STUDY OVERVIEW

The objective of the 2011 Alpine Ice Road Recharge Studies project was the collection and analysis of spring breakup recharge data at nine water withdrawal lakes. Recharge studies were performed at all nine lakes as support for water withdrawal without negatively affecting fish habitat. For the purposes of this report, these are grouped as Detatiled Study Lakes (lakes M9602 and M9605) and the remaining seven General Study Lakes. The 2011 study lakes include:

Detailed Study Lakes			
M9602	M9605		

General Study Lakes			
M9607	M9525	B8531/L9326	L9324
L9323	B8530	B8534/L9282	

The location of each lake and monitoring site with related water bodies within the study area is shown in Figure 1.1.

The work performed at all nine lakes includes pre-breakup and breakup monitoring, water surface elevation (WSE) measurement and spring breakup lake recharge observation and documentation. WSE was measured with hydrologic gages and lake recharge was documented using hydrographs and photos, with focus on as many key hydrologic features as possible, including (but not limited to) riparian level, peak WSE, and inflow/outflow locations.

Delineation of lake catchment basins and determination of basin-specific snow water equivalent (SWE) values were performed for lakes M9602 and M9605 in order to calculate 2011 potential snowmelt contribution and estimated recharge volumes. Catchment basins were delineated prior to field investigations using available topography and aerial imagery, and basin-specific SWE was calculated using data collected during late-season snow surveys performed prior to breakup. Potential snowmelt contribution was calculated using SWE values and delineated catchment basin areas; it is based on the Colville River Delta (CRD) runoff coefficient of 0.67 confirmed in 2007 (Baker 2007). Estimated recharge volumes were calculated using WSE data and delineated catchment basin area. An effort was made to compare the 2007 delta-wide runoff coefficient with M9602 and M9605 basin-specific runoff coefficients.

1.2 Lake Recharge Background

Annual recharge of lakes in the CRD occurs as a result of three primary mechanisms: spring breakup flooding, snow melt, and precipitation. Of these, spring breakup flooding and snow melt were the mechanisms investigated for the purposes of this report; both considered overland flow. Lake elevation and proximity relative to streams, along with local topography, typically dictate the recharge mechanism. Lakes located within annually inundated stream floodplains or otherwise hydraulically connected areas will likely recharge primarily from spring breakup flood flow. Lakes that are not inundated by flood flow either due to distance or topographical limitations must depend solely on snowmelt runoff (and precipitation) for recharge.

Lake recharge may vary annually. The magnitude of spring breakup flooding differs from year to year in terms of stage and discharge. In any given year recharge may not occur, depending on topography and elevation of a lake, if flood stage is relatively low. In addition to spring flooding, flow extents are affected by the unpredictable establishment and release of ice jams, which generally accompany breakup processes. Presence and location of ice jams or proximal lack thereof can determine whether or not a lake is hydraulically connected to a stream recharge source, regardless of flood magnitude.

The amount of snowmelt runoff a lake receives will depend mainly on the properties of snow in the catchment basin area as well as the terrain and topography of the lake catchment basin itself. The depth and density of snow available within a catchment basin in the spring when melting occurs is directly proportional to the quantity of potential snowmelt recharge, measured as SWE. SWE will vary with the type of terrain and may be presented as a weighted, basin-specific value. For lakes sharing similar topographical and climatological features with those previously studied, average SWE values may be multiplied by catchment basin area to calculate a very conservative estimate of potential snowmelt recharge. This method was previously used for lakes M9602 and M9605 (Baker 2010), and a comparison of those results with the results found based on this study is included in Section 4.1.5.

For the purposes of this report, terrain within lake catchment basins was designated as either lake or tundra. Snowmelt contribution from lakes may be reduced to account for the potential of floating ice to displace water and artificially inflate WSE. For this report, however, lake areas were assumed to contribute all snowmelt based on analysis of snow survey data and estimated recharge volumes. All tundra snowmelt, however, will not directly contribute to lake recharge due to variations in vegetation and topography relative to the lake. Lower wetlands areas, for example, will retain a certain portion of snowmelt, with recharge contribution dependant on snowmelt quantities and wetlands elevation relative to the lake. The quantity of snowmelt retained in tundra areas differs for each lake catchment basin.

Kane et al. (1999) performed a study in the Kuparuk River Basin to determine an average quantity of snowmelt retained in tundra areas of lake catchment basins as a percentage of total potential snowmelt contribution, based on estimated and estimated recharge quantities. Study findings suggested that an average runoff coefficient of 0.67 be applied to tundra SWE as a reduction factor to account for snowmelt retention, which is reflected in the total estimated snowmelt contribution for a lake.

In 2007, Baker performed a recharge monitoring and analysis study for lakes within the CRD Results suggested an average tundra SWE runoff coefficient of 0.67, similar to the value obtained by Kane et al. (Baker 2007). For the purposes of this report, 0.67 was used as a tundra SWE runoff coefficient, considering the locations of the nine study lakes relative to the CRD and Kuparuk River Basins and similarity of topography. See Section 3.3.4 for further discussion of SWE and runoff.

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2011 ICE ROAD RECHARGE LAKES MONITORING LOCATIONS

FIGURE 1.1
(SHEET 1 OF 1)

2.0 PERMITS AND WATER USE

All nine study lakes included in this report are permitted for water use by the State of Alaska. Permits are granted on the condition of the user fulfilling fish habitat and temporary water use requirements that specifically regulate the withdrawal of water while maintaining conditions supportive of fish habitat. As one condition of fish habitat support, lakes must seasonally recharge water volumes borrowed during the winter season, in addition to the recharge of water potentially lost naturally through processes such as evaporation. Fish habitat and temporary water use permits stipulate the quantities of water that may be borrowed per water year, which is defined as one year beginning and ending with spring breakup. Actual withdrawal quantities are also reported by the user per water year.

The permits regulating use at the nine study lakes additionally specify the form of water that may be borrowed from each lake, which varies as either liquid only, specific quantities of liquid and ice, or a total of both without designation of individual quantities. Lakes M9602 and M9605 were both permitted for specific borrow quantities of liquid and ice. Lakes B8534/L9282, M9525 and B8530 are permitted for liquid use only, and lakes L9323, L9324, B8531/L9326 and M9607 are permitted for total of both without designation of individual quantities.

Water in the form of ice and/or liquid was withdrawn from seven of the nine study lakes during the 2010/2011 ice road construction season. Excluded were lakes B8534/L9282 and M9525, which were not used as water sources. Lakes M9602 and M9605 were the only two studied for this report that had 2010/2011 annual withdrawal in the form of ice. Lake M9605 additionally had withdrawal in the form of liquid. At the remaining ice road recharge lakes that were used during the 2010/2011 season, withdrawal was in the form of water only.

Lake B8530 is hydraulically connected to Lake M9608. The total recharge potential of both lakes should be considered when evaluating available borrow quantities and actual water withdrawal.

Table 2.1 summarizes the permits regulating water use at the nine studied source lakes, purpose, and permitted and actual withdrawal volumes by form and total based on fourth quarter 2010 and first and second quarter 2011 water use reports (CPAI 2010, 2011a, and 2011b).

TABLE 2.1: SUMMARY OF PERMITTED AND ACTUAL WITHDRAWAL VOLUMES

Lake	Permit		Permit Expiration	Water Use Purpose[1]	Permitted Volume[2]			Withdrawal Volume[4]		
	ADF&G	ADNR			Liquid (mgal)	Ice (mgal)	Total Water[3] (mgal)	Liquid (mgal)	Ice (mgal)	Total Water (mgal)
M9602	FH05-III-0327 #2	TWUP A2010-119 ICE	12/2/2015	Ice Road/Pad	0.78	30.63	31.41	--	1.20	1.20
M9605	FH05-III-0328 #2	TWUP A2010-119 H2O TWUP A2010-119 ICE	12/2/2015	Ice Road/Pad	8.52	13.62	22.14	7.07	2.33	9.40
B8534/L9282	FG02-III-0104 #1	LAS 23897	5/13/2013	-	10.00	--	10.00	--	--	--
M9525	FG03-III-0379 #2	TWUP A2008-180	12/31/2013	-	0.02	3.49	3.51	--	--	--
L9323	FG03-III-0380 #3	LAS 18597 TWUP A2008-181	5/15/02 12/16/2013	Drilling Makeup, Camp Supply, DS/Wells, Dust Control, Ice Road/Pad	*	*	8.51	6.91	--	6.91
L9324	FG03-III-0381 #3	TWUP A2008-181	12/16/2013	Ice Road/Pad	*	*	1.65	1.00	--	1.00
B8531/L9326	FG03-III-0382 #1	TWUP A2008-180	12/16/2013	Ice Road/Pad	*	*	6.59	4.97	--	4.97
B8530	FG03-III-0383 #1	TWUP A2008-180	12/16/2013	Ice Road/Pad	32.00	--	32.00	11.47	--	11.47
M9607	FG03-III-0384 #3	TWUP A2008-180	12/16/2013	Ice Road/Pad	*	*	5.47	3.80	--	3.80

Notes:
1. "-" indicates purpose unknown
2. Per water year
3."*" indicates total permitted withdrawal may be either ice, liquid, or a combination
4. Actual use between June 1, 2010 and May 31, 2011

3.0 STUDY METHODS

3.1 CATCHMENT BASIN AREA DELINEATION (DETAILED STUDY LAKES)

The catchment basins, including lake and tundra areas, for lakes M9602 and M9605 were delineated using satellite imagery, topographic maps, and visual assessment of the local topography prior to the field study. Topographic data for this area is limited, and the catchment basin delineation for both lakes is somewhat subjective as a result. In addition to limited topography, seasonal data about nearby water bodies, such as wetlands and ponds that potentially contribute to recharge flow into the lakes, is lacking. These areas have the capacity to store an undetermined quantity of snowmelt and were not included within the catchment basin delineation.

3.2 WATER SURFACE ELEVATION SURVEYS

In an effort to estimate lake water recharge, changes in WSE were measured at each study lake. A hydrologic gage was installed at the edge of each lake and tied in to either local or British Petroleum Mean Sea Level (BPMSL) control, if available. Water surface elevation monitoring was conducted at each of the nine study lakes during the pre-breakup, breakup, and post-breakup periods.

PHOTO 3.1: HYDROLOGIC GAGE AT LAKE M9605, PRE-BREAKUP

During pre-breakup, a staff gage was installed at each study lake. The staff gage was installed at the edge of the lake ice to monitor WSE and as breakup progressed, additional gages were installed as needed. A single hydrologic gage assembly consists of a metal gage faceplate mounted on a two-by-four timber. The timber is attached with u-bolts to a 1.5-inch wide angle iron driven approximately 2 feet into the ground. All hydrologic gages installed were indirect-read staff gages; meaning, the values read on the gage faceplate do not directly correspond to an actual elevation. Photo 3.1 shows the gage M9605-A which was installed during pre-breakup. Installation of the initial staff gages was completed prior to the arrival of breakup floodwater.

PHOTO 3.2: NEWLY ESTABLISHED TBM (BACKGROUND) AT LAKE M9602 AND GAGE M9602- A (FOREGROUND), PRE- BREAKUP

Standard level loop survey techniques were used to establish hydrologic gage elevations with local temporary benchmarks (TBMs). A single new TBM was installed when a preexisting TBM was farther than ¼ mile of the study lake (Photo 3.2). The new TBM was given an assumed elevation of 100 feet.

The hydrologic gages at lakes M9525, L9323, and L9324 were based off of preexisting TBMs with a known datum – British Petroleum Mean Sea Level (BPMSL). The remaining six lakes were based off of newly established TBMs with assumed elevations and as a result, the hydrologic gages tied to an assumed elevation were relative. In other words, a hydrologic gage tied to an assumed elevation is limited to illustrating a change in WSE for the given lake.

During the pre-breakup period, WSE at lakes M9602 and M9605 was determined by subtracting measured freeboard (the distance from the top of ice to the water surface) from the surveyed ice surface elevation at the sample hole. An electric drill was used to auger a 2-inch sampling hole through the ice. Freeboard was measured using a pocket rod. Ice thickness was measured using either a pocket rod or a graduated pole with a hook on the end. The pole was lowered into the water until the hook found the underside of the ice. The resultant ice thickness was measured from the graduated marks along the pole. At Lake B8534/L9282, pre-breakup WSE was conservatively estimated to be the top of the lake ice elevation near the gage since it was not drilled due to equipment failure.

During site visits the observed water level on the gage faceplates was recorded. Chalk was applied to the angle iron during each site visit to capture high water marks (HWM). Subsequent HWM were recorded during field visits when floodwaters removed the chalk. When water levels were not sufficiently high to be recorded on the staff gage face plates, standard level loop survey techniques were used to measure WSE. The horizontal position of each hydrologic gage and TBM was recorded using a handheld Garmin Rino 520HCx in North American Datum of 1983 (NAD83). Gage readings associated with local ponding were recorded but were not used to generate the lake recharge hydrograph.

3.3 Snow Water Equivalent Surveys (Detailed Study Lakes)

3.3.1 Double Sampling Method

A double sampling method snow survey was conducted on Lakes M9602 and Lake M9605, based on the 2007 Baker report (2007). Prior to fieldwork, snow sampling points were located along predetermined transects.

For the fieldwork, each snow survey transect was positioned such that it was aligned across, or perpendicular to, snow features (such as drifts and local topography) as suggested by Woo (1997). For the double sampling method, measurements were recorded in two ways: first by measuring snow depth and mass at a smaller number of points, and second by measuring only snow depth at a larger number of points. Additionally, while vegetation is not a major factor affecting snow distribution in the arctic, terrain has a major effect. Therefore, terrain-based snow surveys allow for a more accurate determination of mean catchment snow values and thus produce sufficient spatial snow information for most hydrological studies (Woo 1997).

3.3.2 Sampling Transects and Points

Aerial imagery and topographic contours were used to delineate the lake catchment basins. Transects were located perpendicular to local relief radiating from a central point for each lake. Additional transects were selected to capture irregularities, including basin arms, or other departures from a classic bowl shape.

Sampling points were then established along the transects at a uniform spacing of approximately 200 feet. The total number of sampling points on a transect was dependent on the length of the transect, as well as anticipated variability in snow within the terrain unit. By placing a sampling point at the intersection of transects, and then spacing sampling points at a uniform distance along the transects, a random sampling was accomplished. Each terrain type covered by a single transect included at least one snow mass sampling point. Sampling points were stored in two Garmin Rino 520HCx units to ensure valid field sampling.

3.3.3 SNOW DENSITY SAMPLING

Density measurements were conducted according to procedures outlined in *NRCS Snow Survey Sampling Guide* (NRCS 2006) and *British of Columbia Snow Survey Manual* (BC Ministry of Environment 1981), using a 1 5/8-inch ID Model 3600 Mt. Rose (Standard Federal) snow sampling tube and scale. This sampler was chosen based on its common acceptance and use by the NRCS. Snow depth alone was sampled using a graduated snow pole. In addition, if shallow snow was encountered having a SWE of less than 2 inches, bulk sampling was conducted (NRCS 2006). A bulk sampling is a grouping of multiple samples collected in the immediate area of the sample point, recording sample depth of each sample, and weighing of pooled core samples (Baker 2007). Photo 3.3 shows the Model 3600 Mt. Rose snow sampler and the bucket used for pooled snow samples.

PHOTO 3.3: MODEL 3600 MT. ROSE SNOW SAMPLER (TOP) AND BUCKET FOR POOLED SNOW SAMPLES (BOTTOM) WITH SAMPLE HOLES

3.3.4 SWE LAKE RECHARGE METHODS

The SWE lake calculated potential contribution methods and equations used for this report are the same as those from the Baker 2007 report. To summarize, the two primary terrain types that lie within the catchment basins of Lakes M9602 and M9605 are lake and tundra. Terrain specific average snow depths were collected by field crews using the graduated snow pole and snow sampler at M9605 and M9602 (Photo 3.4). To calculate the terrain specific snow depth for each lake catchment, Equation 1 was used.

PHOTO 3.4: FIELD CREW USING SNOW SAMPLER TO COLLECT DEPTHS AND SAMPLES

EQUATION 1 –TERRAIN SPECIFIC SNOW DEPTH OF CATCHMENT

$$d_i = \left[\sum_{l=1}^{p} d_l \right] \Big/ p$$

$$d_i = Terrain\ Specific\ Snow\ Depth\ of\ Catchment\ (in)$$
$$l = Individual\ Sample$$
$$p = Total\ Number\ of\ Terrain\ Specific\ Depth\ Samples$$
$$d_l = Measured\ Snow\ Depth\ (in)$$

Terrain specific average snow densities were then calculated for the two lakes based on the snow sampler's cross sectional area, core depth, and the weights of the snow samples using Equation 2.

EQUATION 2 –TERRAIN SPECIFIC SNOW DENSITY OF CATCHMENT

$$\rho_i = \left[\sum_{k=1}^{m} \left(\frac{M_{snow}}{A_{core} d_{snow}} \right)_k \right] \Big/ m$$

$$\rho_i = Terrain\ Specific\ Snow\ Density\ of\ Catchment\ (lb/in^3)$$
$$k = Individual\ Sample$$
$$m = Total\ Number\ of\ Terrain\ Specific\ Core\ Samples$$
$$M_{snow} = Measured\ Mass\ of\ Snow\ Sample\ (lb)$$
$$A_{core} = Area\ of\ Sampling\ Tube\ (in^2)$$
$$d_{snow} = Depth\ of\ Snow\ Sample\ (in)$$

Using the terrain specific snow densities, terrain specific SWE were then calculated using Equation 3.

EQUATION 3 – TERRAIN SPECIFIC SNOW WATER EQUIVALENT OF CATCHMENT

$$SWE_i = \frac{(\rho_i d_i)}{\rho_w}$$

$$SWE_i = Terrain\ Specific\ Snow\ Water\ Equivalent\ of\ Catchment\ (in)$$
$$\rho_i = Terrain\ Specific\ Snow\ Density\ (lb/in^3)$$
$$d_i = Terrain\ Specific\ Snow\ Depth\ (in)$$
$$\rho_w = Density\ of\ Fresh\ Water\ (lb/in^3)$$

An area weighted snow water equivalent was then calculated for Lake M9602 and Lake M9605 catchment basins. Equations 4 was used in this calculation and was based on what was presented by Woo (1997), with considerations of Rovansek, Kane, and Hinzman (1993).

EQUATION 4 –CATCHMENT SPECIFIC, AREA WEIGHTED SNOW WATER EQUIVALENT

$$SWE_C = \frac{\left(\sum_{i=1}^{n} \rho_i d_i A_i \Big/ \sum_{i=1}^{n} A_i \right)}{\rho_w}$$

$SWE_C = Catchment\ Specific\ Snow\ Water\ Equivalent\ (in)$

$i = Terrain$

$n = Total\ Terrains\ Sampled\ in\ Catchment$

$\rho_i = Terrain\ Specific\ Snow\ Density\ (lb/in^3)$

$d_i = Terrain\ Specific\ Snow\ Depth\ (in)$

$A_i = Terrain\ Specific\ Area\ (ft^2)$

$\rho_w = Density\ of\ Fresh\ Water\ (lb/in^3)$

At lakes M9602 and M9605, potential snowmelt contribution was calculated and compared to estimated recharge quanitites. Total calculated potential snowmelt contribution (V_P) and estimated recharge (V_O) were found for each lake according to the following Equations 5 and 6.

EQUATION 5 –TOTAL CALCULATED POTENTIAL SNOWMELT CONTRIBUTION, PER LAKE

$$V_P = C_1 \left(SWE_l\ A_l + 0.67\ SWE_t\ A_t \right)$$

$V_P = Total\ Calculated\ Potential\ Snowmelt\ Contribution\ (gal)$

$C_1 = Gallons\ of\ Water\ /\ ft^3\ /\ in$

$SWE_l = Lake\ Specific\ Average\ Snow\ Water\ Equivalent\ (in)$

$SWE_t = Tundra\ Specific\ Average\ Snow\ Water\ Equivalent\ (in)$

$A_l = Lake\ Specific\ Area\ (ft^2)$

$A_t = Tundra\ Specific\ Area\ (ft^2)$

$0.67 = 2007\ Delta - wide\ Runoff\ Coefficient$

EQUATION 6 –ESTIMATED RECHARGE, PER LAKE

$$V_O = C_2 A_l WSE_\Delta$$

$$V_O = Estimated\ \mathrm{Re}ch\mathrm{arg}e\ (gal)$$
$$C_2 = Gallons\ of\ Water\ /\ ft^3$$
$$A_l = Lake\ Specific\ Area\ (ft^2)$$
$$WSE_\Delta = Difference\ Between\ \mathrm{Pr}e - Breakup\ and\ Peak\ WSE\ (ft)$$

3.4 LAKE RECHARGE OBSERVATIONS

Throughout breakup, each lake was monitored for changes in WSE. Aerial photographs were taken periodically from a helicopter using a GPS camera. Photos taken from various perspectives were used to capture the extent of snow melt, flow pattern, potential lake water recharge sources, and hydraulic connectivity with other waterbodies. Visual observations combined with time-stamped GPS photos enabled the reconstruction of each lake's recharge extent and timeline.

Hydrographs showing change in WSE over time were also used to determine the extent of lake recharge (see Table 4.3 and Table 4.4 for lakes M9602 and M9605, respectively, and Table 4.7 through Table 4.13 for the General Study Lakes). Recession of floodwaters is evident in a negative slope after peak stage, indicating a lake has recharged over bankfull conditions and is discharging excess water by means of overbank flow. The nine lakes were studied during a pre-breakup through post-breakup monitoring period. WSE was not monitored for a sufficient amount of time after post-breakup to establish a "plateau" on the hydrograph; a consistent WSE over time, which would be indicative of bankfull elevation.

3.5 2010/2011 ICE ROAD CONTRIBUTIONS

As-built drawings for the 2010/2011 ice road construction season were used to estimate the volume of melt water recharge contributed to lakes M9602 and M9605 catchment basins. Ice road contributions were determined using an estimated value of one million gallons of water per mile of ice road (ASCG 2005).

4.0 STUDY RESULTS

4.1 DETAILED STUDY LAKES

4.1.1 CATCHMENT BASIN DELINEATION

Catchment basin delineations for lakes M9602 and M9605 are presented in Figure 4.1 and Figure 4.2, respectively, and are likely somewhat conservative based on available data, as discussed in Section 3.1. Lake areas for M9602 and M9605 were taken from bathymetry reports provided by CPAI in Appendix B.

