Umiak N-16
2012 Annual Sump Monitoring Report

For Submission to the
Northwest Territories Water Board
Under Water License N7L1-1797

Prepared for:

Prepared by:

November 2012

Umiak N-16
2012 Annual Sump Monitoring Report

FOR SUBMISSION TO THE NORTHWEST TERRITORIES WATER BOARD UNDER WATER LICENSE N7L1-1797

Prepared for:

mgm ENERGY CORP.

Prepared by:

KAVIK-STANTEC

November 2012

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1 Introduction

MGM Energy Corp. (MGM) has retained the consulting services of Kavik-Stantec Inc. (Kavik-Stantec) to continue monitoring the Umiak N-16 sump on Richards Island of the Mackenzie Delta in 2012. This 2012 Annual Sump Monitoring Report by Kavik-Stantec details the third subsequent monitoring year after the conclusion of the required five-year monitoring program as per *Part H - Conditions Applying to Abandonment and Restoration* of the *Northwest Territories Water Board Licence N7L1-1797* (NWT Water Board, 2003) issued for the Umiak N-16 Drilling Program. Kavik-Stantec has been involved in monitoring the sump since the inception of the monitoring program after the closure of the sump in 2004.

1.1 Background

EnCana Corporation (EnCana) drilled an exploratory well (Umiak N-16) during the winter of 2004 on Richards Island in the Inuvialuit Settlement Region of the Northwest Territories (see Figure 1-1). The well was drilled to a depth of approximately 3,300 m on Crown Land (UTM: 526727/7702617), and is located in the Tuktoyaktuk Coastal Plain Ecoregion of the Southern Arctic Ecozone. The drilling wastes were disposed of in a sump approximately 20 m x 60 m x 5.4 m deep. The drilling waste was approximately 1 to 1.5 m thick at the bottom of the sump which was capped in 2004.

As part of Water Board *License N7L1-1797*, EnCana was required to monitor the Umiak N-16 sump for a minimum period of five years. In 2007, ownership of the Umiak N-16 assets and sump was transferred from EnCana to MGM.

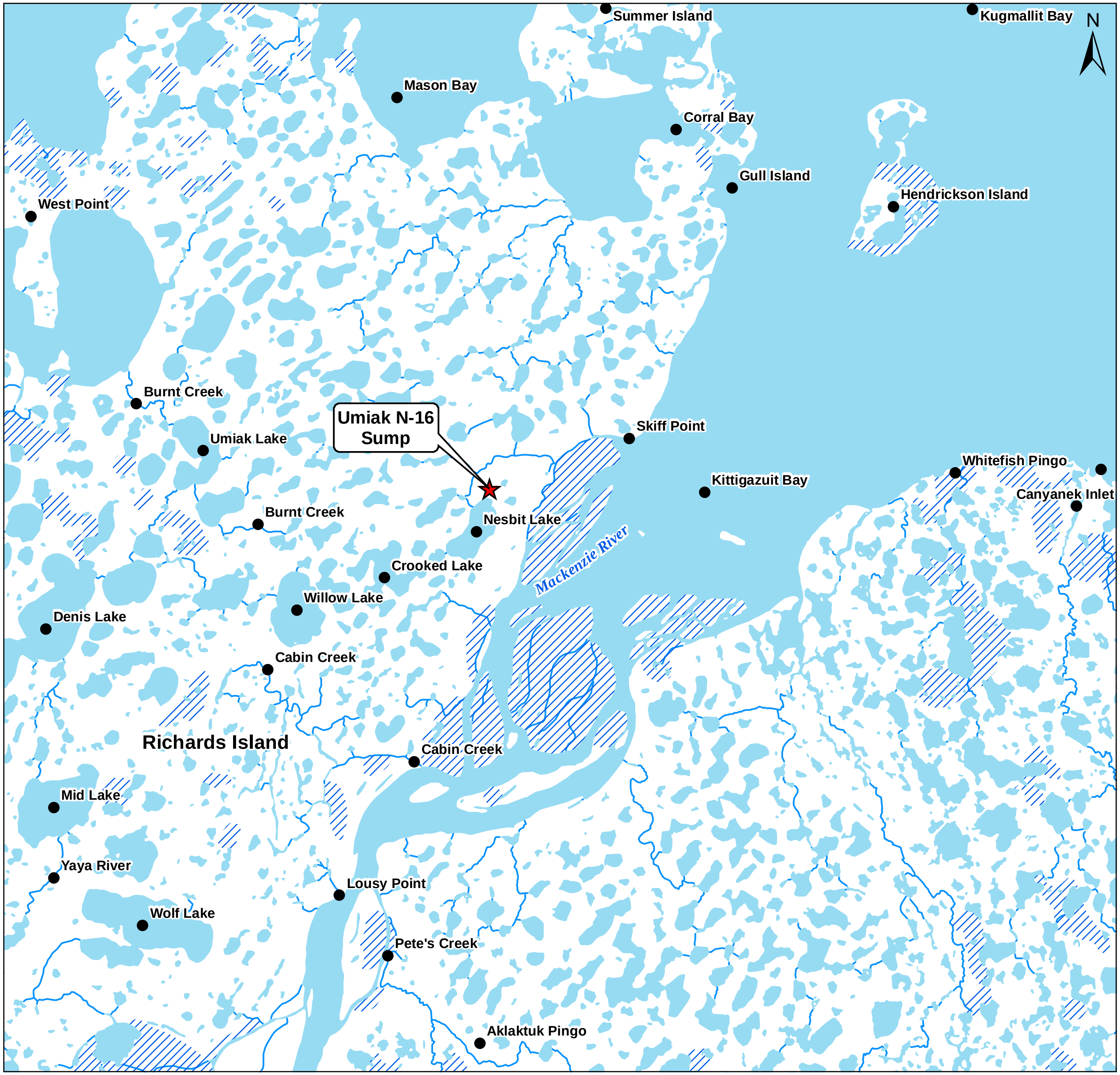
1.2 Scope

This sump monitoring program, initiated in 2004, was prior to the 2006 publication of the *Protocol for the Monitoring of Drilling-waste Disposal Sumps, Inuvialuit Settlement Region, Northwest Territories, October 2005*; however, this report and the monitoring program has been designed to satisfy the requirements outlined in this protocol where possible. The Umiak N-16 Annual Sump Monitoring Report for 2012 includes:

- a visual assessment of the sump during late summer conditions
- electromagnetic (EM) surveys conducted during late summer conditions
- active-layer depth sampling
- water and soil sampling surrounding the sump to characterize and confirm the EM38 survey results and other visually impacted areas
- monitoring any other anomalies or concerns observed during previous monitoring at the Umiak N-16 Sump

The dataloggers and attached thermister strings initially setup to log permafrost and active-layer temperatures to a depth of 14 m were observed to have extensive damage due to wildlife in 2010. As a result, Kavik-Stantec has been unable to collect data from the thermisters since 2009.

The site visits during 2012 to the Umiak N-16 sump occurred on September 6 and 7, 2012 and included a representative from Kinilau Physics Inc. (Kinilau) to complete the EM31 and EM38 surveys and a representative from Kavik-Stantec to obtain active-layer depths, perform a visual assessment of the sump cap and surrounding area, and collect soil and water samples where applicable. This report herein documents the results of the site visit, data monitoring activities including providing a discussion, conclusions and any additional recommendations. See Appendix A for the *Protocol for the Monitoring of Drilling-waste Disposal Sumps* required information as outlined in the Appendix of the *Protocol*.



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Umiak N-16 Sump Location on the Mackenzie Delta

Spatial Information: NAD27 UTM 8 N

Umiak N-16 Sump
Watercourse
Wetland
Waterbody

0 2.5 5 7.5
Kilometres - 1:250,000

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KAVIK-STANTEC

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FIGURE NO.
1-1

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Revised: 2012-09-21 By: sallen

2 Methods

The methods for monitoring the Umiak N-16 sump were developed using the following documents:

1. *Water License No. N7L1-1797* (NWT Water Board, 2003)
2. *Project Description for the proposed EnCana Corporation Burnt Lake Drilling Program Winter 2004* – Project Description submitted to the Inuvialuit Environmental Impact Screening Committee (EnCana, 2003)
3. Previous requests and requirements from the NWT Water Board (NWT Water Board, 2005 and 2006b)
4. *The Protocol for the Management of Drilling Waste Disposal Sumps – Inuvialuit Settlement Region NWT* (NWT Water Board, 2006a)

The following section outlines the methodology followed throughout each component of the monitoring program, including the visual assessment, active-layer depth measurements, ground temperature monitoring from 2004 to 2009, electromagnetic surveys, and soil and water sampling.

2.1 Visual Assessment

The visual assessment was conducted by a Kavik-Stantec representative during site visits on September 6 and 7, 2012 to document conditions of the general physical structure of the sump, including:

- settlement or subsidence
- presence or absence of ponding on the sump cap and surrounding areas
- erosion, stress or tension cracks
- vegetation conditions on the sump cap or surrounding area

The visual assessment was conducted from the air and on the ground. For a photographical log of the sump and surrounding area, see Appendix B; Photos 1 to 10.

2.2 Active-Layer Depths

Active-layer depths were obtained during the September 6, 2012 site visit. Methodology and locations of measurement points were as per the *Protocol for the Monitoring of Drilling-Waste Disposal Inuvialuit Settlement Region Northwest Territories* (NWT Water Board 2006a). Active-layer depths were monitored at a control area, on the sump cap and around the perimeter of the sump cap. The following active-layer measurements were obtained:

- **Control** – 8 active-layer measurements were collected along a 35 m transect (in 5 m intervals) north of the control thermister, paralleling the sump on the east side
- **Sump Cap** – 5 active-layer measurements were collected from the sump cap
- **Sump Perimeter** – 10 active-layer measurements were collected on the undisturbed area surrounding the sump cap within 2 m of the interface between the sump cap and the surrounding undisturbed area

For locations of active-layer measurements see Figure 2-1. See Table 3-1 for the corresponding tabulated depths.

2.3 Ground Temperature Monitoring

In 2004, four thermisters were installed in and surrounding the Umiak N-16 sump to monitor thermal characteristics within the sump and at an undisturbed area (control location) surrounding the sump. The thermisters were initially installed to depths of 14 meters below grade (mbg), including sensors located at depths of 0.5, 0.75, 1.0, 1.5, 3.0, 4.5, 6.0, 7.5, 9.0, 10.5, 12.0 and 14.0 mbg as required under *NWT Water Licence No. N7L1-1797.* Control data was collected from Thermister 1726. Thermisters 1725, 1727 and 1728 were located in the sump (see Figure 2-1 for thermister locations). In 2007, animal damage to the thermisters revealed that thermister strings had been monitoring at different depths than initially reported (MGM, 2007). For revised depths of each thermister sensor, see Table 2-1.

During the August 24, 2010 site assessment, it was discovered that the thermister strings for 1725, 1726 and 1727 had been forcefully removed from the dataloggers and some of the connectors for the dataloggers had been torn from the thermister strings. Animals are assumed to be the source of the damage to the thermister strings and dataloggers. As a result, no data could be retrieved from these dataloggers either at the time of the assessment or once the dataloggers were removed from the site. Data on Thermister 1728 could not be retrieved since 2008 due to an unknown datalogger malfunction. Currently there are no dataloggers logging temperatures at the Umiak N-16 sump. To ensure reporting requirements in this annual report are complete, Kavik-Stantec has included the 2009 ground temperature monitoring data and interpretation for reference.

Dataloggers were recording temperatures twice daily at 0000 and 1200 for thermisters 1725, 1726 and 1728. The datalogger on thermister 1727 was setup in 2008 to log once a day at 1200 (prior to 2008, it was recording temperatures twice daily at 0000 and 1200). Temperatures were averaged for each month and illustrated on graphs. For graphs illustrating the average monthly summary data for each thermister from September 1, 2004 to August 17, 2009 and the corresponding average summary data for each month, see Appendix C. Data missing from the temperature graphs between 2004 and 2009 were a result of either broken/malfunctioning dataloggers and/or dataloggers that ran out of memory during the initial five-year monitoring program.

Table 2-1 Current Logging Depths of Thermister Sensors

Thermister Sensor ID	Current Logging Depths (mbg)			
	Thermister 1725	Thermister 1726[1]	Thermister 1727	Thermister 1728
TH1	-	-	-	-
TH2	-	-	-	-
TH3	-	0.17	-	-
TH4	-	0.67	-	-
TH5	0.83	2.17	1.14	0.74
TH6	2.33	3.67	2.64	2.24
TH7	3.83	5.17	4.14	3.74
TH8	5.33	6.67	5.64	5.24
TH9	6.83	8.17	7.14	6.74
TH10	8.33	9.67	8.64	8.24
TH11	9.83	11.17	10.14	9.74
TH12	11.83	13.17	12.14	11.74

Notes:
[1]Control thermister
- Sensor recording ambient temperatures

2.4 Electromagnetic Surveys

Kinilau completed EM surveys on September 6, 2012 using Geonics EM31 and EM38 ground conductivity meters. These instruments are used to identify the lateral extents of ion-contaminated regions, which might reflect ion migration from the sump to the surrounding areas and help identify the requirement for additional sampling. The survey measures apparent conductivity of the soil around the sump site to determine if ions from the drilling waste are migrating through the soil originating from the sump. The EM38 meter measures depths between about 0 and 1.5 mbg (shallow) while the EM31 meter measures depths between about 0 and 5 mbg (deep). For results of the 2012 EM surveys, see Appendix D. For comparisons between historical EM31 and EM38 surveys, see Appendix E.

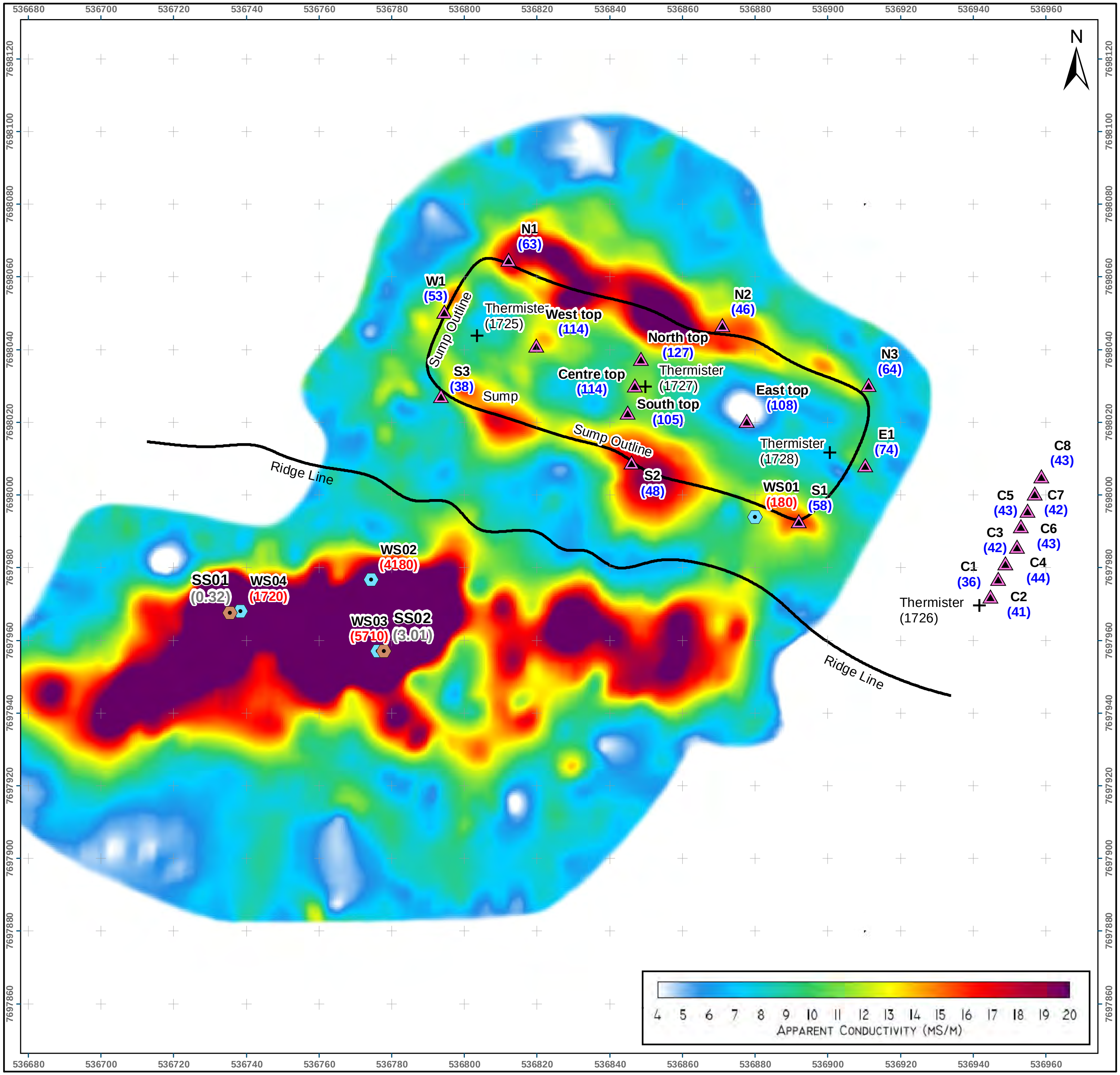
2.5 Soil Sampling

The purpose of the soil investigation on September 7, 2012 was to investigate areas off the sump cap where stressed vegetation and traditionally high apparent conductivities in the EM38 surveys were observed. Two (2) soil samples (SS01 and SS02) were collected directly adjacent to water samples (WS04 and WS03) south of the sump (see Figure 2-1 for sampling locations). The guidelines used to compare the results from the soil sampling program are the Canadian Council of Ministers of the Environment's (CCME 1999, updated 2010) *Soil Quality Guidelines for Environmental and Human Health*.

Soil samples were collected by hand, using clean latex gloves. Every effort was made to eliminate the possibility of cross contamination between soil samples, field equipment, etc. Samples were retained in laboratory-issued zip-lock containers for analysis and submitted to AGAT Laboratories (AGAT) for salinity analysis (see Table 3-2). All samples were stored on ice in coolers until submission to the laboratory. Samples remained onsite at the laboratory until sampling requirements were confirmed and Kavik-Stantec authorized the analysis. For the certified laboratory results from AGAT, see Appendix F.

2.6 Water Sampling

During the 2012 assessment, four (4) surface water samples were obtained to continue to monitor salinity levels at four locations noted to have high salinity values during prior assessments. One (1) sample was obtained from a depressional area adjacent to the southeast corner of the sump cap (WS01). Three (3) additional samples (WS02 to WS04) were collected in a topographical low area south of the sump cap and ridge line in areas that have normally had the highest apparent conductivity readings during historical and current EM38 surveys (see Figure 2-1). Samples were collected at arm's length (about 0.5 m) from the edge of the water, stored in laboratory-issued containers and submitted to AGAT for salinity analysis (see Table 3-3). The guidelines used to compare the results from the water sampling programs are the CCME (1999, updated 2007) *Water Quality Guidelines for the Protection of Aquatic Life*. For the certified laboratory results from AGAT, see Appendix F.



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Sampling and Active-Layer Inspection Locations (EM38 Survey)

Spatial Information: NAD83 UTM 8 N

- Soil Investigation Electrical Conductivity (dS/cm)
- Surface Water Investigation Soluble EC (uS/cm)
- Inspection Depth (cm)
- Thermister

0 10 20 30
Metres - 1:1,500

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KAVIK-STANTEC

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FIGURE NO.
2-1

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Revised: 2012-10-19 By: sallen

3 Results

3.1 Visual Assessment

Visual assessments during 2012 revealed similar conditions to 2011 with no physical evidence of erosion, ponding, subsidence, stress or tension cracks on the surface of the sump cap. The sump cap was in good condition during the late summer site assessments on September 6 and 7, 2012.

Vegetation on both the sump cap and the previously impacted area north of the sump cap (which was utilized for soil storage in winter 2004) was well established, in good health and self-propagating. There still remain a few small isolated bare patches on the sump cap which can be observed on the aerial photos in Appendix B. The sump cap should have enough vegetation growth to restrict either water or wind erosion from having a measured impact on the conditions of the sump cap.

The site is generally more saturated than observed in recent monitoring visits including 2011. There was considerable standing water surrounding the sump, with depressions from ice-wedges filled with surface water. There was no standing water on the sump cap which would be unlikely due to the rapidly drained coarse grained material comprising the sump cap.

During the 2012 site assessment, it was noted that vegetation health and vigour on areas surrounding the sump cap (specifically south of the sump cap) was similar to the conditions observed in 2011. There were no additional areas with stressed and/or potentially dead vegetation noted south of the sump cap. See Photo 5 in Appendix B for the general location of the areas of stressed vegetation. The stressed or dead vegetation also continues to correspond with the areas of highest apparent conductivities traditionally observed in historical EM38.

3.2 Active-Layer Depths

Average Active-layer depths on the sump cap remain unchanged from 2011 with an average of 114 cm and a similar range (105 to 127 cm) to the values collected in 2011. Around the perimeter of the sump cap, the average active-layer depths increased by 4 cm from an average of 51 cm in 2011 to 55 cm (range: 38 to 74 cm) in 2012. The control locations directly north of the Control Thermister had average active-layer depths increase by 6 cm since 2011.

