BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

NYRSTAR

NANISIVIK MINE, NUNAVUT

2020 UPDATE TO POST CLOSURE GEOTECHNICAL MONITORING CONTINGENCY PLAN

PROJECT NO.: 0255030 DATE: March 13, 2020

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March 13, 2020
Project No.: 0255030

Mr. Johan Skoglund
Nyrstar
Tessinerplatz 7
8002 Zurich, Switzerland

Dear Johan,

Re: 2020 Update to Geotechnical Monitoring Contingency Plan, Nanisivik Mine, NU

Please find attached our above captioned report on the Nanisivik geotechnical monitoring contingency plan requested in support of water license 1AR-NAN2030. If there are any questions or comments regarding this report, please contact the undersigned at your convenience.

Yours sincerely,

BGC ENGINEERING INC.
per:

Scott Garrison, M.Eng., P.Eng.
Geological Engineer

EXECUTIVE SUMMARY

This document provides an updated contingency plan for post closure geotechnical monitoring at the Nanisivik Mine site for the duration of the current Water Licence (1AR-NAN2030), effective January 8, 2020 through January 8, 2030. The geotechnical monitoring program consists of monitoring and analysis of geotechnical instruments and visual inspections of reclamation measures by a geotechnical engineer. The report describes a number of potential issues that could arise during the post closure monitoring program, which may warrant implementation of contingency measures. The issues are separated into those related to physical integrity of the reclamation measures and those related to geotechnical monitoring data collected for various purposes at different areas of the mine site. The report provides the following for each potential issue:

- A description of what each issue involves.
- How each issue can be recognized.
- The significance of each issue.
- How prevalent each issue has been during the post closure geotechnical monitoring undertaken to-date.
- A description of potential contingency measures to be considered should each occurrence be observed.

The discussion provided in the report utilizes observations made during post closure geotechnical monitoring undertaken annually at the site since completion of many of the reclamation measures in 2005. Hence, the proposed contingency plan benefits from the nearly 15 years of observed performance. These annual geotechnical monitoring reports should be reviewed in conjunction with this contingency plan document for complete context. For contingency planning regarding geotechnical instrumentation, refer to the separate BGC report titled *2020 Update to Geotechnical Instrumentation Contingency Plan*, to be issued concurrently with this report (BGC, February 28, 2020).

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LIMITATIONS

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1.0 INTRODUCTION

Nanisivik Mine is currently owned by Nyrstar, who obtained the property through its purchase of Breakwater Resources Ltd. (Breakwater) in 2011. The Nanisivik Mine began production of zinc and lead concentrates in 1976. After 27 years of successful operations, the economic mineral deposit was depleted in 2002 and the mine entered the Closure and Reclamation phase in September 2002. The Final Closure and Reclamation Plan (FCRP) for the Nanisivik Mine was submitted to the Nunavut Water Board (NWB) by CanZinco in March 2004 (CanZinco, March 2004). The NWB conveyed its approval of the FCRP for Nanisivik Mine in a letter to Breakwater dated July 6, 2004 (NWB, July 6, 2004). The reclamation of the mine site began in August 2004, with the bulk of reclamation completed between 2004 and 2008. Refer to the most recent annual geotechnical inspection report (BGC, January 24, 2020) for further detail on reclamation activities.

Post closure geotechnical and water quality monitoring programs, including annual geotechnical inspections, have been undertaken annually as outlined in a number of previous water licences issued to Nyrstar by the NWB. A new Licence, 1AR-NAN2030 TYPE “A”, (the New Licence) water licence was issued by the NWB effective January 8, 2020 through January 8, 2030 (NWB, January 9, 2020). Future geotechnical site inspections will be conducted under the terms of the New Licence.

Included in the New Licence was a requirement (Part H, Item 10a.) to update the previously submitted Post Closure Geotechnical Monitoring Contingency Plan (BGC, March 17, 2015) previously developed as a condition of the prior Water Licence. To address this New Licence requirement, Mr. Johan Skoglund, Group Manager Environment, for Nyrstar requested that BGC Engineering Inc. (BGC) update the noted document. This document addresses this requirement of the New Licence and provides an updated contingency plan for geotechnical monitoring to be undertaken at site for the duration of the New Licence. The water quality monitoring program contingency plan is also being updated, by others, as requested in the New Licence.

2.0 POST-CLOSURE GEOTECHNICAL MONITORING PROGRAM

The approved post-closure geotechnical monitoring program (Schedule H, Table 4 in the New Licence) consists of regular monitoring of selected geotechnical instruments (thermistors, frost gauges and piezometers) and visual inspections of reclamation measures by a geotechnical engineer.

The results of the monitoring program are assessed by a qualified geotechnical engineer and are summarized in an annual geotechnical monitoring report. The annual geotechnical monitoring report includes a comprehensive review of observations recorded during the geotechnical site inspection, as well as a detailed assessment of the geotechnical monitoring data collected that year. The annual geotechnical monitoring report is forwarded to the NWB by Nyrstar as part of their annual environmental monitoring report. The most recent annual geotechnical inspection was conducted by BGC in August, 2019 and is detailed in a report to Nyrstar (BGC, February 24, 2020).