No flow was observed in or out of Lake M9602 until a small channel developed at some time between June 7 and June 20. The outflow of Lake M9602 went northeast into Lake M9601 (Photo 4.1). This channel is not considered a means for significant quantities of spring breakup flood flow to recharge Lake M9602 and the catchment basin delineated prior to field investigations was not adjusted.

PHOTO 4.1: OUTFLOW FROM LAKE M9602 INTO LAKE M9601

Hydraulic connections were identified between Lake M9605 and adjacent water bodies, including an unnamed lake to the north via a small channel (Photo 4.2), a wetlands south via a small channel, and to the southwest via polygon cracks (Figure 4.2). This hydraulic connectivity is likely limited to the spring breakup time period. The catchment basin delineated prior to field investigations was not adjusted since we cannot be sure this happens every year.

PHOTO 4.2: CHANNEL FROM LAKE M9605 FLOWING NORTH

4.1.2 SNOW SURVEY AND SNOW WATER EQUIVALENT

Snow water equivalent surveys were conducted at Lake M9605 on May 3 and 4, 2011; and at Lake M9602 on May 4 and 5, 2011. Snow surveys were conducted in conjunction with CRD spring breakup setup. As described in Section 3.3.2, sampling locations were pre-determined based on catchment basin delineations, as well as topographic features identified in aerial imagery.

Seasonal snow cover conditions at both lakes sampled in 2011 were generally consistent with results found by Baker in 2007, although 2011 snow depths were greater. In general, lake snow cover was thinner, denser, and comprised less SWE than adjacent tundra. This is likely related to the potential of tundra vegetation to accumulate snow and to prevailing wind patterns, as snow depth tended to increase on lake ice towards the west with the deepest snow encountered closest to the bank.

The SWE summaries for lakes M9602 and M9605 are presented below in Table 4.1. Comprehensive snow survey data sheets are included in Appendix A.

TABLE 4.1: DETAILED STUDY LAKES SNOW SURVEY SUMMARY

Lake	Area (ft^2)		Average Snow Depth (in)		Average Density (lb/in^3)		Average SWE (in)		Catchment Basin Weighted SWE (in)
	Tundra	Lake	Tundra	Lake	Tundra	Lake	Tundra	Lake	
M9602	14,848,000	28,662,000	20.5	12.6	0.010	0.011	5.47	3.76	4.34
M9605	18,092,000	15,246,000	16.0	11.9	0.009	0.010	3.94	3.37	3.68

At lakes M9602 and M9605, isolated mechanically disturbed areas of snow, associated with the removal of water and ice chips, was evident in the form of cleared areas surrounded by drifts. Visual observations of wind-driven snow quantities accumulated in the previously cleared areas and around the drifts suggest that mechanically clearing and piling snow on ice may facilitate snow deposition on lakes. Evidence of existing drifts at Lake M9602 and M9605 near the beginning of breakup are apparent in Photo 4.3 and Photo 4.4.

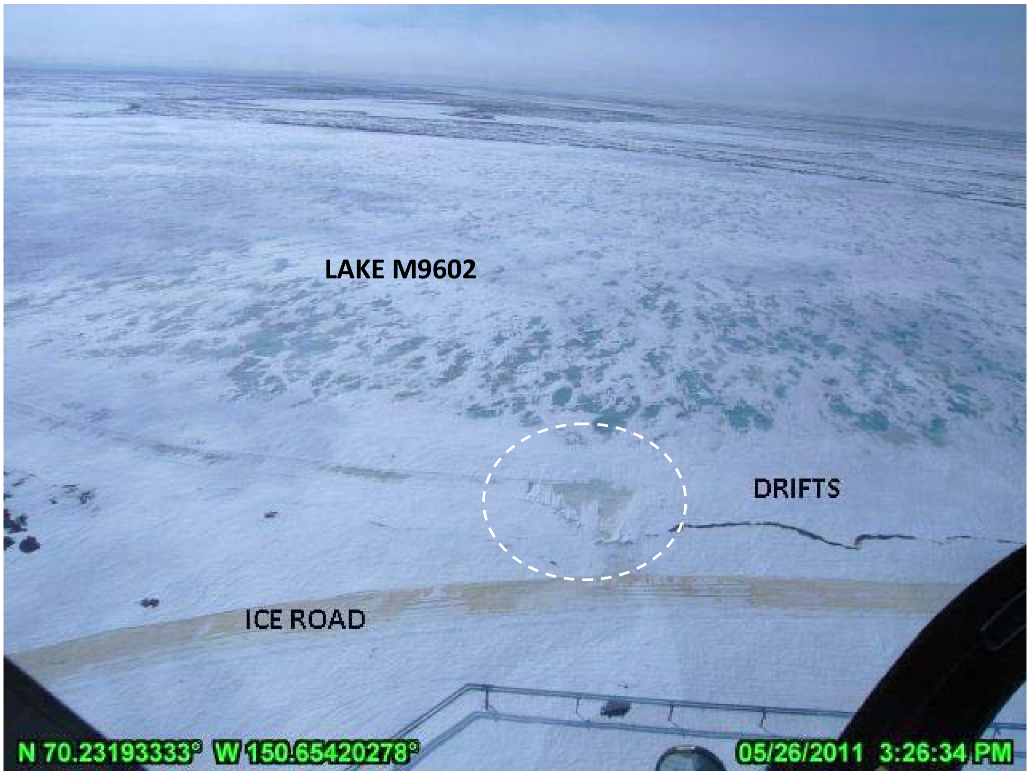
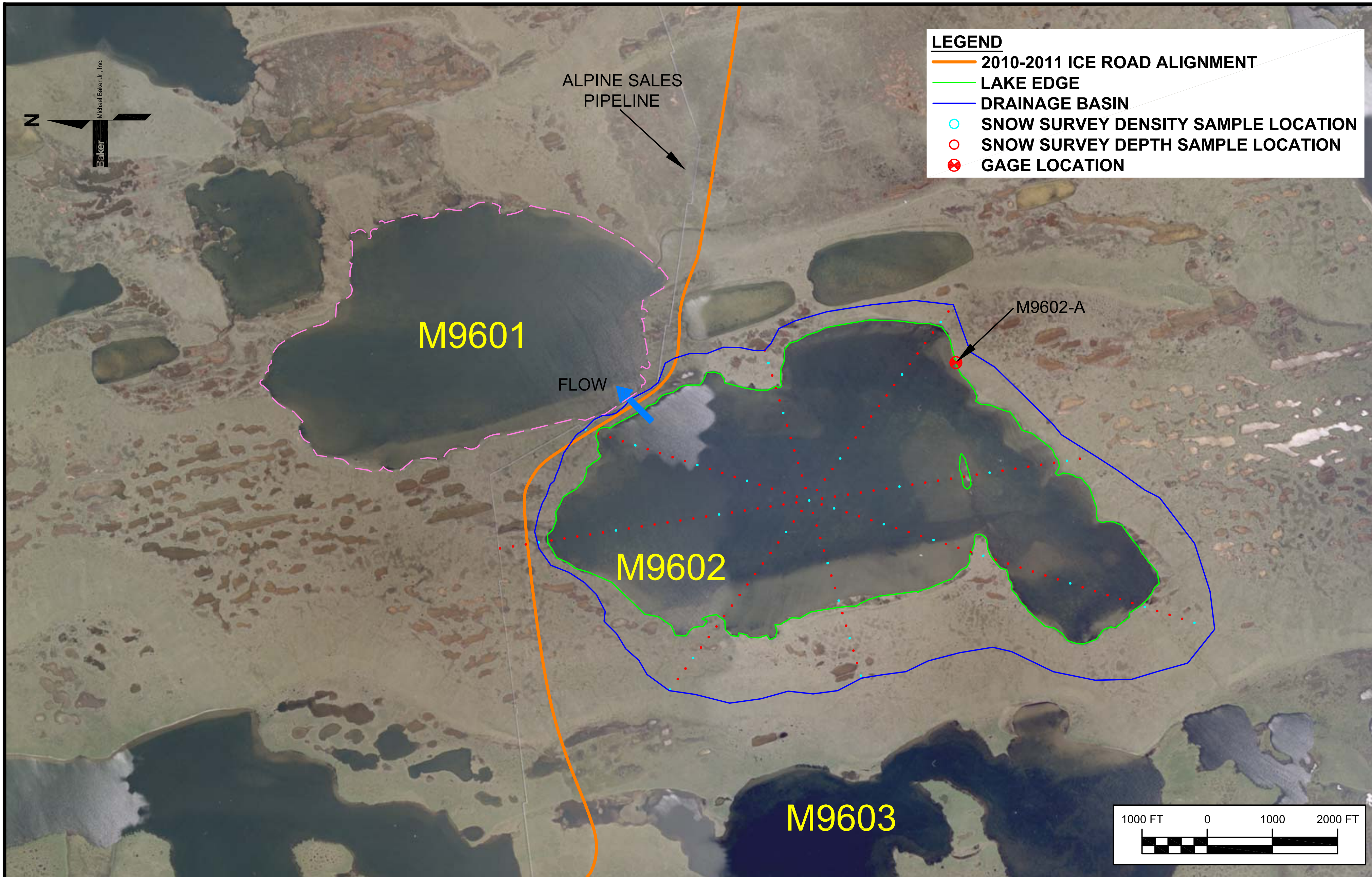


PHOTO 4.3: LAKE M9602 DRIFTS AT THE BEGINNING OF BREAKUP

PHOTO 4.4: LAKE M9605 DRIFTS AT THE BEGINNING OF BREAKUP



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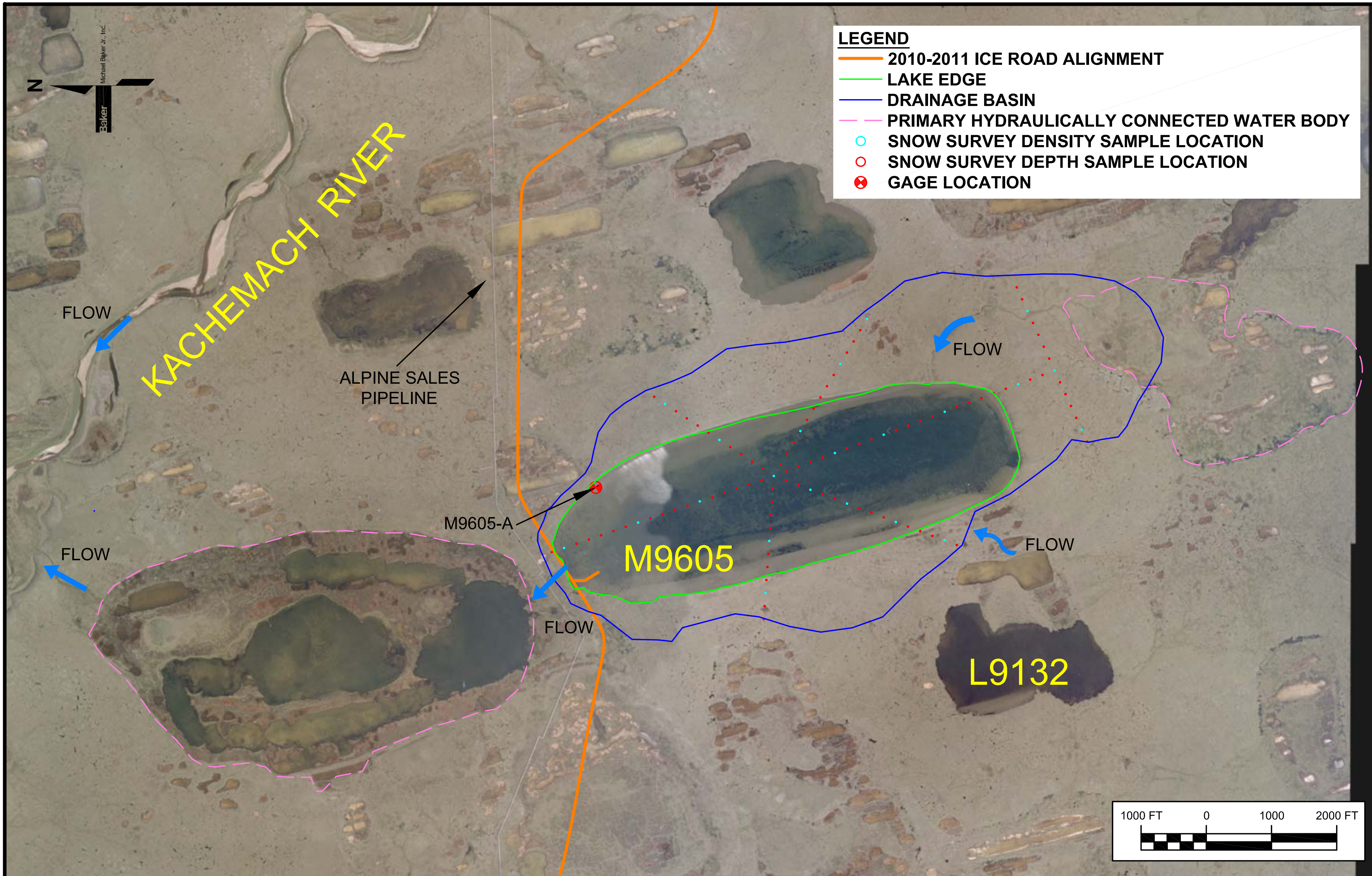
M9602

DRAINAGE BASIN DELINEATION & SNOW SURVEY LOCATIONS

FIGURE 4-1

(SHEET 1 OF 1)



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M9605

DRAINAGE BASIN DELINEATION & SNOW SURVEY LOCATIONS

FIGURE 4-2

(SHEET 1 OF 1)

4.1.3 Water Surface Elevation

Water surface elevation was measured before, during, and after spring breakup at lakes M9602 and M9605. Pre-breakup WSE was surveyed through a hole drilled into the lake ice, as discussed in Section 3.2. Pre-breakup WSE was surveyed on May 17 at Lake M9602 and M9605 as 95.58 and 95.65 feet, respectively. Ice thickness was 4.50 feet at both lakes.

Spring breakup melting of ice and snow at Lake M9602 occurred slower than other lakes within the CRD, which was expected for an area outside of the river delta lacking significant channelized and overland flow. The WSE increased at Lake M9602 from an initial surveyed pre-breakup WSE of 95.58 feet on May 17 to a peak of 96.15 feet on June 16. Over the course of breakup, WSE decreased to 95.76 feet by June 20, at which time more than 50% of the lake ice surface remained and the majority of snow in the catchment had melted (Photo 4.5).

PHOTO 4.5: LAKE M9602 - MAJORITY OF SNOW MELTED AND LAKE ICE PRESENT

During the final visit to Lake M9602 on June 20, the majority of snow in the area had melted and a large portion of lake ice was still present (Photo 4.6). The WSE increased at Lake M9605 from an initial surveyed pre-breakup WSE of 95.65 feet on May 17 to a peak of 96.69 feet based on a HWM recorded on June 7. The HWM was estimated to have occurred sometime on June 6. The increase of WSE at Lake M9605 was the result of local snowmelt and channelized flow. Post break-up, the WSE at Lake M9605 had decreased to 95.89 feet on June 20. Further discussion of Lake M9605 recharge may be found in Section 4.1.4.

PHOTO 4.6: LAKE M9605 - MAJORITY OF SNOW MELTED AND LAKE ICE PRESENT

A summary of pre-breakup, peak, and post-breakup WSE for lakes M9602 and M9605 is shown in Table 4.2. A graphic representation of WSE data for M9602 and M9605 are presented in Table 4.3 and Table 4.4.

TABLE 4.2: SUMMARY OF DETAILED STUDY LAKES OBSERVED WSE

Lake	Observed Water Surface Elevation[1]			
	Pre-Breakup	Peak	Difference[2]	Post-Breakup
	(ft)			
M9602	95.58	96.15	0.57	95.76
M9605	95.65	96.69	1.04	95.89
Notes:	1. Water surface elevations are assumed elevations relative to their respective study lake only. 2. Between pre-breakup and peak			

In addition to WSE measurements, photographs at lake M9602 and M9605 were taken of the riparian zone in relation to WSE (Photo 4.7 through Photo 4.10).

PHOTO 4.7: LAKE M9602 RIPARIAN ZONE

PHOTO 4.8: LAKE M9602 RIPARIAN ZONE AND GAGE M9602- A

PHOTO 4.9: LAKE M9605 RIPARIAN ZONE

PHOTO 4.10: LAKE M9605 RIPARIAN ZONE AND GAGE M9605- A

TABLE 4.3: WSE DATA FOR LAKE M9602

Date and Time	WSE (feet) M9602	Observations
5/17/11 12:00 PM	95.58	Pre-breakup survey to WSE (freeboard = 0.10 ft)
5/31/11 11:44 AM	95.58	Estimated - no water on gage, no melt in area
6/7/11 10:12 AM	96.11	Local melt, no overland flow; significant quantities of snow still present in area
6/16/11 9:25 AM	96.15	Peak WSE
6/20/11 7:35 PM	95.76	

Notes:

1. Elevations are assumed based on TBM M9602-X at 100.00 feet BPMSL, installed by Baker in May 2011.

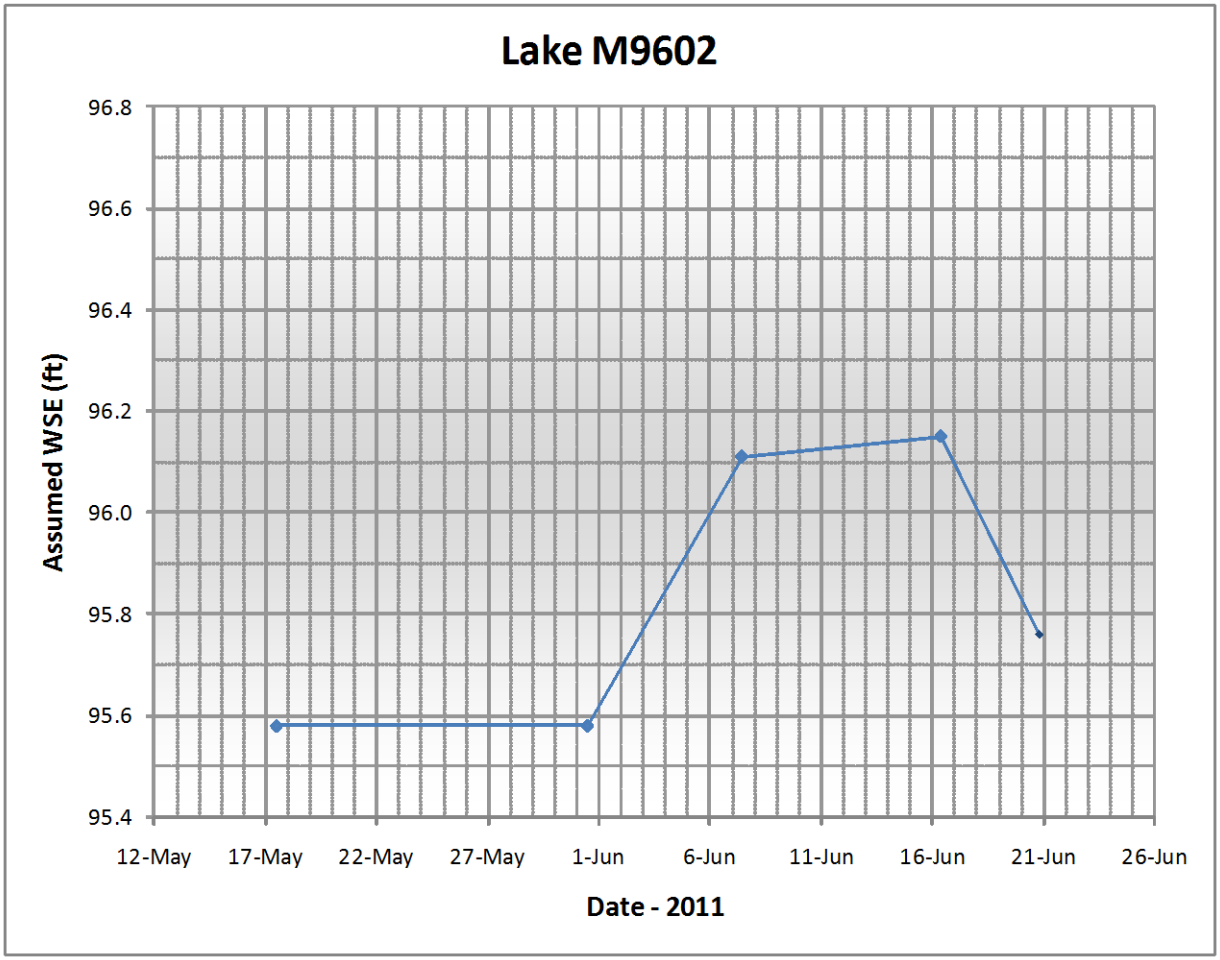
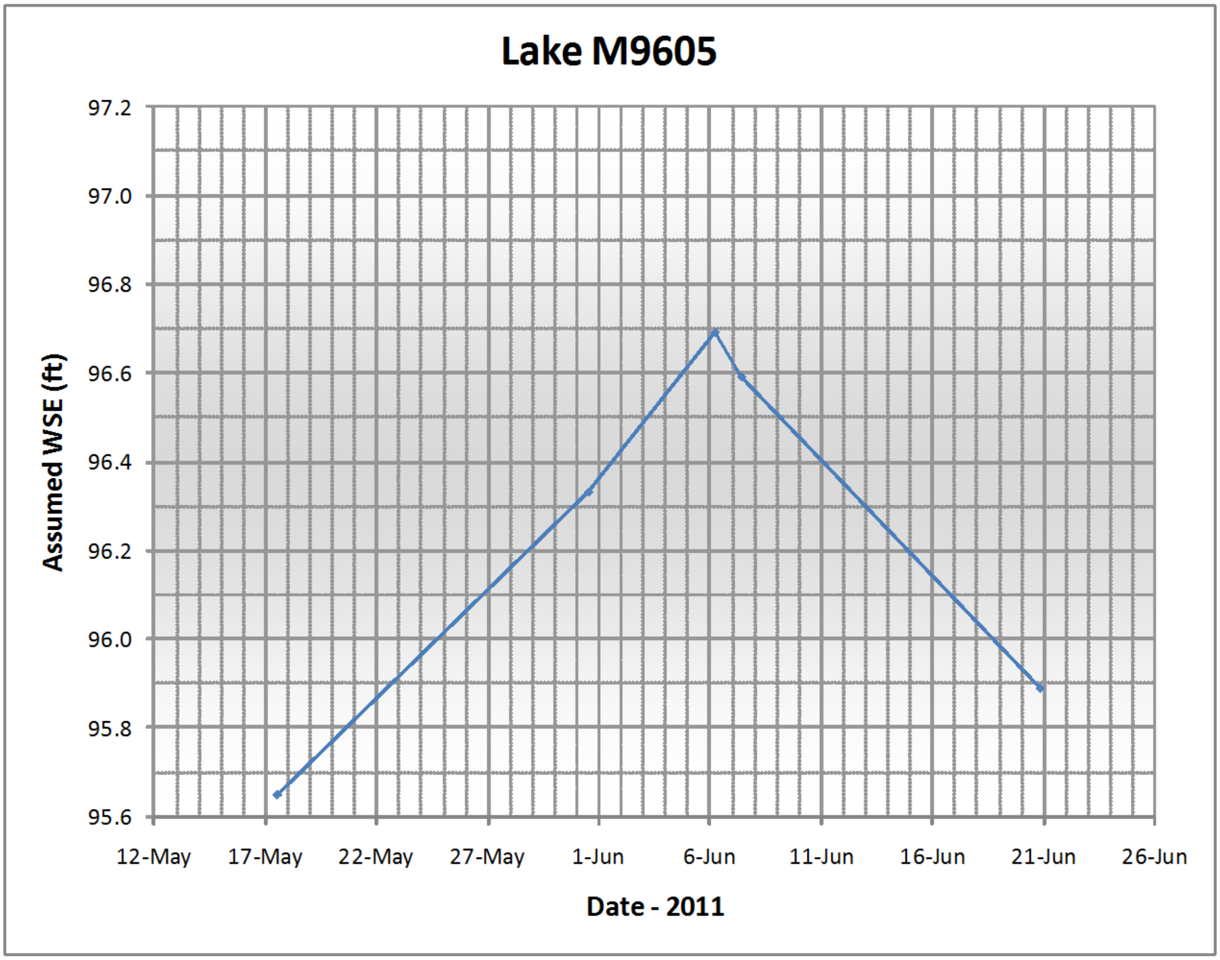


