BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

NYRSTAR

NANISIVIK MINE, NUNAVUT

2013 ANNUAL GEOTECHNICAL INSPECTION

FINAL

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BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Suite 200 - 1121 Centre St. NW
Calgary, AB Canada T2E 7K6
Telephone (403) 250-5185
Fax (403) 250-5330

February 27, 2014
Project No.: 0255-023

Mr. Johan Skoglund
Group Environment Manager, Americas
Nyrstar
Tessinerplatz 7
8002 Zurich, Switzerland

Dear Johan,

Re: 2013 Annual Geotechnical Inspection Nanisivik Mine, Nunavut

Please find attached our above captioned final report on the 2013 Annual Geotechnical Inspection undertaken at Nanisivik Mine. The report has been finalized to reflect your review comments.

If there are any questions or comments regarding this report, please contact the undersigned at your convenience.

Yours sincerely,

BGC ENGINEERING INC.
per:

ISSUED AS DIGITAL DOCUMENT.
SIGNED HARDCOPY ON FILE WITH
BGC ENGINEERING INC.

Geoff Claypool, M.Eng., P.Eng.
Senior Geological Engineer

EXECUTIVE SUMMARY

The Annual Geotechnical Inspection was undertaken at the Nanisivik Mine site in 2013. The program involved the following:

- Completion of a site inspection by a professional geotechnical engineer. The site inspection included visual observations of all reclamation measures undertaken at the Nanisivik Mine site since 2004.
- Download of air temperature monitoring equipment and the re-installation and subsequent download of water level monitoring equipment (in the Reservoir).
- Collection of geotechnical monitoring data from various instruments located around the mine site. The data was collected generally in line with the frequency outlined in the Water License.
- Review of the geotechnical monitoring data to assess the performance of various reclamation measures with respect to the original design intent.

The following paragraphs provide a summary of the significant observations, conclusions and recommendations based on the results of the 2013 Geotechnical Inspection Program undertaken at the Nanisivik Mine site.

Embankments

The breaches in the remnant dykes at the East Adit Treatment Facility continue to permit natural drainage of the area with only limited ponding in the Retention Pond. The size of this ponding is gradually decreasing with time as the low spots in the pond area backfill with natural sediment transported from upslope areas. The Main Tank Farm berm was nearly completely removed at the time of the inspection and no ponding was occurring in the area. The West Twin Dyke was physically stable with no signs of erosion or seepage.

Hydraulic Structures

The West Twin Dyke Spillway continues to effectively drain surface water from the Surface Cell cover into the Reservoir and is generally functioning as intended. Some erosion of the side wall was noted in the past, likely in response to elevated flows during freshet. Re-sloping and placement of additional armour in erosion areas was completed during the 2012 inspection. The remediation work was reviewed during the 2013 inspection and was noted to be in good condition.

As observed during previous inspections, a small head pond developed on the Surface Cell cover at the spillway inlet. The presence of the head pond is not considered to negatively impact the overall cover performance; hence the elimination of the head pond is not considered necessary. Reduction in pond size may continue over time as the intact rock in the base of the spillway inlet becomes more permeable due to freeze thaw effects.

Seepage losses continued at the West Twin Outlet wall in 2013. Despite these seepage losses, the water level in the remnant polishing pond upstream of the wall remained near the

invert of the outlet wall throughout the open water season in 2013. The stable water level in the Reservoir is thought to reflect the generally wetter than normal conditions at site in 2013 as opposed to being indicative of reduction in seepage losses. Increased instability in the shoreline of the polishing pond was also noted in 2013. Based on the water quality measurements collected since the East Twin Lake access road was breached in 2008, the seepage losses through the foundation of the wall do not appear to be affecting the overall performance of the West Twin Area reclamation measures. The seepage losses at the wall should continue to be monitored and additional seepage control measures should be considered.