Table 3-1 Active-Layer Measurements

ID	Thaw Depth (cm)	ID	Thaw Depth (cm)	ID	Thaw Depth (cm)
Sump Perimeter		***Control***		***Sump Cap***	
N1	63	C1	36	North Top	127
N2	46	C2	41	East Top	108
N3	64	C3	42	South Top	105
N4	74	C4	44	West Top	114
E1	58	C5	43	Centre Top	114
S1	48	C6	43	-	-
S2	38	C7	42	-	-
S3	53	C8	43	-	-
S4	63	-	-	-	-
W1	46	-	-	-	
Average:	**55**	**Average:**	**42**	**Average:**	**114**

3.3 Ground Temperature Monitoring

Due to an apparent datalogger malfunction at Thermister 1728 in August 2009, no data has been retrievable from the datalogger since August 2008. Since August 2010, data was not retrievable at the remaining thermisters due to extensive animal damage observed at all datalogging facilities located onsite resulting in no new data since a site visit occurred in August 2009. Results prior to August 2009 indicate that temperature profiles for the thermisters located in the sump had similar patterns to those of the Control Thermister located out of the sump. There had been a general pattern of increasing temperatures in the active-layer and the upper permafrost since the inception of monitoring of the sump in 2004 which can be correlated with a general increase of the logged ambient temperatures over the same time period. There was a slight drop of the average annual peak ambient temperatures for all thermisters in 2009.

None of the thermisters registered temperatures above 0°C at the depths where drilling waste is contained (approximately 4.0 to 5.4 mbg). Generally, thermister strings located in the sump and in the control location have been logging equivalent temperatures at depths below 3 m (Appendix C).

3.4 Electromagnetic Surveys

Elevated responses from the EM38 survey at the sump and extending beyond the perimeter of the sump cap indicate that there continues to be some ionic migration from the sump or sump cap into the surrounding area, which has been occurring since the initiation of monitoring program in 2004. The 2012 EM38 survey indicates that the overall extent of the apparent elevated conductivities south of the sump has increased compared to 2011. The increase in apparent conductivity may be a result of the saturated conditions surrounding the sump and the increased amount of surface water in 2012 compared to 2011 which has traditionally been insufficient to inundate the shallow active-layer. General precipitation in the region (Inuvik weather station) increased almost 50% in the 12 months prior to the site assessments in 2012 compared to 2011 (Environment Canada, 2012). Although the apparent conductivity levels appear to have increased since 2011, it is assumed to be a function of the overall level of saturation in the area and not a direct result of greater concentrations of ions inundating the area.

Results of the 2012 EM31 survey (0 mbg to 5 mbg) revealed that both the magnitude and extent of the apparent conductivities on the sump cap have increased from 2011. This is believed to be a function of the high influence of the apparent conductivity in the active-layer has on the EM31 survey results, since ionic migration within the permafrost would not otherwise be expected to vary by that magnitude from one year to the next.

3.5 Soil Sampling

The salinity analysis of soil sample SS01 revealed an electrical conductivity (EC) of 0.32 dS/m, which is below the CCME guideline of 2.0 dS/m, while the EC for SS02 is 3.01 dS/m which exceeded the CCME guideline (Table 3-2). The pH value for both samples was outside the acceptable CCME guideline range (6 to 8) at 3.66 and 4.46 respectively. The low pH value is likely a response to a naturally occurring low pH in the boggy peat substrate south of the sump. The sodium adsorption ratios for the two soil samples were 0.38 and 1.25 respectively, which are well below the CCME guideline of 5.0. The elevated potassium and chloride concentrations in SS02 appear to be correlated.

Table 3-2 Soil Sampling Results

Parameter	Unit	Guideline[1]	RDL	N16-SS01 3712084	N16-SS02 3712086
pH (CaCl2 Extraction)	pH Units	6 to 8	N/A	3.66	4.46
Electrical Conductivity (Sat. Paste)	dS/m	2.0	0.01	0.32	3.01
Sodium Adsorption Ratio		5.0		0.38	1.25
Saturation Percentage	%	-	N/A	655	449
Chloride, Soluble	mg/L	-	5	60	595
Calcium, Soluble	mg/L	-	1	28	98
Potassium, Soluble	mg/L	-	2	15	537
Magnesium, Soluble	mg/L	-	1	9	29
Sodium, Soluble	mg/L	-	2	9	55
Sulfur (as Sulfate), Soluble	mg/L	-	2	12	10
Sodium, Soluble (meq/L)	meq/L	-	0.09	0.39	2.39
Sodium, Soluble (mg/kg)	mg/kg	-	2	59	247
Calcium, Soluble (meq/L)	meq/L	-	0.05	1.40	4.89
Calcium, Soluble (mg/kg)	mg/kg	-	1	183	440
Chloride, Soluble (meq/L)	meq/L	-	0.06	1.69	16.8
Chloride, Soluble (mg/kg)	mg/kg	-	2	393	2670
Magnesium, Soluble (meq/L)	meq/L	-	0.08	0.74	2.39
Magnesium, Soluble (mg/kg)	mg/kg	-	1	59	130
Potassium, Soluble (meq/L)	meq/L	-	0.05	0.38	13.7
Sulfur (as Sulfate), Soluble (mg/kg)	mg/kg	-	2	79	45
Sulfur (as Sulfate), Soluble (meq/L)	meq/L	-	0.04	0.25	0.21
Theoretical Gypsum Requirement	tonnes/ha	-		0	0
Potassium, Soluble (mg/kg)	mg/kg	-	2	98	2410

Notes:
1. CCME. 1999. Canadian Environmental Quality Guidelines for Residential and Parkland (Highlighted cells exceed criteria). (-) denotes 'no guideline'.
N/A - Not Applicable
RDL - Reported Detection Limit

3.6 Water Sampling

Water sample WS03 was collected in the area with the highest apparent conductivities realized both during the EM38 survey and field screening conducted using a hand-held EC probe. The WS03 sample had a significantly lower EC (5710 µS/cm) than the peak values that were collected in the same location in 2011 (18000 µS/cm) and 2010 (9900 µS/cm). Chloride and potassium parameters continue to account for the major portion of the ions in the shallow groundwater/surface water south of the sump where the highest apparent conductivities have traditionally been observed. Fluoride levels also exceeded CCME guidelines at one location (WS03) which may be associated with the sump's original contents.

The surface water samples collected south of the sump in the topographic low area below the ridge line primarily had acidic pHs below the CCME lower guideline of 6.5, ranging between 3.47 and 5.32. These low pH values are more likely attributed to boggy background conditions as verified in the background sample collected in 2007 (MGM, 2007)

Table 3-3 Water Sampling Results

				N16-WS01	N16- WS02	N16- WS03	N16-WS04
Parameter	**Unit**	**Guideline[1]**	**RDL**	**3712105**	**3712106**	**3712108**	**3712109**
pH	pH Units	6.5 - 9	NA	6.70	5.32	3.47	3.84
p - Alkalinity (as CaCO3)	mg/L	-	5	<5	<5	<5	<5
T - Alkalinity (as CaCO3)	mg/L	-	5	34	<5	<5	<5
Bicarbonate	mg/L	-	5	41	8	<5	<5
Carbonate	mg/L	-	5	<5	<5	<5	<5
Hydroxide	mg/L	-	5	<5	<5	<5	<5
Electrical Conductivity	uS/cm	-	1	180	4180	5710	1720
Fluoride	mg/L	0.12	0.05	<0.05	<0.05	0.2	<0.05
Chloride	mg/L	-	1	27	1160	1760	470
Nitrite	mg/L	-	0.05	<0.05	<0.05	<0.05	<0.05
Nitrate	mg/L	-	0.5	<0.5	<0.5	<0.5	<0.5
Sulfate	mg/L	-	1	5	90	69	27
Dissolved Calcium	mg/L	-	0.3	19.5	260	248	108
Dissolved Magnesium	mg/L	-	0.2	8.0	68.5	80.7	36.6
Dissolved Sodium	mg/L	-	0.6	9.3	80.2	116	37.6
Dissolved Potassium	mg/L	-	0.6	6.2	514	858	165
Dissolved Iron	mg/L	-	0.1	2.2	2.6	24.4	4.9
Dissolved Manganese	mg/L	-	0.005	0.053	2.82	1.88	0.373
Hardness	mg CaCO3/L	-	1	82	931	952	420
Ion Balance	%	-		148	103	92.2	105
Calculated TDS	mg/L	-	1	95	2170	3130	844
Nitrate + Nitrite-N	mg/L	-	0.01	<0.01	<0.01	<0.01	<0.01
Nitrate-N	mg/L	13	0.113	<0.113	<0.113	<0.113	<0.113
Nitrite-N	mg/L	0.6	0.015	<0.015	<0.015	<0.015	<0.015

Notes:
[1] CCME. 1999. Canadian Environmental Quality Guidelines. Canadian Council of Ministers of the Environment. Winnipeg, MG. For the Protection of Aquatic Life (Highlighted cells exceed criteria). (-) denotes 'no guideline'.
N/A – Not Applicable
RDL - Reported Detection Limit
< - Values refer to Report Detection Limits
*Ion Balance has been verified

4 Discussion

The temperature profiles for the thermisters located in the sump had similar profiles to that of the control thermister located out of the sump prior to temperature measurements being discontinued. The logging of the temperature profiles over the five years prior to 2009 has not provided any indication that the drilling fluids located in the sump are having an adverse effect on the permafrost. Although the active-layer is deeper on the sump cap, this is likely a response to the drier granular (sandy) material present in the sump cap (Kavik-Stantec, 2009).

Ground conductivity surveys were conducted in the thaw season to demonstrate the apparent spatial distribution of conductive materials (i.e., anions, cations, metals, etc.) at the sump cap. Changes in the distribution of such materials could be indicative of lateral migration of saline drilling fluids and potential problems with sump integrity (NWT Water Board, 2005). Historical data suggest that lateral migration may have occurred into a large topographical low area (approximately 120 x 40 m) south of the sump. The 2012 EM38 survey indicated that the plume of elevated apparent conductivity may have expanded compared to 2011, which is likely indicative of the more saturated conditions in 2012 compared to 2011. Of note, however, is that ECs in laboratory samples greatly decreased from 2011, as did concentrations of other major ions such as potassium and chloride, which suggests that the distribution of apparent conductivity may be a result of more abundant surface water or shallow active-layer groundwater south of the sump rather than an increase in ion migration. Although the level of surface water saturation increased during 2012, it does not appear to have extended significantly beyond the historical southwestern extent of the plume.

The analysis of soil and surface water samples collected south of the sump continues to suggest some degree of impact from the sump on those areas which appeared to have stressed and/or dead vegetation. The high levels of potassium and chloride within the surface water suggest that the sump is likely the cause of these anomalies, given the historical use of potassium-based drilling fluids. However, it is currently not conclusive that the stressed and/or dead vegetation is a direct result of migration of the sump contents as there may have been other factors. These may include prior surface spillage; also, surface and active-layer drainage from north of the sump to the low area may be resulting in the mobilization of ions from the sump cap.

5 Conclusions

Vegetation on both the sump cap and the previously impacted area north of the sump cap (which was utilized for soil storage in winter 2004) was well established, in good health and self-propagating, with only relatively minor bare areas. There was also no evidence of erosion, settlement/subsidence, ponding or cracks on the surface of the sump cap. The exposure to either water or wind erosion is not assumed to be a concern provided the integrity of the sump is maintained.

Ground temperature and active-layer depth monitoring has not indicated a concern with the sump since the monitoring program began in 2004. The internal thermal regime of the sump, up to when the monitoring stopped in 2009 due to the damaged thermistors, showed a stable and frozen core. Although active-layer depths are deeper on the sump cap, this is likely due to the dry granular sump cap material; however, they have generally been fluctuating similar to background (control) conditions.

After eight years of monitoring the Umiak N-16 sump, it appears that, while the apparent conductivity has increased, the areal extent of the elevated parameters may not be expanding significantly in magnitude year over year. The reason for the elevated parameters may be prior surface spillage during the use of the sump, or surface runoff from the north, and not necessarily a continuing migration of sump contents from within the sump. However, the relative magnitudes of apparent conductivities and laboratory analyzed ECs appear to be related to the degree of surface saturation. To date, natural attenuation does not appear to have addressed these areas of elevated conductivity, which may be adversely impacting the natural vegetation located south of the sump. Since the plume of elevated apparent conductivity does not appear to be migrating significantly beyond the historical southwestern limits, the impact to the vegetation is isolated to an area south of the sump which is approximately 120 x 40 m. However, not all the vegetation within this area has shown signs of stress as effects appear to be isolated to areas which historically have the highest concentrations identified during EM surveys. There were no additional areas identified in 2012 with stressed or dead vegetation. Vegetation is not expected to re-establish and flourish in these areas south of the sump until the high salinity values decrease in the surface/shallow groundwater.

6 Recommendations

2012 was the third subsequent year of monitoring for the Umiak N-16 sump after the required minimum five-year monitoring program stipulated in *Part H - Conditions Applying to Abandonment and Restoration of the Northwest Territories Board Licence N7L1-1797* for the Umiak N-16 Drilling Program was completed. The thermal, physical and vegetation conditions at the sump itself appear to have generally stabilized; however, because the high apparent conductivity values south of the sump have not decreased naturally, Stantec recommends that MGM consider a remediation program in 2013 to remove surface/shallow groundwater at the areas with the highest salinity anomalies. Specifically, the following are the recommended activities for 2013 and 2014:

1. Remediation of impacted areas surrounding the sump which should be carried out to minimize surface disturbance to the active-layer, vegetation and rooting zone whenever possible.
2. It is possible that the high apparent conductivity south of the sump is due to surface or active-layer drainage from the area north of the sump. Consideration should be given to altering surface drainage patterns such that drainage from north of the sump is directed around the sump, thereby reducing the opportunity for potential mobilization of ions from within the sump cap.
3. Vegetation health and vigor should be monitored visually both on and surrounding the sump cap. Soil and/or water samples should be collected and submitted for laboratory analysis at any new areas where stressed or otherwise impact vegetation is identified.
4. Visual observations of sump integrity and degree of ponding in depressions should be undertaken to confirm that physical conditions at the site remain stable. Any significant adverse changes may indicate a need for additional monitoring.
5. Monitoring of active-layer depths on and off the sump should be continued.
6. EM surveys and a laboratory sampling program should be undertaken in 2014 to assess the success of the remediation program.

7 Closure

This report documents work that was performed in accordance with *The Protocol for the Monitoring of Drilling Waste Disposal Sumps, Inuvialuit Settlement Region, Northwest Territories* (NWT Water Board, 2006a), *Water Licence Number N7L1-1797* (NWT Water Board, 2003) and the general accepted professional standards at the time and location in which the services were provided. No other representations, warranties or guarantees are made concerning the accuracy or completeness of the data or conclusions contained within this report, including no assurance that this work has uncovered all potential liabilities associated with the identified property. All information received from the client or third parties in the preparation of this report has been assumed by Kavik-Stantec to be correct. Kavik-Stantec assumes no responsibility for any deficiency or inaccuracy in information received from others.

The opinions in this report can only be relied upon as they relate to the condition of the sump and sump cap at the time the assessment was conducted. The conclusions are based on the site conditions encountered by Kavik-Stantec at the time the assessment was performed at the specific testing and/or sampling locations while conditions may vary among sampling locations. In addition, analysis has been carried out for only a limited number of parameters, and it should not be inferred that other parameters are not present or elevated in the area. Due to the nature of the assessment and data collection requirements, Kavik-Stantec does not warrant against any other undiscovered environmental concerns.

This report was prepared by Mr. Chris Revak, B.Sc. and reviewed by Mr. David R. Williams, Ph.D., P.Eng. of Meridian Environmental Inc. Should you have any questions regarding the information detailed within, please do not hesitate to contact the undersigned.

Sincerely,

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Environmental Planner
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Appendix A Sump Monitoring Protocol Required Information

PROTOCOL FOR THE MONITORING OF DRILLING WASTE DISPOSAL SUMPS

Inuvialuit Settlement Region

Northwest Territories

October 2005

P.O. Box 1326
4916-47 Street
2nd Floor, Goga Cho Building
Yellowknife, NT X1A 2N9
Tel: (867) 765-0106
Fax: (867) 765-0114
E-mail: info@nwtwb.com

APPENDIX

1. SITE IDENTIFICATION AND LOCATION	
Well number and operator	Umiak N-16 MGM Energy Inc.
National Energy Board ID	WID 2000
Water Licence #	N7L1-1797
Lat/UTM	69.389039/7698025N
Long./UTM	-134.062113/536845E

2. SITE HISTORY AND LOCAL ENVIRONMENTAL CONDITIONS

i) Site Background

A. Project background

1. Purpose of well drilled at the lease	Exploration well		
2. Site survey plan. Location of sump, drill rig, equipment storage area, extent of ice pad, location of spoil pile, wellhead and access road. (Attach map)	See Attachments on 2012 Sump Monitoring Report CD		
3. Project team	Name	Responsibilities	Contact Information

B. Site development

1. Bar chart showing time line of all major activities (detail those with respect to the drilling mud sump, i.e.. Excavation date, discharges to sump, closure of sump)	
2. Method of preparing the lease	
3. Reclamation methods	

C. Drilling operations

1. Method and depth of drilling	conventional drilling to 3101 m TVD
2. Problems encountered during operations	
3. Unusual/unexpected events that may have short or long-term environmental impacts	
4. Indicate timing and volume of materials discharged to the sump	

ii) Sump Details - Sump construction and contents

1. Date of excavation	
3. Date of closure	
4. Sump dimensions	
5. Maximum, minimum and mean daily temperatures and precipitation (Attach data sheet)	
6. Problems encountered and mitigation applied	
7. Description of drilling mud as per Water License requirements (Attach data sheet)	Potassium Chloride Mud System
8. Minimum verticle distance (m) from wastes to native ground at sump perimeter	

9. Describe the timing and method of backfill	
10. Other reclamation activities	

iii) Environmental Setting

A. Surface conditions

1.Terrain type (alluvial, upland, coastal)	Upland
2. Slope gradient and topographic setting	Undulating
3. Proximity to nearest water body in meters (indicate type: lake, river, stream, sea)	Approximately 250 m from lake
4. Note the presents of ephemeral drainage ponds	Small drainage ponds (< 100 m2) in various locations
5. Indicate annual frequency and average duration of flooding	None
6. Natural vegetation cover	

B. Soils and ground-ice conditions

1. Describe each major soil unit in upper 5 to 10 m, include excess ice content and thaw	
2. Photographs (attach folder with digital photographs)	

C. Groundwater (may not be applicable in areas of continuous permafrost)

1. Note the presence of groundwater	
2. Primary aquifers or artesian pressures	
3. If groundwater is encountered - obtain samples for baseline groundwater chemistry	

3. SITE CONDITIONS AFTER CLOSURE

i) Infrastructure and sump morphology

A. Photographs (attach folder with photographs)

Photo #	Description (include reference to site map)
1	Aerial overview of Umiak N-16 sump on Richards Island
2	Aerial view of the sump cap from the northeast corner
3	Aerial view of the sump cap from the northwest
4	Aerial view of the sump cap from the east
5	Aerial view of areas with stressed vegetation south of the sump
6	Aerial view of ion migration areas south of the sump
7	Aerial view of sump cap directly from above
8	Vegetation establishment on the sump cap
9	Saturated ground conditions during site assessment south of the sump
10	Area with stressed vegetation south of the sump

B. Sump characteristics

1. Dimension of sump (m) (length & width)	2. Height of cap above grade (m)	3. Nature of cap material	4. Note slumping or settlement of cap material
120 m X 40 m (sump cap)	About 1 to 2 m	Sandy-loam	None observed in 2012

5. Nature of vegetation (% cover; shrubs/grasses; canopy height)	6. Indicate state of soil in areas immediately adjacent to sump	7. Ponding on lease (none, minor, moderate, significant)	8. Percentage of sump cap that has collapsed (if applicable)
Approximatley 60 to 80% of overall sump cap (no plot data for 2012)	Undisturbed	No ponding on the lease was observed in 2012	No collapsing was observed in 2012

See:			
Vegetation List (2009)			
primarily grass			
(Attach excel sheet if necessary)			

ii) Surface water

	1. Electrical conductivity/salinity (pond) (dS/m)	Water chemistry (Attach excel data sheet)
Pond 1	N16-WS01 - 0.2	See "Water Chemistry (2012)" Data Sheet
Pond 2	N16-WS02 - 4.2	
Pond 3	N16-WS03 - 5.7	
Pond 4	N16-WS04 - 1.7	

*Note: include photographs and indicate sampling locations on base map

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4. ACTIVE-LAYER AND GROUND TEMPERATURE MONITORING

i) Active-layer depths

A. Survey date:

September 7, 2012

B. Control

ID	Thaw depth (cm)
1. C1-0m	36
2. C2-5m	41
3. C3- 10m	42
4. C4	44
5. C5	43
6. C6	43
7. C7	42
8. C8	43

C. Sump cap

1. North top	127		Sump	
2. East top	108		Ntop	
3. South top	105	Wtop	Ctop	Etop
4. West top	114		Stop	
5. Centre top	114			

D. Sump perimeter

1. N1	63	N1	N2	N3
2. N2	46			
3. N3	64	W1		E1
4. E1	74			
5. S1	58	S3	S2	S1
6. S2	48			
7. S3	38			
8. W1	53			

ii) Thermal monitoring(Attach separate excel spreadsheet with temperature data)

		Temp.	Temp.	Temp.	Temp.	Temp.	Temp.	Temp.	Temp.
See the following data sheets in the file:	Thermistor depth (m)	0.25	0.5	0.75	1.5	3	6	9	12
"Thermister 1725" Data Sheet	Date								
"Thermister 1726" Data Sheet	Date								
"Thermister 1727" Data Sheet	Date								
"Thermister 1728" Data Sheet	Date								

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5. ELECTROMAGNETIC SURVEY AND SOIL SAMPLING

i) Surveys (Please include map of survey results and indicate locations where active-layer and water samples were obtained)

