2015 Annual Geotechnical Inspection
Tailings Impoundment Area
Doris North Project, Hope Bay, Nunavut
Final Report

Prepared for

TMAC Resources Inc.

Prepared by

SRK Consulting (Canada) Inc.
1CT022.002
April 2016

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Executive Summary

The Doris North Project (Project) is a mining and milling undertaking of TMAC Resources Inc. Site operations are conducted under a Type "A" Nunavut Water Board License 2AM-DOH1323 dated August 16, 2013, which entitles TMAC to use water and dispose of waste associated with their operations. TMAC contracted SRK Consulting (Canada) Inc. to conduct the Annual Geotechnical Inspection for the Tailings Impoundment Area (TIA) in accordance with stipulated License conditions. This inspection was carried out August 15 and 16, 2015.

The TIA consists of two water retaining dams, the North Dam and the South Dam. These dams provide containment for subaqueous deposition of tailings and other Project contact water. The North Dam was constructed during the winters of 2011 and 2012. The South Dam has not been constructed as a result of the Project being placed under care and maintenance between 2012 and 2014. As a result there has been no tailings deposition. Since 2012 contact water from the Doris North Pollution Control Pond (PCP) has been pumped to the TIA in accordance with the Project's Interim Water Management Plan (SRK 2012c). The water level in the TIA has also been maintained through seasonal (summer) discharge to Doris Creek.

Table A below, provides a summary of the inspection components and the primary recommendations stemming from the site inspection, and subsequent review of the monitoring data. The North Dam is functioning as designed, and there are no concerns about the ongoing functioning of the structure. There are however smaller maintenance issues that require attention, and suggestions for improvement of the performance monitoring system.

Table A: Summary of Recommendations

Inspection Item	2014 Recommendations	2015 Recommendations	Significance
Compliance with Monitoring Requirements	• Perform monitoring of the North Dam at the frequency described in the North Dam Monitoring Standard Operating Procedures (SRK 2013b). • Update the North Dam monitoring standard operating procedures to clarify inconsistencies and address winter versus summer monitoring.	• Update the North Dam Monitoring Standard Operating Procedures to clarify datalogger download frequency.	Medium
Ground Temperature Cables (GTCs)	• Collect and review GTC data in accordance with the North Dam Monitoring SOP (SRK 2013b). • Have the dataloggers serviced by a qualified person and manually download data from June 14 to July 9, 2014 from dataloggers CR1000 #1 and CR1000 #2, and data from August 6 to 31, 2014 from CR1000 #1.	• No action required.	N/A

Inspection Item	2014 Recommendations	2015 Recommendations	Significance
	• Ensure all field staff are properly trained and following the North Dam Monitoring SOP (SRK 2013b) to prevent card reader errors in the future. • Play close attention to the temperatures recorded by ND-VTS-130-DS and if temperature spikes are noted in the fall of 2015 additional investigation should be conducted.		
Thermosyphons	• Bring Arctic Foundations Inc. to site to inspect why thermosyphon North 2 is not working, and carry out the necessary repairs. • While Arctic Foundations Inc. is on-site have them inspect all thermosyphons, and carry out any maintenance they recommend.	• Bring Arctic Foundations Inc. to site to inspect thermosyphon North 2, determine why it is not working, and carry out the necessary repairs. • While Arctic Foundations Inc. is on-site have them inspect all thermosyphons, and carry out any maintenance they recommend.	High High
CR1000 Datalogger Battery Voltage	• The SOP for the North Dam monitoring should be revised to include a procedure to test and recharge or replace the batteries annually.	• The CR1000 Datalogger batteries should be tested and recharged, or replaced annually.	High
Inclinometers	• Conduct monthly survey of all survey monitoring points, in accordance with the North Dam Monitoring SOP (SRK 2013b). • Ensure site personnel are properly trained to acquiring readings from the inclinometers.	• No action required.	N/A
Survey Monitoring Points	• Conduct monthly survey of all survey monitoring points, in accordance with the North Dam Monitoring SOP (SRK 2013b).	• Conduct surveys, in accordance with the frequency prescribed in the North Dam Monitoring SOP. • Update North Dam Monitoring SOP to clarify monitoring frequency during the winter months. • Backfill the erosion around ND−DSP−100.	Medium
Walkover Surveys	• Perform walkover surveys in accordance with the monitoring SOP requirements (SRK 2013b). • During the walkover survey, pay particular attention to the exposed GTC and datalogger boxes so any issues	• No action required.	N/A