Some erosion at the East Twin Diversion Dyke was noted during the inspection. The erosion was likely due to elevated flows during freshet in combination with snow blockage in the channel. The erosion appeared to be more advanced in 2013 compared to 2012. In general the dyke remains in stable condition. However, it is recommended that visual observations of flow during freshet be recorded in 2014. Seepage was observed at the toe of the East Twin Diversion Dyke in 2013 upstream of the convergence of flow from West Twin. This seepage is likely originating in the remnant polishing pond. There is no concern with respect to the integrity of the dyke due to the presence of this seepage. However, it is recommended that this seepage point be monitored for increased flows in 2014.

Thermal Covers

The thermal covers were generally performing well in 2013 and in most cases, the thermal performance was the best since the completion of the covers. Only minor erosion, cracking and thermokarsting were observed which were not seen to negatively impact the thermal performance nor the water quality in the surrounding areas. Many of these features have been noted previously and have been observed to be physically stable for the past several years. For the most part, the active layer thaw was contained within the thermal cover at most locations. Continued improvement has also been observed in the quality of the surface water runoff from the Surface Cell cover system. This is an indication of the beneficial impacts related to improved geothermal performance of the cover system. Additionally, the water quality observed at the final discharge point for the West Twin Disposal Area has also been observed to remain well below the discharge criteria.

It is anticipated that, over time, the ice saturation will continue to progress within the base of the cover materials. As this occurs, the geothermal performance of the covers will continue to improve, further confining the active layer thaw within the cover. No maintenance is required for the thermal covers at this time; however, visual monitoring is recommended to check for additional surface deformation.

Talik Freeze-back

Freeze-back of the talik in the Surface Cell and Test Cell appears to be proceeding at anticipated rates. Cooling of the entire geothermal profile was observed in most instruments at similar or accelerated rates of cooling compared to recent years.

The pore pressures in the Surface Cell talik continue to increase, as expected, due to continued freeze-back of the tailings, but have been shown to be lowest near the dyke and highest in the centre of the talik. The piezometers in the Test Cell have demonstrated that the Test Cell talik and Reservoir are hydraulically connected. This was expected based on the available information on the Test Cell talik (BGC 2004a) and was assumed during the development of the contaminant loading model (CanZinco 2004).

Mine Openings, Crown Pillars and Raises

The covers constructed over the mine openings generally appear to be physically stable. Cracking at the East Open Pit crown pillar does not appear to have progressed since 2011. No maintenance is recommended, but continued visual inspection is warranted.

Shale and Armour Borrow Areas

In general, the shale and armour borrow areas appear to be physically stable and are not causing any significant ponding to occur. No maintenance was recommended at any of the borrow areas.

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LIMITATIONS

BGC Engineering Inc. (BGC) prepared this document for the account of Nyrstar. The material in it reflects the judgment of BGC staff in light of the information available to BGC at the time of document preparation. Any use which a third party makes of this document or any reliance on decisions to be based on it is the responsibility of such third parties. BGC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this document.

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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. Nanisivik Mine is located on the Borden Peninsula on northern Baffin Island, just south of Strathcona Sound, as shown on Drawing 1.

Mining operations at Nanisivik ceased in September 2002. Site operations are currently conducted under Nunavut Water Board License 1AR-NAN0914 (the License), dated April 1, 2009 which entitles CanZinco (the Licensee and a subsidiary of Breakwater Resources Ltd.) to use water and dispose of waste associated with the closure and reclamation activities and post-closure monitoring at the Nanisivik Mine. Part I, Item 5 of the License states the following:

> *"The Licensee shall undertake a geotechnical inspection, to be carried out annually by a Geotechnical Engineer, during the months of July, August or September and reported as set out in Part I, Item 6. The inspection shall be conducted in accordance with the Canadian Dam Safety Guidelines, where applicable and be consistent with the "2008 Annual Geotechnical Inspection" (BGC Engineering Inc., January 30, 2009), taking into account all major earthworks and any changes to the project."*

Additionally, the Nunavut Water Board's Letter of Approval for the Mine Reclamation Plan (NWB 2004) states the following:

> *"In addition to the requirements outlined in Part H, item 6, of the previous License (NWB1NAN0208), the Licensee shall include inspection of all portals, audits, mine openings, ventilation shafts associated with the mine and an examination of the area around the Industrial Complex ice lens."*

Also, the approved Nanisivik Mine Reclamation and Closure Monitoring Plan (Gartner Lee Ltd. [GLL] 2004a) states that the annual geotechnical inspection will include "all earth structures, water diversions, rock slopes and soil covers by a professional engineer." As per the Monitoring Plan, "the engineers report will include a professional review and assessment of all thermal monitoring information and flow information relevant to a physical stability assessment."