Water soluble materials in soils (salinity package)	See Figure 2-1 in Umiak N-16 Annual Sump Monitoring Report

ii) Soils

Control soils (Results reported in g/kg and mg/L)

Depth of sample	Parameter	Results	Unit
Surface	*no control samples were collected in 2012		
Middle of active layer			
Base of active-layer			

Area of Stressed Vegetation Surrounding Sump/Umiak N-16 SS01 [Soil Chemistry (2012)]

Depth of sample	Parameter	Results	Unit
Composite active-layer	Electrical conductivity	0.32	dS/cm
Middle of active layer			
Base of active-layer			

Area of Stressed Vegetation Surrounding Sump/Umiak N-16 SS02 [Soil Chemistry (2012)]

Depth of sample	Parameter	Results	Unit
Composite active-layer	Electrical conductivity	3.01	dS/cm
Middle of active layer			
Base of active-layer			

Highlighted cells denotes exceedance of CCME Criteria

If hydrocarbon contamination is suspected, samples should be collected and analyzed appropriately

6. INTERPRETATION OF ENVIRONMENTAL DATA

See the Umiak N-16 2012 Annual Sump Monitoring Report

Appendix B Site Photos

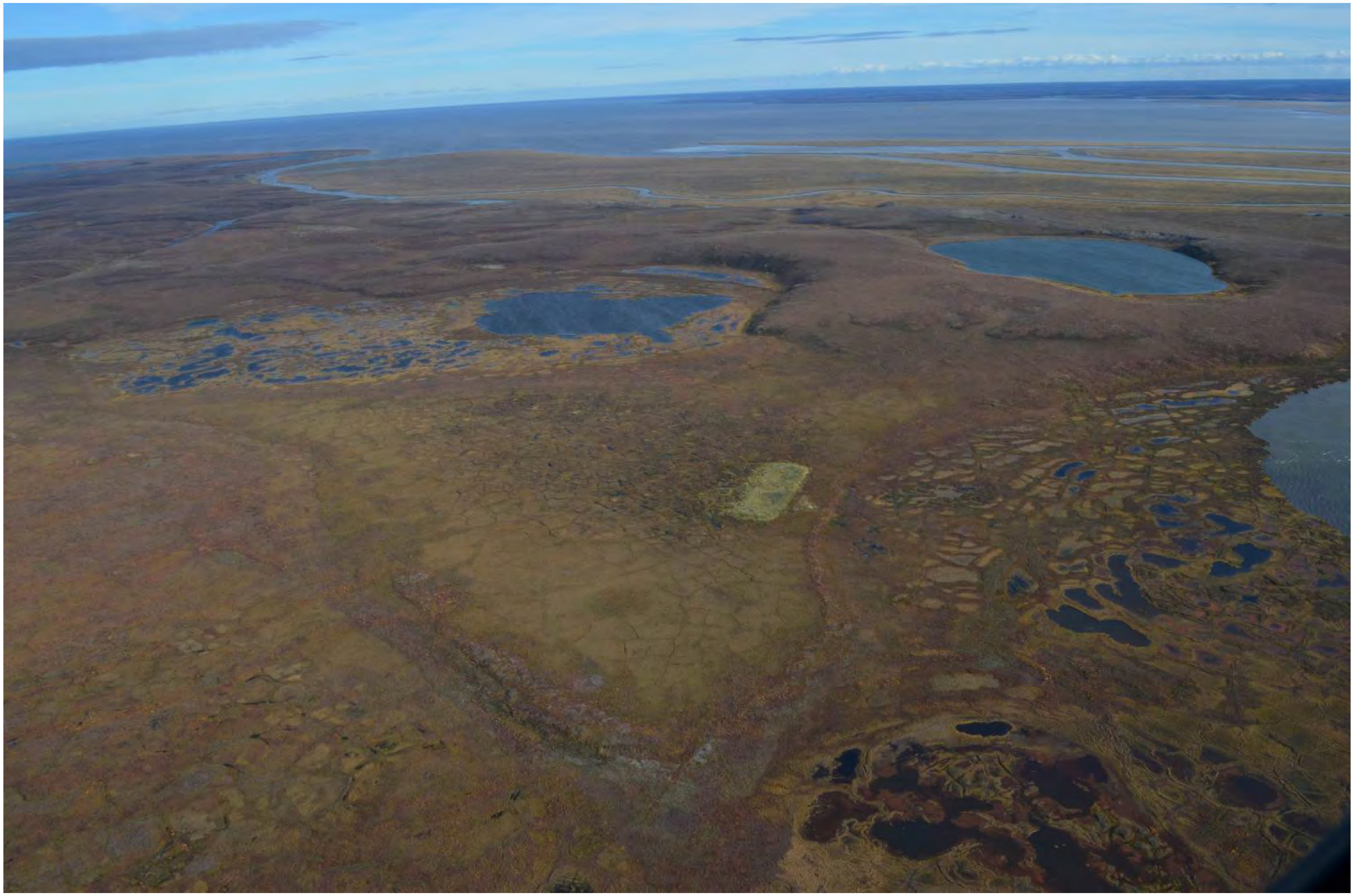


Photo 1: Aerial overview of Umiak N-16 sump on Richards Island (September 6, 2012)

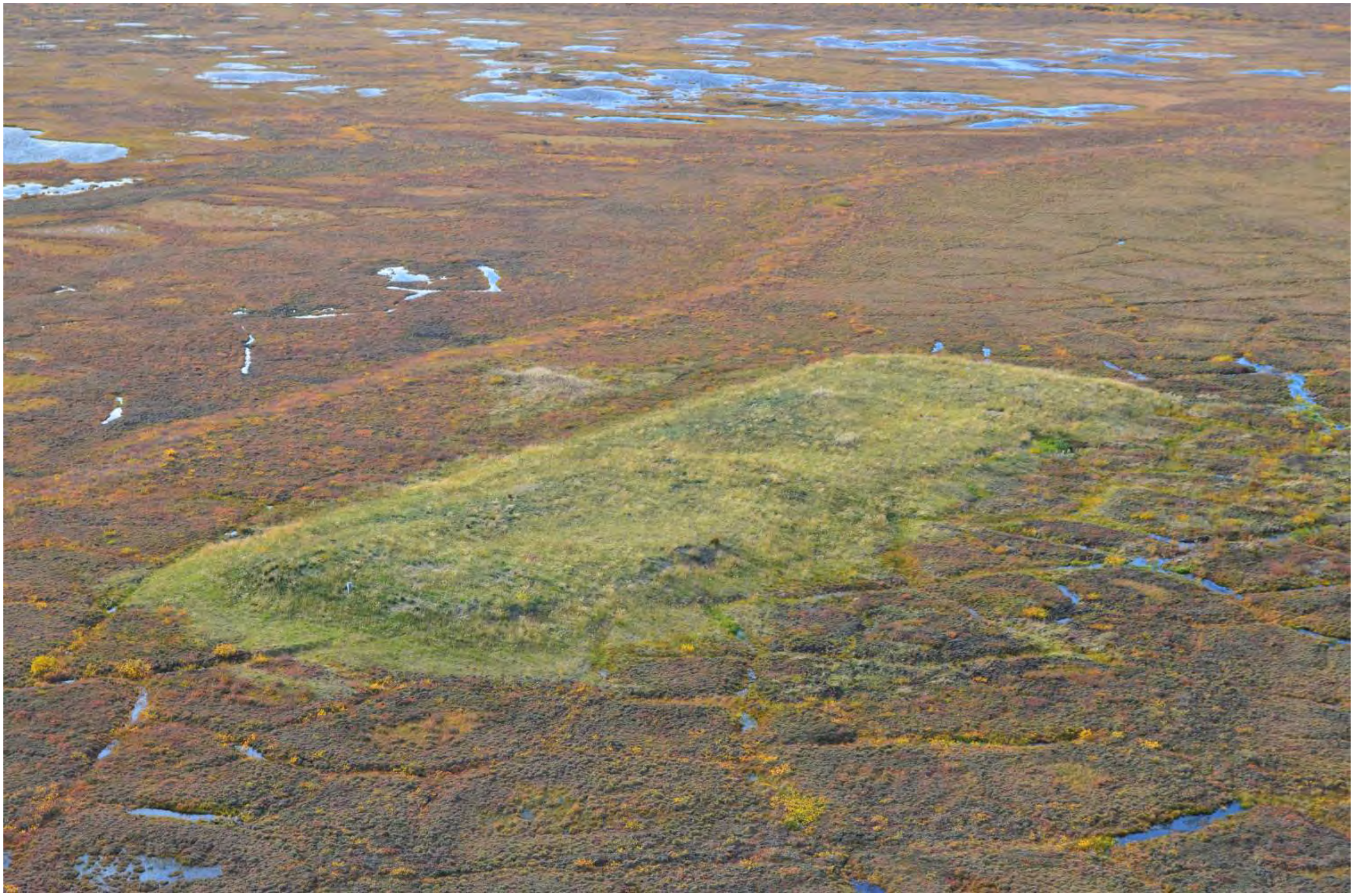


Photo 2: Aerial view of the sump cap from the northeast corner (September 6, 2012)

Photo 3: Aerial view of the sump cap from the northwest (September 6, 2012)

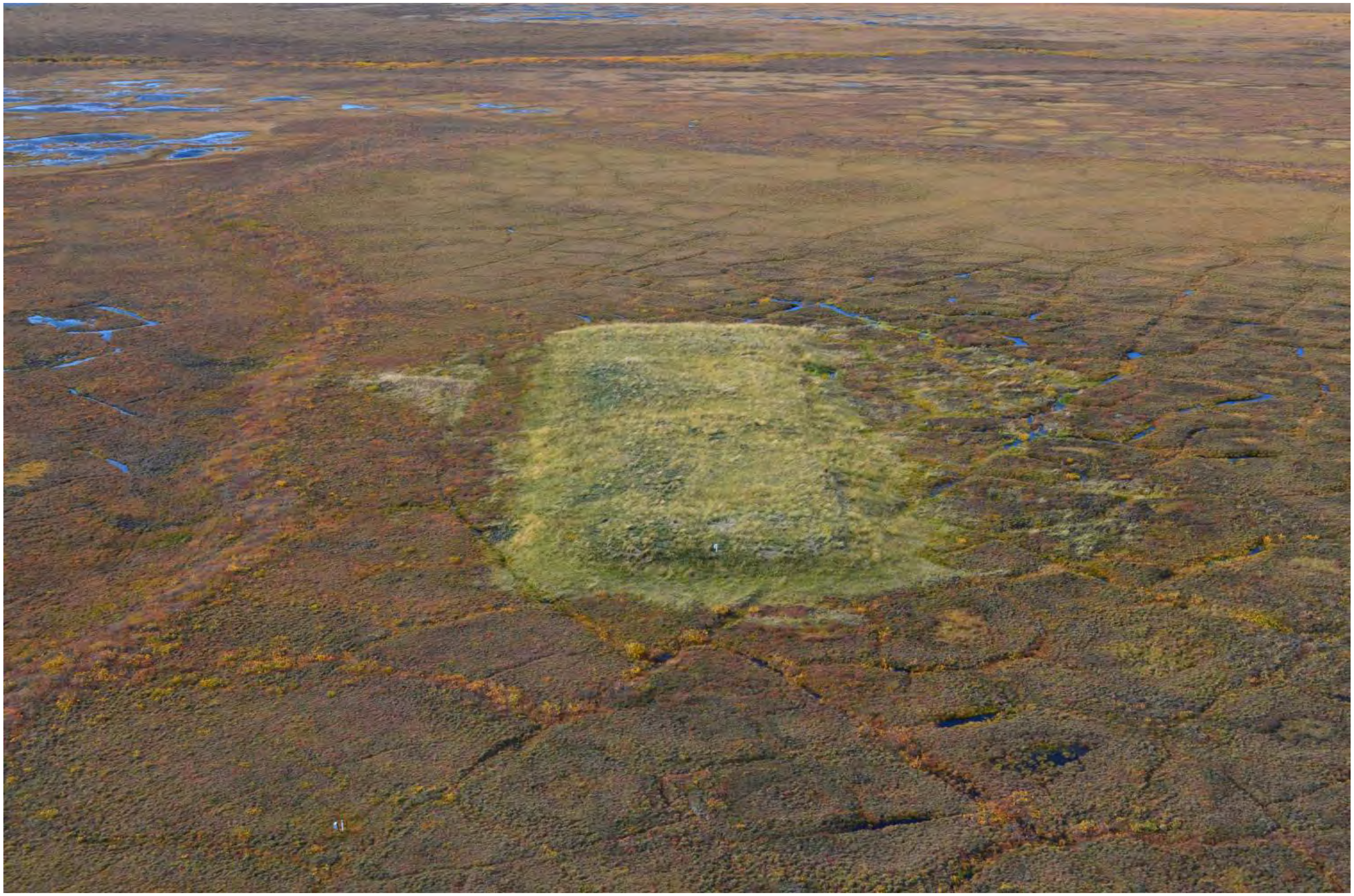


Photo 4: Aerial view of the sump cap from the east (September 6, 2012)

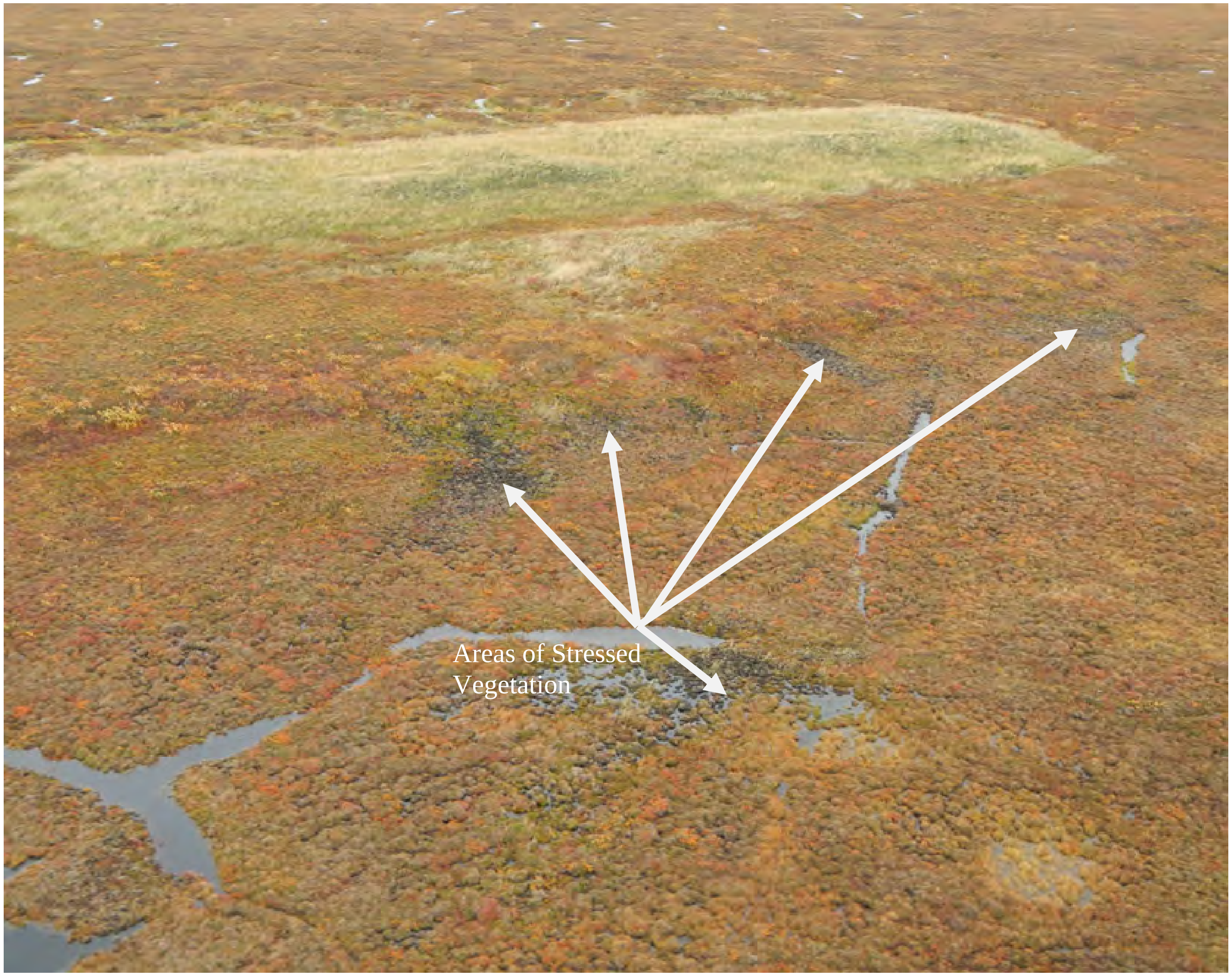


Photo 5: Aerial view of areas with stressed vegetation south of the sump (September 7, 2012)

Photo 6: Aerial view of ion migration areas south of the sump (September 7, 2012)

Photo 7: Aerial view of sump cap directly from above (September 6, 2012)

Photo 8: Vegetation establishment on the sump cap (September 7, 2012)

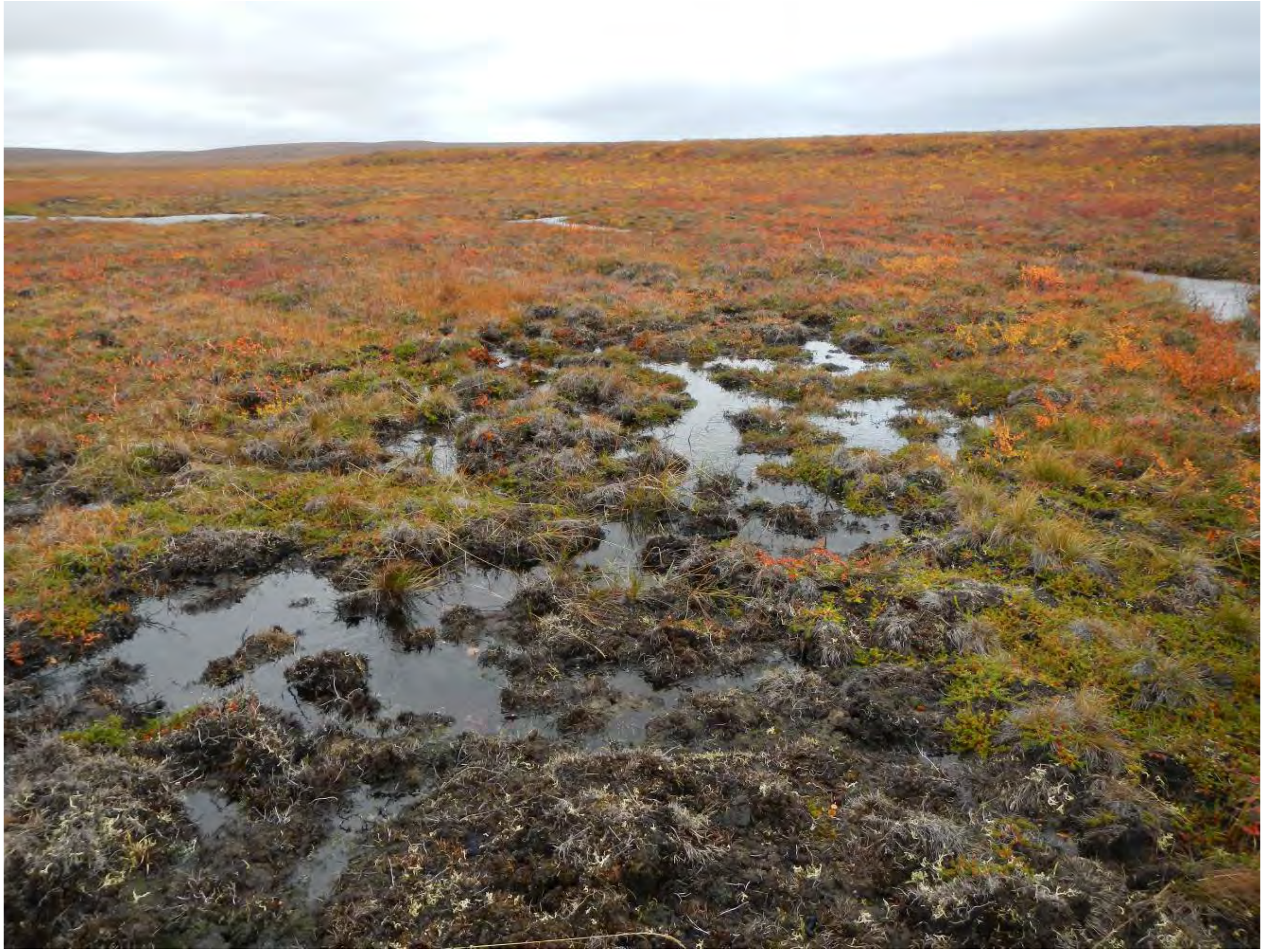


Photo 9: Saturated ground conditions during site assessment south of the sump (September 7, 2012)