Inspection Item	2014 Recommendations	2015 Recommendations	Significance
	(disconnected cables etc.) can be addressed promptly.		
North Dam Physical Inspection	• Survey the locations of the three anomalies (U1, U2 and U3), after which they should be backfilled, compacted, and graded. • Backfill the erosion around the Deep Settlement Monitoring Point ND-DSP-100. • Establish a SOP for tracking and monitoring growth of the depressions, which should include regular survey of the depressions when snow is not on the ground. • Collect water quality samples, to be submitted for laboratory analysis, along the north dam downstream north dam toe and in the original Tail Lake outflow channel to confirm the source of the observed water.	• Update North Dam monitoring SOP to include tracking and monitoring of depressions, including regular surveys when snow is not on the ground.	Medium
TSF Water Level and Shoreline Erosion	• Install a new water level datalogger in the TSF at the start of the 2015 open water season and monitor monthly, in accordance with the North Dam Monitoring SOP (SRK 2013b). • Establish a new benchmark elevation to geodetically reference the new water level gauge measurements. • Implement measures to maintain the water level in the pond at 28.3 masl to prevent onset of permafrost degradation.	• Implement measures to maintain a pond the water level of in the pond at 28.3 masl to prevent onset of permafrost degradation.	High

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1 Introduction

1.1 General

The Doris North Project (Project) is located within the Hope Bay Greenstone Belt, in the Kitikmeot Region of Nunavut, approximately 170 km southwest of Cambridge Bay, as shown in Figure 1.

The Project, which is being developed by TMAC Resources Inc., is licensed to conduct mining, milling and associated activities. Construction of the Project started in 2007, and underground development started in 2010. In addition to supporting construction activities, the site is used to carry out regional exploration. In February 2012 the Project was placed into Care and Maintenance, and therefore much of the licensed infrastructure components have not been constructed, including some items associated with the Tailings Impoundment Area (TIA). The Project was taken out of Care and Maintenance in 2015 and is currently proceeding with construction and underground mine development with the goal of starting commercial production in December 2016.

To fulfill regulatory requirements for an annual geotechnical inspection, TMAC, requested that SRK Consulting (Canada) Inc. conduct the 2015 geotechnical site inspection for the TIA. This report provides a summary of the conditions observed, a review of monitoring data and recommendations to ensure ongoing successful performance of the system. This is the fifth inspection of the TIA. SRK has been performing annual inspections of the TIA since it was constructed in 2011 (SRK 2012a, 2013a, 2014a and 2014b).

The objectives of the inspection were to visually assess the geotechnical performance of the TIA containment structures, which currently consists only of the North Dam and associated elements, and to identify any deficiencies or concerns. In conjunction with the visual inspection, monitoring data collected throughout the year was reviewed and analyzed to evaluate performance.

Mr. Lowell Wade, PEng, PGeo, a Senior Consultant with SRK, conducted the physical geotechnical inspection on August 15 and 16, 2015. Weather conditions during the inspection were overcast with intermittent showers and daily temperatures of approximately 6^{o}C. The detailed inspection of the North Dam was carried out on foot, after conducting an aerial survey of the TIA using a low altitude helicopter flyover. Mr. Paul Christman, MEng, PGeo, PEng, TMAC's Manager of Mining, accompanied SRK on the inspection.

Photos detailing the inspection conditions are included in Figures 5 through 8.

1.2 Inspection Requirements

The Doris North Project, including the TIA, is licensed by the Nunavut Water Board (NWB). Site operations are conducted under the Type "A" License 2AM DOH1323, dated August 16, 2013, which entitles TMAC to use water and dispose of waste associated with their operations. The following inspection requirements, relevant to the TIA, are stated in Part J, items 18 and 19 of the license.

The Licensee shall ensure that a geotechnical inspection is carried out annually between July and September by a Geotechnical Engineer. The inspection shall be conducted in accordance with the Canadian Dam Safety Guidelines where applicable, and take into account all major earthworks, including the following:

- *North and South Dams*
- *Geotechnical instrumentation and associated monitoring data*
- *Tailings Impoundment Area shoreline and erosion strip survey monitoring results*

The Licensee shall submit to the Board, within sixty (60) days of completion of the geotechnical inspection, the Geotechnical Engineer's inspection report. The report shall include a cover letter from the Licensee outlining an implementation plan addressing each of the Geotechnical Engineer's recommendations.

It should be noted that additional inspection requirements for other components of the Project are listed within the water license; these conditions are addressed in the Doris North Project geotechnical inspection report which is submitted to the NWB under a different cover.

1.3 Report Structure

Section 2 of this report describes the general site conditions and history associated with the TIA. Section 3 discusses the North Dam instrumentation and associated monitoring data, as well as physical inspection conditions observed during the annual geotechnical inspection. An overall summary of recommendations is provided in Section 4.

All elements of the TIA discussed in this report are presented in the enclosed figures, which include detailed site photographs. Details of the North Dam instrumentation monitoring are presented in the appendices.

2 Site Conditions

2.1 Tailings Impoundment Area Infrastructure

Tailings for the Project will be deposited subaqueously in the TIA, which is a MMER Schedule 2 listed lake. The TIA is located south-east of the mill and mine location, as shown in Figure 2, and will, when in full operation, consist of the following components:

- Two earthen containment structures (North and South Dams);
- Spillway (at the North Dam);
- Tailings deposition infrastructure;
- Process water reclaim infrastructure;
- Fresh water make-up infrastructure;
- Operational discharge (decant) infrastructure; and
- Shoreline erosion protection infrastructure.