TABLE 4.4: WSE DATA FOR LAKE M9605

Date and Time	WSE (feet)	Observations
	M9605	
5/17/11 12:00 PM	95.65	Pre-breakup survey to WSE (freeboard = 0.15 ft)
5/31/11 12:09 PM	96.33	Lake recharging mainly south from wetlands area
6/6/11 5:00 AM	96.69	**Peak Stage** based on HWM, time and date estimated
6/7/11 9:25 AM	96.59	Lake draining into lake north; significant quantities of snow still present in area
6/20/11 7:50 PM	95.89	

Notes:

1. Elevations are assumed based on TBM M9605-X at 100.00 feet BPMSL, installed by Baker in May 2011.



4.1.4 Lake Recharge

Lakes M9602 and M9605 recharged over bankfull conditions based on the rise and recession of WSE presented in the hydrographs (Table 4.3 and Table 4.4) during the 2011 monitoring period. Potential snowmelt contributions were calculated using the 2007 delta-wide runoff coefficient (0.67) and the 2011 SWE. The estimated recharge volumes were determined by multiplying the lake surface area by the difference between peak and pre-breakup WSE for lakes M9602 and M9605.

These values are presented alongside permitted and actual water use quantities for M9602 and M9605 in Table 4.5.

TABLE 4.5: DETAILED STUDY LAKES SPRING BREAKUP RECHARGE SUMMARY

Lake	Calculated Potential Snowmelt Contribution[1]			Estimated Recharge[2]	Permitted Annual Water Use[3]	Actual Water Use[4]
	Lake	Tundra	Total	May 5 - June 20, 2011	2011 Current	June 2010 - May 2011
	(mgal)					
M9602	67.2	33.9	101.1	122.2	31.4	1.2
M9605	32.0	29.8	61.8	118.6	22.1	9.4

Notes:
1.Using the 2007 delta-wide runoff coefficient (0.67) and 2011 SWE.
2. Area of lake surface multiplied by the difference between peak and pre-breakup WSE. Some quantities of ice were still present in lakes M9602 and M9605 upon termination of observations.
3. Per AK DNR Fish Habitat Permit FH05-III-0327 Amendment #2 for Lake M9602 and FH05-III-0328 Amendment #2 for Lake M9605.
4. Total combined liquid and ice as water equivalent per CPAI water use report.

Estimated recharge volumes for both lakes were greater than both permitted and actual water use quantities, as well as the estimated potential snowmelt contribution which assumed a tundra runoff coefficient of 0.67.

Recharge of Lake M9602 was primarily a result of local snowmelt within the catchment basin. Except for the small channel dicussed in Section 4.1.1, no evidence of channelized inflow or outflow was observed at this lake during the spring breakup 2011 monitoring period. The 2011 breakup season calculated potential snowmelt contribution for Lake M9602 is less than the estimated recharge volume. Most of this discrepancy is likely due to the catchment basin delineation. Additionally, the drifted snow on the lake may have contributed more than the random sampling the study accounted for. The approximately 0.75 miles of ice road located within the M9602 drainage basin contributed an estimated 0.75 million gallons maximum, assuming the entire quantity of melt flowed into the lake.

The volume of total calculated potential snowmelt contribution for Lake M9605 was less than the estimated recharge volume. This discrepancy is likely due to additional recharge quantities from water sources outside of the drainage basin, which contributed to Lake M9605 via small channels. Two channels conveyed flow into the lake from the southeast and southwest (Figure 1.1). The southeastern channel was well defined and connected a large wetland area south of the lake. The southwestern channel was smaller and less defined, draining from a smaller wetland area near Lake L9132. An additional channel drained north from Lake M9605 across the ice road alignment into an unnamed lake. The ice road was not slotted prior to breakup at this location, and this drainage channel was still actively flowing during the final field visit on June 20. Lake M9605 potentially receives flood flow from the Kachemach River; however, a hydraulic connection was not observed during 2011 spring breakup monitoring.

Additional sources of snowmelt contribution volumes may be attributed to catchment basin delineation, the drifted snow on the lake, and the contribution of ice road runoff, similar to Lake M9602. Approximately 0.2 miles of ice road was located within the M9605 drainage basin which has a potential estimated contribution of roughly 0.2 million gallons maximum, assuming the entire quantity of melt flowed into the lake.

Since the estimated recharge quantities at lakes M9602 and M9605 were both greater than the calculated potential snowmelt contribution, reasonable basin-specific runoff coefficients could not be determined for either lake.

4.1.5 Discussion of 2011 vs. 2010 Results

Calculated potential snowmelt contribution quantities for lakes M9602 and M9605 found in December 2010 (Baker 2010) were more conservative than those calculated in this report, a comparison of which is provided in Table 4.6. The 2011 catchment basin delineations were refined to be more conservative than those determined in 2010, and the 2011 estimated recharge volumes were calculated from basin-specific lake and tundra SWE values rather than the empirical CRD-wide lake and tundra SWE coefficients used in 2010.

TABLE 4.6: COMPARISON OF 2010 AND 2011 RESULTS

Comparison of Total Estimated Snowmelt Contributions		
Lake	2010	2011
	(mgal)	
M9602	48.3	101.1
M9605	40.6	61.8

4.2 General Study Lakes

4.2.1 Water Surface Elevation

The WSE was measured before, during, and after spring breakup at lakes B8534/L9282, M9525, L9323, L9324, B8531/L9326, B8530, and M9607. Photos were taken pre-breakup, breakup and post-breakup (Appendix D) to document changes at the lakes. Included in Appendix D are photos of the riparian zone at each lake in reference to WSE.

With the exception of B8534/L9282, WSE was observed to rise to a peak and then recede. The WSE at Lake B8534/L9282 was observed to increase and then decrease as a result of local melt and a peak representative of the entire lake was not captured. However, Lake B8534/L9282 was observed draining into the Sakoonang Channel on June 7 and for that reason, bankfull recharge was indicated (Photo 4.11). Recharge at Lake M9607 was primarily due to local melt. Observations at this location indicated a bankfull recharge, based on a recession of stage following the peak WSE. Further discussion of recharge for the General Study Lakes can be found in Section 4.2.2 and the respective WSE data are presented in Table 4.7 through Table 4.13.

PHOTO 4.11: LAKE B8534/L9282 DRAINING INTO THE SAKOONANG, LOOKING NORTHEAST

TABLE 4.7: WSE DATA FOR LAKE B8534/L9282

Date and Time	WSE (feet)	Observations
	B8534/L9282	
5/10/11 11:00 AM	96.33	**Peak WSE**; Estimate - elevation of pre-breakup top of ice - hydraulically isolated
5/25/11 5:30 PM	96.31	Local melt - Hydraulically isolated
5/30/11 4:43 PM	96.15	Local melt - Hydraulically isolated
6/7/11 3:07 PM	96.18	Lake draining into Sakoonang; recharge due to local melt only
The graph for this location doesn't suggest recharge however this lake did recharge to bankfull as indicated by outflow into the Sakoonang Channel.		

Notes:

1. Elevations are assumed based on TBM B8534/L9282-X at 100.00 feet BPMSL, installed by Baker in May 2011.

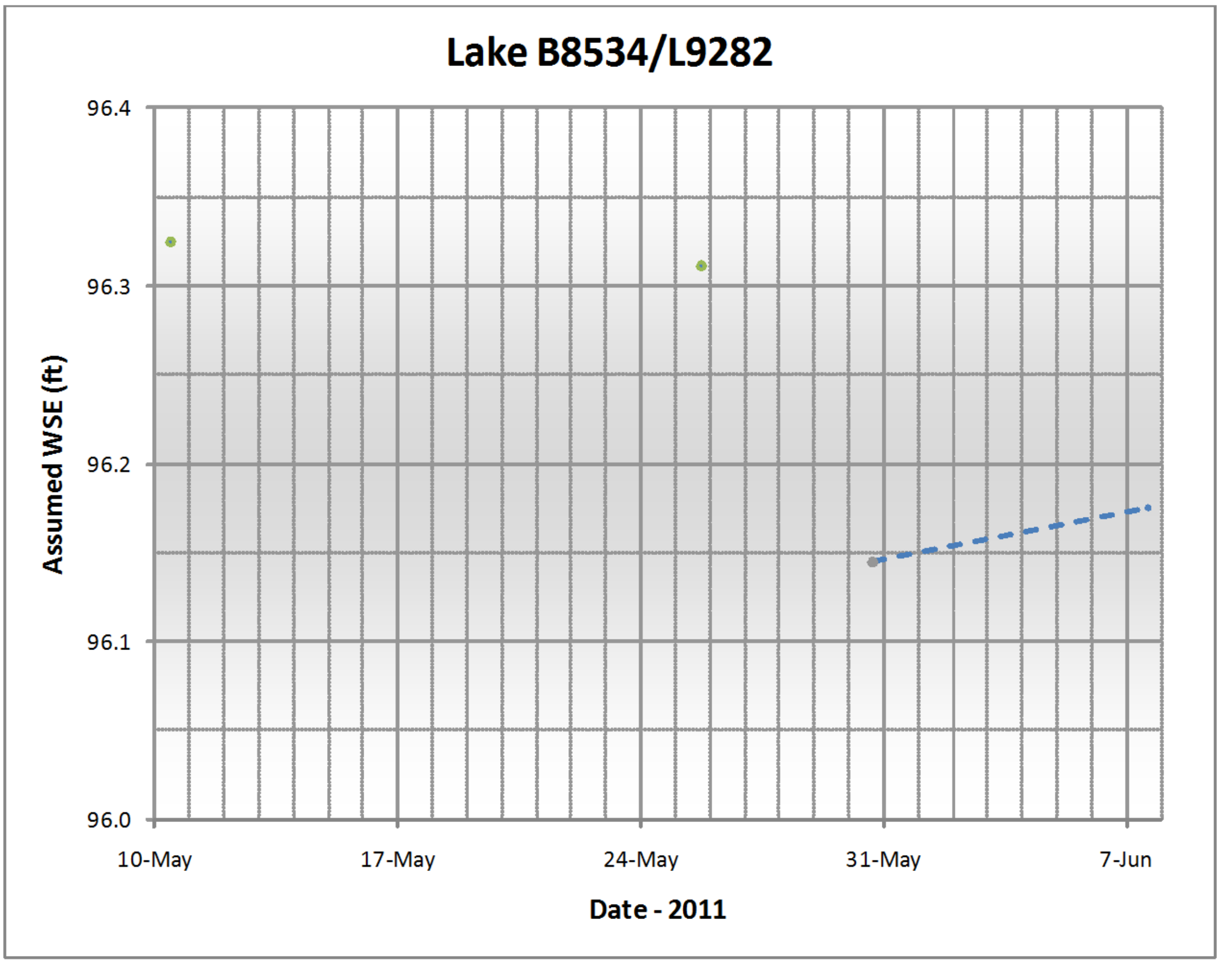


TABLE 4.8: WSE DATA FOR LAKE M9525

Date and Time	WSE (feet BPMSL)	Observations
	M9525	
5/26/11 3:35 PM	3.18	
5/27/11 10:30 AM	3.30	
5/27/11 4:40 PM	3.30	
5/28/11 10:15 AM	3.42	No flow through lake
5/29/11 10:05 AM	6.88	Recharging east via Sakoonang Channel overflow
5/29/11 5:00 PM	9.67	Additional gage installed further up bank
5/30/11 12:00 AM	10.76	**Peak Stage** based on HWM, time estimated
5/30/11 11:10 AM	10.63	
6/6/11 4:45 PM	3.73	

Notes:

1. Elevations are based on top of culvert CD4-6E at 14.669 feet BPMSL, surveyed by LCMF in May 2011.

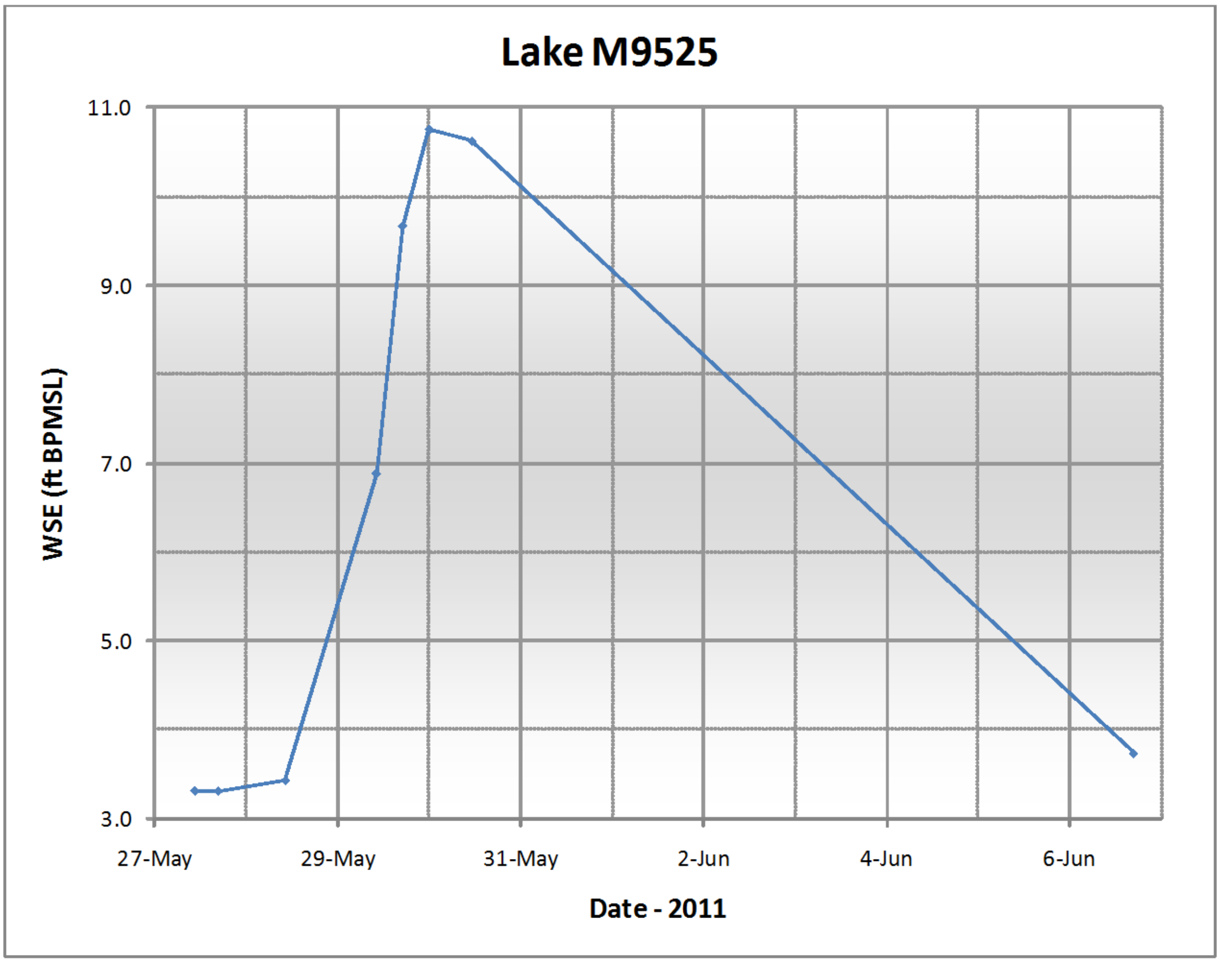


TABLE 4.9: WSE DATA FOR LAKE L9323

Date and Time	WSE (feet BPMSL)	Observations
	L9323	
5/26/11 10:50 AM	8.39	Surveyed - no water on gage
5/27/11 10:45 AM	8.43	
5/28/11 11:34 AM	8.48	
5/29/11 1:00 PM	10.85	**Peak Stage** based on HWM, time estimated
5/30/11 12:05 PM	10.66	Recharging from Sakoonang Channel overflow via L9324 and Nigliq Channel
6/6/11 3:15 PM	8.53	

Notes:

1. Elevations are based on Monument NANUQ 4 at 12.758 feet BPMSL, surveyed by LCMF in May 2011.

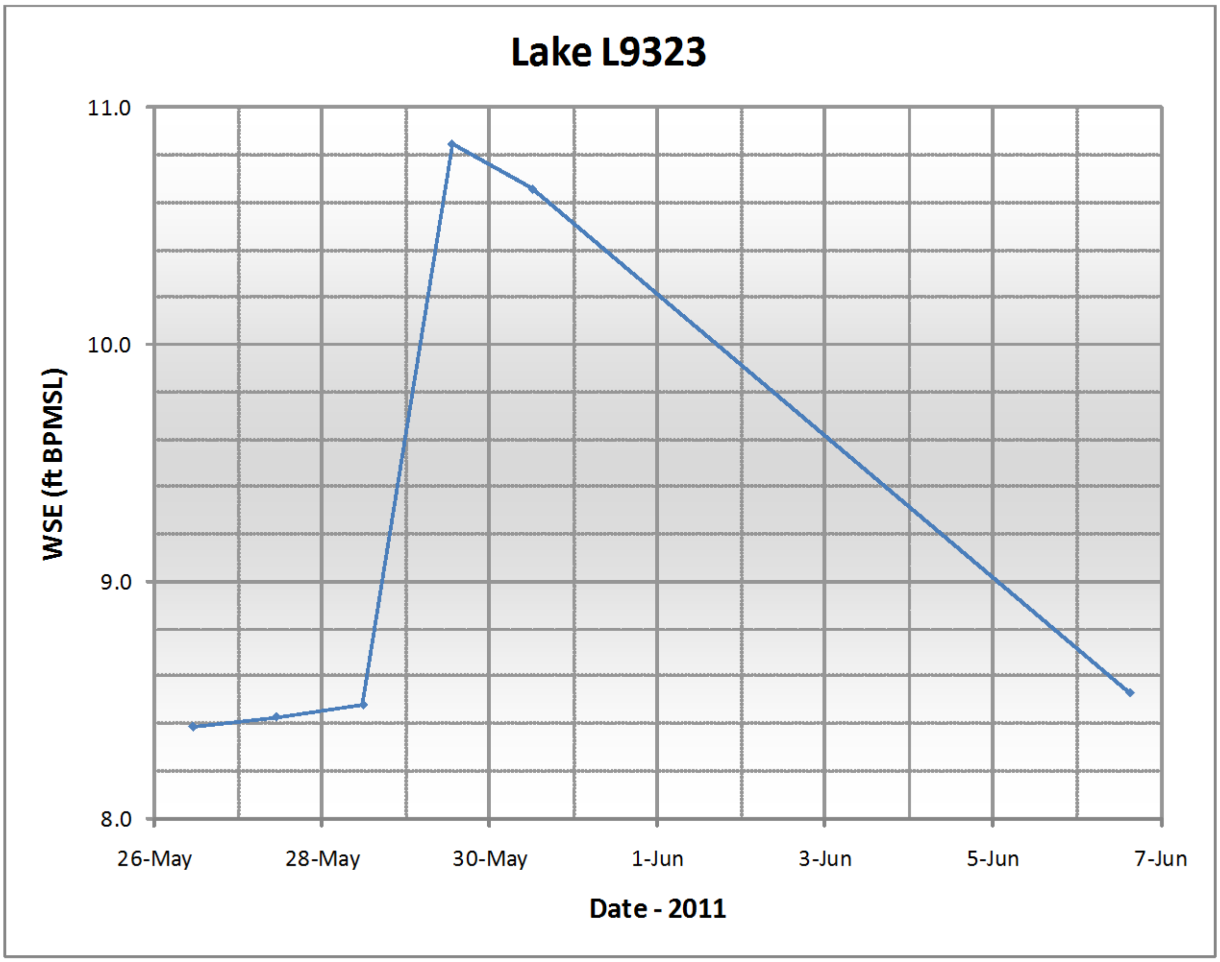


TABLE 4.10: WSE DATA FOR LAKE L9324

Date and Time	WSE (feet BPMSL)	Observations
	L9324	
5/26/11 11:55 AM	6.74	Surveyed - no water on gage
5/27/11 10:55 AM	9.35	
5/27/11 4:25 PM	9.67	Recharging east via Sakoonang Channel; Lake flowing into Nigliq Channel
5/28/11 10:45 AM	10.34	
5/29/11 11:05 AM	12.06	
5/29/11 11:20 AM	12.10	
5/29/11 1:00 PM	12.30	**Peak Stage** based on HWM, time estimated
5/29/11 4:00 PM	11.96	
5/30/11 2:37 PM	10.95	
6/6/11 2:45 PM	6.96	