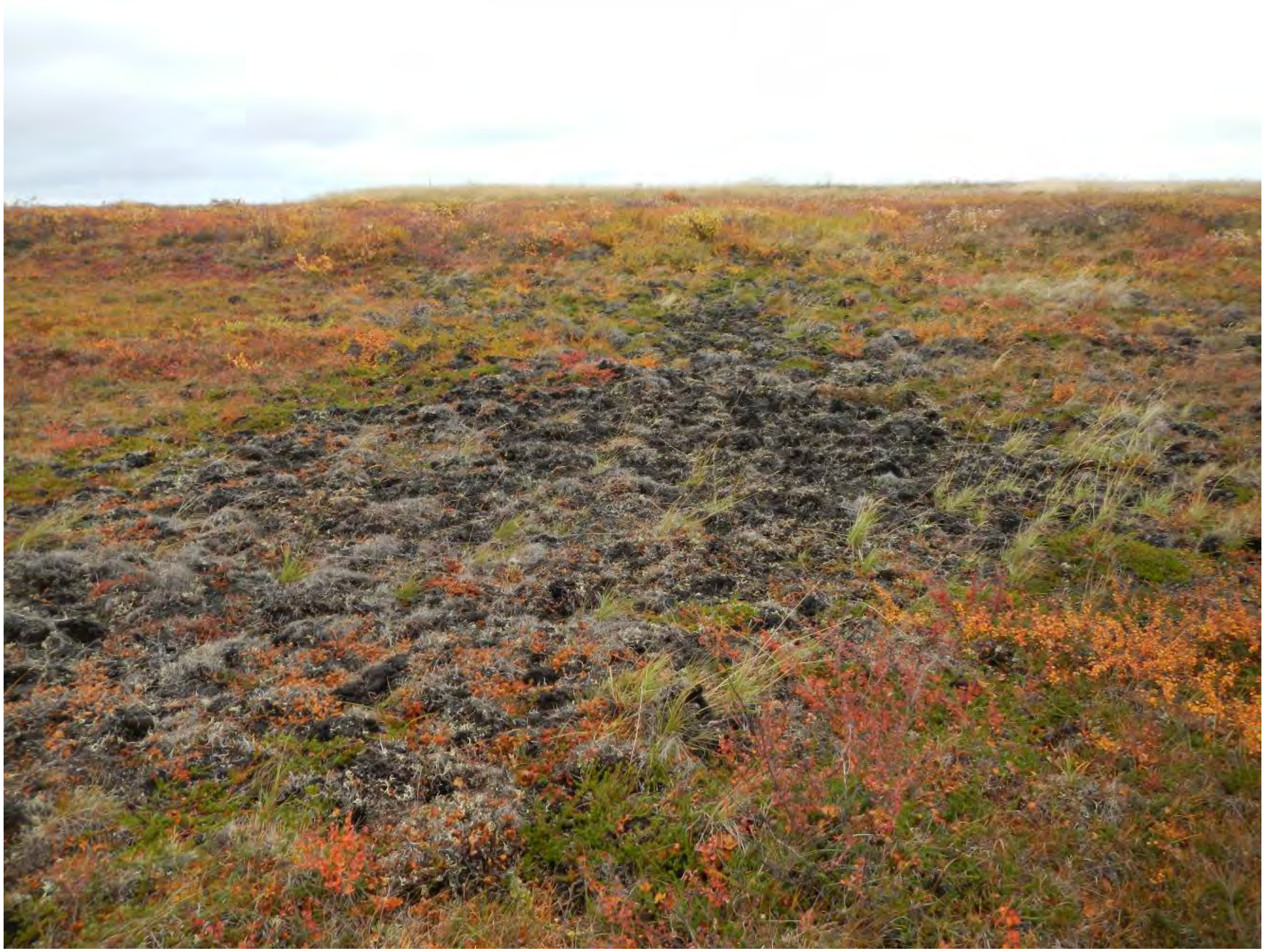


Photo 10: Area with stressed vegetation south of the sump (September 7, 2012)

Appendix C Thermister Temperature Graphs and Monthly Summaries

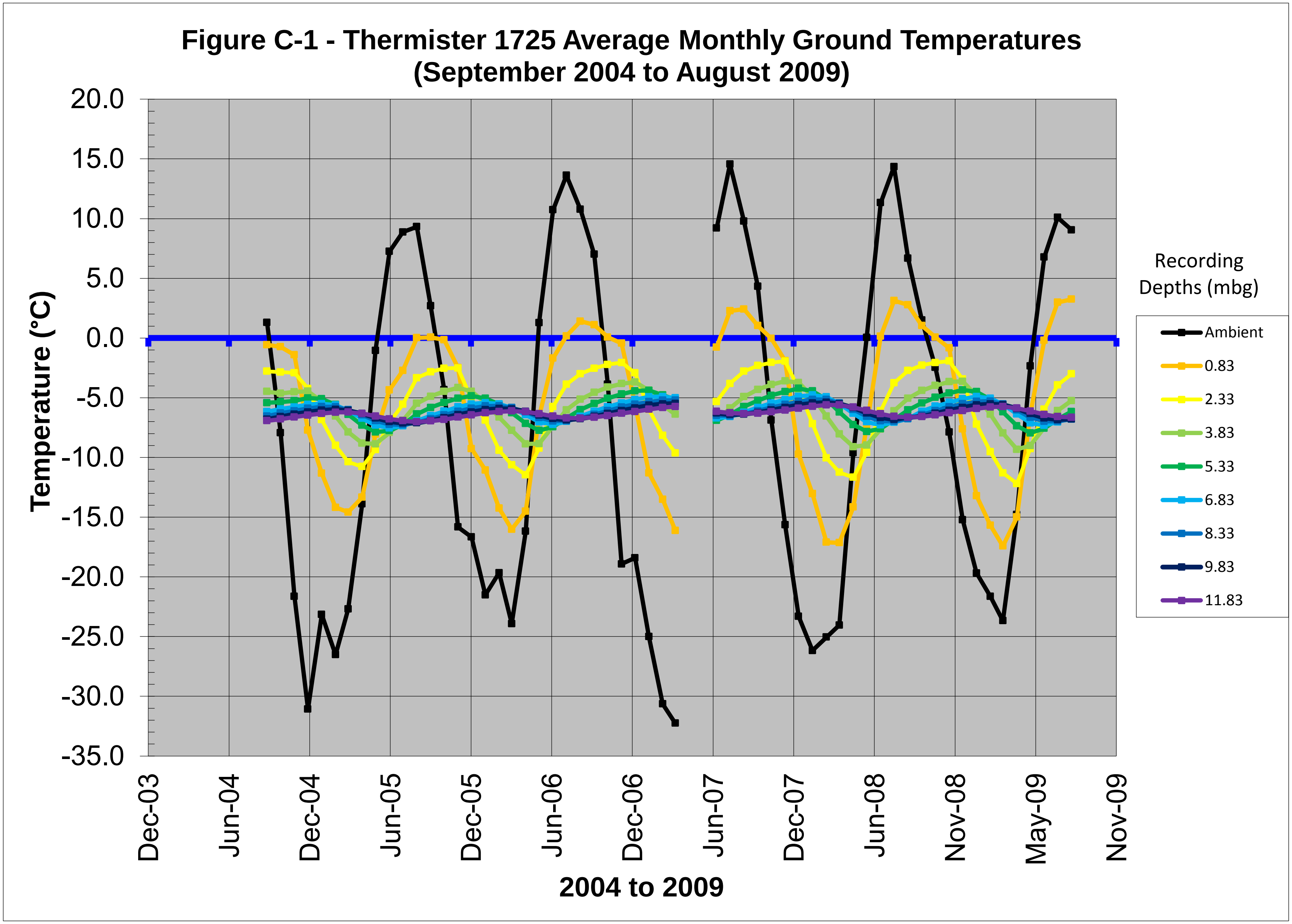


Figure C-1 - Thermister 1725 Average Monthly Ground Temperatures
(September 2004 to August 2009)
Temperature (°C)
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
Dec-03
Jun-04
Dec-04
Jun-05
Dec-05
Jun-06
Dec-06
Jun-07
Dec-07
Jun-08
Nov-08
May-09
Nov-09
2004 to 2009
Recording Depths (mbg)
Ambient
0.83
2.33
3.83
5.33
6.83
8.33
9.83
11.83

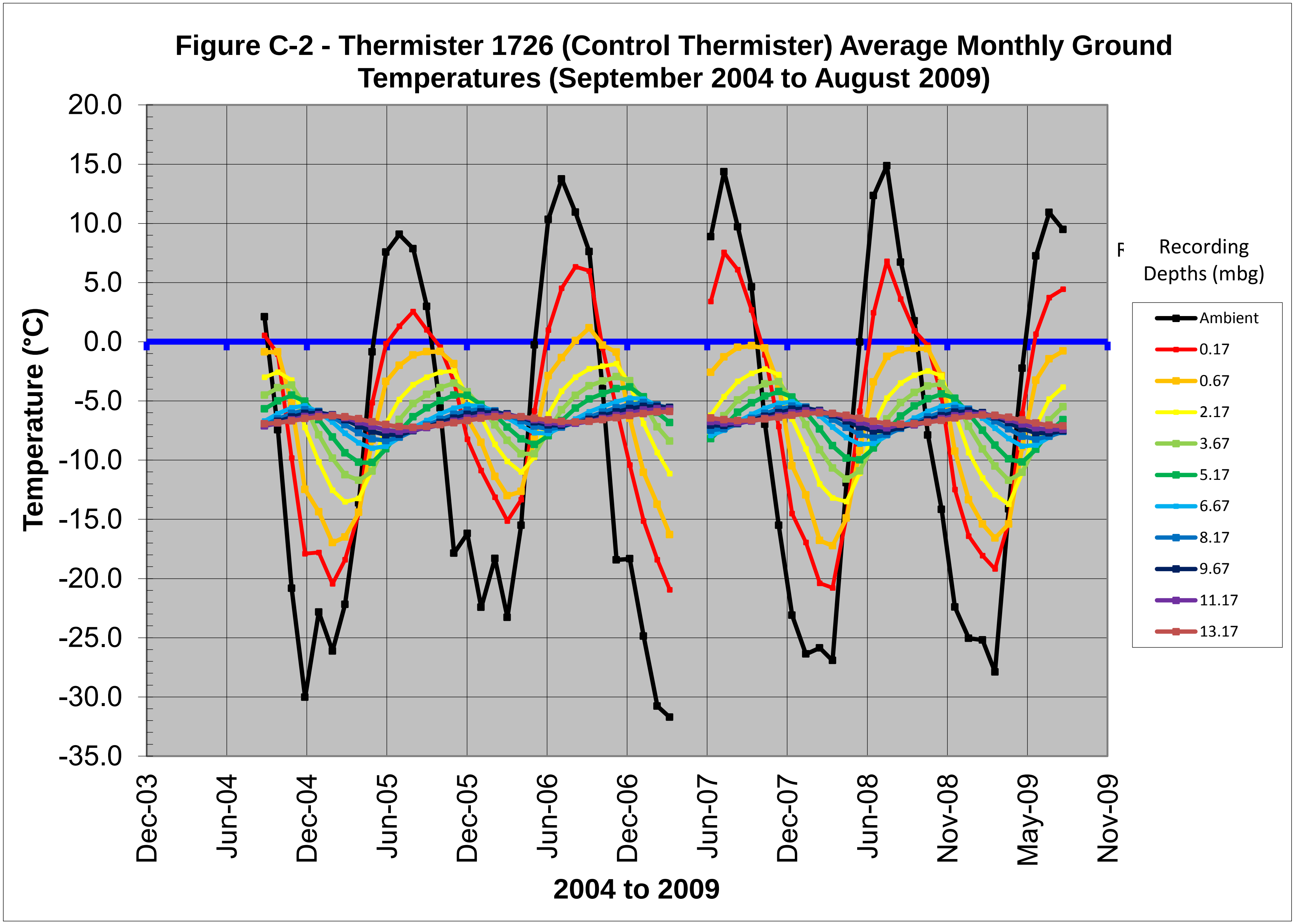


Figure C-2 - Thermister 1726 (Control Thermister) Average Monthly Ground Temperatures (September 2004 to August 2009)
Temperature (°C)
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
Dec-03
Jun-04
Dec-04
Jun-05
Dec-05
Jun-06
Dec-06
Jun-07
Dec-07
Jun-08
Nov-08
May-09
Nov-09
2004 to 2009
Recording Depths (mbg)
Ambient
0.17
0.67
2.17
3.67
5.17
6.67
8.17
9.67
11.17
13.17

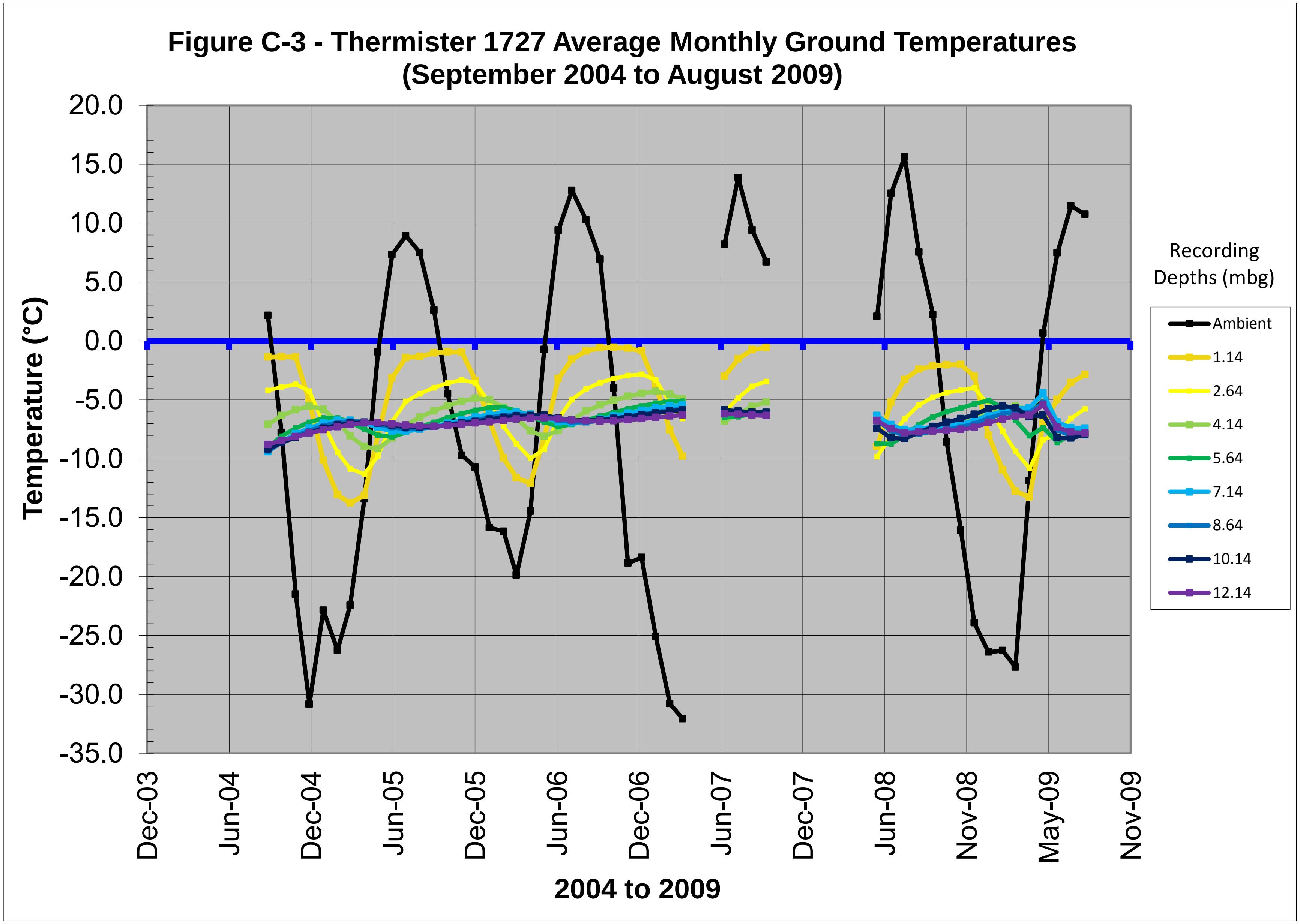


Figure C-3 - Thermister 1727 Average Monthly Ground Temperatures
(September 2004 to August 2009)
Temperature (°C)
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
Dec-03
Jun-04
Dec-04
Jun-05
Dec-05
Jun-06
Dec-06
Jun-07
Dec-07
Jun-08
Nov-08
May-09
Nov-09
2004 to 2009
Recording Depths (mbg)
Ambient
1.14
2.64
4.14
5.64
7.14
8.64
10.14
12.14

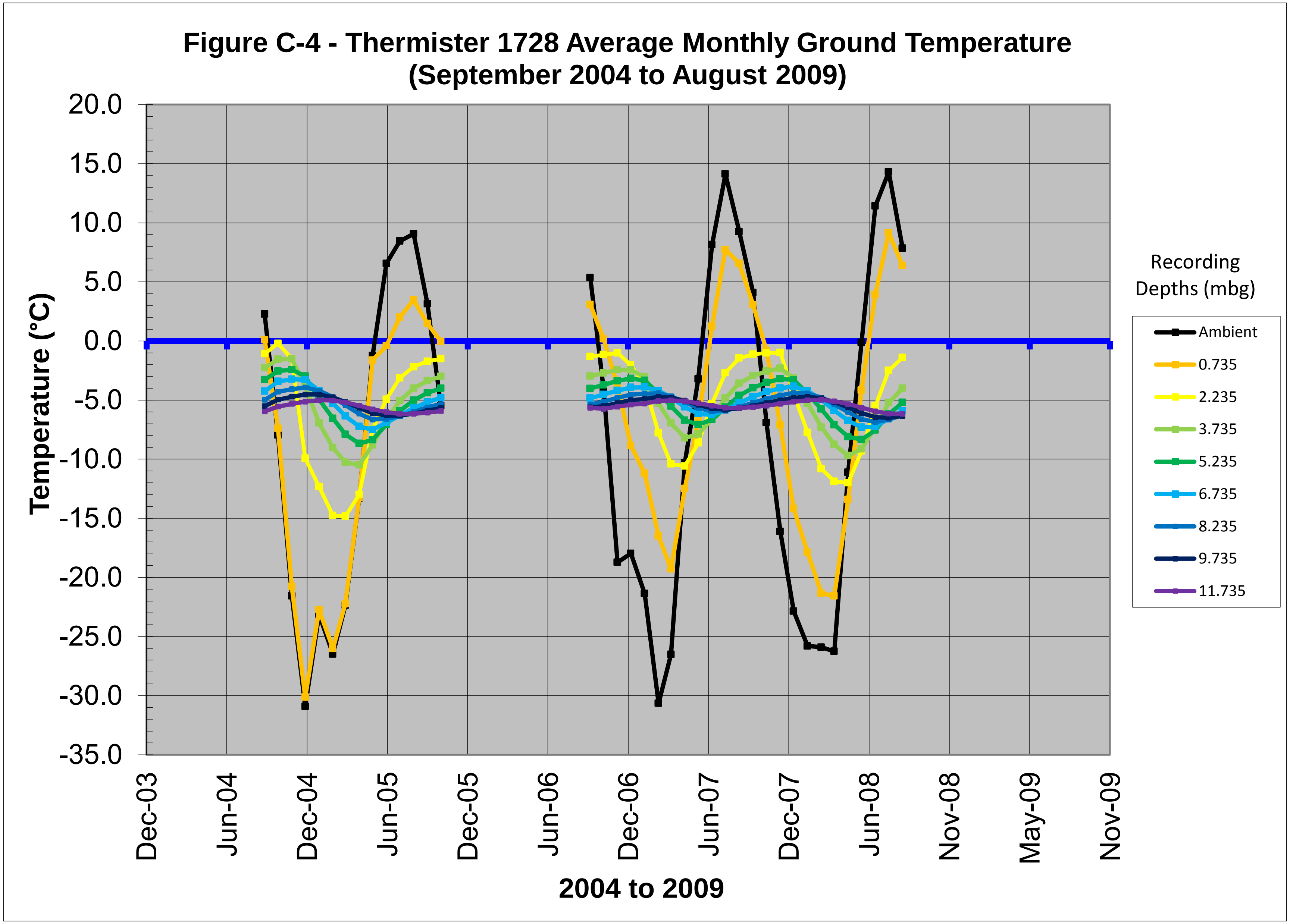


Figure C-4 - Thermister 1728 Average Monthly Ground Temperature
(September 2004 to August 2009)
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
Temperature (°C)
Dec-03
Jun-04
Dec-04
Jun-05
Dec-05
Jun-06
Dec-06
Jun-07
Dec-07
Jun-08
Nov-08
May-09
Nov-09
2004 to 2009
Recording Depths (mbg)
Ambient
0.735
2.235
3.735
5.235
6.735
8.235
9.735
11.735

Table C-1 Thermister 1725 – Average Monthly Temperatures (September 2004 to August 2009)

