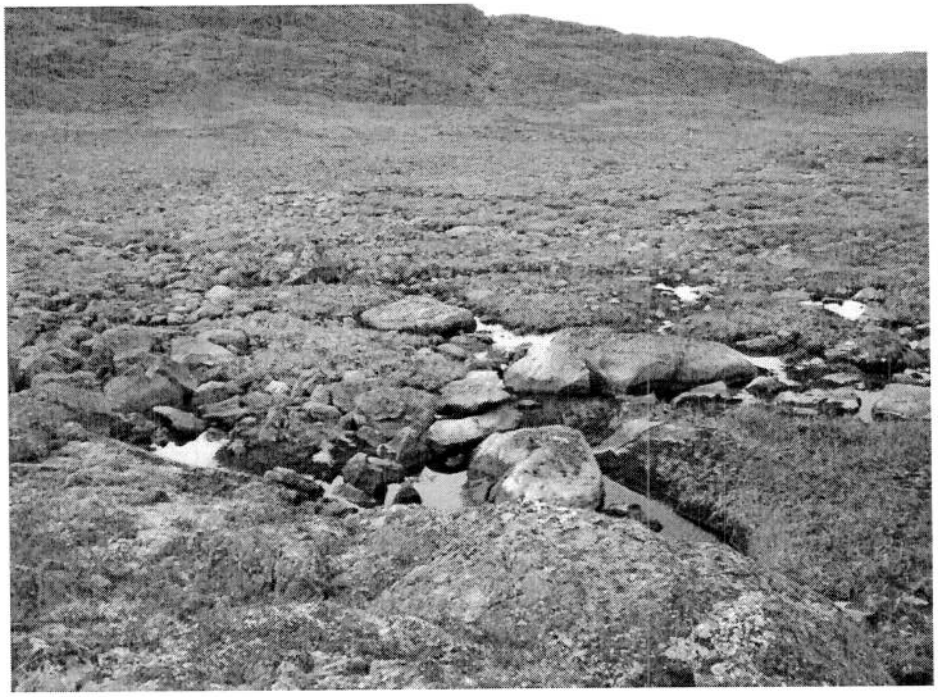
Appendix B

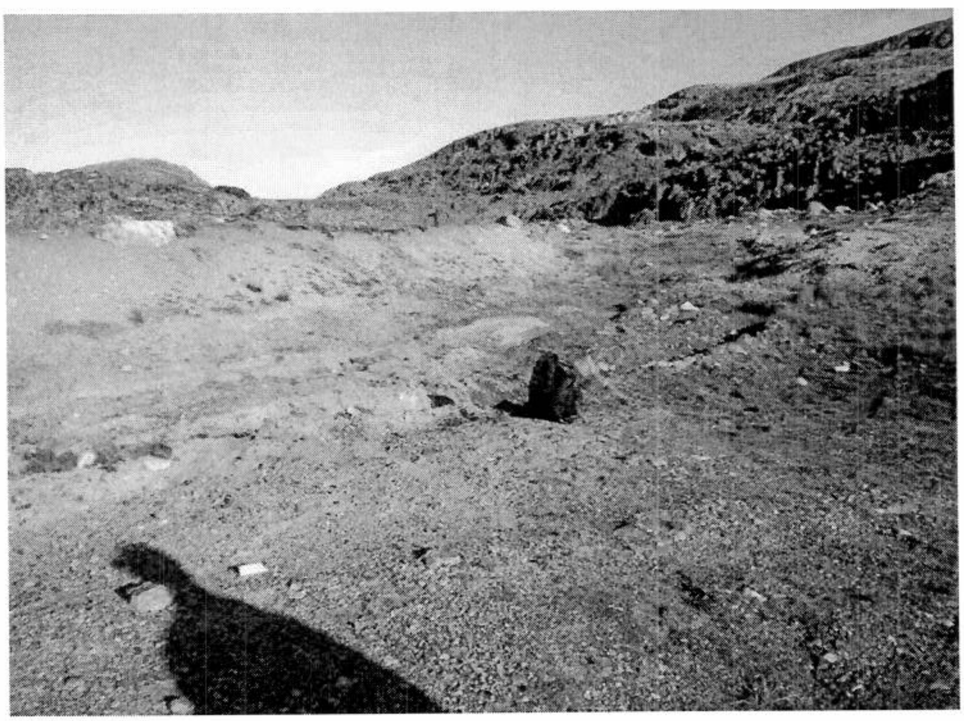
Plates: Select Photographs



Photograph 3: Lagoon Impoundment, looking north from center.

Photograph 4: Southeast corner of Lagoon Impoundment

Photograph 5: Potential clay borrow material near community dump.



Photograph 6: Potential clay borrow material near airport.

Appendix C

Sieve Analysis Reports

SIEVE ANALYSIS REPORT

AMEC Earth & Environmental Limited

amec

To: Dillon Consulting Limited
303 4920 47 Street
Goga Cho Building
Yellowknife, Northwest Territories