Based on the guidance provided in CDA (2014) the West Twin Dyke is considered an embankment slope as opposed to a dam. This classification is based on the following characteristics:

- The West Twin Disposal Area was covered and graded in such a way that the West Twin Dyke does not retain any supernatant water,
- The tailings retained by the dyke are frozen and incapable of flowing in their current state, and
- The dyke and foundation of the dyke remain in a frozen condition, and given the frozen nature of the retained tailings seepage and piping through the dam or foundation of the dam are not considered plausible given current conditions.

Given the embankment classification, the information provided herein does not constitute a formal Failure Modes and Effect Analysis (FMEA). A formal FMEA could be considered for future updates of this document, should conditions warrant though this is considered unlikely given performance of the facility in closure to-date.

2.1. Contingency Plans

The following sections describe a number of potential issues that could arise during the post closure monitoring program, which may warrant implementation of contingency measures. The issues are separated into those related to physical integrity of the reclamation measures and those related to geotechnical monitoring data collected for various purposes at different areas of the mine site. The following sections provide the following for each potential issue:

- A description of what each issue involves
- How each issue can be recognized
- The significance of each issue

- How prevalent each issue has been during the post closure geotechnical monitoring undertaken to-date
- A description of potential contingency measures to be considered should each occurrence be observed.

The discussion provided in the following sections uses observations made during post closure geotechnical monitoring undertaken annually at the site since completion of many of the reclamation measures in 2005. Hence, the proposed contingency plans benefit from the approximately 15 years of observed performance. The observations are documented annually in the geotechnical monitoring report. These annual geotechnical monitoring reports should be reviewed in conjunction with this contingency plan document for complete context. Given the remoteness of site, lack of material stockpiles, and equipment limitations, many of the remedial contingency measures discussed in this report will have a delay in implementation.

2.2. Integrity

The following section describes a number of potential issues related to the physical integrity of the reclamation works which may be observed during a visual inspection of the site.

2.2.1. Erosion of Covers

Surface erosion of the covers involves loss of cover material due to the movement of surface water. It can generally be recognized by the development of a channelized feature such as a gully or rill on the surface of the cover. Surface erosion is significant due to the potential to reduce the cover thickness or, in an extreme case, expose the underlying waste materials. Either of these events have the potential to locally affect the geothermal performance of the cover and, thus, have the potential to negatively impact surface water quality. The covers have generally been constructed using shallow surface grades and erosion resistant materials. As such, significant surface erosion is not anticipated, but this will be a function of cover performance under extreme climatic events. Since construction of most of the covers was completed in 2005, only minor rill erosion (< 10 cm deep) has been observed in select areas of the East Open Pit and Oceanview open pit cover systems, both of which were overbuilt in anticipation of minor erosion. If significant surface erosion is observed, potential mitigation measures include additional placement of coarser surface armour at select locations, re-grading of the slope to a shallower angle or development of armoured drainage swales, potentially including berms and/or water bars, to accommodate observed surface flows.

2.2.2. Development of Thermokarst Features on Covers

Thermokarst features can develop due to melting of ice that is either entrained within the cover materials or in the underlying mine waste. It can generally be recognized by a circular depression in the surface of the cover. The size can vary, but the features observed to date typically range from 30 to 200 cm in diameter and from 30 to 60 cm in depth. Thermokarst features are significant due to the localized thinning of cover and a local negative impact to the geothermal performance of the cover. Due to the ice encountered in the shale borrow areas during construction, thermokarst features were common in the first year following construction as the ice entrained within the shale fill melted. These features were repaired as they were observed throughout the site. Since then, the frequency of thermokarst development has lessened and is not anticipated to be a long-term issue. However, if thermokarst features are observed, the recommended mitigation measure involves backfilling the thermokarst feature with additional armour material.

2.2.3. Development of Frost Heave Features on Covers

Frost heave features can develop due to either seasonal freeze-thaw processes as the ice thickness grows at the base of the active layer, or due to expansion of confined pore water in the tailings as free-back progresses. It can generally be recognized by a gentle circular or oblong bump or raised area that can range in areal extent from several metres to several tens of metres in diameter, and up to several metres high. Frost heave features are significant due to the potential for cracking around the perimeter and on the top of the features that can result in a local negative impact to geothermal performance of the cover. Frost heave features have been noted on the Surface Cell cover system since closure. These features are expected to stabilize and self-heal over time, which has been observed in several locations on the cover. It is recommended that geotechnical inspections of the cover system look for the development of new frost heave features and monitor existing features, including extent, width and depth. If considered warranted by the geotechnical engineer based on visual observation, remote sensing methods could be explored as a monitoring supplement. Should frost heave features be determined by a geotechnical engineer to warrant mitigation, measures may include repairing cracks by grading or by filling cracks with additional armour material.