Operation of the TIA requires a minimum water cover at any given time. Tailings are to be deposited within the deepest sections of the TIA, and only water will be in contact with the two containment dams. Based on this mode of operation the North and South dams have been designed as water retaining frozen core dams with a secondary upstream liner (SRK 2007).

The dams have been designed to maintain the core and the underlying saline permafrost foundation at sufficiently cold temperatures, and over a wide enough area to create an impermeable barrier. Under normal operating conditions the dam core temperature should be −2˚C or colder, and during upset conditions the core should be −1°C or colder. The saline permafrost layer under the dams should be colder than −8°C under normal or upset conditions. The dams have been designed with a 25-year design life in mind, taking into account global warming and upset conditions (SRK 2007).

At this time, only the North Dam has been constructed, and no tailings have been deposited in the TIA. Construction of the North Dam started in February 2011 and was completed in April 2012. Complete as-built details are provided in SRK (2012b).

2.2 North Dam Design

SRK is the Engineer-of-Record for the North Dam. The as-built North Dam general arrangement and typical dam cross-section are presented in Figures 3 and 4.

The North Dam is located roughly 200 m downstream of the northern extremity of the original Tail Lake, which after delisting became the TIA, within a relatively narrow valley and is aligned essentially perpendicular to the valley. The valley bottom is about elevation 26 m and consists of a narrow marshy area that drains from the TIA towards Doris Lake (Figure 3).

The North Dam is approximately 200 m long and 10 m high, with upstream and downstream slopes of 6H:1V and 4H:1V, respectively. The dam consists of a key trench, frozen core, geosynthetic clay liner (GCL), thermosyphons, transition layer and rockfill shell. A typical cross-section is presented in Figure 4.

The North Dam is founded half on sand overburden and half on ice-rich marine clayey silt, as can be seen in Figure 4. All peat that was encountered at the base of the key trench excavation was removed prior to frozen core material placement. Sloped thermosyphons were installed at the base of the key trench to enhance foundation cooling.

The dam core consists of a frozen mass of fine crushed rock that was placed in a near saturated state. On the upstream side of the core, a geosynthetic clay liner (GCL) was installed to provide a secondary water retaining capability should cracks develop in the core due to thermal degradation, creep deformation or differential settlement. The core and GCL extend 1.8 m above the design full supply level (FSL) to provide freeboard.

The core is surrounded by a transition layer consisting of 0.15 m minus crushed rock that acts as a filter, should the dam thaw. A minimum 1.5 m thick outer shell of run-of-quarry rock acts as a thermal protection layer for the frozen core and provides a buttress against creep deformation.

2.3 North Dam Instrumentation

Permanent instrumentation for the North Dam consists of:

- 11 vertical ground temperature cables (also known as thermistors);
- 13 horizontal ground temperature cables;
- 18 Surficial Survey Monitoring Points, located throughout the downstream face;
- 14 Crest Survey Monitoring Points, located along the upstream and downstream crests of the dam;
- 3 Deep Settlement Points;
- 6 Inclinometers, located within the downstream face; and
- 12 thermistors, measuring thermosyphon contact temperatures.

Figure 3 illustrates the North Dam instrumentation with the exception of the ground temperature cables and thermistors.

2.4 Site History

A summary of the TIA permitting, construction, and operations is provided in Table 1.

Table 1: Summary of TIA Development and History

Period	Comments
2003	Doris North Project preliminary economic assessment is completed (SRK 2002a).
2002 - 2005	Geotechnical and geophysical investigations of dam foundations, TIA perimeter and permafrost conditions (SRK 2002b, 2003 and 2005a, 2005b and 2005c).
2005	Environmental Assessment for Doris North Project is completed.
2006	A Project Certificate is issued for the Doris North Project.
2006	Application for addition of TIA to Schedule 2 of the Metal Mining Effluent Regulations (MMER) was submitted.
2008	TIA MMER Schedule 2 listing obtained.
Winter 2011 and Winter 2012	North Dam constructed (SRK 2012b).
Winter 2012	Project placed into care and maintenance.
2012 - 2014	Project development delayed with only limited surface exploration activities. Water within the TIA is managed in accordance with the Interim Water Management Plan (SRK 2012c). No tailings are deposited, but water from the pollution control pond is pumped to the TIA. TIA water is discharged to Doris Creek.
2015	Limited project development with ongoing surface exploration activities. Water within the TIA is managed in accordance with the Interim Water Management Plan (SRK 2012c). No tailings are deposited, but water from pollution control pond is pumped to the TIA. TIA water is discharged to Doris Creek.

2.5 Dam Classification

When designed, both the North and South dams were classified as “Low Hazard” according to the Dam Safety Guidelines (CDA 1999) (SRK 2007). As part of the 2014 annual geotechnical inspection, SRK reassessed the hazard classification of the North Dam considering the most recent Dam Safety Guidelines (CDA 2013), and taking into consideration its use at the time, which remains unchanged at the time of the 2015 inspection.

There are no temporary or permanent communities within the likely inundation area downstream of the dam. Furthermore the only mining infrastructure within the likely inundation area is the Doris Creek Bridge, more than 600 m downstream of the North Dam. Currently, there are no tailings within the TIA and the water quality within the TIA meets discharge criteria. SRK is therefore satisfied that based on the definitions of hazard categories as described in Table 2, the hazard category for the North Dam of “Low” remains appropriate.