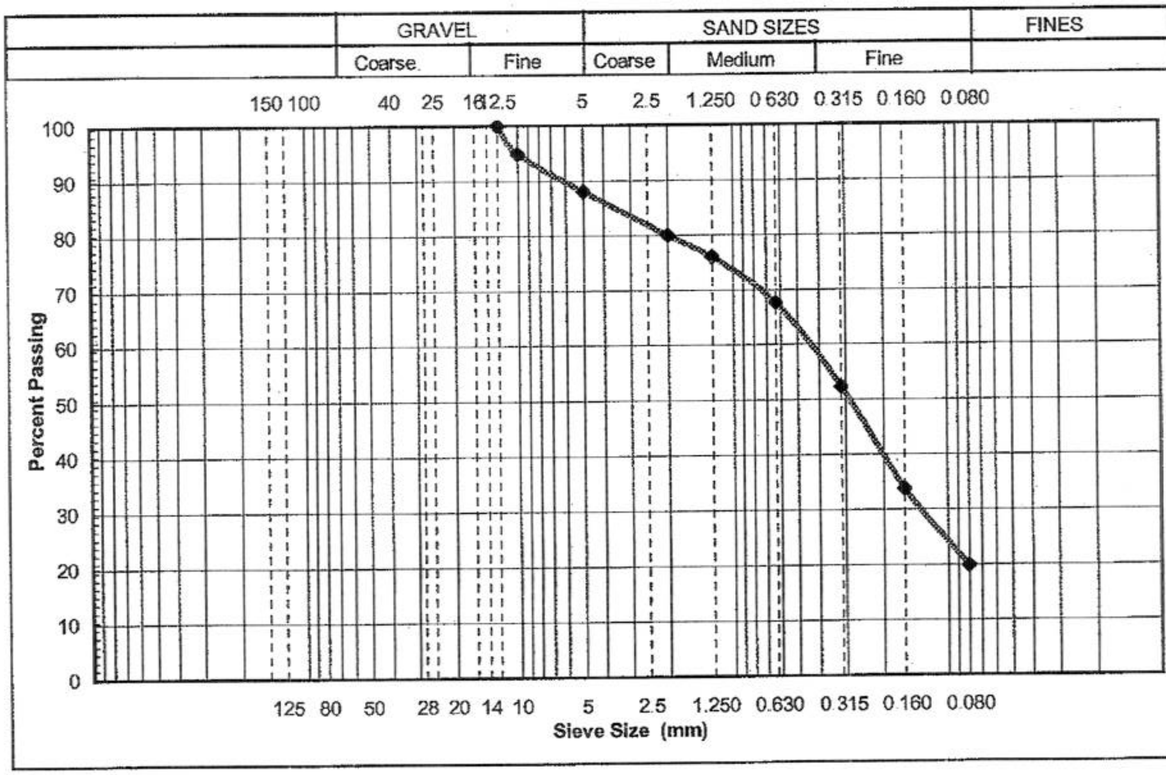
Office : Yellowknife
Project No: YX00748
Client : Dillon Consulting Limited
Copies to :

Attn: Mr. Gary Strong

Project: Investigation of borrow material

Sample ID: 748-02 **Sample Type:** Sandy Silty Clay **Sampled By:** AMEC

Date Sampled: Aug 10 2005 **Date Received:** Aug 15 2005 **Date Tested:** Aug 18 2005



Sieve Size	% Passing
150.0	
125.0	
100.0	
80.0	
50.0	
40.0	
28.0	
25.0	
20.0	
16.0	
14.0	
12.5	100
9.5	95
4.75	88
2.00	80
1.250	76
0.630	68
0.425	52
0.160	34
0.080	19.9

Source: Borrow Pit Cape Dorset, Near CG&S Building , near the airport
Sample Description: Sandy Silty Clay 18W 0425 451 N7 122 814
Comments : Moisture content 14.4%

AMEC Earth & Environmental Limited

Per: ____________

Reporting of these test results constitutes a testing service only Engineering interpretation or evaluation of the test results is provided only on written request.

SIEVE ANALYSIS REPORT

AMEC Earth & Environmental Limited

amec

To: Dillon Consulting Limited
303 4920 47 Street
Goga Cho Building
Yellowknife, Northwest Territories

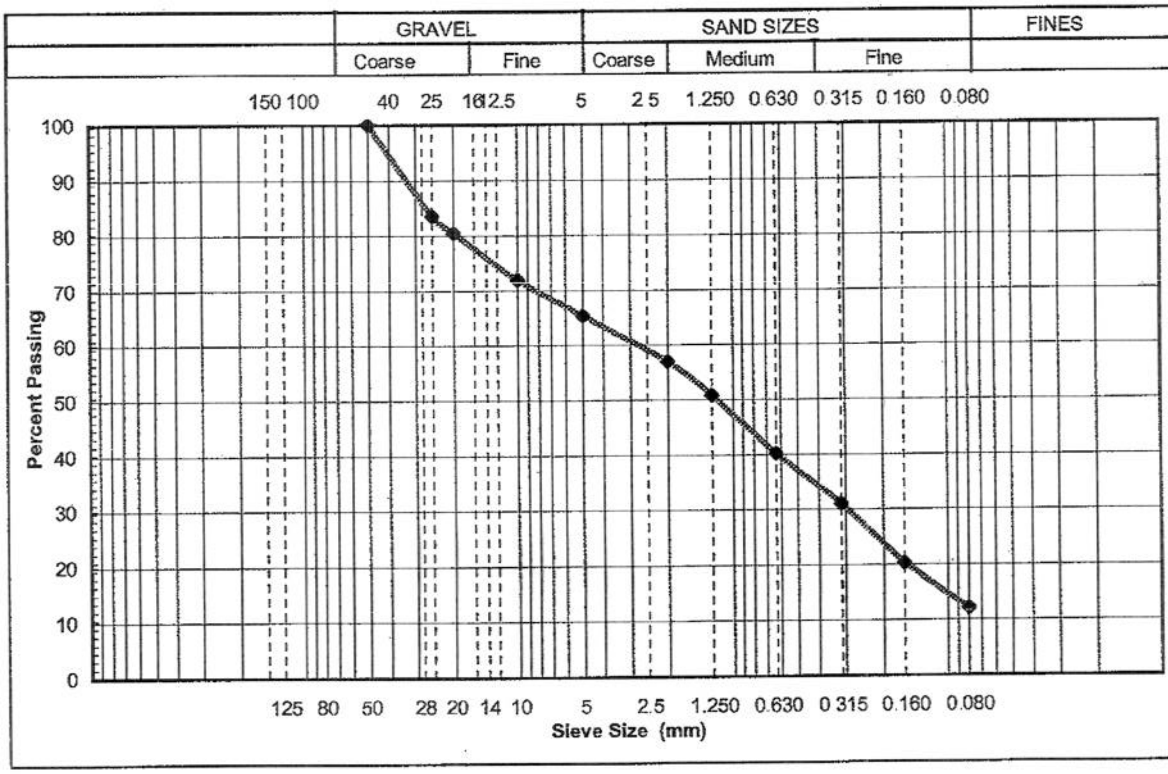
Office : Yellowknife
Project No: YX00748
Client : Dillon Consulting Limited
Copies to :