2.2.4. Sloughing/Slumping of Sloped Covers

Surficial instability of sloping covers can involve sloughing or slumping of material where the material slides downslope due to weak material properties or saturated conditions. Sloped covers are present on waste rock piles, tailings, landfill, and the faces of the West Twin and Test Cell dykes. It can generally be recognized by the development of a head scarp (usually near vertical), with an associated semi-circular crack demonstrating some vertical and/or lateral/downslope movement. Sloughing or slumping of the cover systems can be significant due to the potential to expose the underlying mine waste. Due to the overall gentle slopes of most of the cover systems and the coarse granular particle size of the cover materials, sloughing and slumping of the cover systems has not been observed since construction of the cover systems. However, should sloughing of the cover systems be observed in the future, potential mitigation measures may include buttressing of the unstable area with additional material or improving surface drainage to reduce near-surface moisture conditions depending on the driving factors causing the observed instability.

2.2.5. Erosion of Shoreline Protection in Reservoir

Shoreline protection was constructed along the perimeter of the cover system at the edge of the Reservoir in the West Twin Disposal Area. The shoreline protection comprises dolostone rip rap which was applied to the surface of the sand and gravel armour material to protect the cover materials from wave erosion and to provide some protection from ice plucking. The rip rap extends approximately 1 m below the normal water level in the Reservoir. Erosion of the shoreline protection can be significant due to the potential to expose the underlying cover materials which would then be subject to wave erosion and ice-plucking. This could eventually lead to exposure of the underlying tailings. No erosion of the shoreline protection has been observed since completion of construction in 2005. However, if erosion of the shoreline protection is observed, potential mitigation measures could include increasing the particle size, thickness or decreasing the angle of the face of the rip rap layer.

2.2.6. Erosion of Hydraulic Channels

The West Twin Dyke Spillway and the East Twin Creek Diversion Channel (ETCDC) are the two significant hydraulic channels that function as part of the reclamation of the West Twin Disposal Area (WTDA). The spillway conveys water from the Surface Cell cover into the Reservoir and the ETCDC conveys water between East Twin Lake and the confluence with the outflow from the WTDA at the West Twin Outlet Channel. Both channels have bank armouring to reduce potential for erosion. The potential significance of erosion is unique to each structure. If the banks of the spillway experience significant erosion leading to localized bank instability, the flow within the spillway could become temporarily impeded. However, given the flow volumes relative to the channel capacity, it is unlikely that the flow would exit the spillway channel. If erosion of the left bank of the diversion channel occurs, the performance of the diversion dyke could become compromised and, in an extreme case, the flow from the creek may enter the Polishing Pond. Erosion of a portion of the left bank of the spillway has been observed periodically since construction due to flows during freshet. Similarly, erosion of a portion of the left bank of the diversion channel has been observed in recent years also related to freshet flows. The observed erosion at each structure has been moderate, which some efforts undertaken to address the spillway erosion in 2012 and 2018, and the ETCDC in 2018. Should additional erosion be observed, enhanced armouring (extent, width, fragment size, etc.) of the banks would be required.

2.2.7. Lower than anticipated water level in Reservoir

The water level in the Reservoir is maintained by the West Twin Outlet Structure which includes an armoured channel and concrete weir. Water from the WTDA passes through this channel and proceeds over the weir, prior to entering Twin Lakes Creek. The structure is designed to maintain the water level in the Reservoir at 370.2 m elevation. This maintains a water cover of minimum 1 m thickness over the tailings that remain in the Reservoir. It should be noted that the hydraulic design of the WTDA accounted for the water level in the Reservoir to fluctuate between a low of 370.0 m and a high of 370.8 m, corresponding to the extreme drought conditions and the probable maximum precipitation event, respectively. If the water level in the Reservoir were lower than the design low water level, potential negative impacts to water quality in the Reservoir may occur.

Based on observations during the annual geotechnical inspections since construction of the outlet structure, the water level in the Reservoir during open water season has been observed to fluctuate, within the expected range, in response to inflows of surface water, evaporation and seepage losses through the base of the remnant polishing pond. Should the water level in the Reservoir be observed to be below the design low water level, water quality monitoring would be reviewed to see if a correlation existed whereby effluent quality was degrading. Should this be the case, seepage losses at the West Twin Outlet Structure and polishing pond may need to be assessed and potentially mitigated. This could be addressed by backfilling a portion of the remnant polishing pond immediately upstream of the outlet structure. Additional options may also be considered depending on the observations at that time.

2.2.8. Crown Pillar or Portal/Raise Plug Collapse

Openings to the underground mine workings were closed during reclamation of the mine site by construction of rockfill plugs in the portals and raises. During construction of these plugs, additional backfill was also placed beneath the crown pillar to provide support for these areas. If crown pillar collapse were to occur, surficial cracking may occur but the backfill would prevent an opening to the underground mine workings from developing. If an opening to the underground mine workings were to develop, it could pose safety concerns for people passing through the area. Given the additional support provided by the portal plugs, settlement of the crown pillars, to the point where access to the underground workings is created, is unlikely. Since the closure of the portals in 2005, some settlement and cracking of the East Open Pit crown pillar was observed but has not progressed in many years. Should a collapse be observed, potential mitigation measures may include backfilling the opening to the underground with additional fill to prevent access and/or provide additional support to the remaining crown pillar.