In fulfillment of these regulatory requirements, Mr. Johan Skoglund, Group Environment Manager, Americas for Nyrstar, requested that BGC Engineering Inc. (BGC), conduct an inspection visit. The current report provides a summary of the conditions observed and any resulting recommendations and maintenance issues. Table 1 provides a list of the structures that were included within the inspection.

Table 1. Summary of Inspection Items.

Facility Type	Inspection Item
Embankments and Containment Structures	West Twin Dyke
	Test Cell Dyke
	East Twin Creek Diversion Dyke
	East Adit Treatment Facility
	Day Tank Farm Area
	Main Tank Farm Spill Containment Berm
	West Twin Outlet Channel
Thermal Covers	Surface Cell
	Test Cell
	Toe of Test Cell Dyke
	Toe of West Twin Dyke
	Landfill
	West Open Pit
	East Open Pit
	Oceanview Open Pit
	Area 14
	Upper Dump Pond
	Industrial Complex
Mine Openings, Crown Pillars and Raises	00/01 Portals and crown pillar
	17 N Portal
	Oceanview Portal
	K-Baseline Portal
	Area 14 Portal
	9S Portal
	Former Portal to Mill Foundation
	Lower Adit
	Shale Hill Raise
	Oceanview East and West Raises
	Area 14 Raise

Shale and Armour Borrow Areas	Mt. Fuji Shale Borrow Area
	West Twin Shale Borrow Area
	East Twin Shale Borrow Area
	Area 14 Shale Borrow Area
	Townsite Shale Borrow Area
	Shale Hill Shale Borrow Area
	Twin Lakes Delta Armour Borrow Area
	Kuhulu Lake Road Borrow Area
	09S/17N Armour Borrow Area
	Chris Creek Armour Borrow Area
Other	Concentrate Storage Shed

All pre-1998 site investigation work, geotechnical design and construction monitoring of the West Twin and East Adit containment structures was carried out by Terratech, a division of SNC Inc. and Mr. Frank Tordon, P.Eng. Initial design work relating to the East Twin diversion dyke and channel, and the dump containment ponds was provided by Kilborn Engineering Ltd. Golder Associates Ltd. (Golder) prepared the annual inspection reports for the waste containment dykes in 1998 and 1999, while BGC has provided the annual inspection reports since 2000. These other reports should be reviewed, in combination with this current report, for the sake of consistency regarding performance and maintenance issues.

2.0 MINE RECLAMATION ACTIVITIES

The Final Closure and Reclamation Plan (FCRP) was submitted to the Nunavut Water Board for review and approval in March 2004. The review process included a technical meeting in Yellowknife in May 2004 and a public hearing in Arctic Bay in June 2004. The Board conveyed its approval of the plan in a letter to Breakwater dated July 6, 2004.

The reclamation of the mine site has been ongoing since August 2004. Since then, the following reclamation activities related to the geotechnical inspection have been completed:

- Permafrost aggradation or "thermal" covers were constructed over tailings in the Surface Cell, Test Cell, toe of the Test Cell Dyke, toe of the West Twin Dyke and at the Upper Dump Pond.
- Thermal covers were constructed over waste rock in the West Open Pit, East Open Pit, Oceanview Pit and Area 14 Waste rock pile.
- A thermal cover was constructed over the Nanisivik Landfill.
- A thermal cover was constructed over the Industrial Complex Foundation, which had been backfilled with metals contaminated soil.
- Portal plugs and thermal covers were constructed at the Lower Adit, 09 South, Oceanview, K-Baseline, 17 North, 88 North, 00 and 01 Portals.
- A fill pillar was constructed beneath the 00/01 crown/rib pillar.
- The West Twin Dyke Spillway was constructed to convey water from the Surface Cell to the Reservoir.
- The West Twin Outlet Channel was constructed to control the water level in the Reservoir.
- Additional armour was applied to the face of the East Twin Creek Diversion Berm.
- The East Adit Treatment Facility was decommissioned by breaching each of the dykes.
- The Day Tank Farm was decommissioned by removing the tanks, liner and berms.
- The Lower Dump Pond was decommissioned by removing the berms, tailings and the liner and transporting them to the underground mine workings.
- The Concentrate Storage Shed was dismantled and a surficial cover was constructed over the concrete floor slab.
- The road separating the Polishing Pond and the Reservoir was breached, and the culverts and stop log control structure were removed.
- The Main Tank Farm was demolished and remediation of the hydrocarbon impacted soils from beneath the tank farm is ongoing.