Attn: Mr. Gary Strong

Project: Investigation of borrow material

Sample ID: 748-01 **Sample Type:** Sandy Silty Clay **Sampled By:** AMEC

Date Sampled: Aug 10 2005 **Date Received:** Aug 15 2005 **Date Tested:** Aug 18 2005



Sieve Size	% Passing
150.0	
125.0	
100.0	
80.0	
50.0	100
40.0	
28.0	
25.0	84
20.0	80
16.0	
14.0	
12.5	
9.5	72
4.75	65
2.00	57
1.250	51
0.630	40
0.425	31
0.160	20
0.080	12.1

Source: Borrow Pit Cape Dorset, Near Landfill 18W 0423 046 N7 122 801
Sample Description: Sandy Silty Clay
Comments : Moisture content 8.8%

AMEC Earth & Environmental Limited

Per: ____________

Reporting of these test results constitutes a testing service only. Engineering interpretation or evaluation of the test results is provided only on written request.

APPENDIX-C:

THERMISTORS TEMPERATURE DATA ANALYSIS

(2010)

March 26, 2010
YX00826.100

Government of Nunavut, Baffin Region
Department of Community and Government Services
P.O. Box 379
Pond Inlet, NU, X0A 0S0

Attention: Mr. Bhabesh Roy, M.A.Sc, P.Eng.

Dear Mr. Roy:

Re: Temperature Data Review for Sewage Lagoon Dyke, Cape Dorset, Nunavut.

1.0 INTRODUCTION

At the request of Mr. Bhabesh Roy, P.Eng, Municipal Planning Engineer of the Government of Nunavut, Baffin Region, Department of Community and Government Services (DCGS), AMEC Earth & Environmental (AMEC), a division of AMEC Americas Limited completed a review of temperature data from the Sewage Lagoon Dyke in Cape Dorset, NU. The purpose of the work was to review recorded temperature data from the dyke, compare it with the predicted dyke temperatures developed during design and construction phases using geothermal analysis, and provide conclusions and recommendations relative to dyke performance as would be considered appropriate.

2.0 BACKGROUND INFORMATION

The design and construction of the cape Dorset sewage lagoon dykes was supported by a series of geotechnical reports and documents prepared by AMEC in 2005 thought to 2007. A list of the geotechnical reports and documents is presented below.

1. Geotechnical Investigation for P-Lake Sewage Lagoon, October 2005.
Geotechnical investigation included field reconnaissance, geothermal modeling of the main dyke, recommendations on the main dyke design, and identification of borrow sources.

2. AMEC Responses to Nunavut Water Board Review, July 2006.
Majority of the responses were related to permafrost conditions and boundary conditions applied in the geothermal modeling. It was explained also in the responses that the slope stability and seepage analyses have not been undertaken due to a predicted presence of the frozen core inside the dyke. However, such analyses were carried out at a later date, assuming that no frozen core will be created in the dyke.

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3. Geotechnical Investigation - Sewage Lagoon, November 2006.
Twenty-two boreholes and two test pits were advanced, ranging in depth from 0.2 m to 3.1 m. The boreholes and test pits confirmed that the soil and permafrost conditions at the site are in a

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close agreement with the assumed subsurface conditions described in the AMEC geotechnical report dated October, 2005.

4. Examination of Drawings, September 2006.
Comments on drawings issued for construction of the Cape Dorset sewage lagoon, have been provided. A review was completed on the drawings. A "fatal-flaw" due-diligence examination was not completed.

5. Cut-off Trench Excavation Sewage Lagoon Berms Construction Monitoring, August 2007.
Construction of the cut-off trenches for the sewage lagoon dykes was inspected. The depth of the cut-off trenches and exposed subsurface materials were inspected to confirm that the trench depths were in accordance with the design specifications.

6. Additional Geotechnical Analysis for P-Lake Sewage Lagoon, August 2007.
Geothermal modeling was carried out based on as built information and soil conditions obtained during dyke construction. The geothermal analysis also included a revised schedule of lagoon filling. Slope stability analyses were also undertaken for the dyke and various road sections.

7. Additional Stability and Seepage Analysis for P-Lake Sewage Lagoon, November 2007.
Stability of the upstream slope under rapid drawdown conditions was analysed. Seepage analysis for the case assuming a presence of liner defects was also carried out.

8. Technical Specification for Thermistor String Installation in Berms of New Sewage Lagoon, May 2008.
Technical specifications for drilling, installation of thermistor strings, and frequency of temperature measurements were provided.

9. Sewage Lagoon Berm Inspection, October 2008.
A field inspection of the dyke was conducted to determine possible causes of the dyke leak. Recommendations have been provided to stop the main berm leak.

3.0 LAGOON OPERATION HISTORY

It is understood that no sewage water has been discharged into the lagoon impoundment up to the end of the temperature data provided (December 2009). However, the valve controlling the lagoon drainage pipe was closed in July, 2008, and a significant amount of runoff water was able to accumulate in the lagoon impoundment. In late September, 2008, the water depth in the lagoon impoundment was about 2.0 m. The valve, controlling the lagoon drainage pipe, was re-opened on September 30, 2008, resulting in drainage of the runoff water from the lagoon impoundment into P-Lake.

4.0 THERMISTOR STRING INSTALLATION

Thermistor strings were installed in boreholes using an air rotary drill rig owned by Canadrill (Iqaluit). The diameters of the boreholes were 150 mm to 100 mm, and depth of the drilling was 18.8 m. An electrical metallic tubing (EMT), 12 mm inside diameter, was installed in each borehole to house the thermistor string at each location. EMT couplings and caps were used to assemble the tubes into a single conduit. The thermistor string was then installed in the assembled conduit, and the conduit was placed into the drilled borehole. The annulus between the conduit and the borehole wall was filled with sand.