2.2.9. Excessive Cracking or Deformation of Dyke Structures

Cracking and bulging of dyke structures can occur as a result of dyke instability. Although unlikely based on demonstrated history of performance and stability modelling results, dyke instability is potentially significant because it could result in a release of tailings or tailings pore water to the environment. Annual geotechnical inspections assess the dyke structure for visual signs of instability such as transverse or longitudinal cracks through the dyke or dyke abutments, bulging near the toe of the dyke, or deformation along the dyke. In the 15-year monitoring period since closure, no cracks or deformation of dyke material has been observed. It should be noted that superficial cracking or deformation is possible within cover materials covering the dyke due to thermal effects that do not indicate dyke instability.

Should cracking or deformation of the West Twin Dyke or Test Cell Dyke be noted during an annual site inspection, the cause and severity should be determined in a timely manner by the geotechnical engineer to determine an appropriate course of action. At minimum, contingency measures may likely include increased visual inspection frequency, increased instrument monitoring frequency, or implementation of remote sensing monitoring methods. If warranted, depending on the nature and severity of the instability, physical contingency measures such as containment or diversion of tailings and tailings water, toe buttressing, drilling pore pressure relief wells, or installation of thermosyphons could also be pursued.

2.3. Trigger Levels for Monitoring Data

The following section provides trigger levels and recommended actions should specific data be collected during the monitoring of the geotechnical instrumentation at various locations around the mine site.

2.3.1. Ground Temperatures

The Surface Cell and Test Cell taliks are freezing back with time. The ground temperatures in the Surface Cell and Test Cell taliks are currently being monitored with thermistors and piezometers tips that measure temperature as well. Modelling of the progress of the freezing front into the Surface Cell talik was conducted during the original reclamation plan development and the results were conveyed in BGC (January 30, 2004a). The results of this study suggested that the -0.2°C isotherm[1] in the Surface Cell talik should progress to the bottom of the dike between 7 and 8 years following construction of the cover system. The results also suggested that the entire Surface Cell tailings deposit would be colder than -0.2°C between 27 and 32 years following construction of the cover system. This anticipated freeze-back envelope (elevation versus time) is illustrated on Figure 1. The current geothermal conditions in the Surface Cell talik are also illustrated on Figure 1 by plotting the estimated depth of the -0.2°C isotherm from select thermistors in the Surface Cell. As illustrated on Figure 1, the freeze-back of the Surface Cell talik is currently progressing faster than originally anticipated. Freeze-back is expected to continue but is expected to slow with time until a point of equilibrium is reached. Slower than anticipated freeze-back is not thought to be of significant concern due to the lack of a hydraulic connection between the Surface Cell talik and the Reservoir. However, should the talik cooling trend become significantly slower or reverse, a detailed review of the monitoring results should be undertaken to determine a cause and assess the need for further remedial efforts.

[1] The -0.2°C isotherm was selected during the initial modelling to account for the effects of freezing point depression. Based on recent monitoring results, the freezing point varies with depth and location within the old lakebed. The freezing point of the remaining thawed tailings in the remnant talik is colder than -1°C. However, -0.2°C was used in Figure 1 for comparison purposes with the original modeling results.