Notes:

1. Elevations are based Monument NANUQ 5 at 17.461 feet BPMSL, surveyed by LCMF in May 2011.

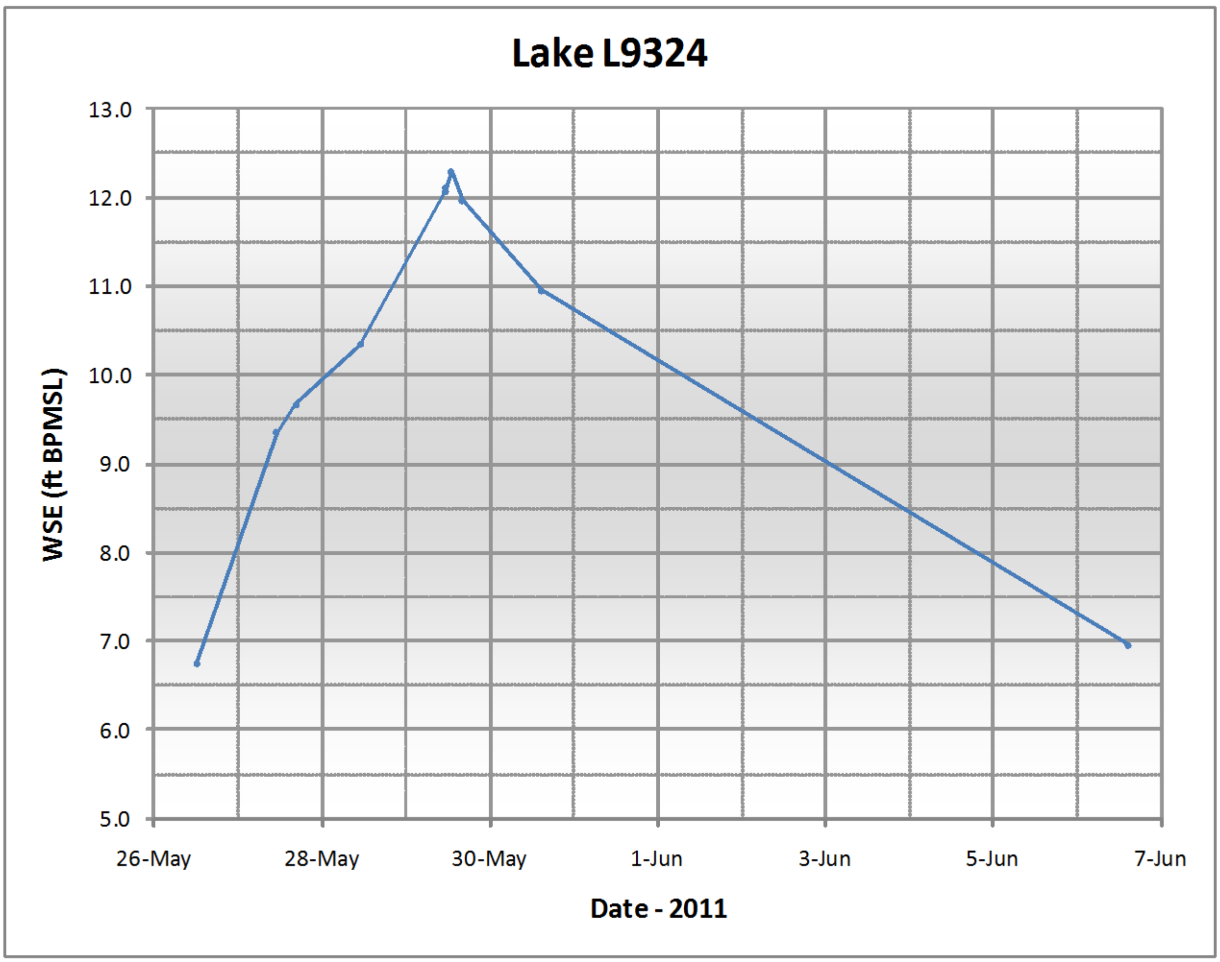


TABLE 4.11: WSE DATA FOR LAKE B8531/L9326

Date and Time	WSE (feet) B8531/L9326	Observations
5/26/11 4:40 PM	91.04	Surveyed - no water on gage
5/27/11 3:00 PM	91.04	Local melt - elevation estimated from 5/26
5/29/11 1:00 PM	96.84	**Peak stage**; recharging east from Sakoonang and south from Nigliq
5/31/11 12:00 AM	96.71	
5/31/11 11:26 AM	96.39	
6/7/11 10:44 AM	93.57	

Notes:

1. Elevations are assumed based on TBM B8531/L9326-X at 100.00 feet BPMSL, installed by Baker in May 2011.

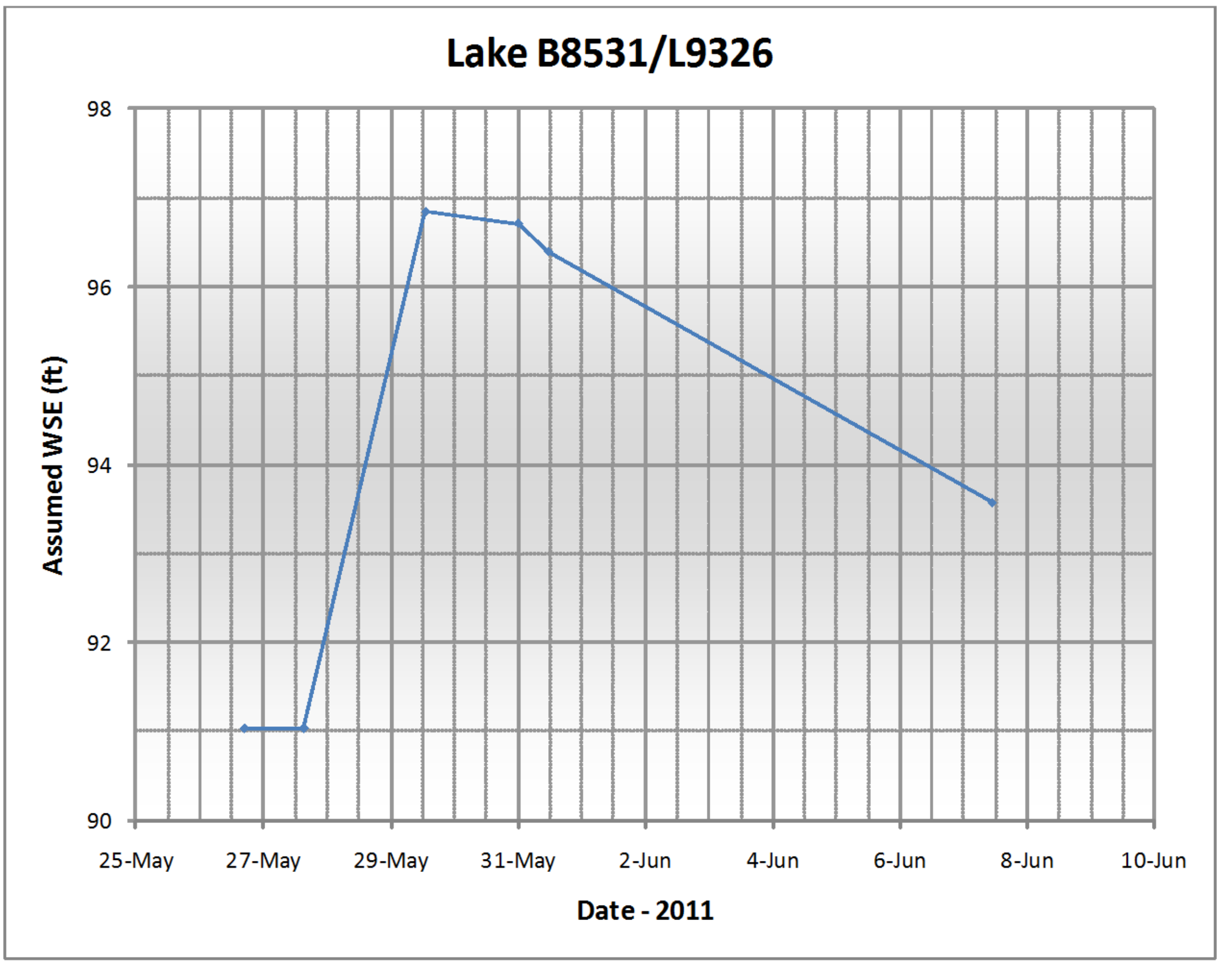


TABLE 4.12: WSE DATA FOR LAKE B8530

Date and Time	WSE (feet)	Observations
	B8530	
5/27/11 3:15 PM	95.93	
5/30/11 2:54 PM	96.87	Recharging south from Nigliq Channel overflow
5/31/11 12:00 AM	98.39	**Peak stage** based on HWM, time estimated
5/31/11 11:37 AM	96.05	
5/31/11 4:50 PM	95.98	
6/7/11 2:40 PM	95.53	

Notes:

1. Elevations are assumed based on TBM B8530-X at 100.00 feet BPMSL, installed by Baker in May 2011.

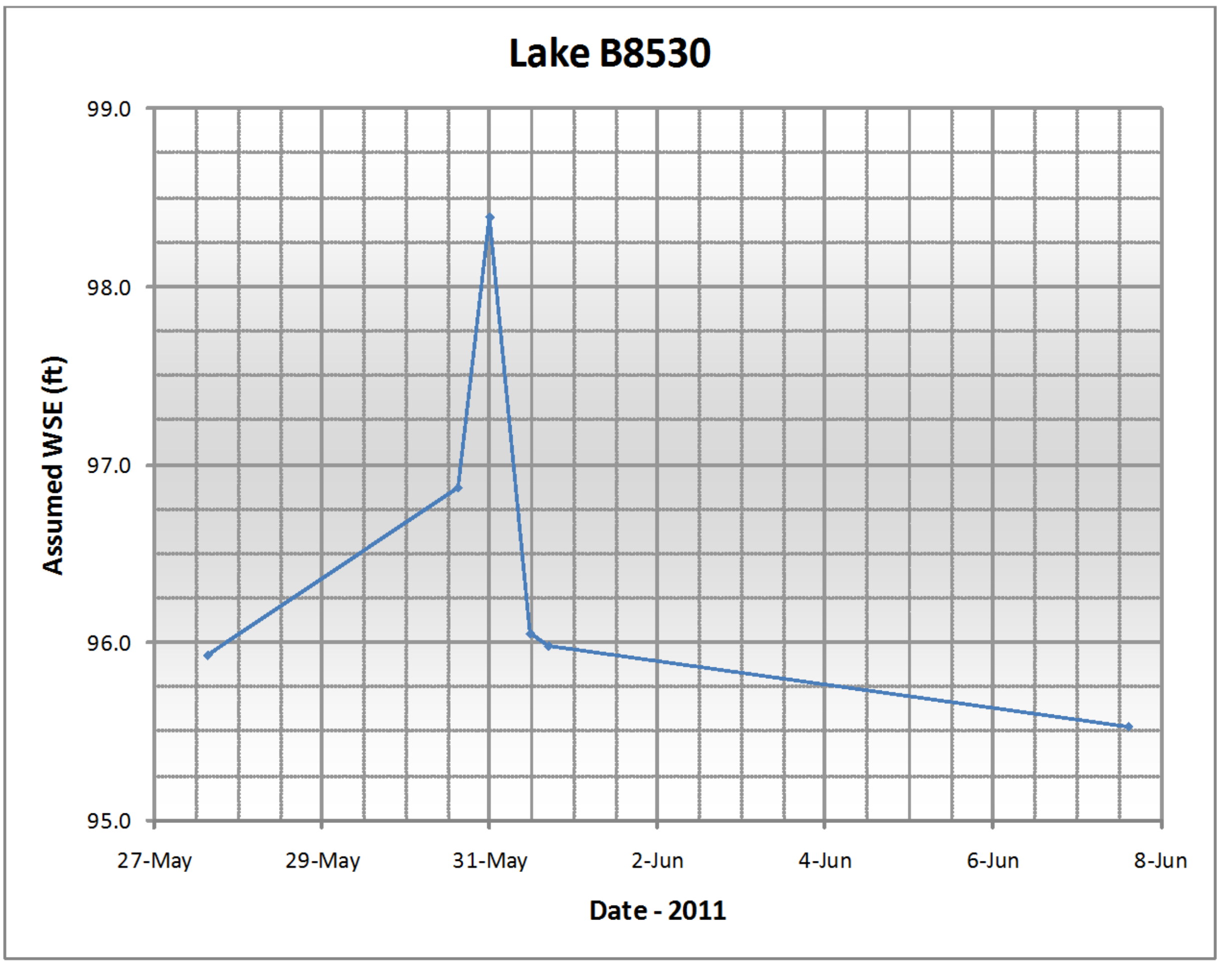
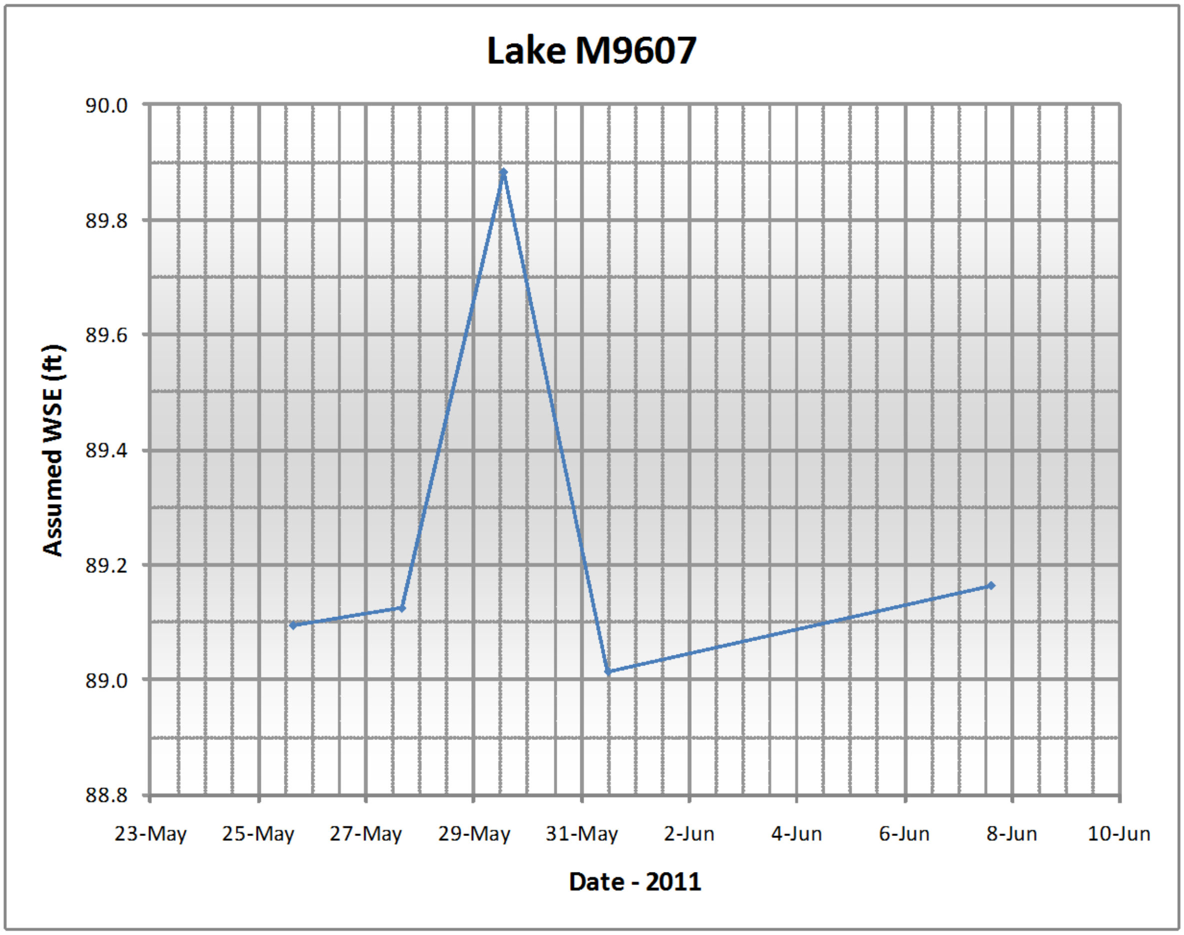


TABLE 4.13: WSE DATA FOR LAKE M9607

Date and Time	WSE (feet)	Observations
	M9607	
5/25/11 3:29 PM	89.09	Local melt - Hydraulically isolated
5/27/11 3:50 PM	89.12	Local melt - Hydraulically isolated
5/29/11 1:00 PM	89.88	**Peak WSE** based on HWM, time estimated
5/31/11 11:44 AM	89.01	M9607 draining into Lake B8530 via small channel across ice road
6/7/11 2:10 PM	89.16	Recharge due to local melt only - no evidence of overland flow into lake

Notes:

1. Elevations are assumed based on TBM M9607-X at 100.00 feet BPMSL, installed by Baker in May 2011.



4.2.2 Lake Recharge

All General Study Lakes were observed to fully recharge over bankfull during the 2011 monitoring season. This was evident by visual observations and the rise and recession of the hydrographs (Table 4.7 through Table 4.13) with the exception of Lake B8534/L9282, as discussed in Section 4.2.1. Lakes B8534/L9282 and M9607 recharged primarily from local melt and drained into nearby water bodies. Lake B8534/L9282 drained into the the Sakoonang Channel and M9607 drained into Lake B8530. Lakes M9525, L9323, L9324, B8531/L9326, and B8530 all recharged by means of overland flow, mainly from the Nigliq or Sakoonang Channels. Lake recharge summary observations are included in Table 4.14.

All General Study Lakes were hydraulically connected to distinct water bodies during spring breakup. This connection is likely seasonal, limited to peak stage conditions during spring breakup, and all of the study lakes should be considered hydraulically isolated except for Lake B8530. For the purposes of borrow water quantities, it should be recognized that Lake B8530 is hydraulically connected to Lake M9608 during the open water season. Potential snowmelt contribution should be determined from their combined catchments when considering lake water recharge as it relates to water withdrawal volumes.

4.3 Summary of Lake Recharge Observations

At the time of the study, all lakes appeared to recharge to or above bankfull elevations via either channelized spring breakup flood flow or local melt. A tabulated compilation of hydrologic observations is provided in Table 4.14.

TABLE 4.14: SUMMARY OF HYDROLOGIC RECHARGE OBSERVATIONS

Study Lake	Recharge to Bankfull	Primary Recharge Mechanism	Additonal Hydraulic Connection[1]	
			Flow In	Flow Out
Detailed Study Lakes				
M9602	√	Local melt	No channelized drainage into lake	Lake M9601 northeast via small channel late in the monitoring period
M9605	√	Local melt	Wetlands southeast and southwest; potential seasonal hydraulic connection with Kachemach River via wetlands southeast	Unnamed lake north via channel across ice road
General Study Lakes				
B8534/L9282[2]	√	Local melt	No channelized drainage into lake	Sakoonang via channel south
M9525	√	Sakoonang via paleolake east	Lake L9323 south via CD4 culverts	Lake L9313 northeast and brief drainage into Lake M9524 via CD4 culverts
L9323	√	Sakoonang via Lake L9324 south	Nigliq via Tapped Lake southwest	Lake M9525 north via CD4 road culverts to equalization prior to recession; Nanuq Lake north
L9324	√	Sakoonang via paleolake southeast	Nigliq via lake L9325 south; lake M9934 south	Lake L9323 north via CD4 road culverts; L9325 and Tapped Lake/Nigliq west
B8531/L9326	√	Nigliq via Lake M9606 south	Lake M9934 northeast - flow in via Sakoonang overflow	
B8530	√	Nigliq via channel south	Lake M9608 west; M9607 east - limited flow	Lake M9606 northwest
M9607	√	Local melt	No channelized drainage into lake	Lake B8530 via small channel west across ice road

Notes: 1. Observations between May 5 and June 20, 2011.
2. Additional annual connection with lakes L9342 west, L9283 east, and M9527 southeast

5.0 REFERENCES

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Appendix A Snow Survey Sheets: M9602 and M9605