Sensor number	1	2	3	4	5	6	7	8	9	10	11	12
Bead Depth (m)	Ambient				0.83	2.33	3.83	5.33	6.83	8.33	9.83	11.83
Month	*Average Temperature (°C)*											
Sep-04	1.3	1.3	1.6	0.8	-0.6	-2.8	-4.5	-5.4	-6.2	-6.5	-6.8	-6.9
Oct-04	-7.9	-7.9	-7.5	-1.3	-0.7	-2.9	-4.6	-5.4	-5.9	-6.3	-6.6	-6.8
Nov-04	-21.6	-21.6	-20.9	-8.9	-1.4	-2.9	-4.5	-5.3	-5.8	-6.1	-6.4	-6.6
Dec-04	-31.1	-31.0	-30.1	-18.4	-7.7	-4.2	-4.5	-5.0	-5.6	-5.9	-6.2	-6.5
Jan-05	-23.2	-23.1	-22.9	-18.2	-11.3	-6.8	-5.3	-5.1	-5.5	-5.8	-6.1	-6.3
Feb-05	-26.5	-26.4	-26.2	-21.2	-14.2	-9.0	-6.5	-5.6	-5.6	-5.8	-6.0	-6.2
Mar-05	-22.7	-22.7	-22.3	-19.1	-14.6	-10.4	-7.9	-6.4	-6.1	-6.0	-6.1	-6.2
Apr-05	-13.9	-13.9	-13.3	-13.5	-13.3	-10.8	-8.8	-7.3	-6.7	-6.4	-6.3	-6.3
May-05	-1.0	-1.2	-0.5	-2.5	-8.1	-9.3	-8.9	-7.9	-7.3	-6.9	-6.7	-6.5
Jun-05	7.3	6.9	7.7	2.3	-4.3	-7.1	-7.9	-7.8	-7.5	-7.2	-7.0	-6.8
Jul-05	8.9	8.8	9.1	4.9	-2.7	-5.6	-6.9	-7.2	-7.4	-7.3	-7.1	-6.9
Aug-05	9.3	9.3	9.4	9.3	0.0	-3.3	-5.5	-6.4	-6.9	-7.1	-7.1	-7.0
Sep-05	2.7	2.6	2.7	2.9	0.1	-2.8	-4.9	-5.8	-6.5	-6.8	-6.9	-6.9
Oct-05	-4.3	-5.2	-4.6	-3.9	-0.2	-2.5	-4.5	-5.4	-6.1	-6.5	-6.7	-6.8
Nov-05	-15.8	-17.4	-15.0	-13.1	-2.5	-2.5	-4.2	-5.0	-5.8	-6.1	-6.4	-6.6
Dec-05	-16.7	-17.3	-16.2	-15.4	-9.3	-5.1	-4.5	-4.9	-5.5	-5.9	-6.2	-6.5
Jan-06	-21.5	-22.2	-21.0	-19.6	-11.1	-6.9	-5.4	-5.1	-5.4	-5.7	-6.0	-6.3
Feb-06	-19.7	-19.9	-19.6	-19.0	-14.3	-9.4	-6.6	-5.5	-5.5	-5.7	-5.9	-6.2
Mar-06	-23.9	-24.8	-23.6	-23.1	-16.0	-10.6	-7.7	-6.3	-5.9	-5.8	-5.9	-6.1
Apr-06	-16.2	-16.2	-16.1	-15.8	-14.5	-11.5	-8.9	-7.2	-6.4	-6.2	-6.1	-6.2
May-06	1.3	1.1	1.2	1.8	-6.6	-9.2	-8.9	-7.7	-7.0	-6.7	-6.5	-6.3
Jun-06	10.7	10.6	10.4	11.0	-1.7	-5.7	-7.4	-7.4	-7.2	-7.0	-6.8	-6.5
Jul-06	13.6	13.9	13.5	13.8	0.2	-3.9	-6.0	-6.7	-7.0	-6.9	-6.9	-6.7
Aug-06	10.8	11.0	10.7	11.2	1.4	-3.0	-5.1	-6.0	-6.6	-6.7	-6.8	-6.7
Sep-06	7.0	7.1	6.7	6.7	1.1	-2.5	-4.6	-5.5	-6.1	-6.4	-6.6	-6.6
Oct-06	-3.9	-3.9	-4.2	-4.2	0.1	-2.2	-4.1	-5.0	-5.8	-6.1	-6.3	-6.5
Nov-06	-18.9	-18.7	-19.0	-19.0	-0.4	-2.1	-3.8	-4.7	-5.4	-5.8	-6.1	-6.3
Dec-06	-18.4	-18.2	-18.4	-18.5	-5.6	-2.9	-3.7	-4.4	-5.2	-5.5	-5.9	-6.2
Jan-07	-25.0	-24.8	-25.1	-25.3	-11.3	-6.0	-4.4	-4.4	-4.9	-5.3	-5.6	-6.0
Feb-07	-30.6	-29.7	-31.3	-31.5	-13.5	-8.2	-5.6	-4.8	-4.9	-5.2	-5.5	-5.8
Mar-07	-32.3	-31.2	-32.7	-32.6	-16.1	-9.6	-6.4	-5.2	-5.0	-5.2	-5.5	-5.7
Apr-07												
May-07												
Jun-07	9.2	12.0	9.2	9.3	-0.8	-5.3	-6.9	-6.9	-6.7	-6.5	-6.3	-6.2
Jul-07	14.6	16.9	14.5	14.3	2.3	-3.8	-5.9	-6.4	-6.6	-6.5	-6.4	-6.3
Aug-07	9.8	10.6	9.7	9.6	2.4	-2.8	-4.9	-5.7	-6.2	-6.3	-6.4	-6.3
Sep-07	4.3	4.6	4.3	4.1	1.0	-2.3	-4.3	-5.2	-5.8	-6.1	-6.2	-6.3
Oct-07	-6.9	-7.0	-6.8	-7.2	0.0	-2.1	-3.9	-4.8	-5.5	-5.8	-6.0	-6.2
Nov-07	-15.6	-15.6	-15.6	-15.6	-1.9	-1.9	-3.6	-4.5	-5.2	-5.6	-5.8	-6.1
Dec-07	-23.3	-23.2	-23.4	-23.3	-9.7	-4.3	-3.7	-4.2	-4.9	-5.3	-5.6	-5.9
Jan-08	-26.2	-26.1	-26.2	-26.3	-13.0	-7.2	-4.9	-4.4	-4.8	-5.1	-5.5	-5.7
Feb-08	-25.0	-25.4	-25.0	-26.2	-17.1	-10.0	-6.5	-5.1	-4.9	-5.2	-5.4	-5.6
Mar-08	-24.0	-25.3	-23.6	-26.9	-17.1	-11.2	-8.0	-6.2	-5.5	-5.5	-5.5	-5.6
Apr-08	-9.6	-10.6	-9.3	-11.8	-14.1	-11.7	-9.1	-7.3	-6.3	-6.0	-5.8	-5.8
May-08	0.0	-0.1	0.1	-0.9	-7.4	-9.6	-9.0	-7.8	-7.0	-6.6	-6.3	-6.1
Jun-08	11.3	11.4	11.3	10.9	0.2	-6.1	-7.6	-7.6	-7.3	-7.0	-6.7	-6.4
Jul-08	14.3	14.3	14.2	13.7	3.1	-3.8	-6.1	-6.8	-7.1	-7.0	-6.8	-6.6
Aug-08	6.7	6.7	6.7	6.5	2.8	-2.7	-5.1	-6.0	-6.8	-6.8	-6.6	-6.6
Sep-08	1.5	1.5	1.6	1.6	1.0	-2.3	-4.4	-5.4	-6.1	-6.4	-6.6	-6.6
Oct-08	-2.5	-2.4	-2.3	-2.4	0.1	-2.1	-4.0	-5.0	-5.7	-6.1	-6.3	-6.4
Nov-08	-7.9	-7.8	-7.6	-7.9	-0.8	-1.9	-3.7	-4.6	-5.4	-5.8	-6.1	-6.3
Dec-08	-15.2	-15.2	-15.0	-15.3	-7.6	-3.4	-3.6	-4.3	-5.1	-5.5	-5.8	-6.1
Jan-09	-19.7	-19.6	-19.6	-19.7	-13.2	-7.2	-4.8	-4.5	-4.9	-5.3	-5.6	-5.9
Feb-09	-21.6	-21.7	-21.6	-21.8	-15.7	-9.5	-6.4	-5.2	-5.0	-5.3	-5.5	-5.8
Mar-09	-23.7	-23.6	-23.5	-23.7	-17.4	-11.3	-8.0	-6.2	-5.6	-5.5	-5.6	-5.7
Apr-09	-14.8	-14.7	-14.7	-14.8	-15.0	-12.2	-9.3	-7.4	-6.4	-6.0	-5.9	-5.9
May-09	-2.3	-2.3	-2.2	-2.1	-6.4	-9.3	-9.0	-8.0	-7.1	-6.6	-6.3	-6.1
Jun-09	6.8	6.8	7.2	7.1	-0.2	-6.0	-7.5	-7.6	-7.3	-7.0	-6.7	-6.4
Jul-09	10.1	10.1	10.4	10.3	3.0	-3.9	-6.1	-6.8	-7.0	-7.0	-6.8	-6.6
Aug-09	9.1	9.0	9.2	9.2	3.2	-3.0	-5.2	-6.2	-6.7	-6.8	-6.8	-6.6

Notes:

Thermister 1725 - west end of Umiak N16 sump

Recording intervals: 12 hrs.

Thermister sensor temperatures in °C

Table C-2 Thermister 1726 (Control Thermister) – Average Monthly Temperatures (September 2004 to August 2009)

Sensor number	1	2	3	4	5	6	7	8	9	10	11	12
Bead Depth (m)	Ambient		0.17	0.67	2.17	3.67	5.17	6.67	8.17	9.67	11.17	13.17
Month	***Average Temperature (°C)***											
Sep-04	2.1	1.4	0.5	-0.9	-3.0	-4.5	-5.7	-6.7	-7.0	-7.1	-7.1	-6.9
Oct-04	-7.5	-4.6	-1.0	-0.9	-2.6	-3.9	-5.0	-6.1	-6.5	-6.7	-6.9	-6.9
Nov-04	-20.8	-15.6	-9.8	-5.2	-3.2	-3.7	-4.5	-5.6	-6.1	-6.4	-6.6	-6.7
Dec-04	-30.0	-23.7	-17.9	-12.5	-7.3	-5.4	-5.0	-5.4	-5.8	-6.1	-6.3	-6.5
Jan-05	-22.8	-20.9	-17.8	-14.4	-10.2	-7.9	-6.6	-6.0	-5.9	-6.0	-6.2	-6.3
Feb-05	-26.1	-23.8	-20.5	-17.0	-12.5	-9.8	-8.1	-6.8	-6.4	-6.2	-6.2	-6.3
Mar-05	-22.2	-20.4	-18.4	-16.5	-13.5	-11.2	-9.4	-7.7	-7.0	-6.6	-6.4	-6.3
Apr-05	-13.6	-14.3	-14.5	-14.4	-13.2	-11.7	-10.2	-8.5	-7.7	-7.1	-6.8	-6.5
May-05	-0.9	-2.5	-5.2	-8.3	-10.8	-10.9	-10.2	-9.0	-8.2	-7.6	-7.1	-6.8
Jun-05	7.6	5.8	-0.2	-3.4	-6.9	-8.5	-9.1	-8.8	-8.4	-7.9	-7.5	-7.0
Jul-05	9.1	7.4	1.3	-2.0	-4.9	-6.6	-7.6	-8.1	-8.1	-7.8	-7.6	-7.2
Aug-05	7.9	6.9	2.6	-1.1	-3.6	-5.2	-6.3	-7.3	-7.5	-7.5	-7.5	-7.2
Sep-05	3.0	2.5	1.0	-0.9	-3.0	-4.5	-5.6	-6.7	-7.0	-7.2	-7.3	-7.2
Oct-05	-5.6	-3.0	-0.5	-0.8	-2.6	-3.9	-5.0	-6.1	-6.6	-6.8	-7.0	-7.0
Nov-05	-17.9	-7.4	-3.4	-1.9	-2.5	-3.5	-4.5	-5.6	-6.1	-6.5	-6.7	-6.9
Dec-05	-16.2	-10.5	-8.2	-6.5	-4.6	-4.2	-4.5	-5.3	-5.8	-6.2	-6.5	-6.7
Jan-06	-22.4	-14.3	-10.9	-8.5	-6.4	-5.6	-5.3	-5.5	-5.7	-6.0	-6.2	-6.5
Feb-06	-18.3	-14.9	-13.1	-11.4	-8.7	-7.0	-6.2	-5.8	-5.9	-6.0	-6.2	-6.4
Mar-06	-23.3	-17.6	-15.1	-13.0	-10.1	-8.3	-7.2	-6.4	-6.2	-6.1	-6.2	-6.3
Apr-06	-15.5	-14.0	-13.3	-12.7	-11.0	-9.5	-8.2	-7.1	-6.7	-6.4	-6.3	-6.3
May-06	-0.3	-3.3	-5.8	-8.2	-9.8	-9.5	-8.7	-7.7	-7.1	-6.8	-6.6	-6.5
Jun-06	10.3	8.6	1.0	-2.9	-6.1	-7.5	-8.0	-7.7	-7.4	-7.0	-6.8	-6.6
Jul-06	13.7	12.2	4.5	-1.4	-4.2	-5.8	-6.7	-7.2	-7.2	-7.1	-6.9	-6.7
Aug-06	10.9	10.4	6.3	0.1	-3.0	-4.5	-5.6	-6.5	-6.8	-6.9	-6.9	-6.8
Sep-06	7.6	7.5	6.0	1.2	-2.3	-3.7	-4.8	-5.9	-6.4	-6.6	-6.7	-6.7
Oct-06	-4.0	-3.1	-0.5	-0.3	-2.1	-3.3	-4.4	-5.5	-6.0	-6.3	-6.5	-6.6
Nov-06	-18.4	-13.8	-5.7	-0.9	-1.9	-3.0	-4.0	-5.1	-5.6	-5.9	-6.2	-6.4
Dec-06	-18.3	-15.9	-10.4	-6.5	-3.5	-3.3	-3.8	-4.8	-5.3	-5.6	-6.0	-6.3
Jan-07	-24.9	-21.2	-15.1	-11.0	-6.9	-5.2	-4.7	-4.8	-5.2	-5.5	-5.8	-6.1
Feb-07	-30.8	-26.2	-18.4	-13.7	-9.4	-7.2	-6.0	-5.4	-5.4	-5.5	-5.7	-5.9
Mar-07	-31.7	-28.0	-21.0	-16.3	-11.1	-8.4	-6.8	-5.9	-5.6	-5.6	-5.7	-5.9
Apr-07												
May-07												
Jun-07	8.9	8.4	3.4	-2.6	-6.2	-7.8	-8.2	-7.9	-7.5	-7.1	-6.8	-6.5
Jul-07	14.4	13.8	7.5	-1.3	-4.6	-6.3	-7.1	-7.5	-7.3	-7.1	-6.9	-6.6
Aug-07	9.7	9.6	6.1	-0.5	-3.4	-4.9	-6.0	-6.8	-6.9	-6.9	-6.9	-6.7
Sep-07	4.6	4.4	2.7	-0.3	-2.7	-4.1	-5.2	-6.1	-6.5	-6.6	-6.7	-6.6
Oct-07	-7.0	-5.3	-1.1	-0.5	-2.3	-3.6	-4.6	-5.6	-6.1	-6.3	-6.5	-6.5
Nov-07	-15.5	-12.6	-7.2	-3.6	-2.8	-3.4	-4.2	-5.2	-5.7	-6.0	-6.3	-6.4
Dec-07	-23.1	-19.9	-14.5	-10.5	-6.5	-5.0	-4.7	-5.1	-5.4	-5.7	-6.0	-6.2
Jan-08	-26.4	-22.2	-17.0	-12.9	-9.1	-7.0	-6.0	-5.5	-5.5	-5.6	-5.9	-6.1
Feb-08	-25.9	-23.9	-20.4	-16.8	-12.0	-9.1	-7.4	-6.3	-5.9	-5.8	-5.9	-6.0
Mar-08	-26.9	-24.8	-20.8	-17.2	-13.2	-10.7	-8.8	-7.2	-6.6	-6.2	-6.1	-6.1
Apr-08	-11.9	-13.9	-14.8	-14.9	-13.5	-11.6	-9.8	-8.1	-7.3	-6.7	-6.4	-6.2
May-08	0.0	-2.4	-5.9	-9.2	-11.1	-10.9	-10.0	-8.7	-7.8	-7.2	-6.8	-6.5
Jun-08	12.3	11.0	2.4	-3.4	-7.1	-8.6	-9.0	-8.6	-8.1	-7.5	-7.1	-6.7
Jul-08	14.9	14.0	6.8	-1.3	-4.8	-6.5	-7.5	-7.9	-7.8	-7.6	-7.3	-6.9
Aug-08	6.7	6.5	3.6	-0.7	-3.5	-5.2	-6.3	-7.1	-7.3	-7.2	-7.0	-7.0
Sep-08	1.8	1.6	0.9	-0.6	-2.8	-4.3	-5.4	-6.5	-6.8	-7.0	-7.0	-6.9
Oct-08	-7.9	-2.8	-0.3	-0.6	-2.5	-3.7	-4.8	-5.9	-6.4	-6.6	-6.8	-6.8
Nov-08	-14.2	-8.1	-4.7	-2.9	-2.9	-3.5	-4.4	-5.5	-6.0	-6.3	-6.5	-6.6
Dec-08	-22.4	-16.0	-12.5	-9.2	-6.0	-4.9	-4.8	-5.3	-5.7	-6.0	-6.3	-6.5
Jan-09	-25.1	-19.4	-16.4	-13.4	-9.4	-7.2	-6.1	-5.7	-5.7	-5.9	-6.1	-6.3
Feb-09	-25.2	-20.5	-18.1	-15.4	-11.5	-9.1	-7.5	-6.4	-6.1	-6.0	-6.1	-6.2
Mar-09	-27.9	-22.0	-19.2	-16.6	-12.9	-10.5	-8.8	-7.3	-6.7	-6.4	-6.3	-6.2
Apr-09	-14.1	-14.7	-15.3	-15.4	-13.7	-11.7	-9.9	-8.2	-7.4	-6.8	-6.6	-6.4
May-09	-2.3	-4.1	-6.1	-8.9	-11.1	-11.0	-10.2	-8.8	-8.0	-7.3	-7.0	-6.6
Jun-09	7.2	6.3	0.6	-3.3	-7.1	-8.7	-9.1	-8.7	-8.2	-7.7	-7.3	-6.9
Jul-09	10.9	10.0	3.7	-1.5	-4.9	-6.6	-7.6	-8.1	-8.0	-7.7	-7.4	-7.1
Aug-09	9.5	9.0	4.4	-0.8	-3.8	-5.5	-6.6	-7.4	-7.6	-7.5	-7.4	-7.1

Notes:

Thermister 1726 - control point thermister located approximately 35 m east of Umiak N16 sump

Recording intervals: 12 hrs.

Thermister sensor temperatures in °C

Table C-3 Thermister 1727 – Average Monthly Temperatures (September 2004 to August 2009)