Table 2: Dam Classification (as defined in CDA 2013)

Dam Class	Population at Risk[1]	Incremental losses		
		Loss of Life[2]	Environmental and Cultural Values	Infrastructure and Economics
Low	None	0	Minimal short-term loss No long-term loss	Low economic losses; area contains limited infrastructure or services
Significant	Temporary only	Unspecified	No significant loss or deterioration of fish or wildlife habitat Loss of marginal habitat only Restoration or compensation in kind highly possible	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes
High	Permanent	10 or fewer	Significant loss or deterioration of *important* fish or wildlife habitat Restoration or compensation in kind highly possible	High economic losses affection infrastructure, public transportation, and commercial facilities
Very high	Permanent	100 or fewer	Significant loss or deterioration of *critical* fish or wildlife habitat Restoration or compensation in kind possible but impractical	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances)
Extreme	Permanent	More than 100	Major loss of *critical* fish or wildlife habitat Restoration or compensation in kind impossible	Extreme losses affecting critical infrastructure or services (e.g., hospital, major industrial complex, major storage facilities for dangerous substances)

[1] Definitions for population at risk:

None – There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.

Temporary – People are only temporarily in the dam-breach inundation zone (e.g., seasonal cottage use, passing through on transportation routes, participating in recreational activities).

Permanent – The population at risk is ordinarily located in the dam-breach inundation zone (e.g., as permanent residents); three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).

[2] Implications for loss of life:

Unspecified – The appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season.

3 North Dam Physical Inspection and Monitoring

3.1 Compliance with Monitoring Requirements

The North Dam monitoring frequency requirements were first outlined in the North Dam As-built Report (SRK 2012b) and have since been updated in the North Dam Monitoring Standard Operating Procedures (SRK 2013b). The monitoring frequency requirements and actual monitoring frequency are summarized in Table 3.

During the 2012 to 2013 monitoring year, SRK provided leeway on monitoring frequency as the Project was under care and maintenance, with only skeleton seasonal staff on-site during the winter months. In early 2014, the status of the Project changed from care and maintenance to active exploration with increased staff. Subsequently SRK recommended that the North Dam monitoring be performed in accordance with the North Dam Monitoring Standard Operating Procedures (SOP) (SRK 2013b). Since 2014, inclinometer surveys and thermosyphon monitoring have generally been in compliance with the monitoring SOP. Datalogger downloads have been compliant in the summer months. Weekly walkover surveys have been compliant since June 2014. Survey monitoring is not in compliance, as only two surveys were performed in 2014, and only one survey was performed in 2015.

Recommendations

- Perform monitoring of the North Dam at the frequency described in the North Dam Monitoring Standard Operating Procedures.
- Update the North Dam Monitoring Standard Operating Procedures to clarify datalogger download frequency.

Table 3: North Dam Monitoring Requirements 2014 to 2015 Monitoring Year[1]

Element	Item	Method	Responsibility	Required Frequency	Conformance with SOP (SRK 2013b)[2]	Comments
Thermal	Ground Temperature Cables	Dataloggers	TMAC	Daily (automated)	Yes	• Dataloggers record data four times daily.
	Thermosyphons	Dataloggers	TMAC	Daily (automated)	Yes	• Thermosyphon temperatures are measured four times daily.
	Dataloggers	Manual	TMAC	Monthly Minimum twice per year	Yes	• Dataloggers not downloaded between October 2014 and May 2015. • Data which was not retrieved in 2014 and 2013, due to a card reader, error was retrieved July 12, 2015.
Deformation	Crest Settlement	Manual	TMAC	Monthly	No	• Two surveys performed in 2014. • Four surveys were performed in 2015.
	Downstream Surface Settlement	Manual	TMAC	Monthly	No	• Two surveys performed in 2014. • Four surveys were performed in 2015.
	Downstream Deep Settlement	Manual	TMAC	Monthly	No	• Two surveys performed in 2014. • Four surveys were performed in 2015.
	Inclinometers	Manual	TMAC	Monthly	Yes	• Monitoring frequency requirements have been met since May 2014, with the exception on when the inclinometer was off-site for calibration between October 2014 and February 2015.
Water Balance	Water Level	Datalogger (if installed)	TMAC	Daily (automated)	Yes	• Water levels recorded daily during open water season.
	Dataloggers (if installed)	Manual	TMAC	Monthly	No	• Data downloaded yearly.
	Seepage Rate	Manual	TMAC	As Required	Yes	• Surface water runoff observed downstream of North Dam of unknown origin.
Visual	Walkover Survey	Manual	TMAC	Weekly (below FSL) Daily (at or above FSL)	Yes	• Weekly monitoring required because the dam is not at the full supply level (FSL). • Monitoring frequency requirements have generally been met since June 2014, only two weeks were missed over the last year.
	Annual Geotechnical Inspection	Manual	Independent Qualified Licensed Geotechnical Engineer	Annually	Yes	• Performed August 2015 by SRK, and documented herein. • Performed July 2014 by SRK (SRK 2014b).