A.1 Lake M9602

Pooled Snow Survey Data Sheet						
Date: 5/4-5/2011	**Start Time:** 12:00		**End Time:** 12:00		**Observers:** JMS/HLR	
Catchment Basin: M9602			**Driving Wrench Used:** No		**Tube Section Used:** 1-2	
Snow Sample No.	**Pooled Sample #**	**Terrain Type**	**Snow Depth (in) w/ Dirt Plug**	**Snow Depth (in) w/o Dirt Plug**	**Calculations**	
PS023	1	Lake	-	14.5	**Bucket & Core Weight (lb) =**	3.52
	2		-	12.0	**Empty Bucket Weight (lb) =**	2.40
	3		-	12.5	**Average Mass (lb) =**	0.22
	4		-	12.0	**Core Area (in^2) =**	2.0739
	5		-	12.0	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 13' 20.3"		**Sum (in) =**	**63.0**	**Average Density (lb/in^3) =**	**0.009**
Longitude	W 150° 44' 20.0"		**Average (in) =**	**12.6**	**Average SWE (in) =**	**2.99**
PS024	1	Lake	-	12.5	**Bucket & Core Weight (lb) =**	3.68
	2		-	11.5	**Empty Bucket Weight (lb) =**	2.38
	3		-	13.0	**Average Mass (lb) =**	0.26
	4		-	13.0	**Core Area (in^2) =**	2.0739
	5		-	13.0	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 13' 29.7"		**Sum (in) =**	**63.0**	**Average Density (lb/in^3) =**	**0.010**
Longitude	W 150° 44' 11.0"		**Average (in) =**	**12.6**	**Average SWE (in) =**	**3.47**
PS025*	1	Lake	-	12.5	**Bucket & Core Weight (lb) =**	4.12
	2		-	13.5	**Empty Bucket Weight (lb) =**	2.36
	3		-	13.5	**Average Mass (lb) =**	0.35
	4		-	13.5	**Core Area (in^2) =**	2.0739
	5		-	13.5	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 13' 37.2"		**Sum (in) =**	**66.5**	**Average Density (lb/in^3) =**	**0.013**
Longitude	W 150° 44' 03.8"		**Average (in) =**	**13.3**	**Average SWE (in) =**	**4.70**
PS026	1	Lake	-	12.0	**Bucket & Core Weight (lb) =**	3.80
	2		-	13.5	**Empty Bucket Weight (lb) =**	2.38
	3		-	12.5	**Average Mass (lb) =**	0.28
	4		-	13.0	**Core Area (in^2) =**	2.0739
	5		-	13.0	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 13' 46.6"		**Sum (in) =**	**64.0**	**Average Density (lb/in^3) =**	**0.011**
Longitude	W 150° 43' 54.7"		**Average (in) =**	**12.8**	**Average SWE (in) =**	**3.79**
PS027	1	Tundra	-	55.5	**Bucket & Core Weight (lb) =**	3.73
	-		-	-	**Empty Bucket Weight (lb) =**	2.38
	-		-	-	**Average Mass (lb) =**	1.35
	-		-	-	**Core Area (in^2) =**	2.0739
	-		-	-	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 13' 54.1"		**Sum (in) =**	**55.5**	**Average Density (lb/in^3) =**	**0.012**
Longitude	W 150° 43' 47.5"		**Average (in) =**	**55.5**	**Average SWE (in) =**	**18.03**
PS028	1	Lake	-	10.0	**Bucket & Core Weight (lb) =**	3.72
	2		-	10.0	**Empty Bucket Weight (lb) =**	2.38
	3		-	10.5	**Average Mass (lb) =**	0.27
	4		-	10.5	**Core Area (in^2) =**	2.0739
	5		-	11.5	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 13' 22.5"		**Sum (in) =**	**52.5**	**Average Density (lb/in^3) =**	**0.012**
Longitude	W 150° 43' 57.6"		**Average (in) =**	**10.5**	**Average SWE (in) =**	**3.58**
PS029	1	Lake	-	11.0	**Bucket & Core Weight (lb) =**	3.57
	2		-	11.0	**Empty Bucket Weight (lb) =**	2.38
	3		-	10.5	**Average Mass (lb) =**	0.24
	4		-	9.5	**Core Area (in^2) =**	2.0739
	5		-	10.5	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 13' 24.2"		**Sum (in) =**	**52.5**	**Average Density (lb/in^3) =**	**0.011**
Longitude	W 150° 43' 40.8"		**Average (in) =**	**10.5**	**Average SWE (in) =**	**3.18**

Note 1: Locations are referenced to NAD 83 datum.
* Ice lenses present

Pooled Snow Survey Data Sheet						
Date: 5/4-5/2011	Start Time: 12:00		End Time: 12:00		Observers: JMS/HLR	
Catchment Basin: M9602		Driving Wrench Used: No			Tube Section Used: 1-2	
Snow Sample No.	Pooled Sample #	Terrain Type	Snow Depth (in) w/ Dirt Plug	Snow Depth (in) w/o Dirt Plug	Calculations	
PS030	1	Tundra	10	9.0	Bucket & Core Weight (lb) =	3.14
	2		9	7.5	Empty Bucket Weight (lb) =	2.38
	3		12.5	10.5	Average Mass (lb) =	0.15
	4		11	9.0	Core Area (in^2) =	2.0739
	5		12.5	10.0	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 26.4"		Sum (in) =	46.0	Average Density (lb/in^3) =	0.008
Longitude	W 150° 43' 18.4"		Average (in) =	9.2	Average SWE (in) =	2.03
PS031	1	Lake	-	11.0	Bucket & Core Weight (lb) =	3.54
	2		-	10.0	Empty Bucket Weight (lb) =	2.36
	3		-	10.5	Average Mass (lb) =	0.24
	4		-	11.5	Core Area (in^2) =	2.0739
	5		-	10.5	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 15.7"		Sum (in) =	53.5	Average Density (lb/in^3) =	0.011
Longitude	W 150° 44' 01.1"		Average (in) =	10.7	Average SWE (in) =	3.15
PS033	1	Lake	-	14.0	Bucket & Core Weight (lb) =	3.76
	2		-	14.5	Empty Bucket Weight (lb) =	2.40
	3		-	13.0	Average Mass (lb) =	0.27
	4		-	12.0	Core Area (in^2) =	2.0739
	5		-	12.5	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 06.5"		Sum (in) =	66.0	Average Density (lb/in^3) =	0.010
Longitude	W 150° 43' 23.3"		Average (in) =	13.2	Average SWE (in) =	3.63
PS034	1	Tundra	17.5	16.0	Bucket & Core Weight (lb) =	4.26
	2		19	17.5	Empty Bucket Weight (lb) =	2.37
	3		18.5	17.5	Average Mass (lb) =	0.38
	4		19	18.0	Core Area (in^2) =	2.0739
	5		18.5	17.5	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 00.7"		Sum (in) =	86.5	Average Density (lb/in^3) =	0.011
Longitude	W 150° 42' 59.7"		Average (in) =	17.3	Average SWE (in) =	5.05
PS035	1	Lake	-	6.0	Bucket & Core Weight (lb) =	2.84
	2		-	6.0	Empty Bucket Weight (lb) =	2.38
	3		-	6.5	Average Mass (lb) =	0.09
	4		-	6.5	Core Area (in^2) =	2.0739
	5		-	6.5	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 16.6"		Sum (in) =	31.5	Average Density (lb/in^3) =	0.007
Longitude	W 150° 44' 23.5"		Average (in) =	6.3	Average SWE (in) =	1.23
PS036*	1	Lake	-	8.5	Bucket & Core Weight (lb) =	3.31
	2		-	7.0	Empty Bucket Weight (lb) =	2.42
	3		-	8.0	Average Mass (lb) =	0.18
	4		-	8.0	Core Area (in^2) =	2.0739
	5		-	9.5	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 09.0"		Sum (in) =	41.0	Average Density (lb/in^3) =	0.010
Longitude	W 150° 44' 30.5"		Average (in) =	8.2	Average SWE (in) =	2.38
PS037*	1	Lake	-	20.5	Bucket & Core Weight (lb) =	5.10
	2		-	19.5	Empty Bucket Weight (lb) =	2.35
	3		-	19.0	Average Mass (lb) =	0.55
	4		-	20.5	Core Area (in^2) =	2.0739
	5		-	20.5	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 01.5"		Sum (in) =	100.0	Average Density (lb/in^3) =	0.013
Longitude	W 150° 44' 37.4"		Average (in) =	20.0	Average SWE (in) =	7.35

Note 1: Locations are referenced to NAD 83 datum.
Note 2: Gaps in snow sample numbering are deliberate.
* Ice lenses present

Pooled Snow Survey Data Sheet						
Date: 5/4-5/2011	Start Time: 12:00		End Time: 12:00		Observers: JMS/HLR	
Catchment Basin: M9602		Driving Wrench Used: No			Tube Section Used: 1-2	
Snow Sample No.	Pooled Sample #	Terrain Type	Snow Depth (in) w/ Dirt Plug	Snow Depth (in) w/o Dirt Plug	Calculations	
PS038	1	Tundra	8	7.0	Bucket & Core Weight (lb) =	3.12
	2		7	6.0	Empty Bucket Weight (lb) =	2.46
	3		17.5	15.5	Average Mass (lb) =	0.13
	4		13	11.5	Core Area (in^2) =	2.0739
	5		11	9.5	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 12' 54.0"		Sum (in) =	**49.5**	Average Density (lb/in^3) =	**0.006**
Longitude	W 150° 44' 44.4"		Average (in) =	**9.9**	Average SWE (in) =	**1.76**
PS040	1	Lake	-	13.0	Bucket & Core Weight (lb) =	4.04
	2		-	14.5	Empty Bucket Weight (lb) =	2.40
	3		-	14.5	Average Mass (lb) =	0.33
	4		-	12.5	Core Area (in^2) =	2.0739
	5		-	13.5	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 12' 40.8"		Sum (in) =	**68.0**	Average Density (lb/in^3) =	**0.012**
Longitude	W 150° 44' 56.5"		Average (in) =	**13.6**	Average SWE (in) =	**4.38**
PS042*	1	Tundra (possibly Lake)	-	19.0	Bucket & Core Weight (lb) =	4.38
	2		-	19.0	Empty Bucket Weight (lb) =	2.38
	3		-	19.0	Average Mass (lb) =	0.40
	4		-	18.0	Core Area (in^2) =	2.0739
	5		-	18.0	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 12' 29.5"		Sum (in) =	**93.0**	Average Density (lb/in^3) =	**0.010**
Longitude	W 150° 45' 07.0"		Average (in) =	**18.6**	Average SWE (in) =	**5.34**
PS043	1	Tundra	14.5	14.5	Bucket & Core Weight (lb) =	3.78
	2		18.5	17.5	Empty Bucket Weight (lb) =	2.36
	3		17.5	16.0	Average Mass (lb) =	0.28
	4		18	17.0	Core Area (in^2) =	2.0739
	5		17.5	16.0	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 12' 22.2"		Sum (in) =	**81.0**	Average Density (lb/in^3) =	**0.008**
Longitude	W 150° 45' 14.0"		Average (in) =	**16.2**	Average SWE (in) =	**3.79**
PS044	1	Lake	-	9.0	Bucket & Core Weight (lb) =	3.37
	2		-	10.0	Empty Bucket Weight (lb) =	2.38
	3		-	10.0	Average Mass (lb) =	0.20
	4		-	10.0	Core Area (in^2) =	2.0739
	5		-	11.0	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 17.5"		Sum (in) =	**50.0**	Average Density (lb/in^3) =	**0.010**
Longitude	W 150° 44' 47.9"		Average (in) =	**10.0**	Average SWE (in) =	**2.64**
PS045*	1	Lake	-	14.0	Bucket & Core Weight (lb) =	4.14
	2		-	15.0	Empty Bucket Weight (lb) =	2.38
	3		-	15.0	Average Mass (lb) =	0.35
	4		-	14.5	Core Area (in^2) =	2.0739
	5		-	13.5	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 15.8"		Sum (in) =	**72.0**	Average Density (lb/in^3) =	**0.012**
Longitude	W 150° 45' 04.7"		Average (in) =	**14.4**	Average SWE (in) =	**4.70**
PS046	1	Tundra (Wetland)	-	19.0	Bucket & Core Weight (lb) =	4.06
	2		20	20.0	Empty Bucket Weight (lb) =	2.36
	3		17.5	16.5	Average Mass (lb) =	0.34
	4		19.5	19.0	Core Area (in^2) =	2.0739
	5		20	19.0	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 14.1"		Sum (in) =	**93.5**	Average Density (lb/in^3) =	**0.009**
Longitude	W 150° 45' 21.4"		Average (in) =	**18.7**	Average SWE (in) =	**4.54**

Note 1: Locations are referenced to NAD 83 datum.
Note 2: Gaps in snow sample numbering are deliberate.
* Ice lenses present

Pooled Snow Survey Data Sheet						
Date: 5/4-5/2011	Start Time: 12:00		End Time: 12:00		Observers: JMS/HLR	
Catchment Basin: M9602			Driving Wrench Used: No		Tube Section Used: 1-2	
Snow Sample No.	Pooled Sample #	Terrain Type	Snow Depth (in) w/ Dirt Plug	Snow Depth (in) w/o Dirt Plug	Calculations	
PS047*	1	Tundra (Wetland)	-	13.5	Bucket & Core Weight (lb) =	4.12
	2		-	14.0	Empty Bucket Weight (lb) =	2.48
	3		-	14.0	Average Mass (lb) =	0.33
	4		-	14.5	Core Area (in^2) =	2.0739
	5		-	13.5	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 12.4"		Sum (in) =	**69.5**	Average Density (lb/in^3) =	**0.011**
Longitude	W 150° 45' 38.2"		Average (in) =	**13.9**	Average SWE (in) =	**4.38**
PS048	1	Lake	-	16.5	Bucket & Core Weight (lb) =	4.08
	2		-	15.5	Empty Bucket Weight (lb) =	2.42
	3		-	15.0	Average Mass (lb) =	0.33
	4		-	15.5	Core Area (in^2) =	2.0739
	5		-	15.5	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 23.8"		Sum (in) =	**78.0**	Average Density (lb/in^3) =	**0.010**
Longitude	W 150° 44' 34.1"		Average (in) =	**15.6**	Average SWE (in) =	**4.434**
PS051	1	Tundra	27.5	27.0	Bucket & Core Weight (lb) =	4.97
	2		22	21.5	Empty Bucket Weight (lb) =	2.38
	3		21	19.5	Average Mass (lb) =	0.52
	4		23	23.0	Core Area (in^2) =	2.0739
	5		21.5	19.5	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 37.7"		Sum (in) =	**110.5**	Average Density (lb/in^3) =	**0.011**
Longitude	W 150° 45' 30.7"		Average (in) =	**22.1**	Average SWE (in) =	**6.92**
PS052	1	Tundra	20	17.5	Bucket & Core Weight (lb) =	4.17
	2		19.5	17.5	Empty Bucket Weight (lb) =	2.44
	3		18.5	17.0	Average Mass (lb) =	0.35
	4		16.5	15.0	Core Area (in^2) =	2.0739
	5		19.5	17.0	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 41.2"		Sum (in) =	**84.0**	Average Density (lb/in^3) =	**0.010**
Longitude	W 150° 45' 44.9"		Average (in) =	**16.8**	Average SWE (in) =	**4.62**
PS053	1	Lake	-	12.0	Bucket & Core Weight (lb) =	3.68
	2		-	12.0	Empty Bucket Weight (lb) =	2.34
	3		-	12.0	Average Mass (lb) =	0.27
	4		-	10.0	Core Area (in^2) =	2.0739
	5		-	12.0	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 33.8"		Sum (in) =	**58.0**	Average Density (lb/in^3) =	**0.011**
Longitude	W 150° 44' 28.3"		Average (in) =	**11.6**	Average SWE (in) =	**3.58**
PS054	1	Lake	-	8.5	Bucket & Core Weight (lb) =	3.26
	2		-	7.5	Empty Bucket Weight (lb) =	2.42
	3		-	7.5	Average Mass (lb) =	0.17
	4		-	7.5	Core Area (in^2) =	2.0739
	5		-	8.5	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 49.2"		Sum (in) =	**39.5**	Average Density (lb/in^3) =	**0.010**
Longitude	W 150° 44' 37.7"		Average (in) =	**7.9**	Average SWE (in) =	**2.24**
PS055	1	Tundra	16	15.0	Bucket & Core Weight (lb) =	4.18
	2		18	17.0	Empty Bucket Weight (lb) =	2.36
	3		17.5	17.0	Average Mass (lb) =	0.36
	4		17	15.5	Core Area (in^2) =	2.0739
	5		18.5	17.5	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 14' 00.8"		Sum (in) =	**82.0**	Average Density (lb/in^3) =	**0.011**
Longitude	W 150° 44' 44.9"		Average (in) =	**16.4**	Average SWE (in) =	**4.86**

Note 1: Locations are referenced to NAD 83 datum.
Note 2: Gaps in snow sample numbering are deliberate.
* Ice lenses present

Pooled Snow Survey Data Sheet						
Date: 5/4-5/2011	Start Time: 12:00		End Time: 12:00		Observers: JMS/HLR	
Catchment Basin: M9602		Driving Wrench Used: No			Tube Section Used: 1-2	
Snow Sample No.	Pooled Sample #	Terrain Type	Snow Depth (in) w/ Dirt Plug	Snow Depth (in) w/o Dirt Plug	Calculations	
PS056	1	Lake	-	15.0	Bucket & Core Weight (lb) =	4.23
	2		-	13.5	Empty Bucket Weight (lb) =	2.40
	3		-	16.0	Average Mass (lb) =	0.37
	4		-	17.0	Core Area (in^2) =	2.0739
	5		-	14.0	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 06.9"		Sum (in) =	**75.5**	Average Density (lb/in^3) =	**0.012**
Longitude	W 150° 44' 11.0"		Average (in) =	**15.1**	Average SWE (in) =	**4.89**
PS057*	1	Lake	-	14.0	Bucket & Core Weight (lb) =	4.22
	2		-	14.0	Empty Bucket Weight (lb) =	2.38
	3		-	18.0	Average Mass (lb) =	0.37
	4		-	16.0	Core Area (in^2) =	2.0739
	5		-	16.0	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 12' 53.4"		Sum (in) =	**78.0**	Average Density (lb/in^3) =	**0.011**
Longitude	W 150° 44' 02.2"		Average (in) =	**15.6**	Average SWE (in) =	**4.92**
PS058	1	Tundra	20.5	18.0	Bucket & Core Weight (lb) =	3.77
	2		19	17.0	Empty Bucket Weight (lb) =	2.38
	3		18.5	18.5	Average Mass (lb) =	0.28
	4		18	16.0	Core Area (in^2) =	2.0739
	5		15.5	13.5	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 12' 41.8"		Sum (in) =	**83.0**	Average Density (lb/in^3) =	**0.008**
Longitude	W 150° 43' 54.6"		Average (in) =	**16.6**	Average SWE (in) =	**3.71**
					Bucket & Core Weight (lb) =	
					Empty Bucket Weight (lb) =	
					Average Mass (lb) =	
					Core Area (in^2) =	
					Freshwater Density (lb/in^3) =	
Latitude			Sum (in) =		Average Density (lb/in^3) =	
Longitude			Average (in) =		Average SWE (in) =	
					Bucket & Core Weight (lb) =	
					Empty Bucket Weight (lb) =	
					Average Mass (lb) =	
					Core Area (in^2) =	
					Freshwater Density (lb/in^3) =	
Latitude			Sum (in) =		Average Density (lb/in^3) =	
Longitude			Average (in) =		Average SWE (in) =	
					Bucket & Core Weight (lb) =	
					Empty Bucket Weight (lb) =	
					Average Mass (lb) =	
					Core Area (in^2) =	
					Freshwater Density (lb/in^3) =	
Latitude			Sum (in) =		Average Density (lb/in^3) =	
Longitude			Average (in) =		Average SWE (in) =	
					Bucket & Core Weight (lb) =	
					Empty Bucket Weight (lb) =	
					Average Mass (lb) =	
					Core Area (in^2) =	
					Freshwater Density (lb/in^3) =	
Latitude			Sum (in) =		Average Density (lb/in^3) =	
Longitude			Average (in) =		Average SWE (in) =	

Note 1: Locations are referenced to NAD 83 datum.
* Ice lenses present

Snow Depth Survey Data Sheet				
Date: 05/4-5/2011		**Start Time:** 2:20:00 PM on 5/4		**Observers:** SMC
Catchment Basin: M9602		**End Time:** 2:00:00 PM on 5/5		
Snow Sample No.	**Terrain Type**	**Snow Depth (in)**	**Location (NAD 83)**	
			Latitude	**Longitude**
SS085	Lake	16.5	N 70° 13' 22.2"	W 150° 44' 18.2"
SS086	Lake	9.4	N 70° 13' 24.1"	W 150° 44' 16.4"
SS087	Lake	8.3	N 70° 13' 26.0"	W 150° 44' 14.6"
SS088	Lake	13.4	N 70° 13' 27.8"	W 150° 44' 12.8"
SS089	Lake	11.0	N 70° 13' 31.6"	W 150° 44' 09.2"
SS090	Lake	10.6	N 70° 13' 33.4"	W 150° 44' 07.4"
SS091	Lake	16.5	N 70° 13' 35.3"	W 150° 44' 05.6"
SS092	Lake	9.8	N 70° 13' 39.1"	W 150° 44' 02.0"
SS093	Lake	8.7	N 70° 13' 40.9"	W 150° 44' 00.2"
SS094	Lake	11.8	N 70° 13' 42.8"	W 150° 43' 58.4"
SS095	Lake	6.3	N 70° 13' 44.7"	W 150° 43' 56.5"
SS096	Tundra	30.3	N 70° 13' 48.4"	W 150° 43' 52.9"
SS097	Tundra	2.4	N 70° 13' 50.3"	W 150° 43' 51.1"
SS098	Tundra	16.5	N 70° 13' 52.2"	W 150° 43' 49.3"
SS099	Lake	8.7	N 70° 13' 20.9"	W 150° 44' 14.4"
SS100	Lake	13.4	N 70° 13' 21.4"	W 150° 44' 08.8"
SS100.5	Lake	12.6	N 70° 13' 22.0"	W 150° 44' 03.2"
SS102	Lake	13.4	N 70° 13' 23.1"	W 150° 43' 52.0"
SS103	Lake	19.3	N 70° 13' 23.6"	W 150° 43' 46.4"
SS104	Lake	23.2	N 70° 13' 24.7"	W 150° 43' 35.2"
SS105	Tundra	10.6	N 70° 13' 25.3"	W 150° 43' 29.6"
SS106	Tundra	22.4	N 70° 13' 25.9"	W 150° 43' 24.0"
SS107	Tundra	18.5	N 70° 13' 27.0"	W 150° 43' 12.9"
SS109	Lake	14.2	N 70° 13' 18.0"	W 150° 44' 10.6"
SS110	Lake	13.0	N 70° 13' 16.9"	W 150° 44' 05.8"
SS111	Lake	11.4	N 70° 13' 14.5"	W 150° 43' 56.4"
SS112	Lake	11.0	N 70° 13' 13.4"	W 150° 43' 51.7"
SS113	Lake	11.8	N 70° 13' 12.2"	W 150° 43' 47.0"
SS113.5	Lake	12.6	N 70° 13' 11.1"	W 150° 43' 42.2"
SS114	Lake	9.8	N 70° 13' 09.9"	W 150° 43' 37.5"
SS115	Lake	11.0	N 70° 13' 08.8"	W 150° 43' 32.8"
SS116	Lake	9.8	N 70° 13' 07.6"	W 150° 43' 28.1"
SS117	Lake	16.5	N 70° 13' 05.3"	W 150° 43' 18.6"
SS118	Lake	12.2	N 70° 13' 04.1"	W 150° 43' 13.9"
SS119	Lake	13.8	N 70° 13' 03.0"	W 150° 43' 09.2"
SS120	Tundra	29.9	N 70° 13' 01.8"	W 150° 43' 04.5"
SS121	Tundra	27.6	N 70° 12' 59.5"	W 150° 42' 55.1"
SS122	Lake	11.8	N 70° 13' 18.4"	W 150° 44' 21.7"
SS123	Lake	12.6	N 70° 13' 14.7"	W 150° 44' 25.2"
SS124	Lake	12.2	N 70° 13' 12.8"	W 150° 44' 27.0"
SS125	Lake	11.0	N 70° 13' 10.9"	W 150° 44' 28.7"
SS126	Lake	7.5	N 70° 13' 07.1"	W 150° 44' 32.2"
SS127	Lake	9.1	N 70° 13' 05.3"	W 150° 44' 34.0"
SS128	Lake	15.0	N 70° 13' 03.4"	W 150° 44' 35.7"
SS129	Lake	10.6	N 70° 12' 59.6"	W 150° 44' 39.2"
SS130	Lake	11.8	N 70° 12' 57.7"	W 150° 44' 40.9"
SS131	Lake	13.4	N 70° 12' 55.8"	W 150° 44' 42.7"
SS132	Tundra	15.4	N 70° 12' 52.1"	W 150° 44' 46.2"
SS133	Lake	13.0	N 70° 12' 50.2"	W 150° 44' 47.9"
Note 1: Gaps in sample location are intentional				