Most of these reclamation measures are summarized in the project completion report (BGC 2009b) and documented in detail in various as-built reports referred to throughout this document. With the exception of completion of the remediation of the hydrocarbon impacted soils from beneath the Main Tank Farm, and some minor maintenance and ongoing monitoring programs, reclamation of the Nanisivik Mine site is essentially complete.

3.0 CLIMATE REVIEW

Climatic data was collected at the Nanisivik Airport by Environment Canada from 1976 to 2010, which is located approximately 10 km south of the West Twin Disposal Area (WTDA) and approximately 250 m higher in elevation. The recorded climate data were analyzed in Golder (1998) to provide a basis for deriving the existing climate parameters such as precipitation, air temperatures and lake evaporation at the project site. The following list is a summary of the main climatic parameters based on the data available in 1998:

- The mean annual air temperature (MAAT) was estimated to be -15.2°C.
- The mean annual precipitation total was estimated to be 240 mm.
- The 24 hour Probable Maximum Precipitation (PMP) value was estimated to range from 140 to 210 mm.
- The mean annual lake evaporation value, as measured at the Nanisivik site, was approximately 200 mm.

Climate monitoring was discontinued at the Nanisivik Airport in January 2011. The nearest available climate monitoring station is located at Arctic Bay, approximately 30 km from Nanisivik. The MAAT recorded at the Arctic Bay weather station in 2013 was approximately -13.5°C, approximately 3°C cooler than 2012. Additionally, the summer temperatures (July and August) in 2013 were approximately 2.5°C cooler than those recorded in 2012. This indicates a much lower potential for active layer thaw in 2013 compared to 2012. While the climate data sets from Arctic Bay and the former Nanisivik Airport weather station are not directly comparable due to elevation differences and proximity to the coast, it is likely that 2013 was the coolest year on average since construction of the covers was complete in 2005.

An assessment of regional air temperatures was conducted to further support the climate assessment. The two closest regional weather stations are located at Resolute Bay (364 km to the northwest) and Pond Inlet, Nunavut (located 235 km to the east). Both stations experienced similar cool years in 2013. The MAAT recorded at Resolute Bay in 2013 was -16.0 °C, which is 2.6 °C cooler than the 2012 MAAT and only 0.4°C warmer than the published 1970 to 2000 Normal of -16.4 °C. The MAAT recorded at Pond Inlet in 2013 was -14.1 °C, which is 1.3 °C cooler than the 2012 MAAT and only 1.0 °C warmer than the published 1970 to 2000 Normal of -15.1 °C. These regional stations also indicate that 2013 was cooler than 2012.

Given its importance to assessing performance of the reclamation measures at the Nanisivik Mine site, it was recommended, in 2011, that consideration should be given to the installation of an air temperature monitoring station at site. In response to this recommendation, an air temperature monitoring station was installed on the Surface Cell cover during the July 2012 inspection (location: E581042, N8104959, UTM NAD 83 Zone 16). The datalogger was downloaded during the July 2013 site inspection. Hourly air temperature readings were recorded between July 25, 2012 and April 26, 2013 before the logger ran out of battery power. The air temperature data collected from the Surface Cell cover system was compared to the data collected from the Arctic Bay weather station. Based on this comparison, the air temperatures recorded at Nanisivik were, on average, 0.9˚C cooler than air temperatures recorded in Arctic Bay.