Source: Adapted from SRK 2013b

Note(s):

(1) Data cut-off for inclusion in this report was September 30, 2015, data received by SRK after September 30, 2015 will be included in the 2016 geotechnical inspection report.

(2) This column lists if the monitoring frequency is compliant with the monitoring frequency requirements since the last annual geotechnical inspection (August 2014).

(3) Details of monitoring dates and data quality are provided in the beginning of the relevant appendices.

3.2 Ground Temperature Cables

To monitor the long term temperature of the frozen core and the dam foundation, a total of twenty-four ground temperature cables (GTCs) were installed during North Dam construction (SRK 2012b). Of the twenty-four installed GTCs twenty-two are still functional. Since September 2012, GTC data for the North Dam is recorded every six hours by two Campbell Scientific CR1000 dataloggers. Data is downloaded from the dataloggers by TMAC personnel using compact flash memory cards.

The frequency of datalogger downloads and the recorded temperature data is presented in Appendix A. Several card download errors occurred in 2014, resulting in two time periods (June 14 to July, 9 2014 and August 6 to August 31, 2014) where temperature data was not available. The missing data was manually downloaded July 12, 2015. As well, the original compact flashcards were replaced with new compact flashcards; subsequent data downloads have not presented any problems.

The status of all North Dam GTCs is summarized in Table 4; there has been no significant changes in GTCs status since the previous inspection.

Table 4: Ground Temperature Cable Status

GTC ID	Status	Comments
ND-VTS-040-KT	Active	
ND-HTS-040-31.5	Active	
ND-HTS-040-33.5	Active	Cable disconnected from datalogger October 10, 2013 to May 13, 2014.
		Connection to datalogger more permanently repaired July 2014.
ND-VTS-060-US	Inactive	Irreparably damaged between April 27 and Aug 8, 2012.
ND-VTS-060-DS	Active	
ND-VTS-060-KT	Active	Spliced during construction.
ND-HTS-060-28.8	Active	Bead 7 - No readings February 11, 2012 to December 8, 2013.
		Bead 7 - No readings since April 21, 2014.
		Bead 7 - Readings between November 1, 2014 and April 19, 2015.
		Bead 9 - No readings October 10, 2013 to May 20, 2015.
ND-HTS-060-31.0	Active	
ND-HTS-060-33.5	Active	
ND-VTS-085-US	Active	
ND-VTS-085-DS	Active	
ND-VTS-085-KT	Active	
ND-HTS-085-25.3	Active	
ND-HTS-085-29.4	Active	
ND-HTS-085-33.5	Inactive	Irreparably damaged during construction.
ND-VTS-130-US	Active	
ND-VTS-130-DS	Active	
ND-VTS-130-KT	Active	
ND-HTS-130-28.8	Active	
ND-HTS-130-31.0	Active	
ND-HTS-130-33.5	Active	
ND-VTS-175-KT	Active	Spliced during construction.
		Incorrectly connected to datalogger as ND-HTS-175-33.5 from August 9, 2012 to June 16, 2014.
		Bead 9, 10 and 11 - No readings August 9, 2012 to June 16, 2014.
ND-HTS-175-32.5	Active	
ND-HTS-175-33.5	Active	Spliced during construction.
		Incorrectly connected to datalogger as ND-HTS-175-KT, from August 9, 2012 to June 16, 2014.

Source: J:\01_SITES\Hope.Bay\!Project_Data (Not Job Specific)\06_NorthDamMonitoringData\[SiteMonitoringSummary.xlsx]ThermisorStatus

The North Dam ground temperature cables were installed to ensure the dam core and foundation remain below the design temperatures of −2˚C and −8˚C respectively. In addition, ground temperature data along with thermosyphon monitoring data can be used to determine if the thermosyphons are functioning correctly. The following observations were made in reviewing the ground temperature data:

- All horizontal ground temperature cables are measuring temperatures well below the core design temperature of −2˚C.

- The horizontal temperature readings of ND−HTS−175−32.5 continue to indicate that thermosyphon, North 2, is not functioning properly. This can be seen by the spike in measured temperatures during the winter months, near the thermosyphon (Appendix A, Figure A.17). More discussion on the status of thermosyphon North 2 is provided in Section 3.3.
- Foundation temperatures as measured by all beads of ND−VTS−085−KT are now less than the foundation design temperature of −8˚C (Appendix A, Figures A.9 and A.10).
- Foundation temperatures for the top six meters below the key trench at station 175, as measured by ND-VTS-175-KT, continue to be warmer than the foundation design temperature of −8˚C (Appendix A, Figure A.17). However, the cooling trend previously observed (SRK 2015) has continued, with the maximum measured temperature decreasing approximately 1°C in the last year. This cooling trend is encouraging, and there are no concerns at this time.
- The maximum measured temperatures of near surface beads for vertical ground temperature cables on the upstream and downstream sides of the North Dam were between −1°C and −2°C. These maximum measured temperatures are colder than what was recorded last year, with the exception of ND−VTS−130−DS. Maximum measured temperatures of -3°C were recorded for ND−VTS−130−DS. This cooling trend is encouraging, and there is no cause for concern.
- Large temperature spikes were noticed for several beads of ND−VTS−130−DS June and November 2013, and again August 2014 (Appendix A, Figure A.15). No temperature spikes were noticed in 2015 (data is available until August 20, 2015). The reason for these temperature spikes is unknown; however, it is hypothesised that the spikes could be due to groundwater flowing through a high saline pocket. This cannot be proven as salinity testing was not performed when the ground temperature cable was installed. Since the anomaly appears to be normalizing there are no concerns.