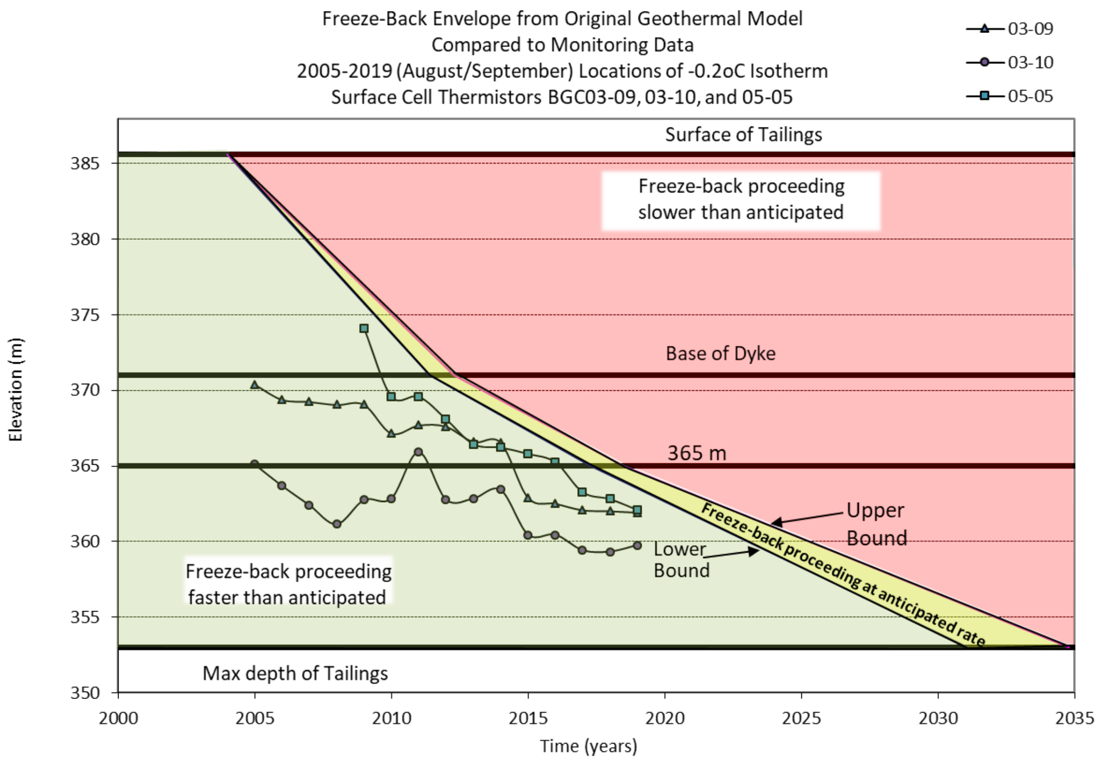

Figure 1. Freeze-back envelope of the Surface Cell talik from the original geothermal model compared to monitoring data (2005-2019) using location of -0.2°C isotherm.

2.3.2. Pore Pressures

As the Surface Cell and Test Cell taliks freeze-back, the pore water pressures in each of the taliks are expected to increase due to the pore water expulsion effect. Pore pressures are monitored using vibrating wire piezometers. However, due to the progression of the downward migration of the freezing front, all piezometers in the Surface Cell and all but two piezometers in the Test Cell are now frozen and incapable of monitoring future pore pressure changes. Replacement of the piezometers is not considered necessary at this time considering the isolated nature of the thawed tailings within the remnant Surface Cell talik and the distance between these thawed tailings and the dyke.The monitoring data collected to-date supports the original assumption that talik pore pressures would increase as the freeze-back progressed. This is specifically true in the Surface Cell which, unlike the Test Cell talik, is not hydro-geologically connected to the Reservoir. Only a small (< 2 m) piezometric increase has been observed in the Test Cell talik since closure, likely due to partial restriction of the hydraulic connection with the reservoir over time. While it's unlikely due to the downward progression of the freezing front observed to-date, high pore pressures in the Surface Cell talik can be significant due to their potentially negative impact on the stability of the West Twin Dike. Should pore pressures increase sufficiently to cause dike instability, tailings and/or tailings pore water, potentially high in metals concentration, could be released to the environment. As such, the pore pressures observed in the Surface Cell talik have been regularly reviewed. The determination of pore pressure "trigger levels" sufficient to cause concern to dyke stability is complex, as the geothermal conditions within the talik are evolving with time, and therefore, the trigger levels also evolve with time. As the talik freezes back, pore pressures are increased but are confined further away from the dyke due to downward progression of the freezing front. Additionally, the soil and rock surrounding the talik gain considerable strength when in a frozen state compared to a thawed state.

The previous Geotechnical Monitoring Contingency Plan report (BGC, March 17, 2015) discussed stability modelling that was conducted in 2014. The results showed that despite an increase in Surface Cell talik pore pressures between 2009 and 2014, a net increase in factor of safety (from 1.9 to 2.1) was achieved.

The model was updated again as part of this report, with model setup and results shown in Appendix B. Using 2020 talik geometry, the West Twin Dyke had a factor of safety of 2.9 against sliding under static conditions, with Surface Cell and Test Cell piezometric elevations of 406 and 373, respectively. The test Cell piezometric elevation is slightly higher than is measured in remaining unfrozen piezometers, while the Surface Cell piezometric elevation was extrapolated from stable trends observed in piezometers before they froze-back. It is expected that the factor of safety will continue to increase with downward migration of the freezing front. It should be noted that although the entire footprint below the West Twin Dyke is believed to be frozen into bedrock, the stability model nonetheless considers a thawed layer above bedrock, as a conservative assumption.

Because of the high factor of safety and because all piezometers in the surface cell are frozen-in, it is no longer practical or possible to use pore pressures as a geotechnical trigger. However, continued monitoring of the frozen-in piezometers to monitor the temperature of the piezometer tip and to determine if pore pressures become re-established is recommended. Geotechnical site inspections should assess for any Dyke cracking or deformation.

Care needs to be taken when reviewing pore pressure data from the taliks to ensure that the pore pressures are reflective of the surrounding area. As the soil around the piezometer tip freezes, pore pressures locally increase or become erratic due to pore water expulsion effects in the confined area directly around the piezometer tip. These pore pressures are not reflective of wide-spread conditions within the talik.

2.3.3. Active Layer Thaw

The cover systems are designed to confine the annual active layer thaw within the cover system and maintain a perennially frozen state in the underlying mine wastes (BGC, September 28, 2004b). The progression of the active layer thaw is currently being monitored using frost gauges and thermistors. Depending on the underlying mine waste, the cover systems vary in thickness (1.25 m minimum over tailings at the WTDA and 2.35 m minimum over waste rock and landfill debris). Monitoring to-date indicates that the active layer thickness has generally been confined within the cover materials throughout the year and the geothermal performance of the cover systems is continuing to improve with time. If the active layer were to progress into the underlying mine wastes, negative impacts on surface water quality could occur. If the monitoring data suggests that the active layer exceeds the minimum cover thickness (provided in Table 2), a detailed review of the monitoring data, including water quality, should be initiated. If additional remedial measures are considered to be warranted, they may include thickening of the cover materials in select locations.