It was noted by site monitoring staff, Mr. Claude Lavallee, that 2013 was a very wet year on site. The site observations are supported by rain gauge data collected on site in 2013 by Mr. Lavallee. The rainfall data collected on site since 2010 is summarized in Table 2. As can be seen, the rainfall at site in the summer of 2012 and 2013 is more than double the rainfall amounts in 2010 and 2011.

Table 2. Nanisivik Site Rain Gauge Data (June to September 2010-2013).

	2010	2011	2012	2013
Rainfall (mm)	45.6	37.0	109.8	109.0

The rainfall measured at site in 2013 was also higher than the published normal at the Nanisivik airport. From 1971-2000, the average rainfall was 61.5 mm. Along with the increased rainfall in 2013, Mr. Lavallee noted that spring run-off occurred earlier than normal in 2013 compared to most years; continuing a trend he has noticed in the area in recent years. Based on observations made during the site inspection, the early run-off contributed to increased erosion at various areas around the site such as the East Twin Creek Diversion Dyke. These observations of erosion are discussed in greater detail throughout this report.

4.0 MINE DESCRIPTION

Mining was conducted at Nanisivik Mine between 1976 and 2002. During that time, mining was conducted at four small open pits (West Open Pit, East Open Pit, East Trench and Oceanview Open Pit) and underground (Main Lens, Area 14, Oceanview and K-Baseline). The locations of each mining area are illustrated on Drawing 1. The ore was processed at the mill and the tailings were transported to the West Twin Disposal Area (WTDA), located at West Twin Lake.

The WTDA is comprised of an upper, solids retention pond, named the Surface Cell, and a lower, water retention pond, called the Reservoir, as shown on Drawing 2. The Surface Cell and Reservoir are separated by the West Twin Dyke, a frozen-core, rockfill dyke. Prior to construction of the West Twin Dyke, tailings were deposited throughout the original West Twin Lake. After construction of the dyke, tailings were primarily deposited into the Surface Cell. Excess water was then siphoned or pumped from the Surface Cell into the Reservoir from where it was reclaimed for use in the mill. The Reservoir was subsequently further separated by constructing the Test Cell Dyke, creating additional tailings disposal capacity in what was known as the Test Cell.

The Reservoir and a final polishing pond were separated by a rockfill causeway and stop log structure. Water from the polishing pond was then discharged to Twin Lakes Creek at the decant structure located at the outlet from the pond. The decant structure was replaced in 2005 by the West Twin Outlet Channel. In September 2008, the stop log structure was removed and the rockfill causeway was breached allowing the Reservoir and Polishing Pond to behave as a flow-through hydraulic system.

5.0 2012 MAINTENANCE RECOMMENDATIONS

The 2012 Annual Geotechnical Inspection Report (BGC 2013a) outlined a number of maintenance recommendations. These recommendations, and their status, as observed during the 2013 inspection, are provided in Table 3.

Table 3. Summary and Status of Previous (2012) Recommendations.

Inspection Item	Recommended Action items (2012)	2013 Comments / Actions
West Twin Dyke Spillway	Continue to monitor stability of the spillway and review options with respect to reducing snow levels in the spillway depression.	Remedial measures undertaken in 2012 appear to have enhanced stability of spillway side slopes. No additional information with respect to reducing snow levels in spillway was collected, continue to review the options.
West Twin Outlet Channel	Re-install monitoring equipment to measure the water levels in the Reservoir. Consider seepage control measures, such as backfilling the Polishing Pond, upstream of outlet wall.	Water level monitoring equipment re-installed and monitored in 2013. Seepage losses continue but impact on upstream water levels lessened due to higher rainfall amounts at site in 2013. Slopes along perimeter of remnant polishing pond continue to exhibit increasing instability.
East Twin Creek Diversion Channel	Monitor creek flows during freshet to assess causes of noted erosion. Monitor seepage discharge point at toe of dyke.	Additional erosion of left bank of channel observed. No change in seepage discharge noted.
Surface Cell Tailings Cover	Continue to visually monitor further deformation of thermokarst areas.	No additional deformation of Surface Cell cover surface noted.
East Open Pit/ East Trench Waste Rock Cover	Continue to visually monitor cracking in EOP crown pillar and minor surficial erosion of EOP and East Trench covers.	No additional cracking of EOP crown pillar observed. No additional erosion of surface of EOP or East Trench covers observed.
Oceanview Pit Waste Rock Cover	Continue to visually monitor surficial erosion along backslope of cover.	Continued minor erosion of backslope of Oceanview Pit cover system observed.
00/01 Portals and crown pillar	Continue to monitor cracking in WOP crown pillar.	No additional cracking of WOP crown pillar observed.