Recommendations

- No action required.

3.3 Thermosyphons

The thermosyphon radiator steel foundations are in good condition. The thermosyphons do not show any physical damage; however, there is rust and peeling paint at the weld between the evaporator pipe and the twin radiators on most of the thermosyphons.

Thermosyphon monitoring for the North Dam has been automated. Single bead thermistors connected to the datalogger system are attached to each thermosyphon evaporator pipe below the ground surface, and insulation has been placed around the thermistor beads to ensure the evaporator pipe temperature, and not the ambient air temperature is measured (SRK 2012b). Dataloggers record the contact surface temperature of each thermosyphon pipe and the air temperature every six hours, and TMAC site personnel download the data from the dataloggers.

To monitor the performance of the thermosyphons, thermosyphon evaporator pipe contact temperatures and air temperature are plotted against time. During the winter months, when thermosyphons are working, the thermosyphon pipe temperature should be roughly 5˚C warmer than the air temperature. If the thermosyphon pipe temperature during the winter months is approximately the same as the air temperature, it indicates that the thermosyphon is not working correctly.

Thermistor data indicates that all of the south thermosyphons are functioning, and all north thermosyphons, with the exception of North 2 are functioning (Appendix D). Since 2012, the measured pipe temperature of North 2 was only slightly higher than the measured air temperature, which indicates a malfunction. Ground temperature readings in the vicinity of the North 2 thermosyphon pipe support the conclusion that the North 2 thermosyphons are not working correctly.

During the 2014 North Dam annual geotechnical inspection, thermosyphon North 2 was inspected in detail to determine the cause of the elevated temperature readings. No damage or reason for the malfunction was observed (SRK 2015). Therefore, SRK recommended that Arctic Foundations Inc. be contacted to investigate further and repair the thermosyphon. Arctic Foundations Inc. provided TMAC a cost estimate and scope of work, dated June 25, 2015, to perform this work and carry out maintenance on all thermosyphons. Thermosyphon repairs did not occur prior to August 20, 2015.

Recommendations

- Bring Arctic Foundations Inc. to site to inspect thermosyphon North 2 to determine why it is not working, and carry out the necessary repairs.
- While Arctic Foundations Inc. is on-site have them also inspect all thermosyphons, and carry out any maintenance they recommend.

3.4 CR1000 Datalogger Battery Voltage

Each CR1000 datalogger is powered by an external lead acid battery. Battery voltage is an important indicator of datalogger performance, if the battery voltage is too low the recorded readings could be incorrect, or readings may not be recorded at all. The dataloggers record the minimum battery voltage four times daily, a graph of battery voltage versus time is provided in Appendix E**Error! Reference source not found.**.

The batteries have only been recharged once since the North Dam was commissioned, June 27, 2014. At no time has the voltage dropped low enough to cause any concerns with data integrity. The batteries should continue to be monitored to ensure that they maintain their charge through the winter months.

Recommendations

- CR1000 Datalogger batteries should be tested and recharged, or replaced annually.

3.5 Inclinometers

Six inclinometers were installed within the downstream face of the North Dam. These inclinometers are used along with the survey monitoring points to monitor deformation within the dam and dam foundation. Inclinometer readings are taken by TMAC site personnel. As discussed in Section 3.1, inclinometer readings were collected intermittently prior to May 2014. Readings were taken at monthly intervals from May 2014 until October 2014, and since February 2015. Readings were not collected October 2014 to February 2014 because the datalogger was offsite for calibration.

Inclinometer measurements are provided in Appendix B; data quality for the surveys has been good. Generally, the inclinometer profiles show only small displacements (less than 20 mm), in the portion of the inclinometer above the natural ground surface. There is no real trend emerging, suggesting that there is not any real movement of concern.

Recommendations

- No action required.

3.6 Survey Monitoring Points

A series of 14 crest survey monitoring points, 3 deep survey monitoring points, and 18 surficial survey points were installed in the North Dam upon completion. These survey monitoring points were installed to monitor any surface movement of the downstream face and deep settlement of the downstream foundation of the dam.

Survey monitoring of the North Dam has only occurred nine times since the survey monitoring points were installed, twice in 2012, once in 2013, twice in 2014, and four times in 2015, which is well below the recommended monthly monitoring (SRK 2013b).