5.0 TEMPERATURE DATA REVIEW AND COMPARISON

Dyke/soil temperatures have been monitored for approximately one year, starting from November 20th, 2008 to December 4, 2009.

Three thermistor strings (Loggers 1, 2, and 3) have been installed along the main west dyke, while the forth thermistor string was located near the middle of the smaller east dyke. Locations of the thermistor strings are shown on Figure 1, Appendix A. The highest thermistor sensor at each location was installed about 1 m above the ground surface, and the remaining thermistor sensors were installed below the ground surface at the following depths: 1.6 m, 4.2 m, 6.8 m, 9.4 m, 11 m, 14.6 m, and 18.8 m.

The temperature data was provided to AMEC, by DCGS, on drawings and electronically in a spreadsheet (November 2008 to December 2009). The drawings showed the measured temperature for selected 30 – day intervals and are presented in Appendix B. The review was conducted using the information from the spreadsheets in conjunction with the data, as presented on the drawings.

Logger 1.

The drawings comprise four sets of data from December 15, 2008 to January 15, 2009, from April 15, 2009 to May 15, 2009, from July 1, 2009 to August 1, 2009, and from October 1, 2009 to November 1, 2009. Drawings showing dyke temperatures at various depths for selected periods of time are presented in Appendix B. Dyke temperatures for various depths and selected dates are also shown at Figure 2, Appendix A.

Dyke fill and native soil temperature was observed to be below 0 °C in December and January. The maximum temperature (about -0.2 °C) was measured at a depth of 4.2 m, and the minimum temperature was observed at a depth of 18.8 m (-3.6 °C). It is interesting to note that the dyke temperature at the 1.6 m (about -0.9 °C) is colder than at the 4.2 m depth. This is considered to be due to cooling effect of cold air temperatures.

Analysis of temperature data from April 15 to May 15, 2009 has shown that the dyke/soil temperature gradually dropped down at the locations of all of the thermistors. The coldest temperature (about -7 °C to -8 °C) was measured at the depth of 1.6 m due to the impact of the cold air temperature. The dyke/soil temperature increases gradually with depth and at depths deeper than 9.4 m is in the range of -2 °C to -3 °C.

An inexplicable temperature drop to about -11.5 °C occurred for all of the thermistors on July 2, 2009. Following that date, the dyke/soil temperature at depths of 1.6 m and 6.8 m begin to warm rapidly and on July 27, 2009 approaches +2 °C at 1.6 m and +3.5 °C at 6.8 m. Such a rapid increase of the dyke/soil temperature likely is due to the ingress of water into the thermistor string conduit. The temperature at 4.2 m is also above 0 °C on August 1, 2009.

Data from October 1, 2009 to November 1, 2009 demonstrates that dyke/soil temperatures at depths from 1.6 m to 9.4 m are above 0 °C. On October 1, 2009 those temperatures were ranging from +0.9 °C at 9.4 m to +3 °C at 1.6 m and 4.2 m depths. On November 1, 2009, the temperatures down to 9.4 m were still above 0 °C and ranged from +0.2 °C at 9.4 m to +1.5 °C at 4.2 m. The temperatures below 9.4 m range from -1.1 °C to -3 °C, at 11 m and 18.8 m depths, respectively.

Logger 2.
The drawings comprise three sets of data from April 15, 2009 to May 15, 2009, from July 1, 2009 to August 1, 2009, and from October 1, 2009 to November 1, 2009. The thermistor string was installed in the central part of the main dyke. Drawings showing dyke temperatures at various depths for selected periods of time are presented in Appendix B. Dyke temperatures for various depths and selected dates are al so shown at Figure 3, Appendix A.

On April 15, 2009, the coldest temperature was observed at a 1.6 m depth (-11 °C), and the warmest temperatures, ranging from -4.1 °C to -4.4 °C were measured at depths deeper than 9.4 m. On July 1, 2009, the dyke/soil temperatures ranged from -3.8 °C at a depth of 1.6 m to -6.2 °C at a depth of 4.2 m. An inexplicable drop of temperatures occurred on July 2, 2009. Following that date, the temperature at 1.6 m began rapidly to increase to +2 °C on August 1, 2009. The increase in temperature is due to heating effect of warm air temperatures. Other temperatures at deeper depths remained frozen and ranged in tem perature from about -4 °C to -6 °C.

The temperature at 1.6 m began to cool down from +4 °C (1.6m) on August 15, 2009. On October 1, 2009, the temperature at 1.6 m was about +1.3 °C. The cooling rate of the upper portion of the dyke increased in October, and the temperature at the 1.6 m on November 1, 2009 was already -0.6 °C. Below the 1.6 m depth, the dyke/soil temperatures in October, 2009, remained steady, ranging from about -1 °C (depth 4.2 m) to about -4.5 °C (depths below 9.4 m).

Logger 3.
The drawings comprise three sets of data from December 15, 2008 to January 15, 2009, from July 1, 2009 to August 1, 2009, and from October 1, 2009 to November 1, 2009. This thermistor string was installed within the southern section of the main dyke. Drawings showing dyke temperatures at various depths for selected periods of time are presented in Appendix B. Dyke temperatures for various depths and selected dat es are also shown at Figure 4, Appendix A.

On December 15, 2008, the warmest temperature -0.9 °C was measured at 6.8 m. Above this depth, the dyke temperature was about -2 °C at the 1.6 m depth. Below the 6.8 m depth, the soil temperature gradually decreased from about -1.6 °C to -3.3 °C, at depths of 9.4 m and 18.8 m, respectively. During the second half of December, 2008, and January, 2009, the dyke/soil temperature was steady with the exception of the temperature at the 1.6 m, which gradually dropped down to about -5.5 °C on January 15, 2009.

On July 1, 2009, all of the measured dyke/soil temperatures were below 0 °C. The warmest temperature at about -1 °C was observed at the 1.6 m depth, while the temperatures at deeper depths were about -2.5 °C. The temperatures at 1.6 m approached 0 °C on July 17, 2009, and on August 1, 2009 were already warmer than +2 °C.