Snow Depth Survey Data Sheet				
Date: 05/4-5/2011		**Start Time:** 2:20:00 PM on 5/4		**Observers:** SMC
Catchement Basin: M9602		**End Time:** 2:00:00 PM on 5/5		
Snow Sample No.	**Terrain Type**	**Snow Depth (in)**	**Location (NAD 83)**	
			Latitude	**Longitude**
SS133.5	Lake	13.4	N 70° 12' 48.5"	W 150° 44' 49.6"
SS134	Lake	13.8	N 70° 12' 46.4"	W 150° 44' 51.4"
SS135	Lake	15.4	N 70° 12' 44.6"	W 150° 44' 53.1"
SS136	Lake	14.2	N 70° 12' 42.7"	W 150° 44' 54.9"
SS137	Lake	12.2	N 70° 12' 38.9"	W 150° 44' 58.3"
SS138	Lake	8.3	N 70° 12' 37.0"	W 150° 45' 00.1"
SS138.5	Lake	9.4	N 70° 12' 35.2"	W 150° 45' 01.8"
SS139	Lake	11.4	N 70° 12' 33.3"	W 150° 45' 03.6"
SS140	Lake	12.2	N 70° 12' 31.4"	W 150° 45' 05.3"
SS141	Tundra	24.0	N 70° 12' 27.6"	W 150° 45' 08.8"
SS142	Tundra	19.3	N 70° 12' 25.7"	W 150° 45' 10.5"
SS143	Tundra	21.3	N 70° 12' 23.9"	W 150° 45' 12.3"
SS144	Lake	9.4	N 70° 13' 19.8"	W 150° 44' 25.6"
SS145	Lake	11.8	N 70° 13' 19.2"	W 150° 44' 31.1"
SS146	Lake	11.4	N 70° 13' 18.6"	W 150° 44' 36.7"
SS147	Lake	10.6	N 70° 13' 18.1"	W 150° 44' 42.3"
SS148	Lake	11.8	N 70° 13' 16.9"	W 150° 44' 53.5"
SS149	Lake	13.4	N 70° 13' 16.4"	W 150° 44' 59.1"
SS150	Lake	41.7	N 70° 13' 15.2"	W 150° 45' 10.2"
SS151	Tundra	15.0	N 70° 13' 14.7"	W 150° 45' 15.8"
SS152	Tundra	20.1	N 70° 13' 13.5"	W 150° 45' 27.0"
SS153	Tundra	16.1	N 70° 13' 13.0"	W 150° 45' 32.6"
SS154	Lake	7.9	N 70° 13' 21.5"	W 150° 44' 24.7"
SS155	Lake	9.8	N 70° 13' 22.6"	W 150° 44' 29.4"
SS156	Lake	13.4	N 70° 13' 25.0"	W 150° 44' 38.9"
SS157	Lake	15.4	N 70° 13' 26.1"	W 150° 44' 43.6"
SS158	Lake	14.6	N 70° 13' 27.3"	W 150° 44' 48.3"
SS159	Lake	14.6	N 70° 13' 28.4"	W 150° 44' 53.0"
SS159.5	Lake	15.7	N 70° 13' 29.6"	W 150° 44' 57.7"
SS160	Lake	13.0	N 70° 13' 30.7"	W 150° 45' 02.4"
SS161	Lake	11.4	N 70° 13' 31.9"	W 150° 45' 07.1"
SS162	Lake	16.1	N 70° 13' 33.1"	W 150° 45' 11.8"
SS162.5	Tundra	23.2	N 70° 13' 34.2"	W 150° 45' 16.6"
SS163	Tundra	27.2	N 70° 13' 35.4"	W 150° 45' 21.3"
SS164	Tundra	16.1	N 70° 13' 36.5"	W 150° 45' 26.0"
SS165	Tundra	19.3	N 70° 13' 38.9"	W 150° 45' 35.4"
SS166	Tundra	16.5	N 70° 13' 40.0"	W 150° 45' 40.2"
SS168	Lake	13.8	N 70° 13' 24.2"	W 150° 44' 22.4"
SS169	Lake	11.8	N 70° 13' 26.1"	W 150° 44' 23.5"
SS170	Lake	15.0	N 70° 13' 28.0"	W 150° 44' 24.7"
SS171	Lake	13.0	N 70° 13' 30.0"	W 150° 44' 25.9"
SS172	Lake	15.7	N 70° 13' 31.9"	W 150° 44' 27.1"
SS173	Lake	15.0	N 70° 13' 35.7"	W 150° 44' 29.5"
SS174	Lake	15.7	N 70° 13' 37.6"	W 150° 44' 30.6"
SS175	Lake	14.2	N 70° 13' 39.6"	W 150° 44' 31.8"
SS176	Lake	11.8	N 70° 13' 41.5"	W 150° 44' 33.0"
SS177	Lake	13.8	N 70° 13' 43.4"	W 150° 44' 34.2"
SS178	Lake	9.1	N 70° 13' 45.4"	W 150° 44' 35.4"
SS179	Lake	14.6	N 70° 13' 47.3"	W 150° 44' 36.6"
SS180	Lake	11.4	N 70° 13' 51.2"	W 150° 44' 38.9"
Note 1: Gaps in sample location are intentional				

Snow Depth Survey Data Sheet				
Date: 05/4-5/2011		**Start Time:** 2:20:00 PM on 5/4		**Observers:** SMC
Catchement Basin: M9602		**End Time:** 2:00:00 PM on 5/5		
Snow Sample No.	**Terrain Type**	**Snow Depth (in)**	**Location (NAD 83)**	
			Latitude	**Longitude**
SS181	Lake	15.4	N 70° 13' 53.1"	W 150° 44' 40.1"
SS182	Lake	7.5	N 70° 13' 55.0"	W 150° 44' 41.3"
SS183	Lake	13.0	N 70° 13' 56.9"	W 150° 44' 42.5"
SS184	Tundra	21.3	N 70° 13' 58.9"	W 150° 44' 43.7"
SS185	Tundra	15.7	N 70° 14' 02.7"	W 150° 44' 46.0"
SS186	Tundra	23.2	N 70° 14' 04.7"	W 150° 44' 47.2"
SS187	Tundra	17.3	N 70° 14' 06.6"	W 150° 44' 48.4"
SS188	Lake	13.0	N 70° 13' 18.4"	W 150° 44' 18.6"
SS189	Lake	11.8	N 70° 13' 16.5"	W 150° 44' 17.3"
SS190	Lake	9.4	N 70° 13' 14.5"	W 150° 44' 16.0"
SS191	Lake	11.0	N 70° 13' 12.6"	W 150° 44' 14.8"
SS192	Lake	9.8	N 70° 13' 10.7"	W 150° 44' 13.5"
SS193	Lake	10.6	N 70° 13' 08.8"	W 150° 44' 12.3"
SS194	Lake	14.6	N 70° 13' 05.0"	W 150° 44' 09.8"
SS195	Lake	11.4	N 70° 13' 03.0"	W 150° 44' 08.5"
SS196	Lake	11.0	N 70° 13' 01.1"	W 150° 44' 07.2"
SS197	Lake	12.2	N 70° 12' 59.2"	W 150° 44' 06.0"
SS198	Lake	10.6	N 70° 12' 57.2"	W 150° 44' 04.7"
SS199	Lake	17.7	N 70° 12' 55.3"	W 150° 44' 03.4"
SS200	Lake	16.1	N 70° 12' 51.4"	W 150° 44' 00.9"
SS201	Lake	12.2	N 70° 12' 49.5"	W 150° 43' 59.6"
SS202	Lake	9.1	N 70° 12' 47.6"	W 150° 43' 58.4"
SS203	Lake	12.2	N 70° 12' 45.7"	W 150° 43' 57.1"
SS204	Tundra	54.7	N 70° 12' 43.7"	W 150° 43' 55.8"
SS205	Tundra	23.2	N 70° 12' 39.8"	W 150° 43' 53.3"

A.2 Lake M9605

Pooled Snow Survey Data Sheet						
Date: 5/3-4/2011	Start Time: 12:00		End Time: 12:00		Observers: JMS/HLR	
Catchment Basin: M9605		Driving Wrench Used: No			Tube Section Used: 1-2	
Snow Sample No.	Pooled Sample #	Terrain Type	Snow Depth (in) w/ Dirt Plug	Snow Depth (in) w/o Dirt Plug	Calculations	
PS001	1	Lake	-	10.5	Bucket & Core Weight (lb) =	3.30
	2		-	11.5	Empty Bucket Weight (lb) =	2.34
	3		-	11.5	Average Mass (lb) =	0.24
	4		-	11.0	Core Area (in^2) =	2.0739
	-		-	-	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 16.0"		Sum (in) =	**44.5**	Average Density (lb/in^3) =	**0.010**
Longitude	W 150° 30' 56.6"		Average (in) =	**11.1**	Average SWE (in) =	**3.21**
PS002	1	Lake	-	8.0	Bucket & Core Weight (lb) =	3.20
	2		-	5.0	Empty Bucket Weight (lb) =	2.40
	3		-	7.0	Average Mass (lb) =	0.16
	4		-	10.0	Core Area (in^2) =	2.0739
	5		-	7.5	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 27.3"		Sum (in) =	**37.5**	Average Density (lb/in^3) =	**0.010**
Longitude	W 150° 31' 07.9"		Average (in) =	**7.5**	Average SWE (in) =	**2.14**
PS003	1	Lake	-	12.0	Bucket & Core Weight (lb) =	3.56
	2		-	12.5	Empty Bucket Weight (lb) =	2.38
	3		-	11.5	Average Mass (lb) =	0.24
	4		-	12.0	Core Area (in^2) =	2.0739
	5		-	13.0	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 36.6"		Sum (in) =	**61.0**	Average Density (lb/in^3) =	**0.009**
Longitude	W 150° 31' 17.1"		Average (in) =	**12.2**	Average SWE (in) =	**3.15**
PS004*	1	Lake	-	10.0	Bucket & Core Weight (lb) =	3.32
	2		-	11.0	Empty Bucket Weight (lb) =	2.34
	3		-	9.5	Average Mass (lb) =	0.20
	4		-	10.5	Core Area (in^2) =	2.0739
	5		-	11.0	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 45.9"		Sum (in) =	**52.0**	Average Density (lb/in^3) =	**0.009**
Longitude	W 150° 31' 26.4"		Average (in) =	**10.4**	Average SWE (in) =	**2.62**
PS005	1	Lake	-	8.5	Bucket & Core Weight (lb) =	3.10
	2		-	9.5	Empty Bucket Weight (lb) =	2.40
	3		-	9.5	Average Mass (lb) =	0.18
	4		-	8.5	Core Area (in^2) =	2.0739
	-		-	-	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 24.3"		Sum (in) =	**36.0**	Average Density (lb/in^3) =	**0.009**
Longitude	W 150° 30' 40.7"		Average (in) =	**9.0**	Average SWE (in) =	**2.34**
PS006	1	Tundra	7.0	5.0	Bucket & Core Weight (lb) =	2.75
	2		9.5	9.0	Empty Bucket Weight (lb) =	2.36
	3		4.0	2.0	Average Mass (lb) =	0.10
	4		8.5	7.0	Core Area (in^2) =	2.0739
	-		-	-	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 32.6"		Sum (in) =	**23.0**	Average Density (lb/in^3) =	**0.008**
Longitude	W 150° 30' 24.9"		Average (in) =	**5.8**	Average SWE (in) =	**1.30**
PS007	1	Lake	-	7.5	Bucket & Core Weight (lb) =	3.24
	2		-	6.0	Empty Bucket Weight (lb) =	2.42
	3		-	9.5	Average Mass (lb) =	0.16
	4		-	10.5	Core Area (in^2) =	2.0739
	5		-	7.5	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 12.0"		Sum (in) =	**41.0**	Average Density (lb/in^3) =	**0.010**
Longitude	W 150° 30' 35.6"		Average (in) =	**8.2**	Average SWE (in) =	**2.19**

Note 1: Locations are referenced to NAD 83 datum.
* Near area of disturbed snow

Pooled Snow Survey Data Sheet						
Date: 5/3-4/2011	**Start Time:** 12:00		**End Time:** 12:00		**Observers:** JMS/HLR	
Catchment Basin: M9605			**Driving Wrench Used:** No		**Tube Section Used:** 1-2	
Snow Sample No.	**Pooled Sample #**	**Terrain Type**	**Snow Depth (in) w/ Dirt Plug**	**Snow Depth (in) w/o Dirt Plug**	**Calculations**	
PS008	1	Tundra	15	14.0	**Bucket & Core Weight (lb) =**	3.38
	2		15	12.0	**Empty Bucket Weight (lb) =**	2.41
	3		16.5	15.5	**Average Mass (lb) =**	0.19
	4		13	11.5	**Core Area (in^2) =**	2.0739
	5		14.5	11.0	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 13' 06.0"		**Sum (in) =**	**64.0**	**Average Density (lb/in^3) =**	**0.007**
Longitude	W 150° 30' 06.4"		**Average (in) =**	**12.8**	**Average SWE (in) =**	**2.59**
PS009	1	Tundra	15	12.0	**Bucket & Core Weight (lb) =**	4.20
	2		21.5	21.0	**Empty Bucket Weight (lb) =**	2.40
	3		23.5	23.0	**Average Mass (lb) =**	0.36
	4		24.5	24.5	**Core Area (in^2) =**	2.0739
	5		22.5	22.5	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 13' 02.0"		**Sum (in) =**	**93.3**	**Average Density (lb/in^3) =**	**0.009**
Longitude	W 150° 29' 46.3"		**Average (in) =**	**18.7**	**Average SWE (in) =**	**4.81**
PS010	1	Lake	-	11.0	**Bucket & Core Weight (lb) =**	3.80
	2		-	14.0	**Empty Bucket Weight (lb) =**	2.42
	3		-	13.0	**Average Mass (lb) =**	0.28
	4		-	12.0	**Core Area (in^2) =**	2.0739
	5		-	12.5	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 13' 06.8"		**Sum (in) =**	**68.7**	**Average Density (lb/in^3) =**	**0.010**
Longitude	W 150° 30' 46.1"		**Average (in) =**	**13.7**	**Average SWE (in) =**	**3.69**
PS011	1	Lake	-	14.0	**Bucket & Core Weight (lb) =**	4.07
	2		-	14.0	**Empty Bucket Weight (lb) =**	2.37
	3		-	15.0	**Average Mass (lb) =**	0.34
	4		-	15.0	**Core Area (in^2) =**	2.0739
	5		-	13.0	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 12' 59.4"		**Sum (in) =**	**71.7**	**Average Density (lb/in^3) =**	**0.011**
Longitude	W 150° 30' 37.8"		**Average (in) =**	**14.3**	**Average SWE (in) =**	**4.54**
PS012	1	Lake	-	11.0	**Bucket & Core Weight (lb) =**	3.60
	2		-	11.5	**Empty Bucket Weight (lb) =**	2.38
	3		-	10.0	**Average Mass (lb) =**	0.24
	4		-	11.0	**Core Area (in^2) =**	2.0739
	5		-	11.0	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 12' 50.2"		**Sum (in) =**	**57.8**	**Average Density (lb/in^3) =**	**0.010**
Longitude	W 150° 30' 27.4"		**Average (in) =**	**11.6**	**Average SWE (in) =**	**3.26**
PS013	1	Tundra	15.5	15.5	**Bucket & Core Weight (lb) =**	3.24
	2		14.5	12.5	**Empty Bucket Weight (lb) =**	2.40
	3		11.5	9.5	**Average Mass (lb) =**	0.17
	4		9	7.5	**Core Area (in^2) =**	2.0739
	5		13.5	11.5	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 12' 39.2"		**Sum (in) =**	**56.6**	**Average Density (lb/in^3) =**	**0.007**
Longitude	W 150° 30' 14.9"		**Average (in) =**	**11.3**	**Average SWE (in) =**	**2.24**
PS014	1	Tundra	18.5	17.0	**Bucket & Core Weight (lb) =**	3.76
	2		14.5	11.0	**Empty Bucket Weight (lb) =**	2.42
	3		18.5	16.5	**Average Mass (lb) =**	0.27
	4		17	15.5	**Core Area (in^2) =**	2.0739
	5		18.5	14.5	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 12' 33.8"		**Sum (in) =**	**71.3**	**Average Density (lb/in^3) =**	**0.009**
Longitude	W 150° 30' 08.5"		**Average (in) =**	**14.3**	**Average SWE (in) =**	**3.58**

Note 1: Locations are referenced to NAD 83 datum.

Pooled Snow Survey Data Sheet

Date: 5/3-4/2011	**Start Time:** 12:00		**End Time:** 12:00		**Observers:** JMS/HLR	
Catchment Basin: M9605			**Driving Wrench Used:** No		**Tube Section Used:** 1-2	
Snow Sample No.	**Pooled Sample #**	**Terrain Type**	**Snow Depth (in)**		**Calculations**	
			w/ Dirt Plug	**w/o Dirt Plug**		
PS015	1	Tundra	24	24.0	**Bucket & Core Weight (lb) =**	5.40
	2		25.5	25.5	**Empty Bucket Weight (lb) =**	2.35
	3		25	25.0	**Average Mass (lb) =**	0.61
	4		25	22.5	**Core Area (in^2) =**	2.0739
	5		25.5	25.5	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 12' 29.7"		**Sum (in) =**	**122.5**	**Average Density (lb/in^3) =**	**0.012**
Longitude	W 150° 30' 35.0"		**Average (in) =**	**24.5**	**Average SWE (in) =**	**8.15**
PS016	1	Tundra	16.5	14.5	**Bucket & Core Weight (lb) =**	3.45
	2		16	16.0	**Empty Bucket Weight (lb) =**	2.40
	3		15	14.0	**Average Mass (lb) =**	0.21
	4		12	10.5	**Core Area (in^2) =**	2.0739
	5		14.5	13.5	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 12' 38.0"		**Sum (in) =**	**68.5**	**Average Density (lb/in^3) =**	**0.007**
Longitude	W 150° 29' 42.1"		**Average (in) =**	**13.7**	**Average SWE (in) =**	**2.80**
PS017	1	Lake	-	12.0	**Bucket & Core Weight (lb) =**	3.92
	2		-	14.5	**Empty Bucket Weight (lb) =**	2.36
	3		-	13.5	**Average Mass (lb) =**	0.31
	4		-	14.0	**Core Area (in^2) =**	2.0739
	5		-	12.5	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 13' 10.5"		**Sum (in) =**	**66.5**	**Average Density (lb/in^3) =**	**0.011**
Longitude	W 150° 31' 02.5"		**Average (in) =**	**13.3**	**Average SWE (in) =**	**4.17**
PS018	1	Lake	-	13.0	**Bucket & Core Weight (lb) =**	3.84
	2		-	12.5	**Empty Bucket Weight (lb) =**	2.41
	3		-	13.0	**Average Mass (lb) =**	0.29
	4		-	12.5	**Core Area (in^2) =**	2.0739
	5		-	13.0	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 13' 04.9"		**Sum (in) =**	**64.0**	**Average Density (lb/in^3) =**	**0.011**
Longitude	W 150° 31' 08.5"		**Average (in) =**	**12.8**	**Average SWE (in) =**	**3.82**
PS019	1	Tundra	7	5.0	**Bucket & Core Weight (lb) =**	2.90
	2		9	7.0	**Empty Bucket Weight (lb) =**	2.38
	3		10.5	10.5	**Average Mass (lb) =**	0.10
	4		11	8.5	**Core Area (in^2) =**	2.0739
	5		10	8.5	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 12' 57.5"		**Sum (in) =**	**39.5**	**Average Density (lb/in^3) =**	**0.006**
Longitude	W 150° 31' 16.5"		**Average (in) =**	**7.9**	**Average SWE (in) =**	**1.39**
PS020	1	Tundra	17	16.0	**Bucket & Core Weight (lb) =**	4.76
	2		24.5	23.0	**Empty Bucket Weight (lb) =**	2.38
	3		21.5	20.5	**Average Mass (lb) =**	0.48
	4		10	6.0	**Core Area (in^2) =**	2.0739
	5		33	32.5	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 12' 50.1"		**Sum (in) =**	**98.0**	**Average Density (lb/in^3) =**	**0.012**
Longitude	W 150° 31' 24.5"		**Average (in) =**	**19.6**	**Average SWE (in) =**	**6.36**
PS021	1	Lake	-	33.0	**Bucket & Core Weight (lb) =**	6.81
	2		-	38.0	**Empty Bucket Weight (lb) =**	2.40
	3		-	37.5	**Average Mass (lb) =**	0.88
	4		-	38.0	**Core Area (in^2) =**	2.0739
	5		-	38.0	**Freshwater Density (lb/in^3) =**	0.0361
Latitude	N 70° 13' 16.8"		**Sum (in) =**	**184.5**	**Average Density (lb/in^3) =**	**0.012**
Longitude	W 150° 31' 25.6"		**Average (in) =**	**36.9**	**Average SWE (in) =**	**11.78**

Note 1: Locations are referenced to NAD 83 datum.