Sensor number	1	2	3	4	5	6	7	8	9	10	11	12
Bead Depth (m)	Ambient				1.14	2.64	4.14	5.64	7.14	8.64	10.14	12.14
Month	*Average Temperature (°C)*											
Sep-04	2.2	2.2	2.3	1.5	-1.4	-4.2	-7.1	-9.0	-9.4	-9.3	-9.2	-8.8
Oct-04	-7.8	-7.8	-7.6	-2.0	-1.3	-3.9	-6.3	-8.1	-8.5	-8.6	-8.6	-8.4
Nov-04	-21.5	-21.5	-20.7	-6.3	-1.3	-3.7	-5.8	-7.4	-7.9	-8.1	-8.2	-8.1
Dec-04	-30.8	-30.9	-29.9	-14.4	-5.1	-4.2	-5.5	-6.9	-7.4	-7.6	-7.8	-7.8
Jan-05	-22.9	-22.9	-22.9	-18.1	-10.1	-7.0	-5.8	-6.5	-7.0	-7.2	-7.4	-7.5
Feb-05	-26.2	-26.3	-26.0	-19.3	-13.1	-9.4	-6.8	-6.5	-6.7	-6.9	-7.1	-7.3
Mar-05	-22.4	-22.6	-22.4	-17.9	-13.8	-10.9	-8.1	-6.9	-6.7	-6.8	-6.9	-7.1
Apr-05	-13.4	-13.5	-13.4	-13.4	-13.1	-11.3	-9.0	-7.5	-7.0	-6.8	-6.9	-7.0
May-05	-0.9	-0.8	-0.5	-0.3	-7.9	-9.8	-9.1	-8.0	-7.4	-7.1	-7.0	-7.0
Jun-05	7.3	7.4	7.2	7.7	-3.1	-6.8	-8.2	-8.1	-7.7	-7.3	-7.2	-7.0
Jul-05	8.9	8.9	8.9	9.4	-1.4	-5.1	-7.1	-7.8	-7.7	-7.5	-7.3	-7.1
Aug-05	7.5	7.3	7.4	7.5	-1.3	-4.5	-6.5	-7.3	-7.5	-7.4	-7.3	-7.2
Sep-05	2.6	2.6	2.7	2.7	-1.0	-4.0	-5.9	-6.9	-7.3	-7.3	-7.3	-7.2
Oct-05	-4.5	-2.9	-1.7	-0.8	-0.9	-3.6	-5.5	-6.5	-7.0	-7.1	-7.1	-7.2
Nov-05	-9.7	-7.2	-5.6	-3.4	-0.9	-3.3	-5.1	-6.2	-6.7	-6.9	-7.0	-7.1
Dec-05	-10.7	-9.4	-8.4	-7.9	-3.3	-3.5	-4.9	-5.9	-6.5	-6.7	-6.8	-7.0
Jan-06	-15.8	-14.3	-12.9	-11.8	-6.8	-5.3	-5.0	-5.6	-6.2	-6.5	-6.6	-6.9
Feb-06	-16.2	-15.0	-14.3	-14.0	-9.9	-7.2	-5.6	-5.6	-6.1	-6.3	-6.5	-6.7
Mar-06	-19.9	-18.5	-17.5	-16.7	-11.6	-8.7	-6.6	-5.9	-6.0	-6.2	-6.4	-6.6
Apr-06	-14.5	-14.2	-14.0	-13.9	-12.1	-10.0	-7.6	-6.4	-6.2	-6.3	-6.3	-6.6
May-06	-0.7	-0.8	-0.6	-1.0	-8.2	-9.2	-8.1	-6.9	-6.5	-6.4	-6.3	-6.5
Jun-06	9.4	9.2	9.4	9.6	-3.2	-6.6	-7.6	-7.3	-6.9	-6.7	-6.5	-6.6
Jul-06	12.8	12.5	12.8	12.8	-1.5	-5.0	-6.7	-7.1	-7.0	-6.9	-6.7	-6.7
Aug-06	10.3	10.2	10.4	10.5	-0.9	-4.1	-5.9	-6.7	-6.9	-6.9	-6.7	-6.8
Sep-06	6.9	6.9	7.1	6.8	-0.6	-3.5	-5.4	-6.4	-6.6	-6.8	-6.7	-6.8
Oct-06	-4.0	-4.0	-3.9	-2.3	-0.5	-3.2	-5.0	-6.1	-6.4	-6.6	-6.6	-6.8
Nov-06	-18.9	-18.9	-18.5	-5.4	-0.6	-2.9	-4.7	-5.7	-6.1	-6.4	-6.4	-6.7
Dec-06	-18.4	-18.4	-17.8	-5.9	-0.8	-2.8	-4.4	-5.5	-5.9	-6.2	-6.3	-6.6
Jan-07	-25.1	-25.1	-24.4	-11.8	-3.8	-3.3	-4.3	-5.3	-5.7	-6.0	-6.1	-6.5
Feb-07	-30.8	-31.1	-30.6	-16.8	-7.6	-5.2	-4.5	-5.1	-5.5	-5.9	-5.9	-6.4
Mar-07	-32.1	-32.3	-31.9	-19.4	-9.8	-6.6	-4.9	-5.1	-5.4	-5.8	-5.9	-6.3
Apr-07												
May-07												
Jun-07	8.2	8.2	8.4	8.9	-3.0	-6.0	-6.8	-6.5	-6.1	-6.1	-5.9	-6.2
Jul-07	13.9	13.8	14.0	13.6	-1.5	-4.8	-6.2	-6.4	-6.2	-6.2	-6.0	-6.2
Aug-07	9.4	9.4	9.4	9.6	-0.7	-3.8	-5.5	-6.2	-6.2	-6.3	-6.0	-6.3
Sep-07	6.7	6.6	6.6	6.7	-0.6	-3.4	-5.2	-6.0	-6.1	-6.2	-6.1	-6.3
Oct-07												
Nov-07												
Dec-07												
Jan-08												
Feb-08												
Mar-08												
Apr-08												
May-08	2.1			-1.3	-8.9	-9.8	-6.7	-8.7	-6.3	-6.7	-7.4	-6.8
Jun-08	12.5			10.0	-5.2	-8.1	-7.6	-8.7	-7.1	-7.6	-8.2	-7.4
Jul-08	15.6			12.5	-3.3	-6.6	-7.9	-8.0	-7.5	-8.0	-8.3	-7.8
Aug-08	7.5			5.7	-2.4	-5.4	-7.7	-7.1	-7.4	-7.9	-7.7	-7.7
Sep-08	2.2			0.7	-2.1	-4.8	-7.3	-6.4	-7.3	-7.7	-7.3	-7.6
Oct-08	-8.6			-2.6	-2.0	-4.4	-7.1	-6.0	-7.1	-7.5	-6.9	-7.6
Nov-08	-16.1			-4.8	-2.0	-4.2	-6.8	-5.7	-7.0	-7.3	-6.6	-7.5
Dec-08	-23.9			-9.5	-3.0	-4.0	-6.5	-5.3	-6.7	-7.0	-6.2	-7.3
Jan-09	-26.4			-14.5	-8.0	-5.4	-6.0	-5.0	-6.3	-6.5	-5.7	-6.9
Feb-09	-26.3			-16.9	-10.9	-7.6	-5.7	-5.6	-6.0	-6.2	-5.5	-6.6
Mar-09	-27.7			-18.5	-12.8	-9.3	-5.5	-6.7	-5.7	-6.0	-5.7	-6.4
Apr-09	-11.9			-14.3	-13.3	-10.8	-5.8	-8.0	-5.7	-6.1	-6.4	-6.3
May-09	0.7			-0.9	-7.0	-8.4	-4.4	-7.4	-4.4	-5.2	-6.3	-5.4
Jun-09	7.5			7.0	-5.0	-7.9	-7.6	-8.6	-6.9	-7.6	-8.2	-7.3
Jul-09	11.5			10.3	-3.5	-6.6	-7.9	-8.0	-7.4	-8.0	-8.2	-7.7
Aug-09	10.7			8.2	-2.8	-5.7	-7.8	-7.3	-7.4	-8.0	-7.9	-7.8

Notes:

Thermister 1727 - thermister located in middle of Umiak N16 sump

Recording intervals: 12 hrs.

Thermister sensor temperatures in °C

Table C-4 Thermister 1728 – Average Monthly Temperatures (September 2004 to August 2009)

Sensor number	1	2	3	4	5	6	7	8	9	10	11	12
Bead Depth (m)	Ambient				0.735	2.235	3.735	5.235	6.735	8.235	9.735	11.735
Month	*Average Temperature (°C)*											
Sep-04	2.3	2.2	2.4	2.3	0.1	-1.1	-2.3	-3.3	-4.3	-5.0	-5.5	-6.0
Oct-04	-8.0	-7.9	-7.7	-7.8	-7.4	-0.2	-1.5	-2.6	-3.4	-4.3	-5.0	-5.5
Nov-04	-21.6	-21.3	-20.6	-21.0	-20.8	-1.5	-1.5	-2.4	-3.2	-4.1	-4.7	-5.3
Dec-04	-30.9	-29.5	-29.8	-31.2	-30.1	-9.9	-3.8	-3.0	-3.3	-3.9	-4.5	-5.1
Jan-05	-23.1	-23.2	-23.0	-23.0	-22.7	-12.3	-6.9	-4.9	-4.2	-4.2	-4.5	-5.0
Feb-05	-26.5	-26.3	-25.8	-26.0	-26.0	-14.8	-9.0	-6.5	-5.3	-4.7	-4.8	-5.0
Mar-05	-22.4	-22.3	-22.2	-22.2	-22.2	-14.8	-10.3	-7.9	-6.4	-5.4	-5.2	-5.2
Apr-05	-13.3	-12.9	-12.8	-12.4	-13.3	-13.0	-10.5	-8.7	-7.2	-6.2	-5.7	-5.5
May-05	-1.2	-1.4	-1.2	-1.1	-1.6	-7.5	-8.8	-8.4	-7.5	-6.6	-6.1	-5.8
Jun-05	6.6	6.9	6.8	7.0	-0.4	-4.9	-6.6	-7.1	-6.9	-6.6	-6.3	-6.0
Jul-05	8.4	8.6	8.6	8.7	2.0	-3.1	-5.1	-5.9	-6.3	-6.4	-6.3	-6.2
Aug-05	9.1	9.1	9.0	9.1	3.5	-2.2	-4.0	-5.0	-5.7	-6.0	-6.1	-6.2
Sep-05	3.1	3.1	3.0	3.0	1.5	-1.7	-3.4	-4.4	-5.2	-5.6	-5.9	-6.1
Oct-05	-5.5	-5.6	-5.7	-5.8	0.0	-1.5	-3.0	-4.0	-4.8	-5.3	-5.7	-5.9
Nov-05												
Dec-05												
Jan-06												
Feb-06												
Mar-06												
Apr-06												
May-06												
Jun-06												
Jul-06												
Aug-06												
Sep-06	5.4	5.3	5.3	5.3	3.1	-1.3	-3.0	-4.0	-4.8	-5.4	-5.6	-5.7
Oct-06	-4.1	-4.1	-4.2	-4.2	0.2	-1.2	-2.7	-3.7	-4.5	-5.1	-5.5	-5.7
Nov-06	-18.7	-18.8	-18.8	-18.8	-3.8	-1.0	-2.4	-3.4	-4.2	-4.8	-5.2	-5.6
Dec-06	-18.0	-18.0	-18.0	-18.0	-8.8	-2.0	-2.4	-3.2	-3.9	-4.5	-5.0	-5.4
Jan-07	-21.4	-21.4	-21.5	-21.5	-11.2	-3.7	-3.1	-3.3	-3.9	-4.5	-4.9	-5.3
Feb-07	-30.7	-30.8	-30.9	-31.2	-16.5	-7.8	-5.3	-4.4	-4.2	-4.4	-4.7	-5.1
Mar-07	-26.5	-26.6	-26.8	-27.2	-19.3	-10.4	-6.9	-5.5	-4.8	-4.7	-4.8	-5.0
Apr-07	-10.3	-10.1	-10.2	-10.3	-12.5	-10.6	-8.2	-6.7	-5.6	-5.2	-5.0	-5.1
May-07	-3.2	-2.8	-2.9	-3.0	-6.7	-8.6	-7.9	-7.1	-6.2	-5.7	-5.4	-5.3
Jun-07	8.1	8.4	8.3	8.5	1.2	-5.3	-6.6	-6.7	-6.3	-6.0	-5.7	-5.5
Jul-07	14.1	14.2	14.1	14.4	7.7	-2.7	-4.8	-5.6	-5.8	-5.9	-5.8	-5.6
Aug-07	9.2	9.3	9.3	9.5	6.6	-1.4	-3.6	-4.6	-5.2	-5.6	-5.7	-5.7
Sep-07	4.1	4.1	4.1	4.2	3.1	-1.1	-2.9	-4.0	-4.7	-5.2	-5.5	-5.6
Oct-07	-6.9	-6.9	-6.9	-6.8	-0.8	-1.0	-2.6	-3.5	-4.3	-4.9	-5.2	-5.5
Nov-07	-16.1	-16.2	-16.2	-16.1	-7.1	-1.0	-2.3	-3.2	-4.0	-4.6	-5.0	-5.3
Dec-07	-22.9	-22.9	-23.0	-23.0	-14.2	-4.5	-3.1	-3.3	-3.8	-4.4	-4.8	-5.1
Jan-08	-25.8	-25.9	-25.9	-25.9	-17.9	-7.7	-5.3	-4.4	-4.2	-4.4	-4.7	-5.0
Feb-08	-25.9	-26.0	-26.0	-26.0	-21.3	-10.8	-7.3	-5.8	-5.0	-4.8	-4.8	-5.0
Mar-08	-26.3	-26.3	-26.2	-25.8	-21.6	-11.9	-8.8	-7.1	-5.9	-5.4	-5.2	-5.1
Apr-08	-11.1	-11.0	-10.9	-10.8	-13.4	-12.0	-9.7	-8.1	-6.7	-6.0	-5.6	-5.3
May-08	-0.1	0.1	0.1	0.2	-4.2	-9.3	-9.1	-8.3	-7.3	-6.6	-6.1	-5.6
Jun-08	11.4	11.7	11.7	11.8	3.9	-5.5	-7.3	-7.5	-7.2	-6.9	-6.4	-6.0
Jul-08	14.3	14.5	14.5	14.6	9.1	-2.5	-5.2	-6.2	-6.6	-6.6	-6.5	-6.1
Aug-08	7.8	7.9	7.9	8.2	6.4	-1.4	-4.0	-5.2	-5.9	-6.3	-6.3	-6.2
Sep-08												
Oct-08												
Nov-08												
Dec-08												
Jan-09												
Feb-09												
Mar-09												
Apr-09												
May-09												
Jun-09												
Jul-09												
Aug-09												

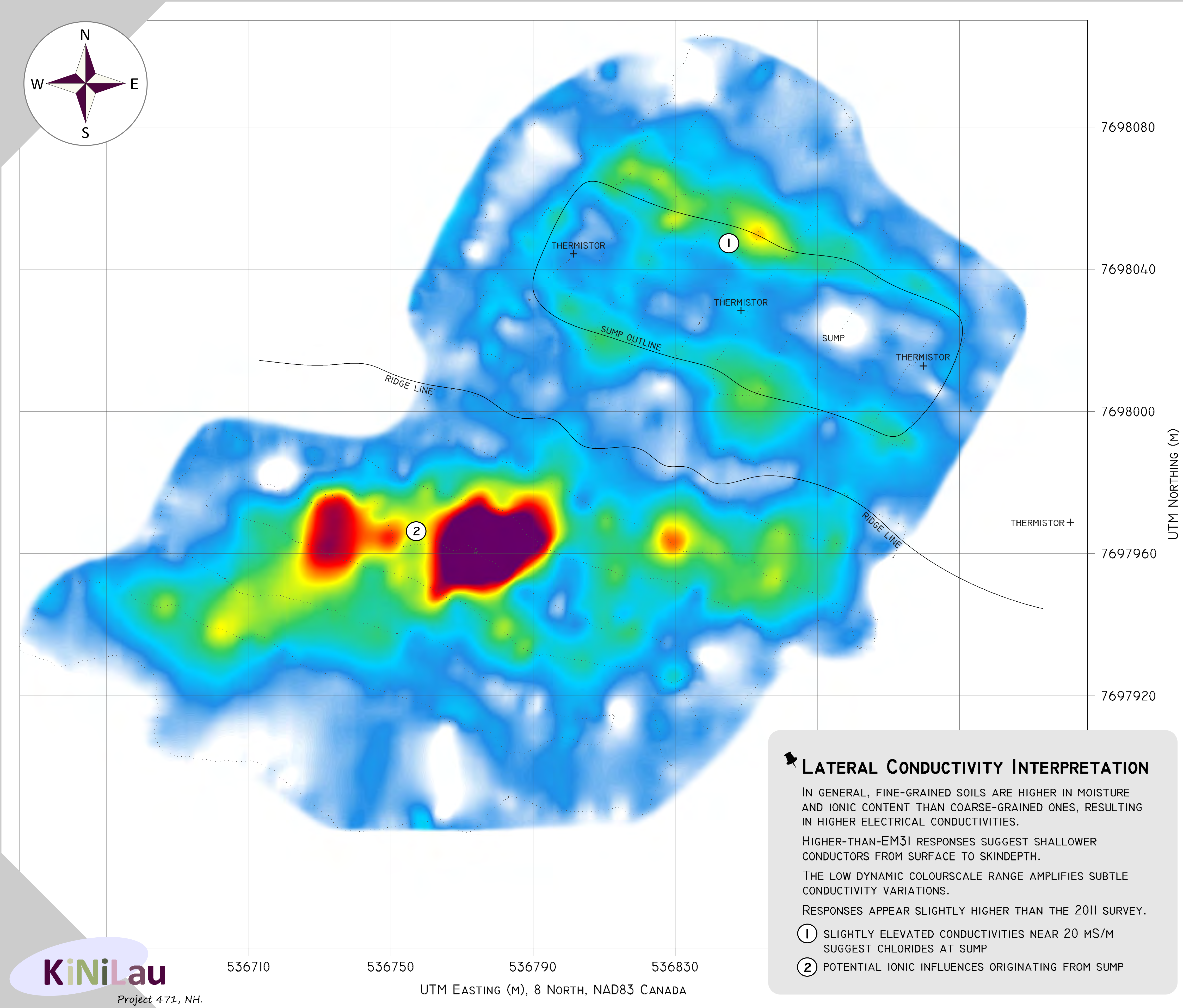
Notes:

Thermister 1728 - thermister located at east end of remote Umiak N16 sump

Recording intervals: 12 hrs.

Thermister sensor temperatures in °C

Appendix D EM Surveys



Lateral Conductivity Interpretation

In general, fine-grained soils are higher in moisture and ionic content than coarse-grained ones, resulting in higher electrical conductivities.

Higher-than-EM31 responses suggest shallower conductors from surface to skindepth.

The low dynamic colourscale range amplifies subtle conductivity variations.

Responses appear slightly higher than the 2011 survey.

1. Slightly elevated conductivities near 20 mS/m suggest chlorides at sump
2. Potential ionic influences originating from sump

Lateral Conductivity Detail (EM38)

MGM Energy Corp.
Umiak N-16 Sump

Inuvik, Northwest Territories
September 6, 2012

Legend

- Curved Feature (road, bush)
- Straight Feature (fence, house)
- Buried Pipe / Utility Line
- Interpretation Event
- Point Feature (sign, pole, tree)
- Geophysical Measurement Station
- Outline (swamp, trees, scrap)

Apparent Conductivity (mS/m)

5 10 15 20 25 30 35 40

This single-page Lateral Conductivity Detail serves as all-in-one, comprehensive and graphical reporting tool. Please visit www.kinilau.ca to download a traditional report.

Bluish colors indicate target onset, transitioning to deep maroon with increased significance.

The color soil conductivity image is derived using EM induction and DGPS positioning data. It reveals the conductivity distribution from surface to the varying skindepth of the inductive EM signal. The image does not represent data from any specific depth. Use VC (Vertical Conductivity) data for depth information.

While presented geophysical data have high intrinsic accuracy, their interpretation has multiple solutions (equivalence). Such data must always be correlated to some form of analytics.

Respectfully submitted,
KiNiLau Physics Inc.

Per:

Sean A. Clarke, P.Geoph.
Sr. Geophysicist

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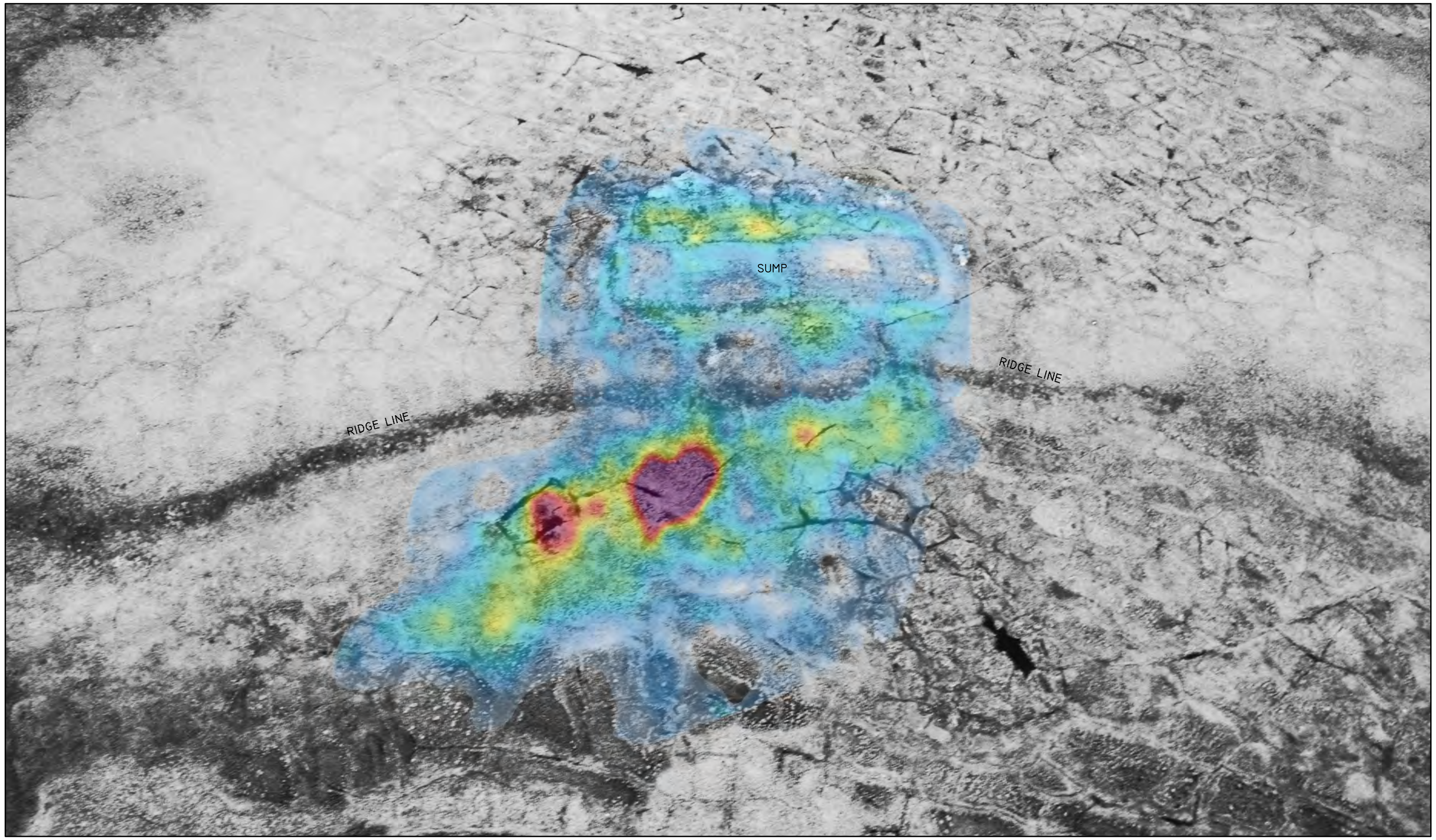
Signature
Date September 6, 2012
PERMIT NUMBER P10762
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

Lateral Conductivity Detail (EM38 & Aerial Underlay)

N
E
W
S

MGM Energy Corp.
Umiak N-16 Sump

Inuvik, Northwest Territories
September 6, 2012



LEGEND

- Curved Feature (road, bush)
- Straight Feature (fence, house)
- Buried Pipe / Utility Line
- Point Feature (sign, pole, tree)
- Geophysical Measurement Station
- Outline (swamp, trees, scrap)

Apparent Conductivity (mS/m)

5 10 15 20 25 30 35 40

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Sr. Geophysicist

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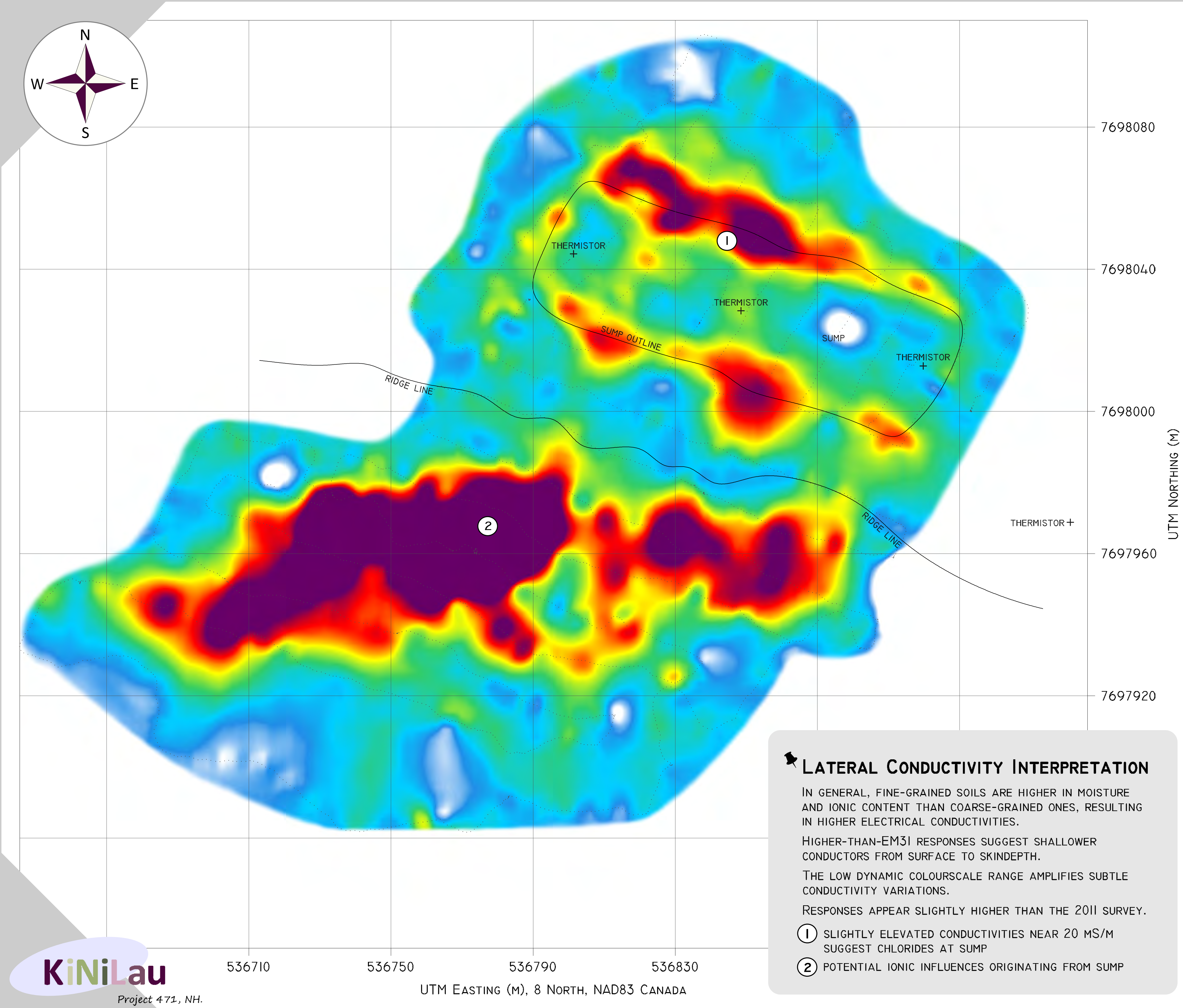

Lateral Conductivity Interpretation

In general, fine-grained soils are higher in moisture and ionic content than coarse-grained ones, resulting in higher electrical conductivities.