The temperature at 1.6 m remained above 0 °C until November 3, 2009. Temperatures at other dyke/soil depths were steady in October, 2009. The temperature data shows that the dyke/soil temperature gradually decreased from about -0.2 °C to about -3 °C, at depths of 4.2 m and 18.8 m, respectively.

Logger 4.
The drawings comprise four sets of data from December 15, 2008 to January 15, 2009, from March 6, 2009 to May 6, 2009, from July 1, 2009 to August 1, 2009, and from October 1, 2009 to November 1, 2009. The thermistor string sensors located at depths of 4.2 m, 6.8 m, and 9.4 m provided incorrect readings (-67.48 °C) up to October 1, 2009. Drawings showing dyke temperatures at various depths for selected periods of time are presented in Appendix B. Dyke temperatures for various depths and selected dat es are also shown at F igure 5, Appendix A.

The temperature at the 1.6 m depth decreased from about -0.1 °C on November 23, 2008 to about -3 °C on December 15, 2008. The same soil temperature of -3 °C on December 15 was also at a depth of 11 m. Below the 11 m depth, the soil temperature gradually dropped down to -3.7 °C at a depth of 18.8 m. It is interesting to note that the soil temperature below the 11 m depth remained at about -3.5 °C within the described range during December, 2008, and January-May, 2009. However, the temperature at the 1.6 m depth began to drop down rapidly from December 23, 2008, and was as cold as -6 °C on January 2, 2009. The temperature at the 1.6 m depth gradually decreased to about -11.4 °C on March 26, 2009.

In April 2009, dyke temperature at the 1.6 m depth was gradually getting warmer, and approached about -2 °C on July 1, 2009, and 0 °C on July 17, 2009. The soil temperatures at depths below 11 m remained in a range of -3 °C to -3.5 °C untill the end of the monitoring observations, dated Dec ember 4, 2009.

A maximum temperature of +3 °C at 1.6 m was observed on September 19, 2009 at 11:48 am. However, temperatures up to +12 °C were measured at 1.6 m on September 19 at 19:48 pm, on September 20 (all readings), and on September 21 at 3:48 am. AMEC considers these readings (+12 °C) as incorrect, because a rapid increase of the temperature during 32 hours cannot be explained from a geothermal point of view. Later on, the temperature at the 1.6 m depth started to gradually dropped down to 0 °C on October 27, 2009.

Temperature data for the following depths 4.2 m, 6.8 m, and 9.4 m was available for October and November, 2009, and this data demonstrates that the east dyke and underlying soils are in a frozen state at the end of November, 2009. The warmest temperature at about -0.4 °C was measured at the 4.2 m depth, while the dyke/soil temperatures gradually decreased to -3.5 °C at the 18.8 m depth.

Measured and Predicted Temperatures.
Temperature data from Logger 2 and 3 were used for the comparison of modelled and measured dyke/soil temperatures. The modelled temperatures are presented at Figure 6, Appendix A. This figure is a copy of Figure 2 from the AMEC report titled "Additional Geotechnical Analysis for P-Lake Sewage Lagoon", dated August, 2007. The figure provided the modelled/predicted dyke soil temperatures following 1 year of lagoon operation, corresponding to the end of summer, represented by the September 30 date. The measured temperatures for the same date have been selected from Loggers 2 and 3. The modelled and measured temperatures are summarized in Table 1.

Table 1: Comparison of Predicted and Measured Dyke Temperatures

Depth, m	Predicted Temp., °C	Logger 2 Temp, °C	Logger 3 Temp., °C
1.6	+0.2	+1.3	+1.4
4.2	-0.3	-0.9	-0.2
6.8	-0.6	-3.2	-1.5
9.4	-1.0	-4.3	No data
11.0	-1.3	-4.6	-2.6
14.6	-2.5	-4.5	-2.8
18.8	-3.6	-4.4	-3.1

Comparing the predicted and measured temperatures shows that there is an agreement between the data sets. However, the thickness of the active layer based on September 29, 2009, temperature data (Logger 3) is greater then the thickness of the active layer predicted by the geothermal model after 12 months of lagoon operation, corresponding to September 30 (measured and modelled thickness of the active layer is 3.85 m and 2.70 m, respectively). The discrepancy in the thickness of the active layer is explained by a discrepancy of the mean summer air temperatures. For instance, the mean summer air temperature in 2009 in Cape Dorset was estimated at +7.3 °C, while the mean summer air temperature in the model was assumed to be +4.2 °C based on Climate Normals for 1970 to 2000.

The measured temperatures, starting from a 4.2 m depth, in general are slightly colder than the predicted temperatures. The difference in temperatures is believed to be due to warming effect of sewage water that was included in the geothermal modeling conducted during the project design phase. The geothermal model incorporated sewage water being stored within the impoundment during the first year of operation, but the measured temperatures represented conditions with no sewage water within the impoundment.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The measured temperature data demonstrates that the west (main) and east dykes are in a frozen state on December, 2009. The measured temperatures are in general agreement with modelled temperatures. Starting from the 4.2 m depth, the dyke temperatures and native soil temperatures are colder than the predicted temperatures. Monitoring observations demonstrated that there is a trend for aggradation of frozen soils in the dyke and native soils below the dyke. This tendency has been shown in a long term by results of the geothermal modeling (AMEC's report "Additional Geotechnical Analysis for P-Lake Sewage Lagoon", 2007).

The thickness of the active layer in the dyke may vary depending on mean summer air temperature. However, as it was predicted, a trend toward decreasing of the active layer thickness should be observed in measured temperatures in future years. It is recommended that the thermal monitoring be continued in future years to assess dyke conditions and temperature trends.

The Logger 1 temperature data shows that the dyke temperatures at this location was above 0 °C or marginally below 0 °C down to a 9.4 m depth throughout the second half of summer and fall in 2009. It is believed that the above 0 °C temperatures are due to the ingress of melt water and runoff water entering the possibly damaged EMT conduit. AMEC recommends confirmation of this suggestion during a field reconnaissance in summer of 2010.