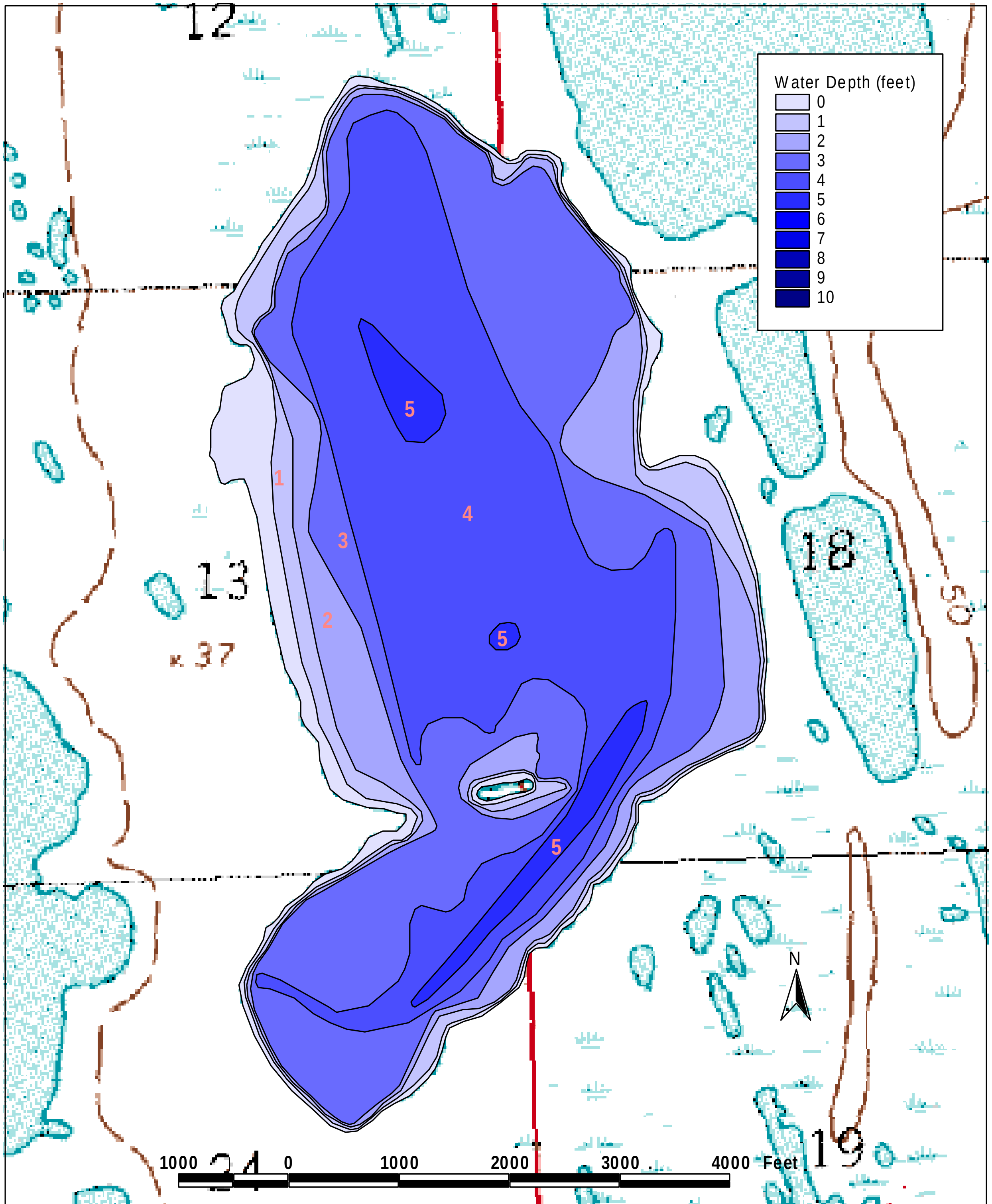
Pooled Snow Survey Data Sheet						
Date: 5/3-4/2011	Start Time:	12:00	End Time:	12:00	Observers:	JMS/HLR
Catchment Basin:	M9605		Driving Wrench Used:	No	Tube Section Used:	1-2
Snow Sample No.	Pooled Sample #	Terrain Type	Snow Depth (in) w/ Dirt Plug	Snow Depth (in) w/o Dirt Plug	Calculations	
PS022	1	Tundra	18	15.0	Bucket & Core Weight (lb) =	3.40
	2		13	10.5	Empty Bucket Weight (lb) =	2.40
	3		15.5	14.0	Average Mass (lb) =	0.20
	4		11	10.0	Core Area (in^2) =	2.0739
	5		15	12.5	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 17.4"		Sum (in) =	**62.0**	Average Density (lb/in^3) =	**0.008**
Longitude	W 150° 31' 48.9"		Average (in) =	**12.4**	Average SWE (in) =	**2.67**
PS00X*	1	Tundra	14	12.5	Bucket & Core Weight (lb) =	4.18
	2		16	15.0	Empty Bucket Weight (lb) =	2.38
	3		14	13.0	Average Mass (lb) =	0.36
	4		17.5	17.0	Core Area (in^2) =	2.0739
	5		17.5	17.0	Freshwater Density (lb/in^3) =	0.0361
Latitude	N 70° 13' 51.2"		Sum (in) =	**74.5**	Average Density (lb/in^3) =	**0.012**
Longitude	W 150° 31' 31.4"		Average (in) =	**14.9**	Average SWE (in) =	**4.81**
					Bucket & Core Weight (lb) =	
					Empty Bucket Weight (lb) =	
					Average Mass (lb) =	
					Core Area (in^2) =	
					Freshwater Density (lb/in^3) =	
Latitude			Sum (in) =		Average Density (lb/in^3) =	
Longitude			Average (in) =		Average SWE (in) =	
					Bucket & Core Weight (lb) =	
					Empty Bucket Weight (lb) =	
					Average Mass (lb) =	
					Core Area (in^2) =	
					Freshwater Density (lb/in^3) =	
Latitude			Sum (in) =		Average Density (lb/in^3) =	
Longitude			Average (in) =		Average SWE (in) =	
					Bucket & Core Weight (lb) =	
					Empty Bucket Weight (lb) =	
					Average Mass (lb) =	
					Core Area (in^2) =	
					Freshwater Density (lb/in^3) =	
Latitude			Sum (in) =		Average Density (lb/in^3) =	
Longitude			Average (in) =		Average SWE (in) =	
					Bucket & Core Weight (lb) =	
					Empty Bucket Weight (lb) =	
					Average Mass (lb) =	
					Core Area (in^2) =	
					Freshwater Density (lb/in^3) =	
Latitude			Sum (in) =		Average Density (lb/in^3) =	
Longitude			Average (in) =		Average SWE (in) =	
					Bucket & Core Weight (lb) =	
					Empty Bucket Weight (lb) =	
					Average Mass (lb) =	
					Core Area (in^2) =	
					Freshwater Density (lb/in^3) =	
Latitude			Sum (in) =		Average Density (lb/in^3) =	
Longitude			Average (in) =		Average SWE (in) =	

Note 1: Locations are referenced to NAD 83 datum.
* Between lake and ice road, near area of disturbed snow

Snow Depth Survey Data Sheet				
Date: 05/3-4/2011		**Start Time:** 11:15:00 AM on 5/3		**Observers:** SMC
Catchment Basin: M9605		**End Time:** 2:00:00 PM on 5/4		
Snow Sample No.	**Terrain Type**	**Snow Depth (in)**	**Location**	
			Latitude	**Longitude**
SS001	Lake	6.7	N 70° 13' 17.9"	W 150° 30' 58.4"
SS002	Lake	11.0	N 70° 13' 19.7"	W 150° 31' 00.3"
SS003	Lake	9.1	N 70° 13' 21.6"	W 150° 31' 02.1"
SS004	Lake	10.2	N 70° 13' 23.5"	W 150° 31' 04.0"
SS005	Lake	9.4	N 70° 13' 25.4"	W 150° 31' 05.9"
SS006	Lake	13.4	N 70° 13' 29.1"	W 150° 31' 09.6"
SS007	Lake	8.3	N 70° 13' 30.9"	W 150° 31' 11.5"
SS008	Lake	17.3	N 70° 13' 32.8"	W 150° 31' 13.3"
SS009	Lake	12.2	N 70° 13' 34.7"	W 150° 31' 15.2"
SS010	Lake	5.5	N 70° 13' 38.4"	W 150° 31' 18.9"
SS011	Lake	6.7	N 70° 13' 40.3"	W 150° 31' 20.9"
SS012	Lake	10.2	N 70° 13' 42.2"	W 150° 31' 22.7"
SS013	Lake	10.6	N 70° 13' 44.0"	W 150° 31' 24.5"
SS014	Lake	6.7	N 70° 13' 47.8"	W 150° 31' 28.4"
SS015	Lake	9.8	N 70° 13' 49.6"	W 150° 31' 30.1"
SS016	Lake	9.8	N 70° 13' 17.7"	W 150° 30' 53.4"
SS017	Lake	7.1	N 70° 13' 19.3"	W 150° 30' 50.2"
SS018	Lake	8.7	N 70° 13' 21.0"	W 150° 30' 47.1"
SS019	Lake	7.9	N 70° 13' 22.6"	W 150° 30' 43.9"
SS020	Lake	8.3	N 70° 13' 25.9"	W 150° 30' 37.6"
SS021	Lake	14.6	N 70° 13' 27.6"	W 150° 30' 34.4"
SS022	Tundra	31.9	N 70° 13' 29.2"	W 150° 30' 31.2"
SS023	Tundra	19.7	N 70° 13' 30.9"	W 150° 30' 28.1"
SS024	Tundra	9.4	N 70° 13' 34.2"	W 150° 30' 21.7"
SS025	Lake	12.2	N 70° 13' 15.0"	W 150° 30' 51.7"
SS026	Lake	7.5	N 70° 13' 14.0"	W 150° 30' 46.6"
SS027	Lake	8.7	N 70° 13' 13.0"	W 150° 30' 41.5"
SS028	Lake	8.3	N 70° 13' 11.0"	W 150° 30' 31.5"
SS029	Lake	7.5	N 70° 13' 10.0"	W 150° 30' 26.5"
SS030	Lake	12.6	N 70° 13' 09.1"	W 150° 30' 21.4"
SS031	Lake	48.4	N 70° 13' 08.0"	W 150° 30' 16.4"
SS032	Tundra	10.6	N 70° 13' 07.0"	W 150° 30' 11.4"
SS033	Tundra	16.5	N 70° 13' 05.0"	W 150° 30' 01.3"
SS034	Tundra	15.7	N 70° 13' 04.0"	W 150° 29' 56.3"
SS035	Tundra	28.0	N 70° 13' 03.0"	W 150° 29' 51.3"
SS036	Lake	9.4	N 70° 13' 14.2"	W 150° 30' 54.5"
SS037	Lake	7.9	N 70° 13' 12.3"	W 150° 30' 52.4"
SS038	Lake	4.3	N 70° 13' 10.5"	W 150° 30' 50.3"
SS039	Lake	10.2	N 70° 13' 08.7"	W 150° 30' 48.2"
SS040	Lake	9.4	N 70° 13' 05.0"	W 150° 30' 44.1"
SS041	Lake	7.9	N 70° 13' 03.1"	W 150° 30' 42.0"
SS042	Lake	12.2	N 70° 13' 01.3"	W 150° 30' 39.9"
SS043	Lake	7.1	N 70° 12' 57.6"	W 150° 30' 35.7"
SS044	Lake	10.6	N 70° 12' 55.9"	W 150° 30' 33.6"
SS045	Lake	8.3	N 70° 12' 53.9"	W 150° 30' 31.5"
SS046	Lake	9.1	N 70° 12' 52.1"	W 150° 30' 29.5"
SS047	Lake	5.5	N 70° 12' 48.4"	W 150° 30' 25.3"
SS048	Lake	5.9	N 70° 12' 46.6"	W 150° 30' 23.2"
SS049	Lake	63.0	N 70° 12' 44.7"	W 150° 30' 21.1"

Snow Depth Survey Data Sheet				
Date:	05/4-5/2011	**Start Time:**	11:15:00 AM on 5/3	**Observers:** SMC
Catchement Basin:	M9602	**End Time:**	2:00:00 PM on 5/4	
Snow Sample No.	**Terrain Type**	**Snow Depth (in)**	**Location**	
			Latitude	**Longitude**
SS050	Tundra	10.6	N 70° 12' 42.9"	W 150° 30' 19.0"
SS051	Tundra	17.7	N 70° 12' 41.0"	W 150° 30' 17.0"
SS052	Tundra	20.5	N 70° 12' 37.3"	W 150° 30' 12.8"
SS053	Tundra	13.8	N 70° 12' 35.5"	W 150° 30' 10.7"
SS054	Tundra	22.4	N 70° 12' 33.0"	W 150° 30' 13.8"
SS055	Tundra	22.4	N 70° 12' 32.1"	W 150° 30' 19.1"
SS056	Tundra	31.9	N 70° 12' 31.3"	W 150° 30' 24.4"
SS057	Tundra	29.1	N 70° 12' 30.5"	W 150° 30' 29.7"
SS058	Tundra	21.3	N 70° 12' 28.8"	W 150° 30' 40.3"
SS059	Tundra	17.7	N 70° 12' 34.6"	W 150° 30' 03.2"
SS060	Tundra	27.2	N 70° 12' 35.5"	W 150° 29' 57.9"
SS061	Tundra	29.5	N 70° 12' 36.3"	W 150° 29' 52.7"
SS062	Tundra	21.7	N 70° 12' 37.1"	W 150° 29' 47.4"
SS063	Tundra	28.7	N 70° 12' 38.8"	W 150° 29' 36.8"
SS064	Tundra	14.6	N 70° 12' 39.6"	W 150° 29' 31.5"
SS065	Lake	13.0	N 70° 13' 14.2"	W 150° 30' 58.5"
SS066	Lake	13.8	N 70° 13' 12.3"	W 150° 31' 00.5"
SS067	Lake	8.3	N 70° 13' 08.6"	W 150° 31' 04.5"
SS068	Lake	10.6	N 70° 13' 06.7"	W 150° 31' 06.5"
SS069	Lake	9.1	N 70° 13' 03.0"	W 150° 31' 10.5"
SS070	Lake	18.9	N 70° 13' 01.2"	W 150° 31' 12.5"
SS071	Tundra	43.7	N 70° 12' 59.3"	W 150° 31' 14.5"
SS072	Tundra	18.1	N 70° 12' 55.6"	W 150° 31' 18.5"
SS073	Tundra	12.6	N 70° 12' 53.8"	W 150° 31' 20.4"
SS074	Tundra	17.7	N 70° 12' 51.9"	W 150° 31' 22.4"
SS075	Tundra	7.5	N 70° 12' 48.2"	W 150° 31' 26.4"
SS076	Lake	9.4	N 70° 13' 16.2"	W 150° 31' 02.4"
SS077	Lake	13.4	N 70° 13' 16.3"	W 150° 31' 08.2"
SS078	Lake	15.0	N 70° 13' 16.5"	W 150° 31' 14.0"
SS079	Lake	14.6	N 70° 13' 16.6"	W 150° 31' 19.8"
SS080	Tundra	48.4	N 70° 13' 16.9"	W 150° 31' 31.4"
SS081	Tundra	11.0	N 70° 13' 17.1"	W 150° 31' 37.2"
SS082	Tundra	16.1	N 70° 13' 17.2"	W 150° 31' 43.0"
SS083	Tundra	20.9	N 70° 13' 17.5"	W 150° 31' 54.7"
SS084	Tundra	14.6	N 70° 13' 17.7"	W 150° 32' 00.5"

Appendix B Lake Bathemetry: M9602 and M9605



Depth contours of lake M9602 based on transects surveyed on July 12, 2005
(depths in 1 foot intervals)

(not to be used for navigation or to direct use of heavy equipment)

Lake M9602

Other Names: AA10.1
Location: 70.22147°N 150.73865°W
USGS Quad Sheet: Harrison Bay A-2: T10N R5/6E, Sec 112/13/24/7/18/19
Habitat: Tundra Lake
Area: 658 acres
Maximum Depth: 6.4 feet
Active Outlet: No
Total Lake Volume: 734.9 million gallons (2005 data)
Volume Under 4 ft of ice: 42.9 million gallons
Volume Under 5 ft of ice: 2.6 million gallons
Volume Under 7 ft of ice: 0.0 million gallons
Potential Aggregate: 391.5 acres (water depth 4 ft or less)

Maximum Recommended Winter Removal: **0.78 million gallons**
(30% of volume under 5 feet of ice)
(does not include volume associated with ice aggregate)

Water Use History:

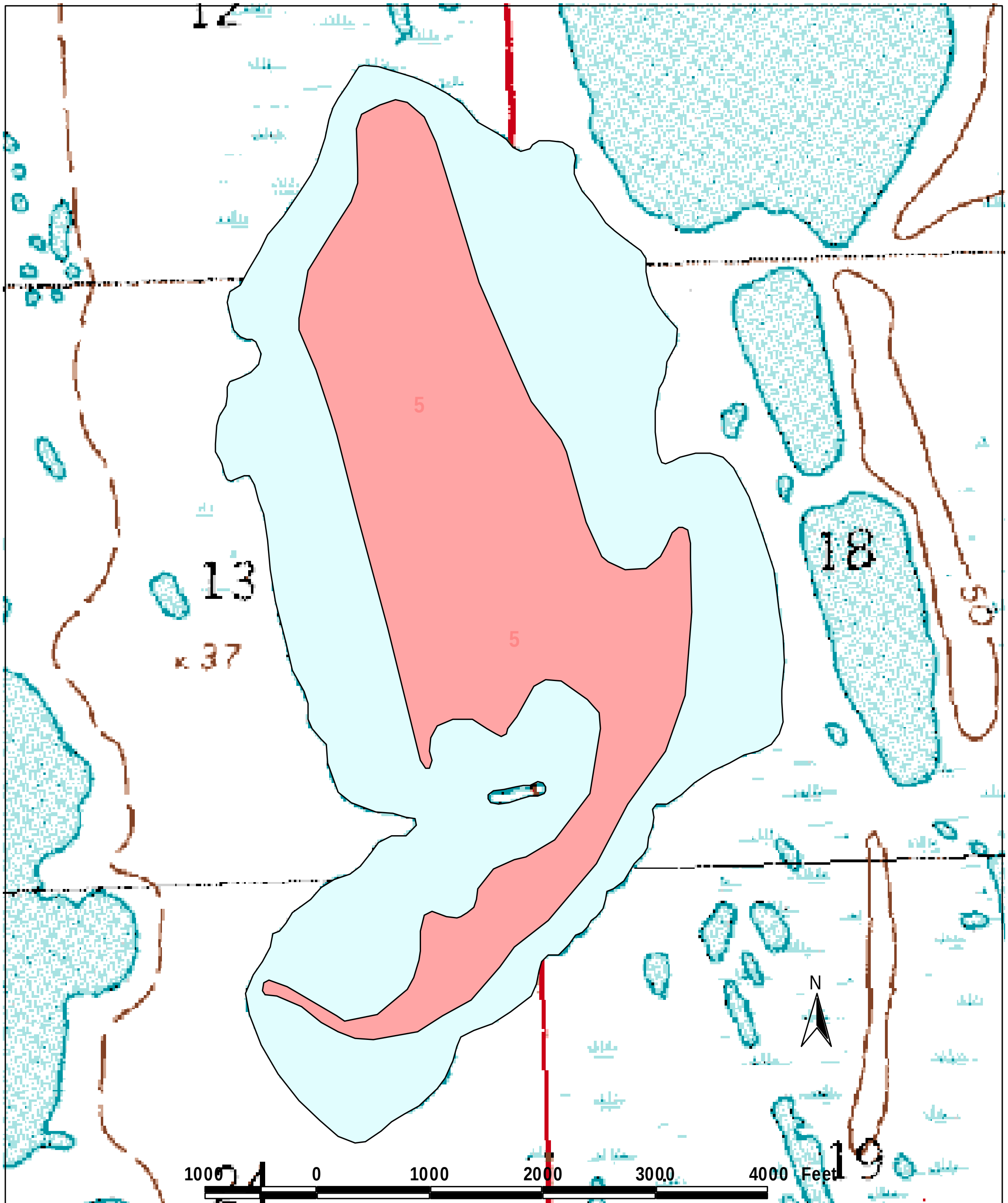
Year	Water Removed (all sources) (mill. Gals)
1998/1999	3.03
2000/2001	7.96
2001/2002	2.84
2002/2003	13.69
2003/2004	3.65
2004/2005	7.83

Water Chemistry:

Year of Test	Calcium (mg/l)	Magnesium (mg/l	Chloride (mg/l)	Sodium (mg/l)	Total Hardness [CaCO3] (mg/l)	Specific Conductance (microS/cm)	Turbidity (NTU)	pH	Source
1996	15.9	13.5	2.9	31.5	90				J. Lobdell
1997								8.04	
2002						209	0.8	8.02	
2005	25.0	2.3	14.8	4.9	72	142	1.5	8.00	