Higher-than-EM31 responses suggest shallower conductors from surface to skindepth.

The low dynamic colourscale range amplifies subtle conductivity variations.

Responses appear slightly higher than the 2011 survey.

1. Slightly elevated conductivities near 20 mS/m suggest chlorides at sump
2. Potential ionic influences originating from sump

Lateral Conductivity Detail (EM38)

MGM Energy Corp.
Umiak N-16 Sump

Inuvik, Northwest Territories
September 6, 2012

Legend

- Curved Feature (road, bush)
- Straight Feature (fence, house)
- Buried Pipe / Utility Line
- Interpretation Event
- Point Feature (sign, pole, tree)
- Geophysical Measurement Station
- Outline (swamp, trees, scrap)

Apparent conductivity (mS/m)

4 6 8 10 12 14 16 18 20

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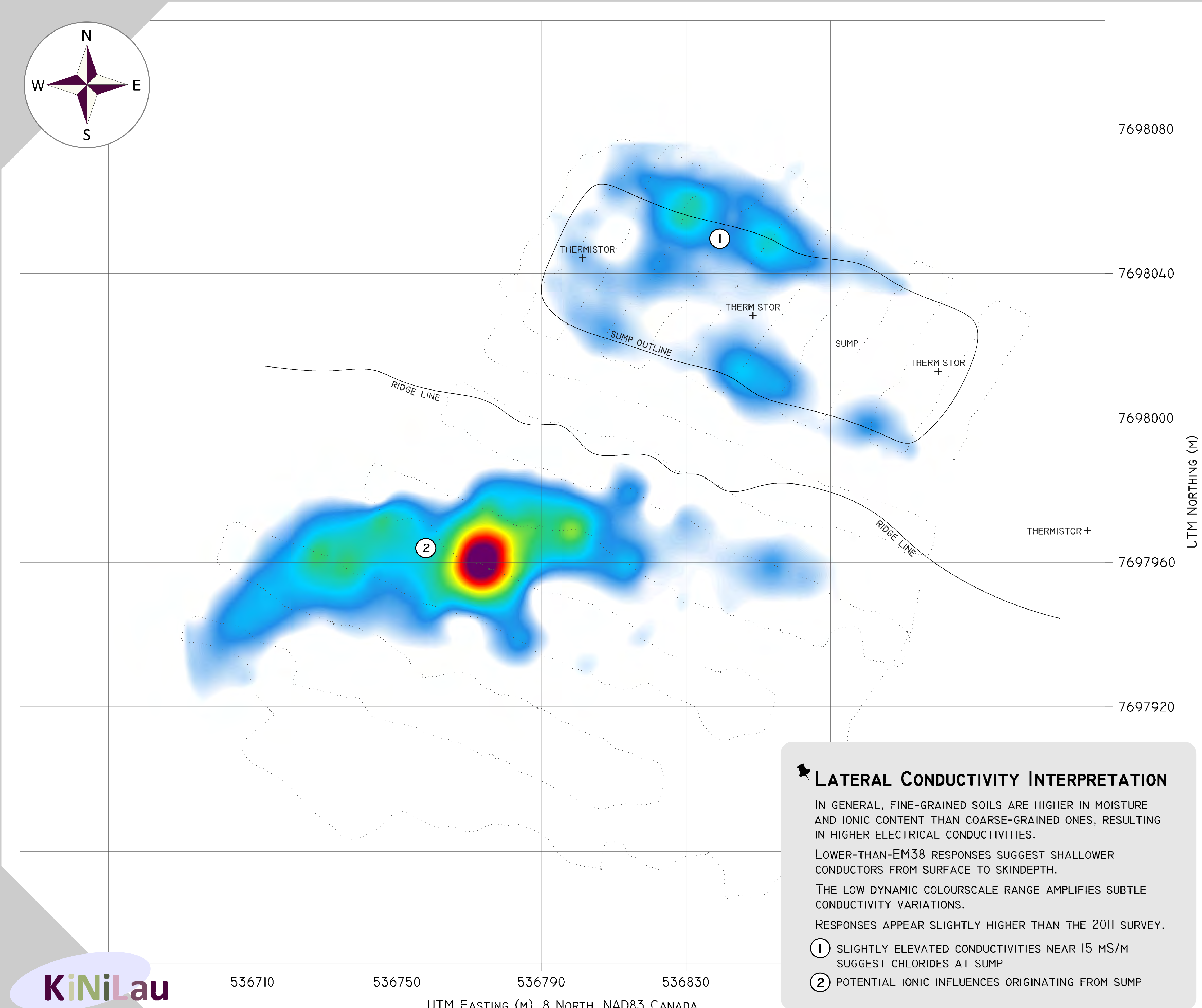

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Lateral Conductivity Detail (EM31)

MGM Energy Corp.
Umiak N-16 Sump

Inuvik, Northwest Territories
September 6, 2012

Legend

- Curved Feature (road, bush)
- Straight Feature (fence, house)
- Buried Pipe / Utility Line
- (1) Interpretation Event
- \+ Point Feature (sign, pole, tree)
- Geophysical Measurement Station
- Outline (swamp, trees, scrap)

Apparent conductivity (mS/m)

5 10 15 20 25 30 35 40

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Lateral Conductivity Interpretation

In general, fine-grained soils are higher in moisture and ionic content than coarse-grained ones, resulting in higher electrical conductivities.

Lower-than-EM38 responses suggest shallower conductors from surface to skindepth.

The low dynamic colourscale range amplifies subtle conductivity variations.

Responses appear slightly higher than the 2011 survey.

1. Slightly elevated conductivities near 15 mS/m suggest chlorides at sump
2. Potential ionic influences originating from sump

Respectfully submitted,
KiNiLau Physics Inc.

Per:

Sean A. Clarke, P.Geoph.
Sr. Geophysicist

Permit to Practice
KiNiLau Physics Inc.

Signature

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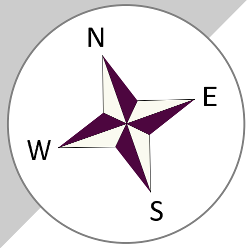
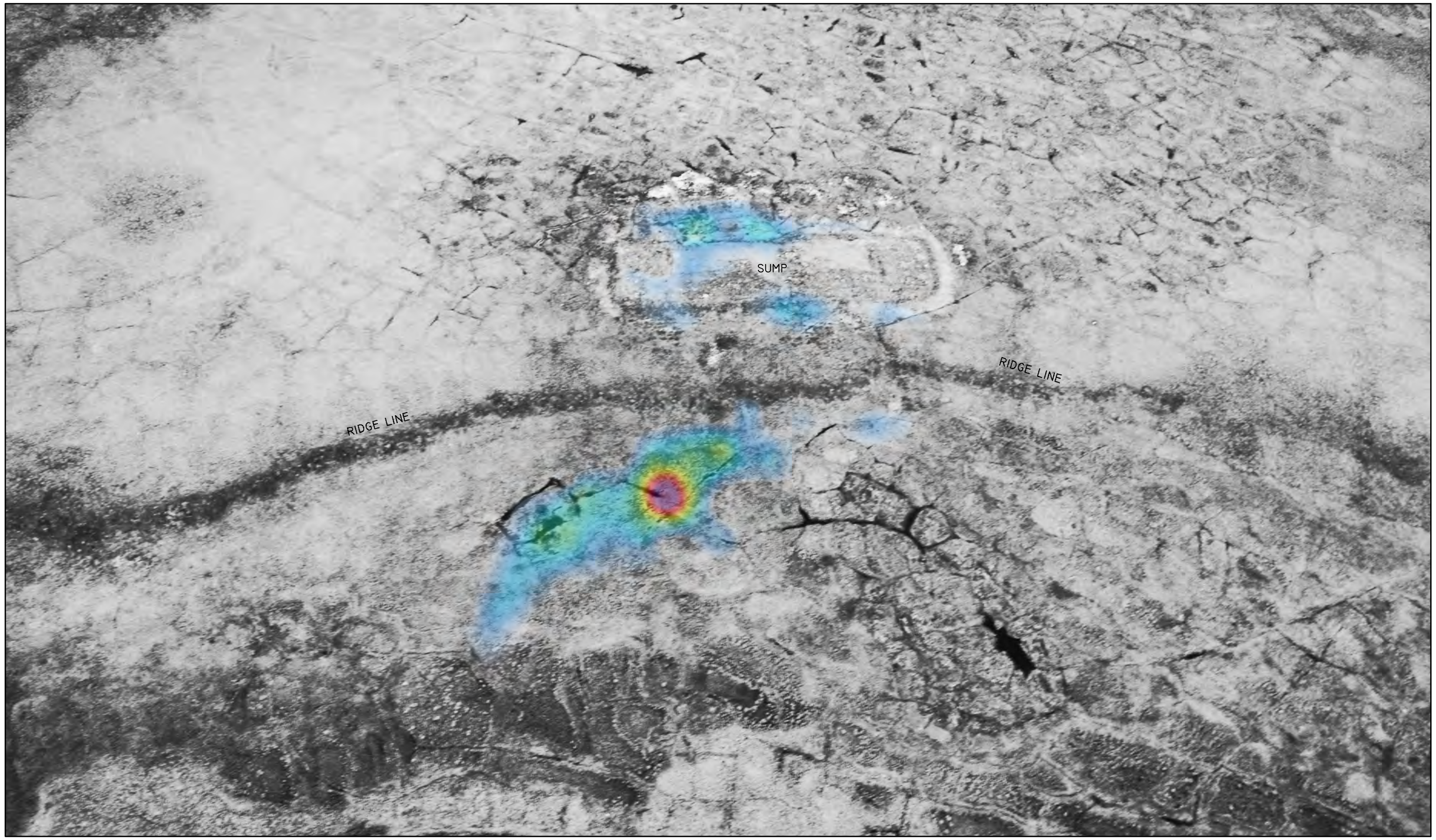


Lateral Conductivity Detail (EM31 & Aerial Underlay)

MGM Energy Corp.
Umiak N-16 Sump

Inuvik, Northwest Territories
September 6, 2012



Legend

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- Straight Feature (fence, house)
- Buried Pipe / Utility Line
- Point Feature (sign, pole, tree)
- Geophysical Measurement Station
- Outline (swamp, trees, scrap)

Apparent Conductivity (mS/m)

5 10 15 20 25 30 35 40

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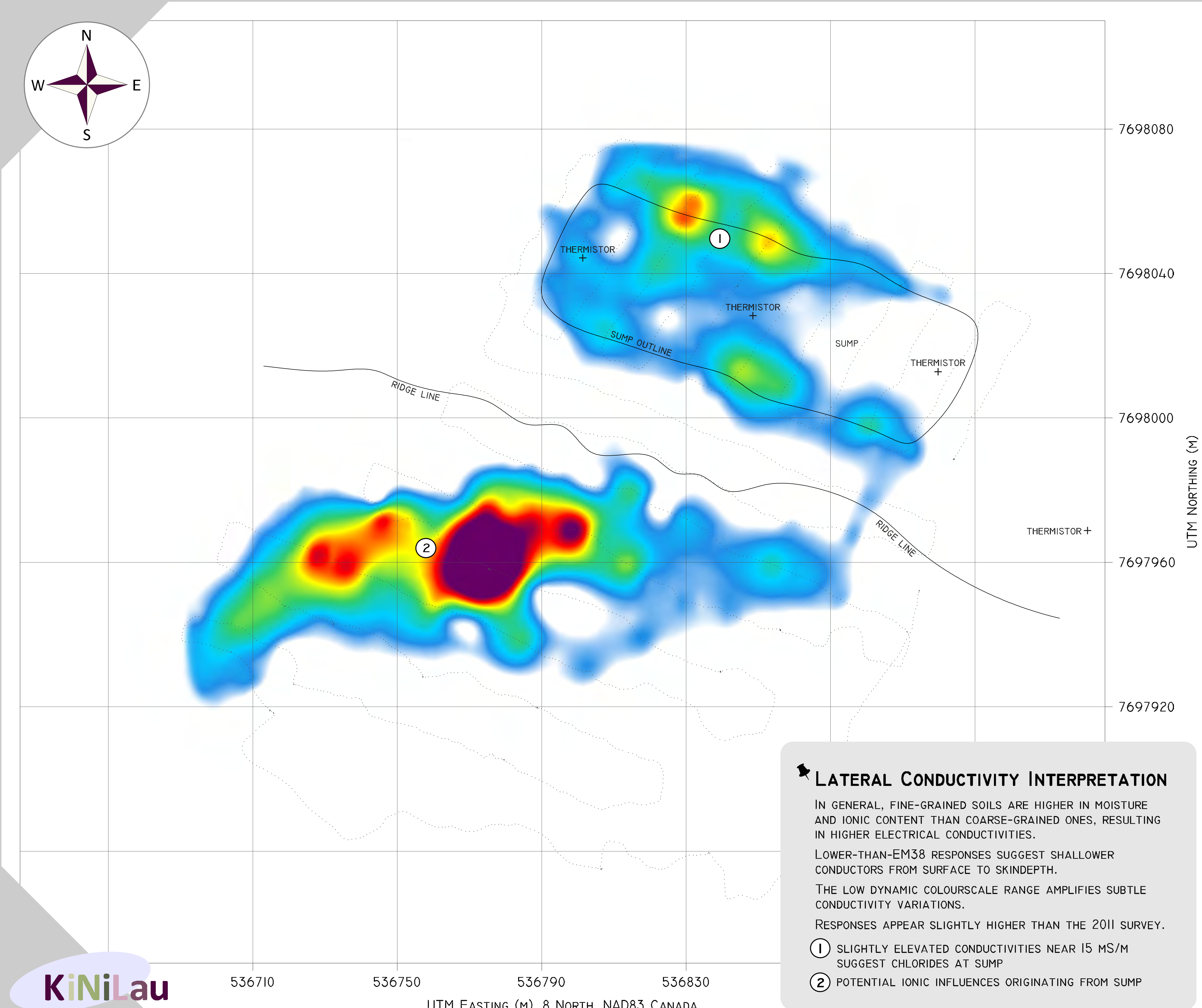

Lateral Conductivity Detail (EM31)

MGM Energy Corp.
Umiak N-16 Sump

Inuvik, Northwest Territories
September 6, 2012

Legend

- Curved Feature (road, bush)
- Straight Feature (fence, house)
- Buried Pipe / Utility Line
- Interpretation Event
- Point Feature (sign, pole, tree)
- Geophysical Measurement Station
- Outline (swamp, trees, scrap)

Apparent conductivity (mS/m)

4 6 8 10 12 14 16 18 20

This single-page Lateral Conductivity Detail serves as all-in-one, comprehensive and graphical reporting tool. Please visit www.kinilau.ca to download a traditional report.

Bluish colors indicate target onset, transitioning to deep maroon with increased significance.

The color soil conductivity image is derived using EM induction and DGPS positioning data. It reveals the conductivity distribution from surface to the varying skindepth of the inductive EM signal. The image does not represent data from any specific depth. Use VC (Vertical Conductivity) data for depth information.

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Lateral Conductivity Interpretation

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SEAN T. CLARKE

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Appendix E 2007 to 2012 EM Survey Figures

Figure E-1 2007 to 2012 EM38 Surveys

Scale:
4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
APPARENT CONDUCTIVITY (MS/M)