7.0 CLOSURE

The findings and recommendations presented herein are based on review of temperature data for the sewage lagoon dyke provided by Department of Community and Government Services, Government of Nunavut. AMEC was involved in the design of the monitoring boreholes, however, manufacturing of thermistor strings and data logger(s), drilling of the monitoring boreholes, construction of the EMT conduit, backfilling and the installation of the thermistor strings was undertaken by another company.

This review report has been prepared for the exclusive use of Government of Nunavut and its agents for assessment of existing permafrost conditions in the Cape Dorset sewage lagoon dykes. Any reliance or decisions made by third parties for other dykes are the sole responsibility of those parties. The present report has been prepared in accordance with generally accepted permafrost engineering practice. No other warranty, expressed or implied, is made.

Respectfully submitted,
AMEC Earth and Environmental

March 26, 2010

Alexandre Tchekhovski, Ph.D., P.Eng.
Associate Geotechnical and Permafrost Engineer

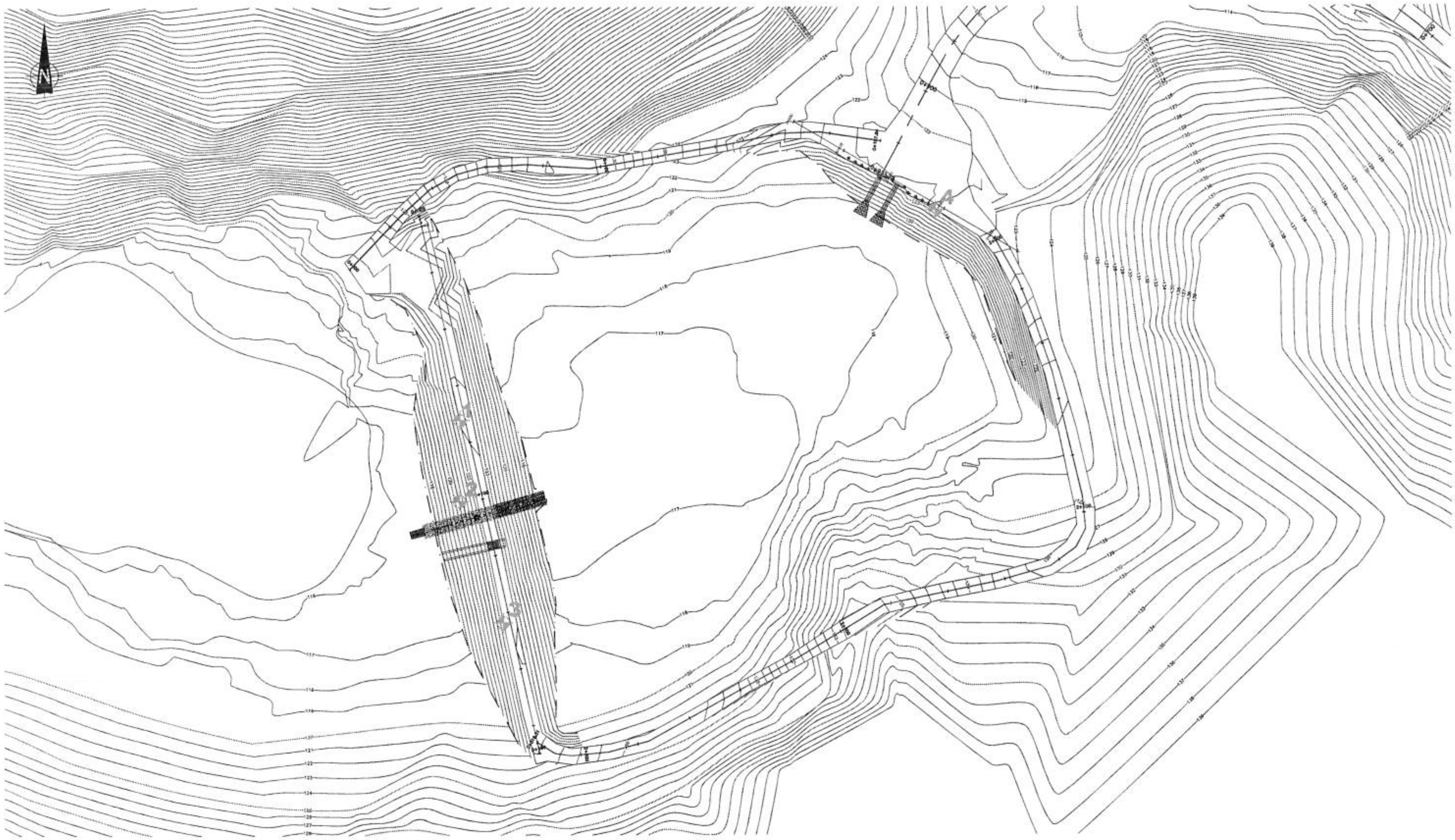
REGISTERED PROFESSIONAL ENGINEER
Mar. 26/10
D. DUMSKY
LICENSEE
NWT/NU

Dmitry Dumsky, P.Eng
Geotechnical and Permafrost Engineer

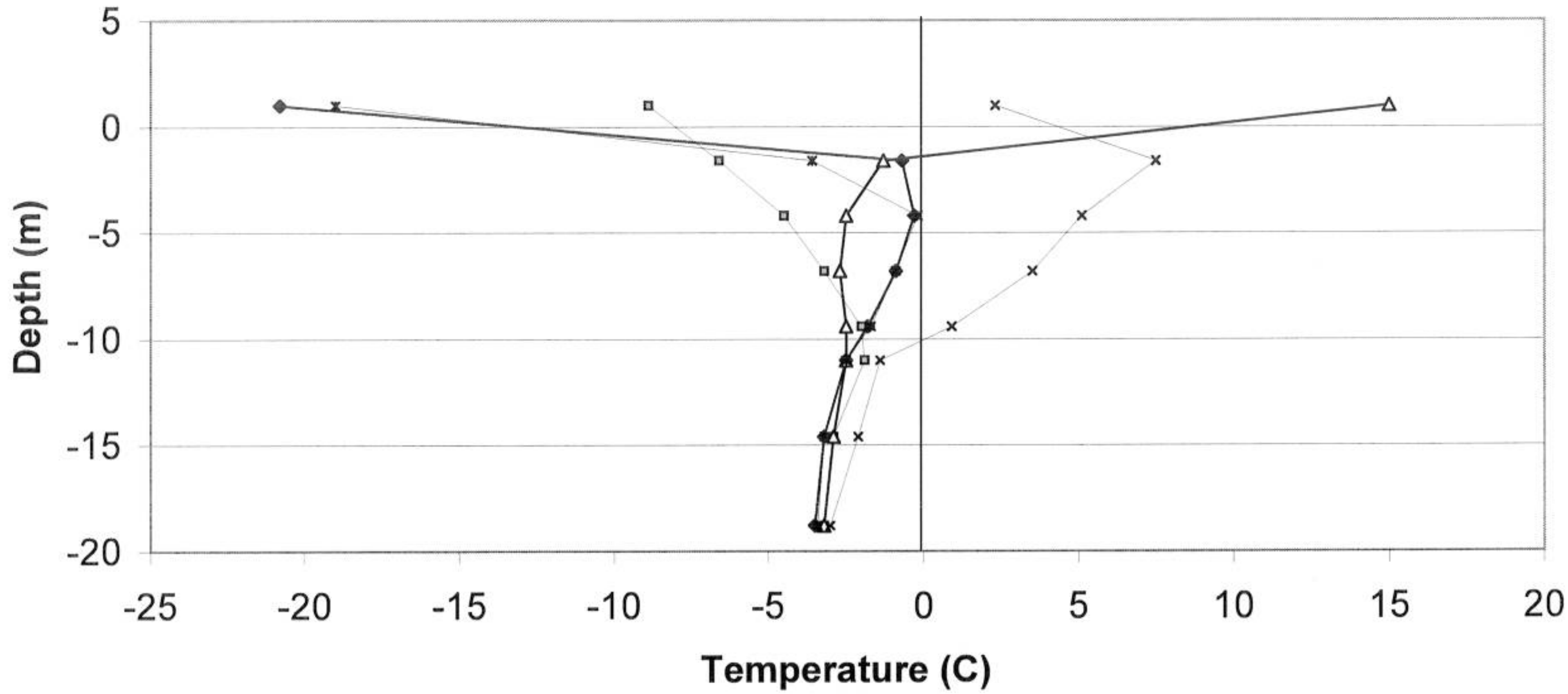
Reviewed by:
Paul Cavanagh, M. Eng, P. Eng
Associate Geotechnical Engineer

PERMIT TO PRACTICE
AMEC Earth & Environmental, a Division of AMEC Americas Limited
Signature
Date March 26, 2010
PERMIT NUMBER: P 047
The Association of Professional Engineers, Geologists and Geophysicists of the NWT / NU