3.0 DECISION MAKING/REPORTING RESPONSIBILITY

The contingency measures and trigger levels provided in the preceding sections are to be used only as a guide when reviewing the results of the on-going post closure geotechnical monitoring of the Nanisivik Mine site. Prior to the implementation of any of the proposed remedial actions, a qualified professional geotechnical engineer with appropriate permafrost experience should be consulted to review the monitoring results and current site conditions. Any decision to implement remedial measures requires the input of both the owner and the geotechnical engineer. Any remedial measures undertaken should be documented to an appropriate level of detail such that they can be included within the annual geotechnical report.

4.0 CLOSURE

We trust the above satisfies your requirements at this time. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

BGC ENGINEERING INC.
per:

REGISTERED PROFESSIONAL ENGINEER
S.D. GARRISON
LICENSEE
Mar 13/20
NT/NU

PERMIT TO PRACTICE
BGC ENGINEERING INC.
Signature
Date 13 - March - 2020
PERMIT NUMBER: P 285
NT/NU Association of Professional Engineers and Geoscientists

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Reviewed by:

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SG/GC/jwc/cs

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APPENDIX A
CONTINGENCY PLAN TABLES

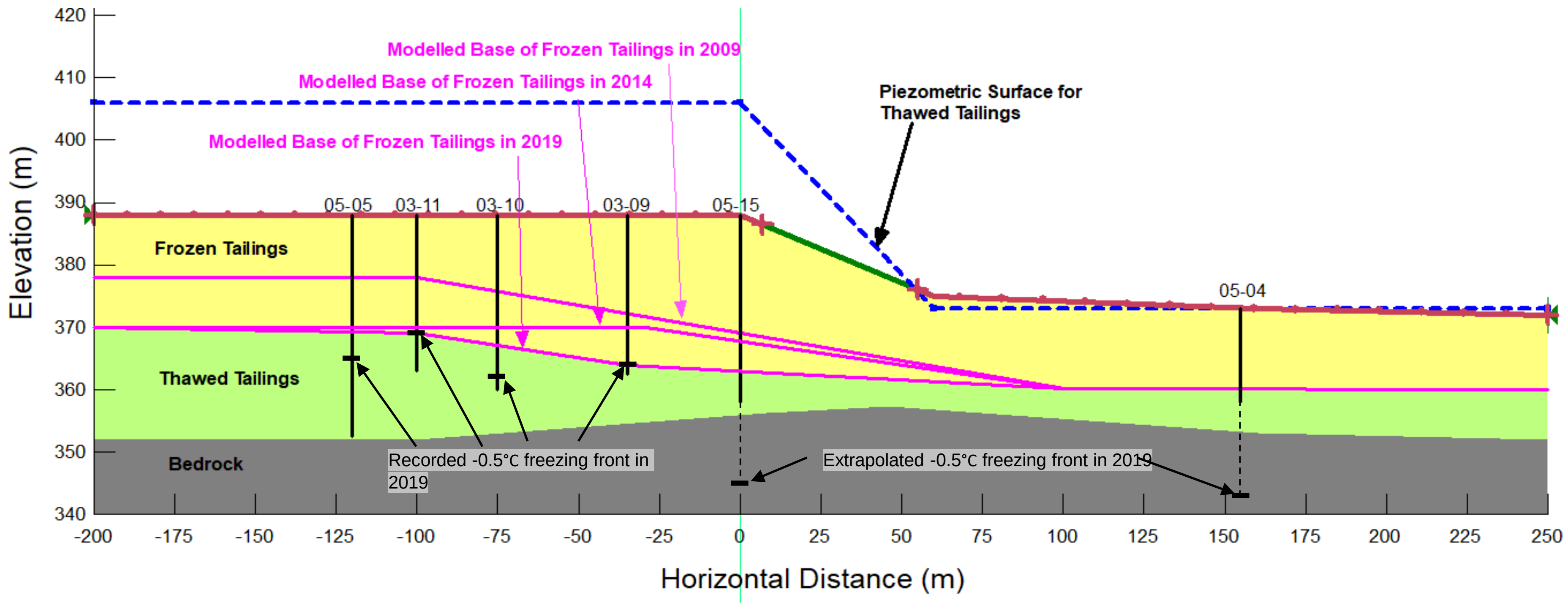
Table A-1. Contingency measures for physical integrity issues.