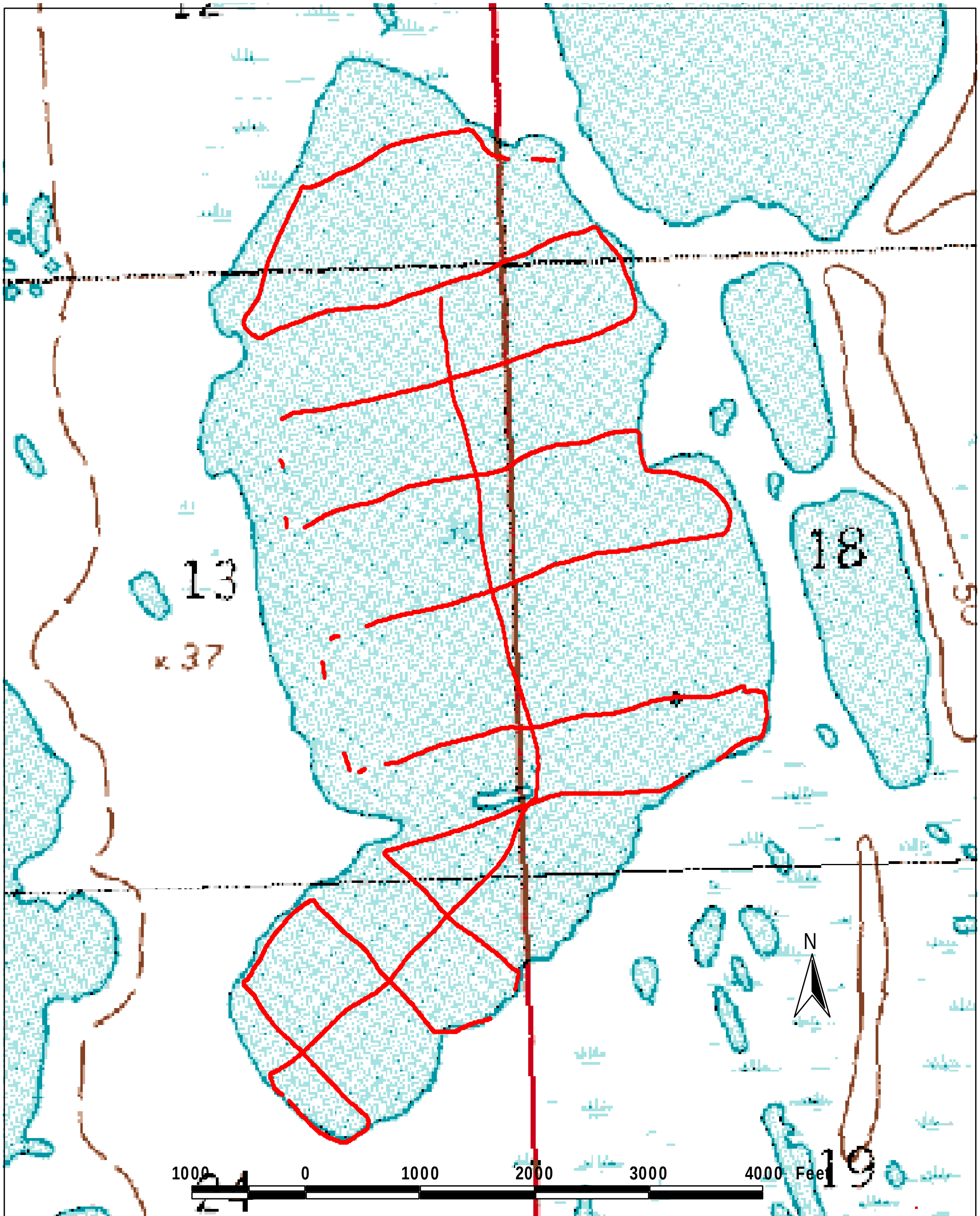
Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught
Gill Net	Jul 26 96	10.7	None	0
Observed	Jul 15 02		Ninespine stickleback	many

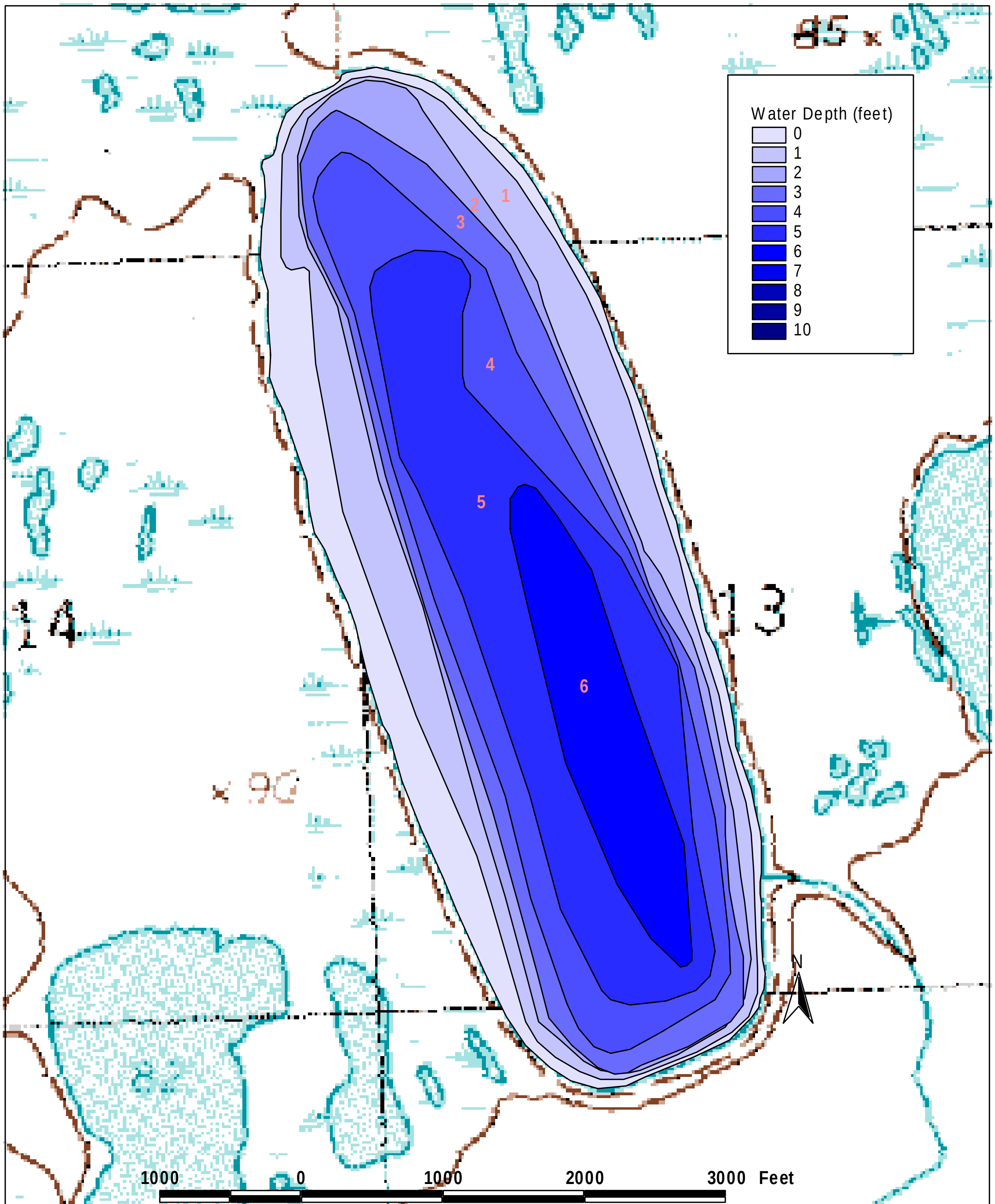


Regions of lake M9602 less than 4 fet deep (light shaded) and likely to be available for ice chips, based on transects surveyed on July 12, 2005 .

(not to be used for navigation or to direct use of heavy equipment)



Depth transects measured at lake M9602 on July 12, 2005.



Depth contours of lake M9605 based on transects surveyed on July 20, 2005
(depths in 1 foot intervals)

(not to be used for navigation or to direct use of heavy equipment)

Lake M9605

Other Names:	AA14.1
Location:	70.22099°N 150.51572°W
USGS Quad Sheet:	Harrison Bay A-1: T10N R6E, Sec 11/12/13/14/24
Habitat:	Tundra Lake
Area:	350 acres
Maximum Depth:	7.2 feet
Active Outlet:	No
Total Lake Volume:	408.9 million gallons (2005 data)
Volume Under 4 ft of ice:	75.9 million gallons
Volume Under 5 ft of ice:	28.4 million gallons
Volume Under 7 ft of ice:	0.0 million gallons
Potential Aggregate:	174.1 acres (water depth 4 ft or less)

Maximum Recommended Winter Removal: **8.52 million gallons**
(30% of volume under 5 feet of ice)
(does not include volume associated with ice aggregate)

Water Use History:

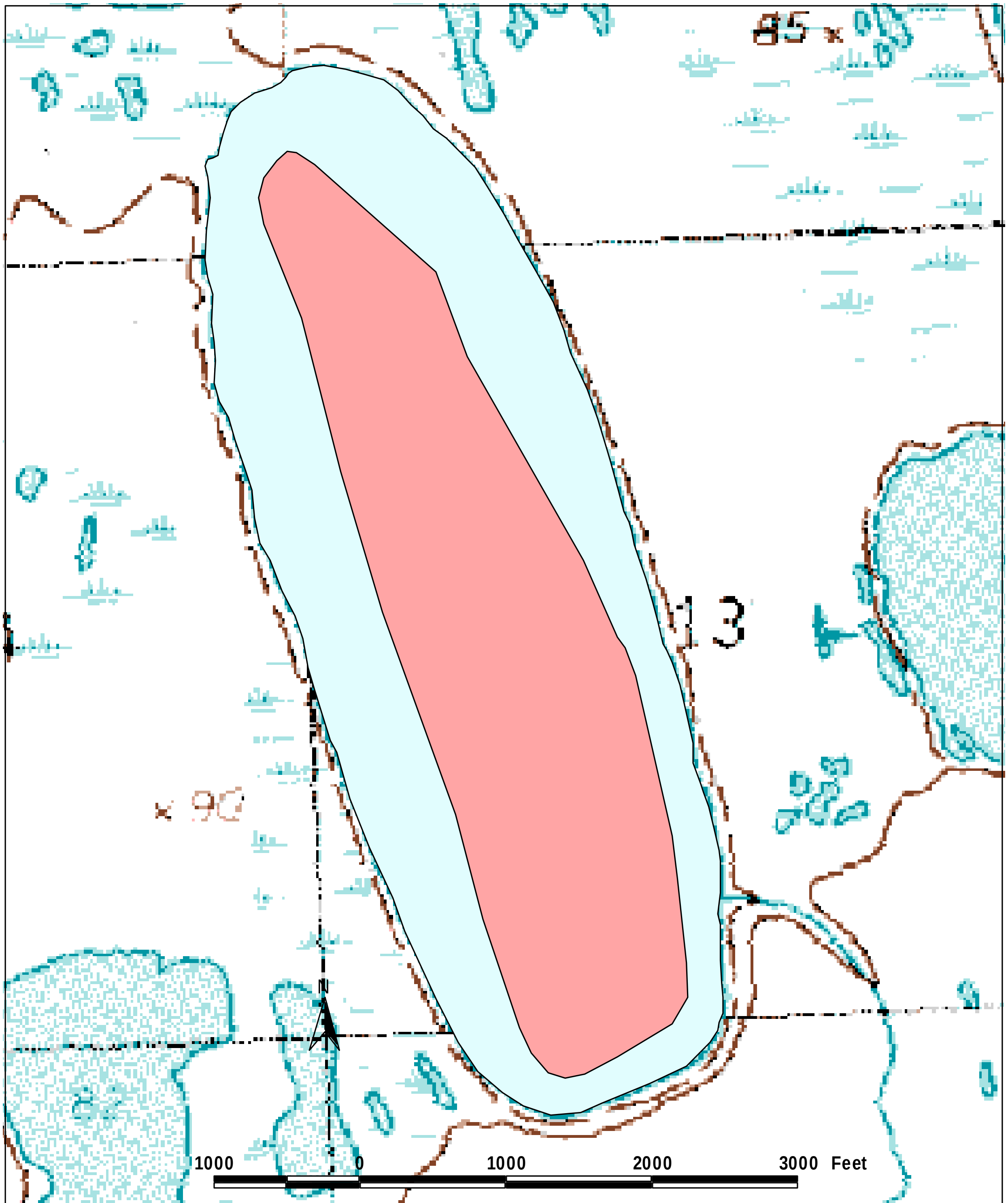
Year	Water Removed (all sources) (mill. Gals)
1998/1999	6.13
2000/2001	18.26
2001/2002	9.22
2002/2003	17.34
2003/2004	5.89
2004/2005	12.82

Water Chemistry:

Year of Test	Calcium (mg/l	Magnesium (mg/l)	Chloride (mg/l)	Sodium (mg/l)	Total Hardness [CaCO3] (mg/l)	Specific Conductance (microS/cm)	Turbidity (NTU)	pH	Source
1996	9.8	9.8	2.9	31.2	90				J. Lobdell
2005	21.0	1.7	8.9	3.3	59	137	0.7	8.10	

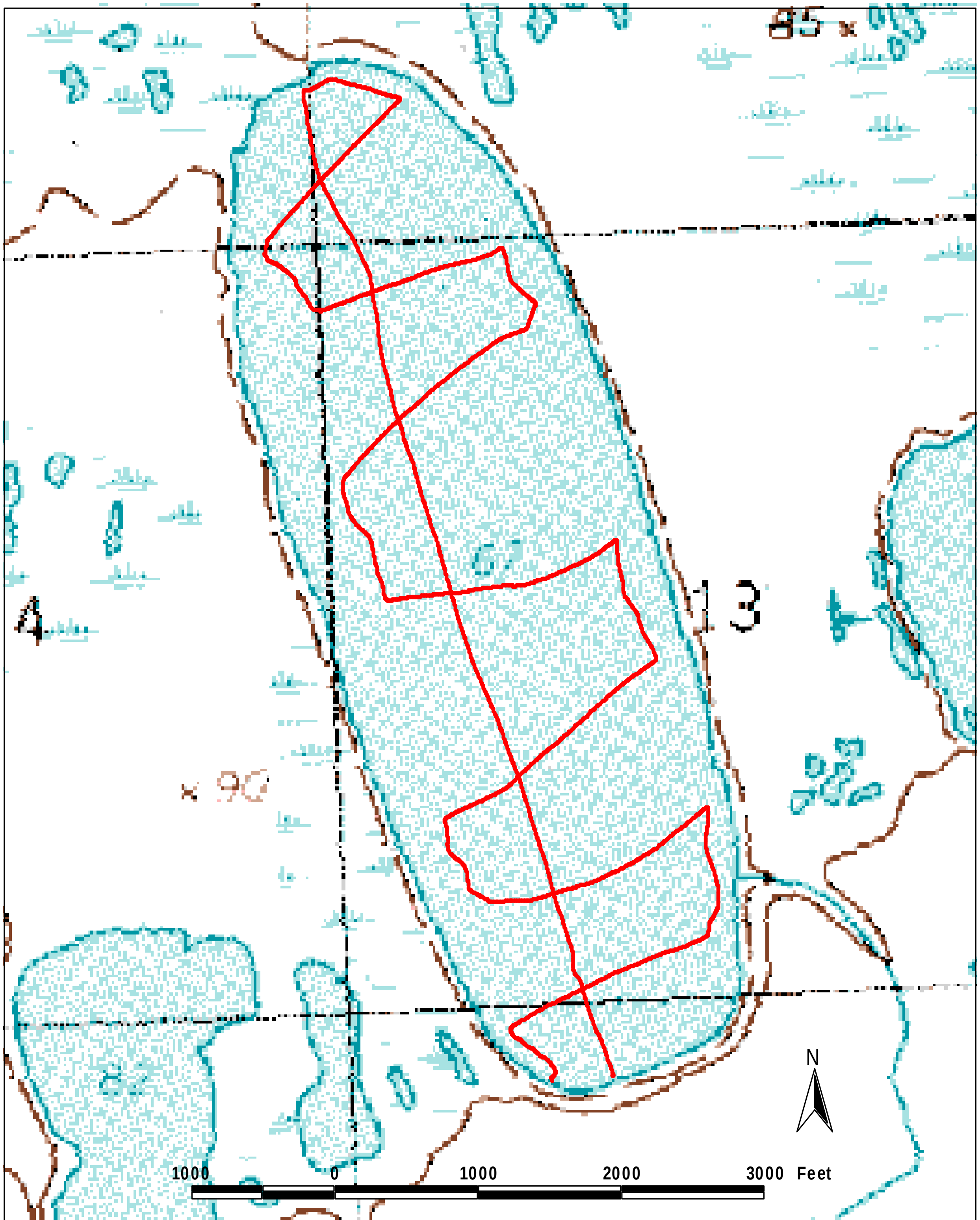
Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught
Gill Net	Jul 18 96	4.3	None	0
Gill Net	Jul 20 05	6.7	None	0
Minnow Traps	Jul 20 05	12.2	Ninespine stickleback	1



Regions of lake M9605 less than 4 fet deep (light shaded) and likely to be available for ice chips, based on transects surveyed on July 20, 2005 .

(not to be used for navigation or to direct use of heavy equipment)



Depth transects measured at lake M9605 on July 20, 2005.

Appendix C Gage And Control Locations

Monitoring Location	Site Name	Type	Latitude (NAD 83)	Longitude (NAD83)
Ice Road Recharge Lakes				
B8534/L9282	L9282/B8534-A	Gage	N 70° 20' 38.5"	W 150° 53' 12.5"
	L9282/B8534-X	TBM	N 70° 20' 38.7"	W 150° 53' 14.1"
M9525	M9525-A	Gage	N 70° 20' 03.7"	W 150° 58' 11.5"
	M9525-B	Gage	N 70° 20' 04.0"	W 150° 58' 14.0"
	CD4-6E	TBM - Culvert Top	N 70° 20' 05.2"	W 150° 58' 14.8"
L9323	L9323-A	Gage	N 70° 17' 44.0"	W 150° 59' 02.5"
	NANUQ 4	TBM LCMF 2003 3"ALCAP	N 70° 17' 43.6"	W 150° 58' 53.0"
L9324	L9324-A	Gage	N 70° 17' 29.1"	W 150° 58' 52.7"
	L9324-B	Gage	N 70° 17' 29.1"	W 150° 58' 52.9"
	NANUQ 5	TBM LCMF 2000 3"ALCAP	N 70° 17' 30.0"	W 150° 58' 50.4"
B8531/L9326	L9326/B8531-A	Gage	N 70° 16' 21.6"	W 150° 59' 41.0"
	L9326/B8531-X	TBM	N 70° 16' 21.3"	W 150° 59' 41.2"
B8530	B8530-A	Gage	N 70° 14' 37.3"	W 150° 52' 54.6"
	B8530-X	TBM	N 70° 14' 36.8"	W 150° 52' 53.7"
M9607	M9607-A	Gage	N 70° 14' 38.2"	W 150° 52' 05.0"
	M9607-X	TBM	N 70° 14' 38.6"	W 150° 52' 03.8"
M9602	M9602-A	Gage	N 70° 12' 57.2"	W 150° 43' 22.7"
	M9602-X	TBM	N 70° 12' 57.0"	W 150° 43' 22.6"
M9605	M9605-A	Gage	N 70° 13' 49.8"	W 150° 31' 02.7"
	M9605-X	TBM	N 70° 13' 50.0"	W 150° 31' 03.1"

Appendix D General Study Lake Photos

D.1 Lake B8534/L9282

PHOTO D.1: LAKE B8534/L9282 PRE- BREAKUP – LOOKING SOUTHEAST

PHOTO D.2: LAKE B8534/L9282 DURING BREAKUP – LOOKING EAST

PHOTO D.3: LAKE B8534/L9282 POST- BREAKUP – LOOKING EAST

PHOTO D.4: LAKE B8534/L9282 RIPARIAN ZONE

D.2 Lake M9525

PHOTO D.5: LAKE M9525 PRE- BREAKUP – LOOKING SOUTH

PHOTO D.6: LAKE M9525 DURING BREAKUP – LOOKING NORTHWEST

PHOTO D.7: LAKE M9525 POST- BREAKUP – LOOKING NORTHEAST

PHOTO D.8: LAKE M9525 RIPARIAN ZONE

D.3 Lake L9323

PHOTO D.9: LAKE L9323 PRE- BREAKUP – LOOKING SOUTHWEST

PHOTO D.10: LAKE L9323 DURING BREAKUP – LOOKING EAST

PHOTO D.11: LAKE L9323 POST- BREAKUP – LOOKING SOUTHEAST

PHOTO D.12: LAKE L9323 RIPARIAN ZONE

D.4 Lake L9324

PHOTO D.13: LAKE L9324 PRE- BREAKUP – LOOKING SOUTH

PHOTO D.14: LAKE L9324 DURING BREAKUP – LOOKING SOUTHEAST

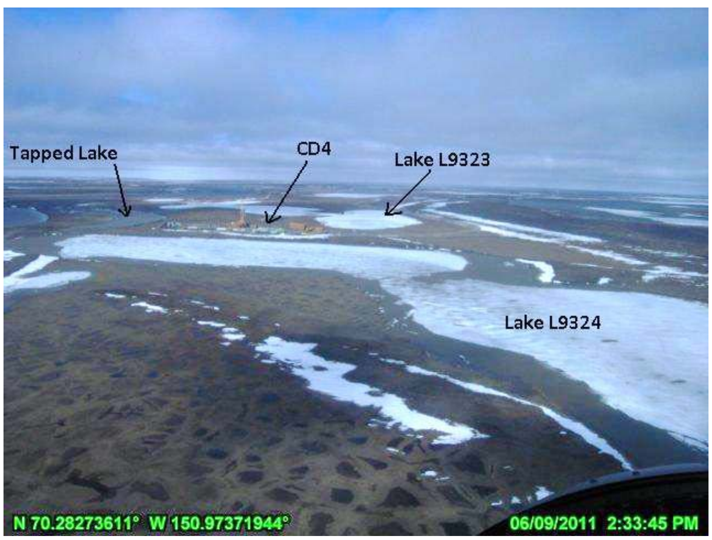


PHOTO D.15: LAKE L9324 POST- BREAKUP – LOOKING NORTHEAST

PHOTO D.16: LAKE L9324 RIPARIAN ZONE

D.5 Lake B8531/L9326

PHOTO D.17: LAKE B8531/L9326 PRE- BREAKUP – LOOKING SOUTHEAST

PHOTO D.18: LAKE B8531/L9326 DURING BREAKUP – LOOKING EAST

PHOTO D.19: LAKE B8531/L9326 POST- BREAKUP – LOOKING WEST

PHOTO D.20: LAKE B8531/L9326 RIPARIAN ZONE

D.6 Lake B8530

PHOTO D.21: LAKE B8530 PRE- BREAKUP – LOOKING WEST

PHOTO D.22: LAKE B8530 DURING BREAKUP – LOOKING WEST

PHOTO D.23: LAKE B8530 POST- BREAKUP – LOOKING WEST

PHOTO D.24: LAKE B8530 RIPARIAN ZONE

D.7 Lake M9607

PHOTO D.25: LAKE M9607 PRE- BREAKUP – LOOKING NORTH

PHOTO D.26: LAKE M9607 DURING BREAKUP – LOOKING NORTHWEST

PHOTO D.27: LAKE M9607 POST- BREAKUP – LOOKING SOUTHEAST

PHOTO D.28: LAKE M9607 RIPARIAN ZONE