Overall the measured horizontal and vertical displacement for the crest survey monitoring points (SMP) and deep survey monitoring points (DSP) is less than 0.1 m which is considered to be close to the survey accuracy. As expected the surficial survey points have larger measured displacement with horizontal and vertical displacement in the range of 0.2 m for most points. Generally these measured displacements have not changed since the 2013 survey, indicating that most of the movement was from settlement directly following construction. At this time none of the displacements are of concern.

There is significant erosion around the deep settlement monitoring point ND−DSP−100. This was noted during the 2013 and 2014 inspections (SRK 2014a and 2014b), yet the recommended remedial action has not been carried out. This should be repaired as soon as possible as it will continue to increase in size, and ultimately the instrument's integrity will be compromised.

Recommendations

- Backfill the erosion around ND−DSP−100.
- Update North Dam Monitoring SOP to clarify monitoring frequency during the winter months.
- Conduct surveys, in accordance with the frequency prescribed in the North Dam Monitoring SOP.

3.7 Walkover Surveys

Walkover surveys of the North Dam have been reported regularly since June 2014. The walkover survey reports and tracks any changes to the dam surface, damage to dataloggers and thermosyphons, and signs of erosion. Since the dam is not at the full supply level walkover surveys are required weekly.

To date, the only observations of note from the walkover surveys are surface depressions on the upstream and downstream faces of the dam. Six of these depressions were observed and given a unique identifying name during the 2014 SRK inspection. Since the 2014 SRK inspection, walkover surveys have identified and named up to an additional five depressions on the upstream side of the dam, and an additional 16 depressions on the downstream side of the dam. SRK examined these depressions during the physical inspection of the dam, the identified depressions are surface irregularities, which are not a cause for concern and do not need to be tracked. During the physical investigation of the dam SRK communicated this to TMAC site personnel.

The walkover survey reports, including photos, are provided in Appendix F, and a summary of the depression tracking is presented in Appendix H.

Recommendations

- No action required.

3.8 Physical Inspection of North Dam

During the 2013 inspection, two depressions (D2 and D3, as shown in Appendix H) were identified on the downstream face of the dam, and four additional depressions (D1, U1, U2 and U3, as shown in Appendix H) were identified in 2014 (SRK 2014b). A recommendation was made to regularly survey these depressions; however, these depressions have only been surveyed once in September 2013. Although there is no actual survey data, it appears as if these depressions have increased slightly in size over the year. SRK hypothesizes that these depressions are caused by fines migrating into the coarse rock fill of the dam, rather than being early indicators of foundation settlement. This conclusion seems to be supported by the survey monitoring point, inclinometer and thermal data.

Sixteen additional depressions on the downstream side of the dam, and five additional depressions on the upstream side of the dam have been identified by TMAC site personnel since the 2014 annual geotechnical inspection. Based on inspection of the areas, SRK is of the opinion that these are simply areas of poorly graded rock, rather than depressions. In all cases the crests of the depressions have been outlined with spray paint, and photos are regularly taken to track the growth. The approximate location of these depressions, a table tracking the growth and development of the depressions, and photos are provided in Appendix H.

Going forward, only significant depressions need to be identified and monitored (significant depressions identified to-date are D1, D2, D3, U1, U2 and U3). Additionally regular surveys should be performed on the toe and crest of the significant depressions, as the current monitoring method is too subjective to be of value. An updated monitoring SOP should be provided to give guidance on what is considered a significant depression and survey frequency.

Similar to the observations made in 2013 and 2014 (SRK 2014a and 2014b), there is evidence of surface water flow along the downstream toe of the North Dam. It is unlikely that this seepage is from the dam, but more likely from within the active layer of the north abutment which naturally flows along the downstream toe of the dam.

Available seepage and water quality data (SRK, 2012d, 2013c, and 2014c) were examined to see if the source of the water at the toe of the dam could be identified. The results of this examination were inconclusive because the water within the TIA did not have any chemical signatures which could be used to differentiate it from rainwater runoff. Field electrical conductivity values measured at the toe of the North Dam were 139 µS/cm and 223 µS/cm in 2012 and 2013 respectively (SRK 2013c and 2014c), while electrical conductivities within the TIA and former Tail Lake have measured between 84.6 µS/cm and 343 µS/cm. Seepage testing to evaluate the source of the water observed at the toe of the North Dam should be performed again once tailings are deposited within the TIA, as it is assumed that deposition of tailings will give the TIA water chemical signatures that will distinguish it from rainwater.

Recommendations

- Backfill the erosion around ND−DSP−100.
- Update North Dam monitoring SOP to include tracking and monitoring of depressions, including regular surveys when snow is not on the ground.

3.9 TIA Water Level and Shoreline Erosion

Daily water levels in the TIA have been measured with a series of data loggers, since 2011. Prior to 2015, the dataloggers have not been georeferenced and instead water levels were measured against an arbitrary benchmark of 100 masl. These arbitrary readings were then georeferenced in comparison to staff gauge readings. On July 15, 2015, ERM installed a new datalogger at a depth of approximately 5 m below the TIA water level of 29.08 m. TMAC site personnel have also measured the pond water levels daily from June 6 to September 22, 2015 with a staff gauge set up near the upstream toe of the North Dam. Pond water level since 2011 is provided in Appendix G.