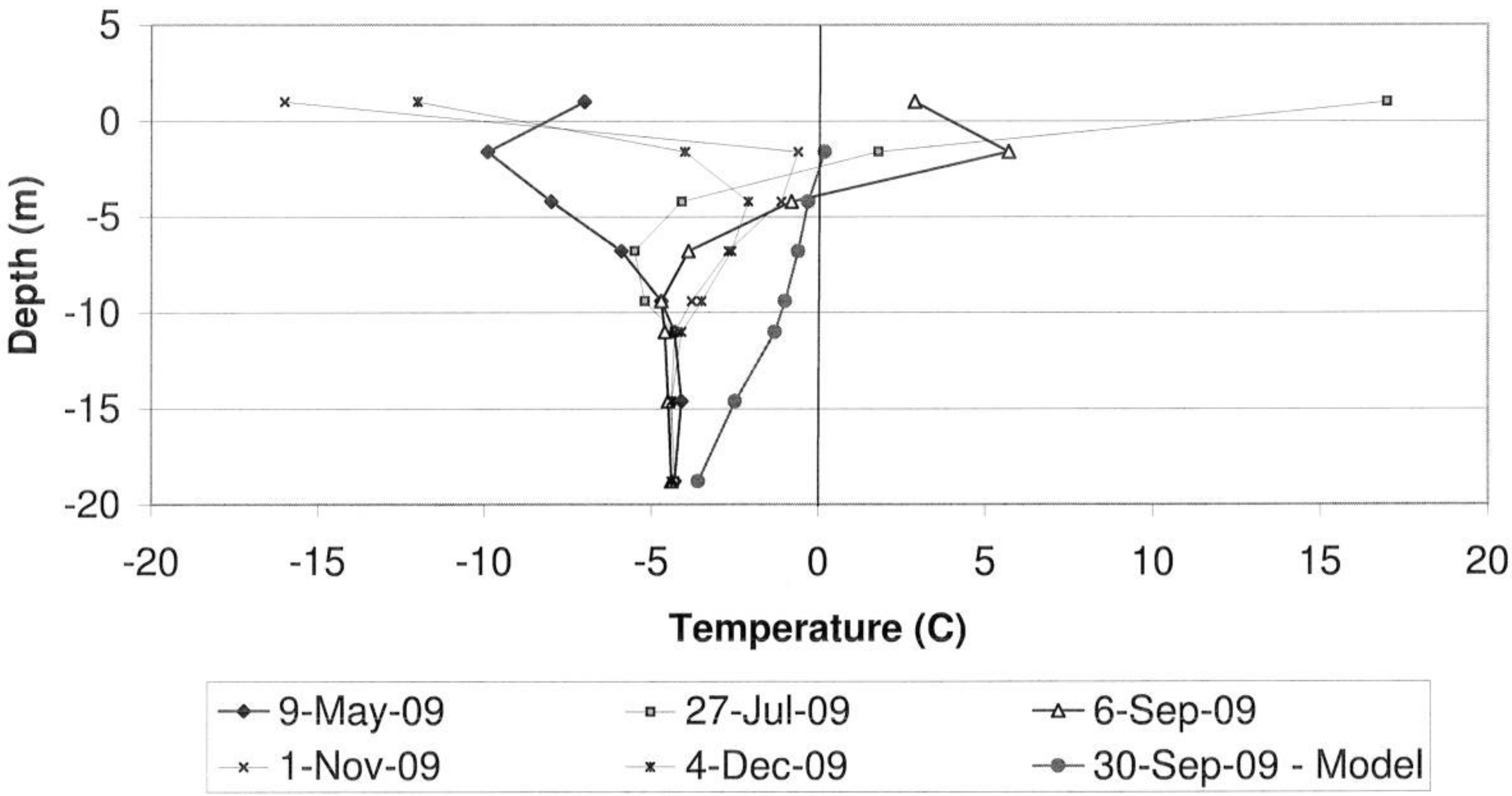
APPENDIX A



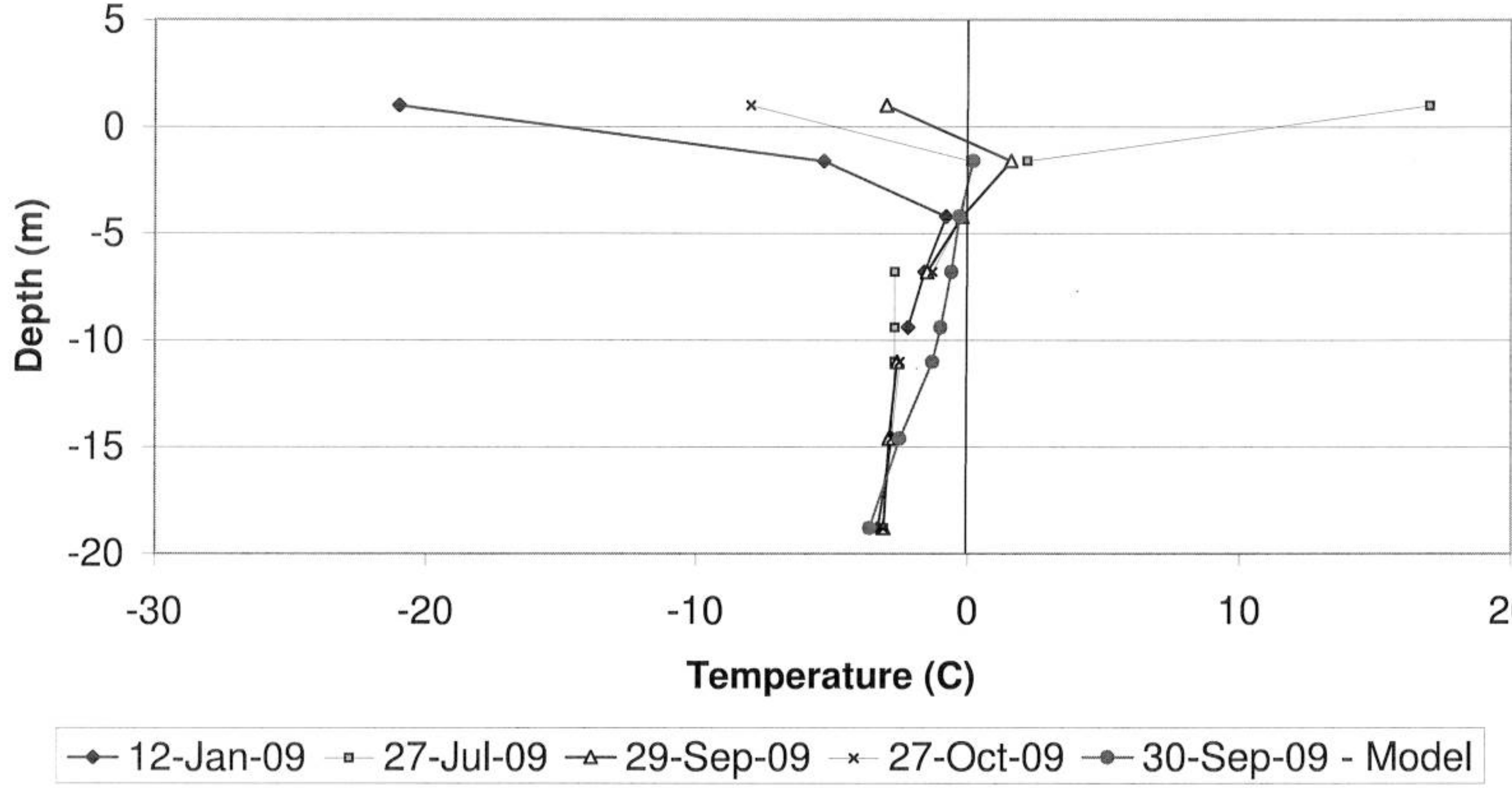
amec	PROJECT: P LAKE AREA SEWAGE LAGOON SYSTEM - CAPE DORSET				
	TITLE: THERMISTOR LOCATIONS				
CLIENT: DEPARTMENT OF COMMUNITY AND GOVERNMENT SERVICES, GOVERNMENT OF NUNAVUT	DATE: FEBRUARY 2010	JOB No.: YX00826	CAD FILE: 00826N01.dwg	FIGURE No.: FIGURE 1	REV. A



Client: Government of Nunavut Department of Community and Government Services	Figure 2		amec
Project: Temperature Data Review Cape Dorset Sewage Lagoon	Date: March, 2010	Revision	
Title: Selected Temperature Data Logger 1	Job No. YX00826.100		



Client: **Government of Nunavut Department of Community and**	**Figure 3**		amec
Project: Temperature Data Review Cape Dorset Sewage Lagoon	Date: **March, 2010**	Revision	
Title: Selected Temperature Data Logger 2, and Modeled Temperatures	Job No. **YX00826.100**		



Client	Government of Nunavut Department of Community and	Figure 4	
Project	Temperature Data Review Cape Dorset Sewage Lagoon	Date: March, 2010	Revision
Title	Selected Temperature Data Logger 3, and Modeled Temperatures	Job No. YX00826.100	