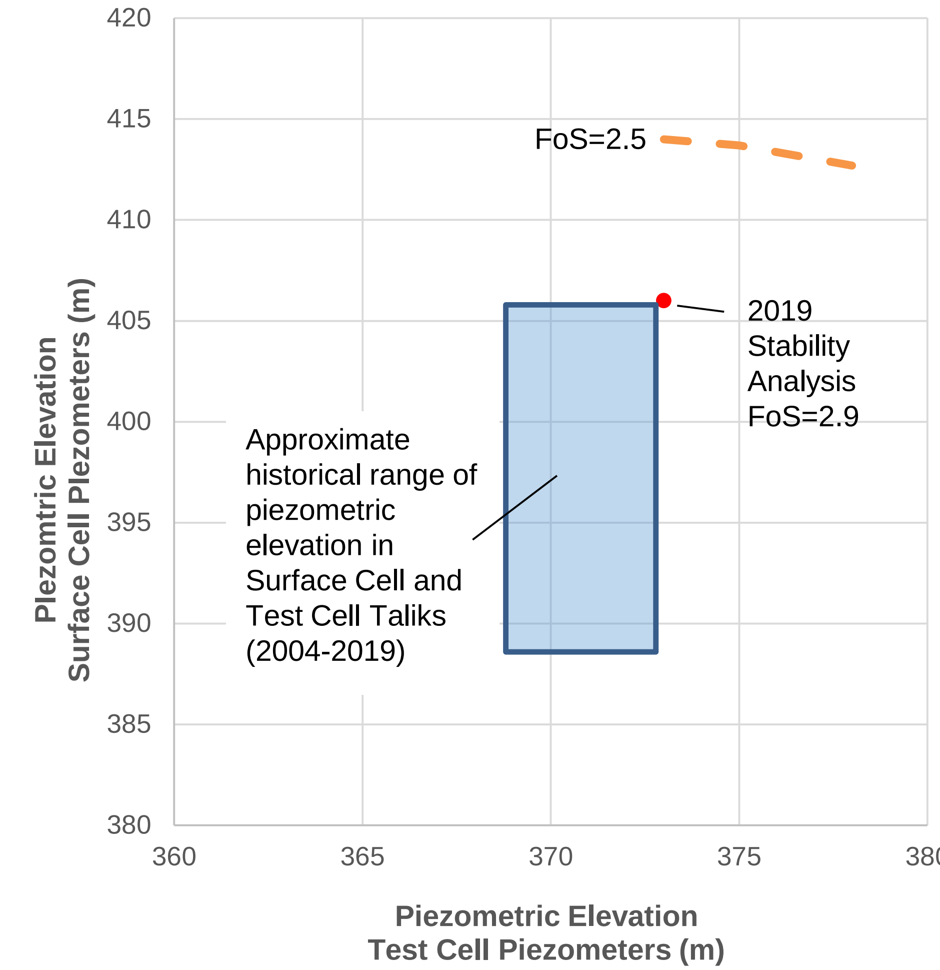
Issues	Recognizable Characteristics	Potential Consequences	Potential Contingency Measures
Cracking or Deformation of West Twin Dyke or Test Cell Dyke	Cracking of the dyke or dyke abutments that is not limited to cover material. Bulging of the dyke face or dyke toe.	Release of tailings or tailings water to the environment.	Determine causation and severity. Increased monitoring frequency/intensity, containment or diversion of tailings and tailings water, toe buttressing, drilling pore pressure relief wells, installation of thermosyphons.
Erosion of Covers	Channelized feature (rills to gullies) on the surface of the cover formed as a result of material loss due to running surface water.	Thinning of cover locally affecting geothermal performance of cover. In extreme case, exposure of underlying mine waste.	Additional placement of larger diameter surface armour at select locations, re-grading of the slope to a shallower angle or construction of armoured drainage berms / swales to locally manage water.
Development of Thermokarst Features	Circular depression in surface of cover related to thawing of entrained ice in cover materials or underlying mine wastes. Generally, 30 to 200 cm in diameter and 30 to 60 cm in depth.	Localized thinning of cover and a local negative impact to geothermal performance of cover.	Backfill with additional armour material to original surface grade.
Development of Frost Heave Features	Circular or oblong bump or raised area caused by ice build-up at the base of the active layer. Can range in size from several metres to several tens of metres in diameter, and up to several metres high.	Cracking of cover and potential negative impact to geothermal performance of cover.	Monitor cracks for self-healing. Explore remote sensing methods for monitoring. Repair cracks by grading or filling with additional armour material.
Sloughing/Slumping of Sloped Covers	Development of a headscarp, a semi-circular crack demonstrating some vertical and/or lateral/downslope movement.	Exposure of underlying mine waste.	Buttressing of unstable area. Improving surface drainage to reduce near surface moisture conditions.
Erosion of Shoreline Protection in Reservoir	Downslope movement or loss of rip rap materials.	Exposure of underlying cover materials to erosive effects of waves and ice.	Increase particle size or layer thickness or decrease slope angle of rip rap layer.
Erosion of Side Slopes of Hydraulic Channels	Disturbance/removal of bank armouring materials.	If occurs in spillway, could temporarily interrupt flow between Surface Cell and Reservoir, but likely that flow would still be confined in channel. If occurs in East Twin Creek Diversion Channel, potential to combine with outflow from Reservoir in Polishing Pond.	Increasing armour sizing/thickness and/or re-grading of side-slopes to a shallower slope angle.
Low Water Levels in the Reservoir	Water level below 370.0 m elevation.	Thinning or loss of water cover over tailings high points under water cover in Reservoir. Negative impacts on water quality in Reservoir.	Address seepage losses at West Twin Outlet Structure by backfilling a portion of the polishing pond upstream of the outlet structure.
Crown Pillar/Portal/Raise Plug Collapse	Settlement or an opening into the underground mine workings due to collapse of crown pillar or plug.	Safety concerns for people and wildlife passing through area.	Backfilling opening to prevent access, grade to prevent water infiltration and provide additional support to remaining portion of crown pillar if movement on-going.