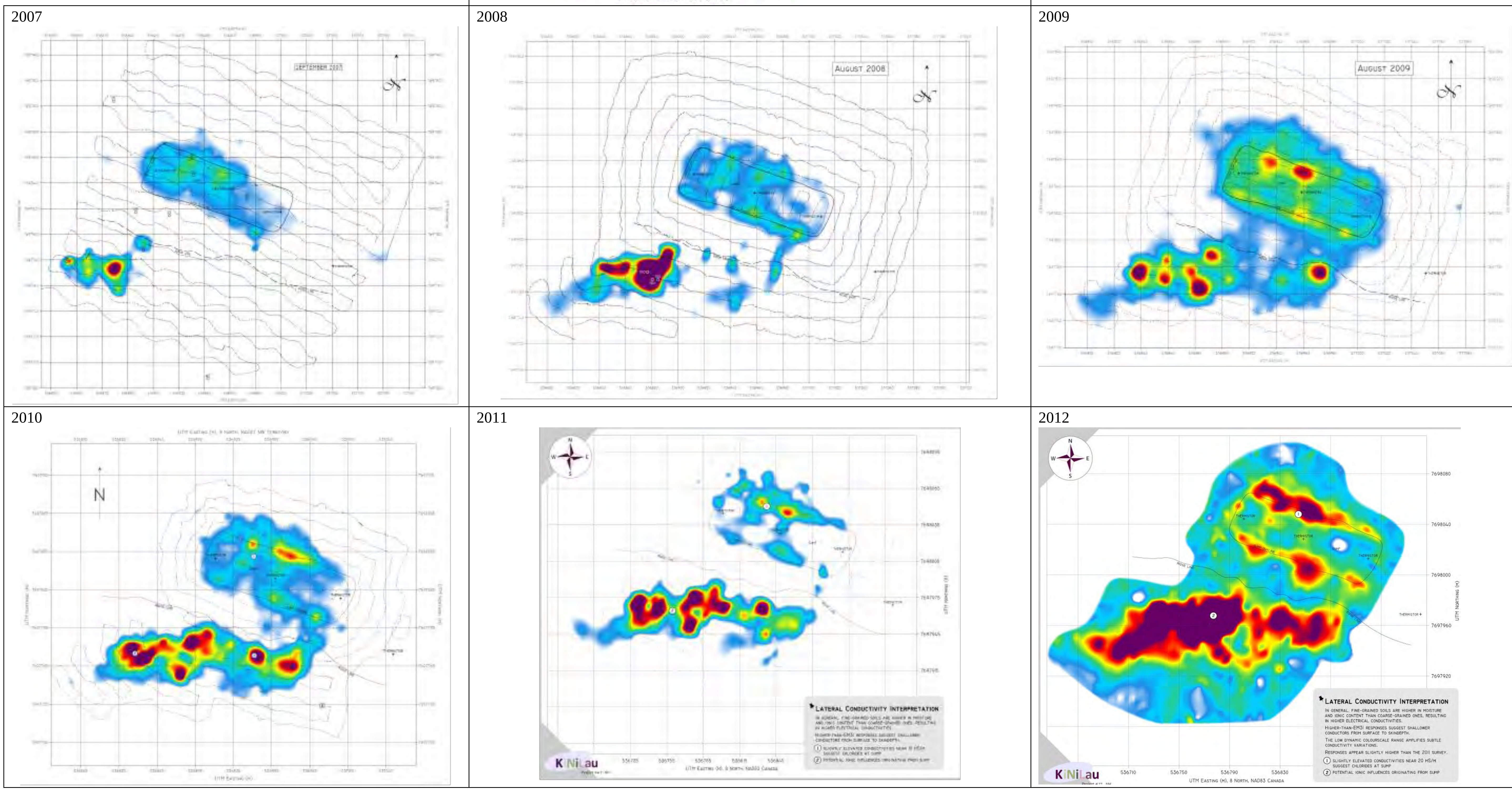
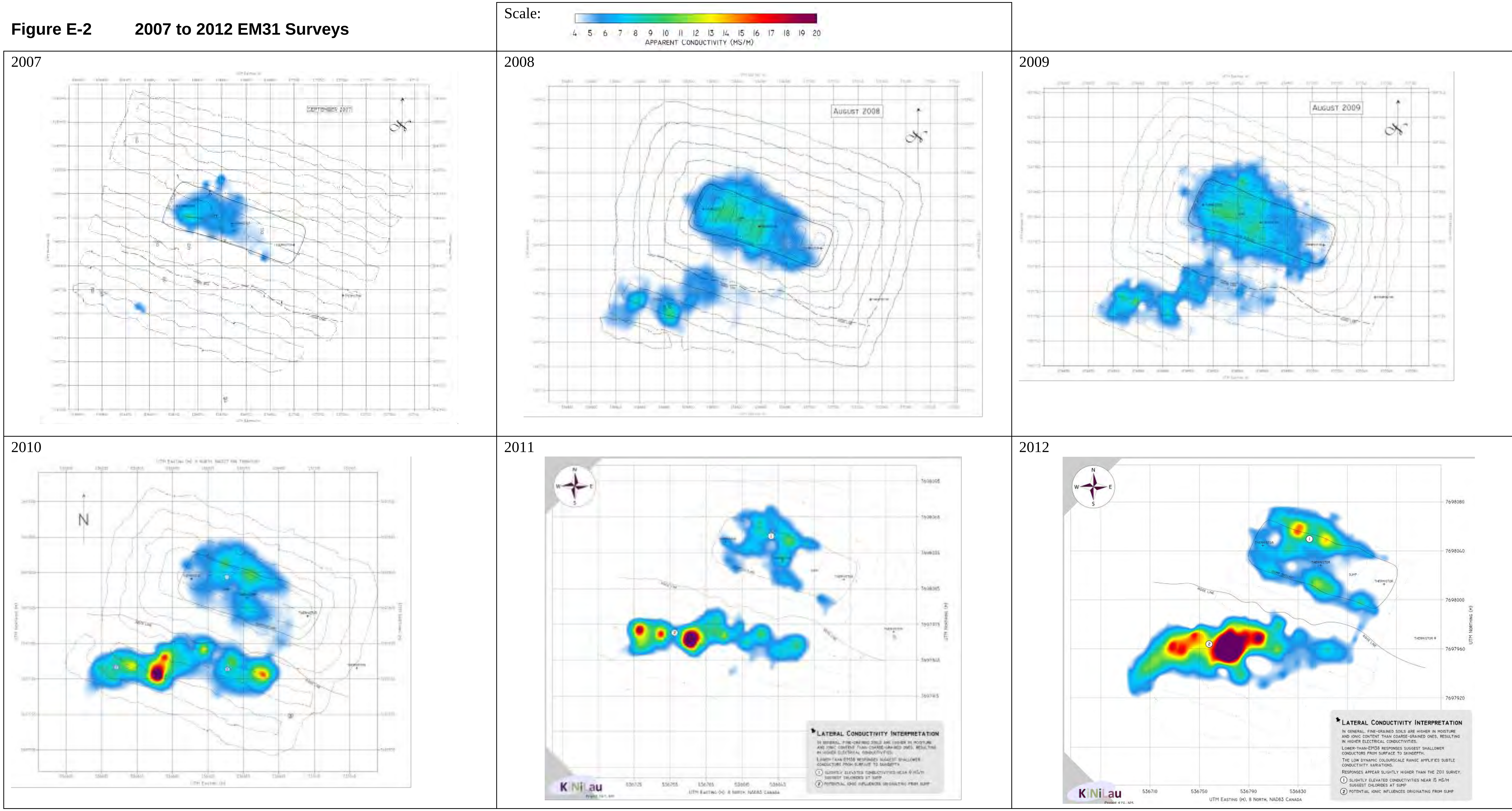


Figure E-2 2007 to 2012 EM31 Surveys



Appendix F Laboratory Analysis

6310 ROPER ROAD
EDMONTON, ALBERTA
CANADA T6B 3P9
TEL (780)395-2525
FAX (780)462-2490
http://www.agatlabs.com

CLIENT NAME: MGM ENERGY CORP.
4100-350 7TH AVE SW
Calgary, AB T2P3N9
(403) 781-7817

ATTENTION TO: Tim Taylor

PROJECT NO: 122300069

AGAT WORK ORDER: 12E642298

SOIL ANALYSIS REVIEWED BY: Jarrod Roberts, Operations Manager

WATER ANALYSIS REVIEWED BY: Shanna Mills, Inorganics Manager

DATE REPORTED: Oct 05, 2012

PAGES (INCLUDING COVER): 7

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (780) 395-2525

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 12E642298

PROJECT NO: 122300069

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CANADA T6B 3P9
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http://www.agatlabs.com

CLIENT NAME: MGM ENERGY CORP.

ATTENTION TO: Tim Taylor

Soil Analysis - Salinity (AB Tier 1 - pH Calcium Chloride)

DATE SAMPLED: Sep 07, 2012 | DATE RECEIVED: Sep 10, 2012 | DATE REPORTED: Oct 05, 2012 | SAMPLE TYPE: Soil

Parameter	Unit	G / S	RDL	Kumok 2012 Soil 1 3712058	Kumok 2012 Soil 2 3712074	Umiak N05-2012 Soil 1 3712075	Umiak N05-2012 Soil 2 3712076	Umiak N05-2012 Soil 3 3712077	Umiak N05-2012 Soil 4 3712080	Umiak N16-2012 Soil 1 3712084	Umiak N16-2012 Soil 2 3712086
pH (CaCl2 Extraction)	pH Units		N/A	3.86	4.82	6.14	4.07	4.18	4.64	3.66	4.46
Electrical Conductivity (Sat. Paste)	dS/m	4	0.01	0.25	1.98	2.27	2.05	2.05	3.43	0.32	3.01
Sodium Adsorption Ratio				0.72	0.44	1.03	3.13	1.00	2.14	0.38	1.25
Saturation Percentage	%		N/A	62	162	69	523	511	834	655	449
Chloride, Soluble	mg/L		5	19	35	342	444	379	667	60	595
Calcium, Soluble	mg/L		1	15	248	258	89	95	73	28	98
Potassium, Soluble	mg/L		2	3	9	28	117	275	627	15	537
Magnesium, Soluble	mg/L		1	11	126	76	42	36	23	9	29
Sodium, Soluble	mg/L		2	15	34	73	143	45	82	9	55
Sulfur (as Sulfate), Soluble	mg/L		2	60	1100	336	12	33	5	12	10
Calcium, Soluble (meq/L)	meq/L		0.05	0.75	12.4	12.9	4.44	4.74	3.64	1.40	4.89
Calcium, Soluble (mg/kg)	mg/kg		1	9	402	178	465	485	609	183	440
Chloride, Soluble (meq/L)	meq/L		0.06	0.54	0.99	9.65	12.5	10.7	18.8	1.69	16.8
Chloride, Soluble (mg/kg)	mg/kg		2	12	57	236	2320	1940	5560	393	2670
Magnesium, Soluble (meq/L)	meq/L		0.08	0.91	10.4	6.25	3.46	2.96	1.89	0.74	2.39
Magnesium, Soluble (mg/kg)	mg/kg		1	7	204	52	220	184	192	59	130
Potassium, Soluble (meq/L)	meq/L		0.05	0.08	0.23	0.72	2.99	7.03	16.0	0.38	13.7
Potassium, Soluble (mg/kg)	mg/kg		2	<2	15	19	612	1410	5230	98	2410
Sodium, Soluble (meq/L)	meq/L		0.09	0.65	1.48	3.18	6.22	1.96	3.57	0.39	2.39
Sodium, Soluble (mg/kg)	mg/kg		2	9	55	50	748	230	684	59	247
Sulfur (as Sulfate), Soluble (meq/L)	meq/L		0.04	1.25	22.9	7.00	0.25	0.69	0.10	0.25	0.21
Sulfur (as Sulfate), Soluble (mg/kg)	mg/kg		2	37	1780	232	63	169	42	79	45
Theoretical Gypsum Requirement	tonnes/ha			0	0	0	0	0	0	0	0

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to CCME (Ind,F)

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Certificate of Analysis

AGAT WORK ORDER: 12E642298

PROJECT NO: 122300069

CLIENT NAME: MGM ENERGY CORP.

ATTENTION TO: Tim Taylor

Routine Chemistry Water Analysis

DATE SAMPLED: Sep 07, 2012 | DATE RECEIVED: Sep 10, 2012 | DATE REPORTED: Oct 05, 2012 | SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	Ellice 2012 W1 3712087	Ellice 2012 W2 3712088	Kumok 2012 WS 01 3712089	Kumok 2012 WS 02 3712090	Umiak N-05 WS 01 3712091	Umiak N-05 WS 02 3712098	Umiak N-05 WS 03 3712099	Umiak N-05 WS 04 3712100
pH	pH Units	6 - 8	NA	8.02	7.95	7.73	6.16	6.72	3.76	6.40	4.10
p - Alkalinity (as CaCO3)	mg/L		5	<5	<5	<5	<5	<5	<5	<5	<5
T - Alkalinity (as CaCO3)	mg/L		5	158	161	360	12	136	<5	78	<5
Bicarbonate	mg/L		5	193	196	439	17	166	<5	96	<5
Carbonate	mg/L		5	<5	<5	<5	<5	<5	<5	<5	<5
Hydroxide	mg/L		5	<5	<5	<5	<5	<5	<5	<5	<5
Electrical Conductivity	uS/cm	4	1	4150	4770	3960	63	6460	2910	9740	4850
Fluoride	mg/L	2000	0.05	<0.05	0.08	<0.05	<0.05	0.06	0.2	0.6	0.3
Chloride	mg/L		1	1210	1370	3	4	1820	857	2910	1600
Nitrite	mg/L		0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrate	mg/L		0.5	1	0.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sulfate	mg/L		1	124	159	2580	4	2	6	4	6
Dissolved Calcium	mg/L		0.3	201	240	550	6.0	251	123	285	312
Dissolved Magnesium	mg/L		0.2	89.3	101	434	3.3	108	53.6	124	171
Dissolved Sodium	mg/L		0.6	564	602	95.1	3.5	221	143	232	293
Dissolved Potassium	mg/L		0.6	3.5	51.2	10.2	1.1	921	302	1770	144
Dissolved Iron	mg/L		0.1	<0.1	<0.1	<0.1	0.7	131	1.3	120	1.3
Dissolved Manganese	mg/L		0.005	<0.005	0.017	0.646	0.116	5.43	4.23	5.11	5.43
Calculated TDS	mg/L		1	2290	2620	3890	29	3400	1480	5370	2530
Hardness	mg CaCO3/L		1	870	1020	3160	29	1070	528	1220	1480
Ion Balance	%			105	106	111	167	111	103	101	103
Nitrate + Nitrite-N	mg/L		0.01	0.23	0.18	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate-N	mg/L		0.113	0.226	0.181	<0.113	<0.113	<0.113	<0.113	<0.113	<0.113
Nitrite-N	mg/L		0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015

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Certificate of Analysis

AGAT WORK ORDER: 12E642298

PROJECT NO: 122300069

CLIENT NAME: MGM ENERGY CORP.

ATTENTION TO: Tim Taylor

Routine Chemistry Water Analysis

DATE SAMPLED: Sep 07, 2012 | DATE RECEIVED: Sep 10, 2012 | DATE REPORTED: Oct 05, 2012 | SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	Umiak N-05 WS 05 3712101	Umiak N-05 WS 06 3712102	Umiak N-05 WS 07 3712104	Umiak N16 WS 01 3712105	Umiak N16 WS 02 3712106	Umiak N16 WS 03 3712108	Umiak N16 WS 04 3712109
pH	pH Units	6 - 8	NA	5.57	6.49	7.29	6.70	5.32	3.47	3.84
p - Alkalinity (as CaCO3)	mg/L		5	<5	<5	<5	<5	<5	<5	<5
T - Alkalinity (as CaCO3)	mg/L		5	7	42	360	34	<5	<5	<5
Bicarbonate	mg/L		5	14	51	438	41	8	<5	<5
Carbonate	mg/L		5	<5	<5	<5	<5	<5	<5	<5
Hydroxide	mg/L		5	<5	<5	<5	<5	<5	<5	<5
Electrical Conductivity	uS/cm	4	1	2800	5140	7440	180	4180	5710	1720
Fluoride	mg/L	2000	0.05	0.2	0.3	0.1	<0.05	<0.05	0.2	<0.05
Chloride	mg/L		1	890	1390	1630	27	1160	1760	470
Nitrite	mg/L		0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrate	mg/L		0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sulfate	mg/L		1	72	410	1540	5	90	69	27
Dissolved Calcium	mg/L		0.3	101	298	957	19.5	260	248	108
Dissolved Magnesium	mg/L		0.2	38.2	73.9	216	8.0	68.5	80.7	36.6
Dissolved Sodium	mg/L		0.6	254	162	307	9.3	80.2	116	37.6
Dissolved Potassium	mg/L		0.6	230	760	349	6.2	514	858	165
Dissolved Iron	mg/L		0.1	4.1	0.7	1.9	2.2	2.6	24.4	4.9
Dissolved Manganese	mg/L		0.005	12.8	15.6	17.9	0.053	2.82	1.88	0.373
Calculated TDS	mg/L		1	1590	3120	5220	95	2170	3130	844
Hardness	mg CaCO3/L		1	410	1050	3280	82	931	952	420
Ion Balance	%			100	102	106	148	103	92.2	105
Nitrate + Nitrite-N	mg/L		0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate-N	mg/L		0.113	<0.113	<0.113	<0.113	<0.113	<0.113	<0.113	<0.113
Nitrite-N	mg/L		0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to CCME (Ind,F)

3712087-3712089 < - Values refer to Report Detection Limits.

3712090 < - Values refer to Report Detection Limits.
*Ion Balance has been verified.

3712091-3712104 < - Values refer to Report Detection Limits.

3712105 < - Values refer to Report Detection Limits.
* Ion Balance has been verified.

3712106-3712109 < - Values refer to Report Detection Limits.

Certified By: [signature]

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Quality Assurance

CLIENT NAME: MGM ENERGY CORP. AGAT WORK ORDER: 12E642298

PROJECT NO: 122300069 ATTENTION TO: Tim Taylor

Soil Analysis

RPT Date: Oct 05, 2012			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Soil Analysis - Salinity (AB Tier 1 - pH Calcium Chloride)															
pH (CaCl2 Extraction)	354	3764265	6.16	6.26	1.6%	N/A	98%	90%	110%						
Electrical Conductivity (Sat. Paste)	354	3764265	0.25	0.25	0.0%	< 0.01	103%	90%	110%						
Saturation Percentage	352	3764265	62	62	0.0%	N/A	90%	80%	120%						
Chloride, Soluble	386	3749005	7	8	13.3%	< 5	91%	80%	120%	86%	80%	120%	90%	80%	120%
Calcium, Soluble	111	3749005	28	28	0.0%	< 1	102%	80%	120%				114%	80%	120%
Potassium, Soluble	111	3749005	4	4	0.0%	< 2	94%	80%	120%				98%	80%	120%
Magnesium, Soluble	111	3749005	8	9	11.8%	< 1	103%	80%	120%				107%	80%	120%
Sodium, Soluble	111	3749005	30	30	0.0%	< 2	94%	80%	120%				98%	80%	120%
Sulfur (as Sulfate), Soluble	111	3749005	18	17	5.7%	< 2	89%	80%	120%				87%	80%	120%

Comments: N/A: Not applicable

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Quality Assurance

CLIENT NAME: MGM ENERGY CORP.

AGAT WORK ORDER: 12E642298

PROJECT NO: 122300069

ATTENTION TO: Tim Taylor

Water Analysis

RPT Date: Oct 05, 2012			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Routine Chemistry Water Analysis															
pH	211	3712087	8.03	8.02	0.1%		100%	90%	110%						
T - Alkalinity (as CaCO3)	211	3712087	159	158	0.6%	< 5	94%	80%	120%						
Bicarbonate	211	3712087	194	193	0.5%	< 5									
Electrical Conductivity	211	3712087	4180	4150	0.7%	< 1	96%	90%	110%						
Fluoride	211	3758334	0.05	0.06	18.2%	< 0.05	95%	80%	120%	93%	80%	120%	92%	80%	120%
Chloride	211	3758334	18	18	0.0%	< 1	95%	80%	120%	96%	80%	120%	99%	80%	120%
Nitrite	211	3758334	< 0.05	< 0.05	0.0%	< 0.05	103%	80%	120%	97%	80%	120%	96%	80%	120%
Nitrate	211	3758334	< 0.5	< 0.5	0.0%	< 0.5	96%	80%	120%	97%	80%	120%	96%	80%	120%
Sulfate	211	3758334	3	3	0.0%	< 1	100%	80%	120%	99%	80%	120%	101%	80%	120%
Dissolved Calcium	392	3712087	193	201	4.1%	< 0.3	106%	80%	120%				101%	80%	120%
Dissolved Magnesium	392	3712087	89.4	89.3	0.2%	< 0.2	104%	80%	120%				107%	80%	120%
Dissolved Sodium	392	3712087	550	564	2.5%	< 0.6	108%	80%	120%				101%	80%	120%
Dissolved Potassium	392	3712087	3.6	3.5	1.2%	< 0.6	92%	80%	120%				105%	80%	120%
Dissolved Iron	392	3712087	<0.1	<0.1	0.0%	< 0.1	104%	80%	120%				105%	80%	120%
Dissolved Manganese	392	3712087	<0.005	<0.005	0.0%	< 0.005	104%	80%	120%				102%	80%	120%

Comments: N/A - Not Available.

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Method Summary

CLIENT NAME: MGM ENERGY CORP. AGAT WORK ORDER: 12E642298

PROJECT NO: 122300069 ATTENTION TO: Tim Taylor

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
pH (CaCl2 Extraction)	INOR-171-6207	SHEPPARD 2007; HENDERSHOT 2008	PH METER
Electrical Conductivity (Sat. Paste)	INOR-171-6208	SHEPPARD 2007; MILLER 2007	CONDUCTIVITY METER
Sodium Adsorption Ratio	INOR-171-6201 & INOR-171-6002	McKeague 3.26	CALCULATION
Saturation Percentage	INOR-171-6002	MILLER 2007; SHEPPARD 2007	GRAVIMETRIC
Chloride, Soluble	INOR-171-6200 & INOR-171-6002	SHEPPARD 2007, EATON 2005	CONTINUOUS FLOW ANALYZER
Calcium, Soluble	INOR-171-6201 & INOR-171-6002	SHEPPARD 2007; EATON 2005; MILLER 2007, SM 3120B	ICP/OES
Potassium, Soluble	INOR-171-6201 & INOR-171-6002	SHEPPARD 2007; EATON 2005; MILLER 2007, SM 3120B	ICP/OES
Magnesium, Soluble	INOR-171-6201 & INOR-171-6002	SHEPPARD 2007; EATON 2005; MILLER 2007, SM 3120B	ICP/OES
Sodium, Soluble	INOR-171-6201 & INOR-171-6002	SHEPPARD 2007; EATON 2005; MILLER 2007, SM 3120B	ICP/OES
Sulfur (as Sulfate), Soluble	INOR-171-6201 & INOR-171-6002	SHEPPARD 2007; EATON 2005; MILLER 2007, SM 3120B	ICP/OES
Water Analysis			
pH	INOR-171-6205	SM 4500 H+	PC Titrate
p - Alkalinity (as CaCO3)	INOR-171-6205	SM 2320 B	PC Titrate
T - Alkalinity (as CaCO3)	INOR-171-6205	SM 2320 B	PC Titrate
Bicarbonate	INOR-171-6205	SM 2320 B	PC Titrate
Carbonate	INOR-171-6205	SM 2320 B	PC Titrate
Hydroxide	INOR-171-6205	SM 2320 B	PC Titrate
Electrical Conductivity	INOR-171-6205	SM 2510 B	PC Titrate
Fluoride	INOR-171-6200	SM 4110 B	ION CHROMATOGRAPH
Chloride	INOR-171-6200	SM 4110 B	ION CHROMATOGRAPH
Nitrite	INOR-171-6200	SM 4110 B	ION CHROMATOGRAPH
Nitrate	INOR-171-6200	SM 4110 B	ION CHROMATOGRAPH
Sulfate	INOR-171-6200	SM 4110 B	ION CHROMATOGRAPH
Dissolved Calcium	INOR-171-6201, INOR-171-6100	SM 3120 B	ICP/OES
Dissolved Magnesium	INOR-171-6201, INOR-171-6100	SM 3120 B	ICP/OES
Dissolved Sodium	INOR-171-6201, INOR-171-6100	SM 3120 B	ICP/OES
Dissolved Potassium	INOR-171-6201, INOR-171-6100	SM 3120 B	ICP/OES
Dissolved Iron	INOR-171-6201, INOR-171-6100	SM 3120 B	ICP/OES
Dissolved Manganese	INOR-171-6201, INOR-171-6100	SM 3120 B	ICP/OES