The normal water level in the pond is 28.3 m, since there is no natural outflow, the water level of the pond is being managed though active pumping. At the time of the site inspection the water level was 29.09 m, which is 0.79 m above the original lake water level. Therefore, a large section of shoreline has been flooded, which has resulted in vegetation die-back. At this time there are no signs of shoreline erosion.

Water levels above the natural pond water level will ultimately will lead to thaw of permafrost and erosion of the overburden soils. Erosion of the overburden soils will increase the total suspended solids in the pond, which is an expected consequence of the Project; however, steps should be taken to minimize this as much as possible.

Recommendations

- Implement measures to maintain a pond water level of 28.3 masl to prevent onset of permafrost degradation.

4 Recommendations and Conclusions

The North Dam is functioning as designed. Any of the issues observed in the physical inspection and any anomalies observed in the monitoring data can be explained and are not of concern. **Error! Reference source not found.** presents a summary of the recommendations listed throughout this report.

Table 5: Summary of Recommendations

Inspection Item	2014 Recommendations	2015 Recommendations
Compliance with Monitoring Requirements	• Perform monitoring of the North Dam at the frequency described in the North Dam Monitoring Standard Operating Procedures (SRK 2013b). • Update the North Dam monitoring standard operating procedures to clarify inconsistencies and address winter versus summer monitoring.	• Perform monitoring of the North Dam at the frequency described in the North Dam Monitoring Standard Operating Procedures. • Update the North Dam Monitoring Standard Operating Procedures to clarify datalogger download frequency.
Ground Temperature Cables (GTCs)	• Collect and review GTC data in accordance with the North Dam Monitoring SOP (SRK 2013b). • Have the dataloggers serviced by a qualified person and manually download data from June 14 to July 9, 2014 from dataloggers CR1000 #1 and CR1000 #2, and data from August 6 to 31, 2014 from CR1000 #1. • Ensure all field staff are properly trained and following the North Dam Monitoring SOP (SRK 2013b) to prevent card reader errors in the future. • Play close attention to the temperatures recorded by ND-VTS-130-DS and if temperature spikes are noted in the fall of 2015 additional investigation should be conducted.	• No action required.
Thermosyphons	• Bring Arctic Foundations Inc. to site to inspect why thermosyphon North 2 is not working, and carry out the necessary repairs. • While Arctic Foundations Inc. is on-site have them inspect all thermosyphons, and carry out any maintenance they recommend.	• Bring Arctic Foundations Inc. to site to inspect thermosyphon North 2, determine why it is not working, and carry out the necessary repairs. • While Arctic Foundations Inc. is on-site have them inspect all thermosyphons, and carry out any maintenance they recommend.
CR1000 Datalogger Battery Voltage	• The SOP for the North Dam monitoring should be revised to include a procedure to test and recharge or replace the batteries annually.	• The CR1000 Datalogger batteries should be tested and recharged, or replaced annually.
Inclinometers	• Conduct monthly survey of all survey monitoring points, in accordance with the North Dam Monitoring SOP (SRK 2013b).	• No action required.

Inspection Item	2014 Recommendations	2015 Recommendations
	• Ensure site personnel are properly trained to acquiring readings from the inclinometers.	
Survey Monitoring Points	• Conduct monthly survey of all survey monitoring points, in accordance with the North Dam Monitoring SOP (SRK 2013b).	• Backfill the erosion around ND−DSP−100. • Conduct surveys, in accordance with the frequency prescribed in the North Dam Monitoring SOP. • Update North Dam Monitoring SOP to clarify monitoring frequency during the winter months.
Walkover Surveys	• Perform walkover surveys in accordance with the monitoring SOP requirements (SRK 2013b). • During the walkover survey, pay particular attention to the exposed GTC and datalogger boxes so any issues (disconnected cables etc.) can be addressed promptly.	• No action required.
North Dam Physical Inspection	• Survey the locations of the three anomalies (U1, U2 and U3), after which they should be backfilled, compacted, and graded. • Backfill the erosion around the Deep Settlement Monitoring Point ND-DSP-100. • Establish a SOP for tracking and monitoring growth of the depressions, which should include regular survey of the depressions when snow is not on the ground. • Collect water quality samples, to be submitted for laboratory analysis, along the north dam downstream north dam toe and in the original Tail Lake outflow channel to confirm the source of the observed water.	• Update North Dam monitoring SOP to include tracking and monitoring of depressions, including regular surveys when snow is not on the ground.
TSF Water Level and Shoreline Erosion	• Install a new water level datalogger in the TSF at the start of the 2015 open water season and monitor monthly, in accordance with the North Dam Monitoring SOP (SRK 2013b). • Establish a new benchmark elevation to geodetically reference the new water level gauge measurements. • Implement measures to maintain the water level in the pond at 28.3 masl to prevent onset of permafrost degradation.	• Implement measures to maintain a pond the water level of in the pond at 28.3 masl to prevent onset of permafrost degradation.

This final report, 2015 Annual Geotechnical Inspection, Tailings Impoundment Area, Doris North Project, Hope Bay, Nunavut, was prepared by

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All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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