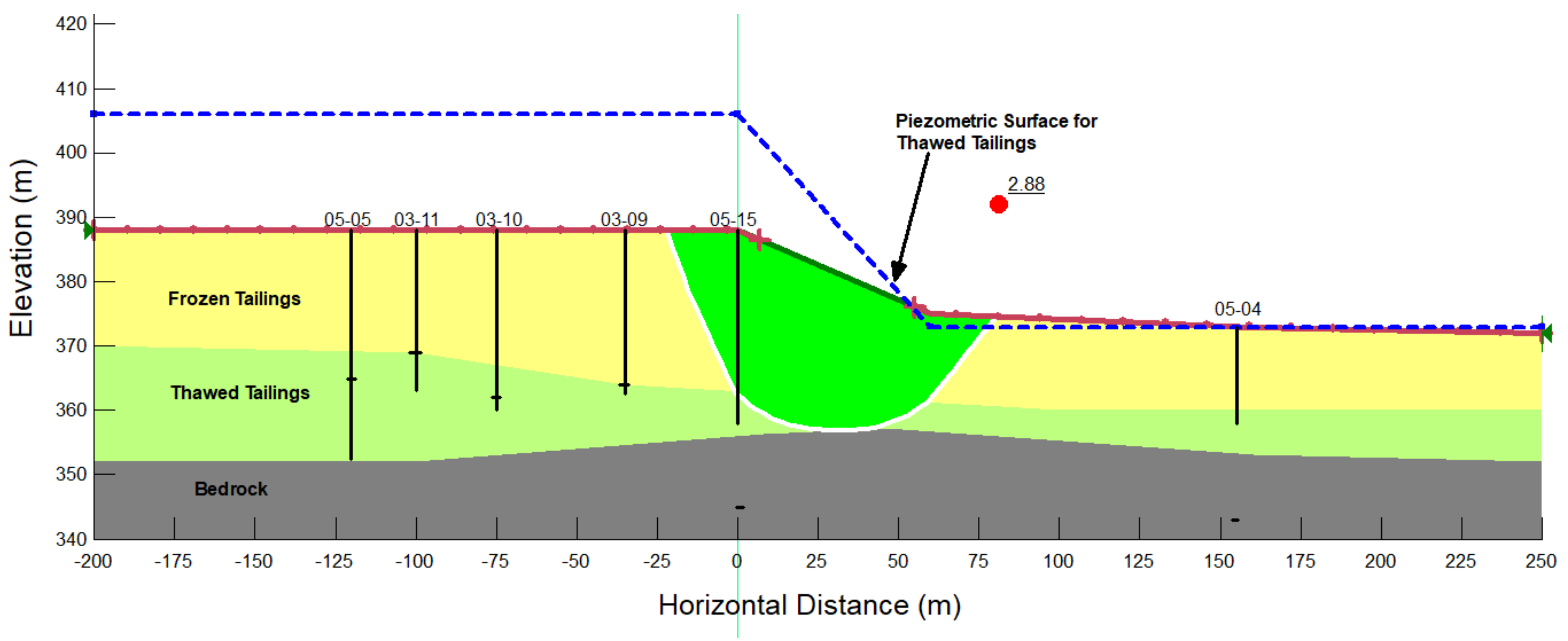
Table A-2. Trigger levels and contingency measures for geotechnical monitoring data.

Issues	Trigger Levels	Potential Consequences	Potential Contingency Measures
Ground Temperatures	Vertical location of -0.2°C isotherm from thermistors 03-09, 03-10 and 03-11 on freeze-back envelop plot (Figure 1).	Slower than anticipated freeze-back.	Assess impact and extend post-closure monitoring program.
Pore Pressures	Increasing tip temperature and/or re-establishment of pore pressures	Potential thawing if tailings, pore pressure generation and negative effect on dike stability.	Review geothermal and piezometric conditions. Assess dike stability. Pore pressure relief wells, in extreme case.
Active Layer Thaw	Tailings Covers at WTDA. Active layer thickness exceeds 1.25 m, as indicated by data from frost gauges and thermistors. Covers over waste rock. Active layer thickness exceeds 2.35 m, as indicated by data from frost gauges and thermistors.	Potential negative impacts on quality of surface water run-off.	Review of monitoring data, including water quality. Local thickening of cover materials in select locations, in extreme case.

APPENDIX B
2020 WEST TWIN DYKE STABILITY MODELLING UPDATE







Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	Bedrock	Bedrock (Impenetrable)				
	Frozen Tailings	Mohr-Coulomb	24	25	27	
	Thawed Tailings	Mohr-Coulomb	24	0	27	1

DRAWING TO BE READ WITH BGC REPORT TITLED: "NANISIVIK MINE 2020 UPDATE TO POST CLOSURE GEOTECHNICAL MONITORING CONTINGENCY PLAN", DATED MARCH 2020

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

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