Any recommendations identified in previous inspections that have yet to be addressed, or have only been partially addressed, have been carried forward as recommendations for 2013. More information regarding the 2013 recommendations is provided in Section 6.

6.0 2013 INSPECTION CONDITIONS

Mr. Geoff Claypool, P.Eng., conducted the geotechnical site inspection between July 11 and 13, 2013. Each of the elements from Table 1 was inspected on foot. Pertinent observations concerning the physical condition of each element were recorded by photograph. Select photos are provided in Appendix I. The following sections review the results of the geotechnical inspection and geotechnical instrumentation monitoring program at the various site facilities.

6.1. Embankments and Containment Structures

Several embankments and containment structures were constructed at Nanisivik Mine throughout its history for various purposes. These include the following:

- West Twin Dyke;
- Test Cell Dyke;
- East Adit Treatment Pond Dyke;
- East Adit Retention Pond Dyke;
- Day Tank Farm Spill Containment Berm; and
- Main Tank Farm Spill Containment Berm.

The following sections provide a summary of the inspection conditions at each of the structures mentioned above. It should be noted that since the West Twin Dyke and Test Cell Dyke have been incorporated into the Surface Cell and Test Cell tailings covers, respectively, the inspection conditions for these structures are reviewed in Section 6.4 (Thermal Covers).

6.1.1. East Adit Treatment Facility Dykes

Construction Details

The East Adit Treatment Facility was located approximately 3 km east of the mill, downslope from the East Adit area, as shown on Drawing 1. The facility was comprised of a Treatment Pond and a Retention Pond, both of which employed earthen dykes to retain surface water flow. Water that flows through this area is runoff water from the surrounding drainage basin, where the water quality is affected and/or impacted by natural mineralized soil and rock.

Both dykes are shale rockfill structures mixed with a combination of one or more of the following: regional talus, glacial till, marine clay and/or bentonitic clay. The Treatment Pond Dyke is approximately 5 m above the surrounding ground surface. The Retention Pond Dyke is approximately 3 m above the surrounding ground surface.

Commitments were made in the 2004 Reclamation and Closure Plan (CanZinco 2004) to restore natural drainage by breaching/removing any man made diversions or catchments. As such, both dykes were breached in late 2006. The breaches are approximately 5 m wide at the base and are sloped back to the remnant crest of the dykes at an angle of approximately 3(H):1(V).

Inspection Conditions

The main observations made during the inspection are summarized by the following:

- Both the breach of the East Adit Retention Pond and the breach of the East Adit Treatment Pond appear to be free of sediment and able to promote drainage of the ponds as intended.
- As observed during previous inspections, a small remnant pond was observed in the East Adit Retention Pond area which has been present since breaching. The ponding has been reduced in aerial extent over time due to continued natural backfilling of the area by sediments, mostly weathered shale, being transported and deposited in this area from upslope.
- Some channelization of remnant sediments was observed in the bottom of the East Adit Treatment Pond.

As expected, natural sedimentation has steadily been reducing the aerial extent of remnant ponding in the East Adit Retention Pond. As such, additional remedial actions at the East Adit Treatment Facility are not considered necessary.

6.1.2. Day Tank Farm Spill Containment Berm

Construction Details

The Day Tank Farm Spill Containment Berm was located just uphill from the Industrial Complex, as shown on Drawing 1. The berm provided contingency storage for fuels in the event of that the day tanks leak or spill. The berm was approximately 4 m high, at its highest point, and had a crest width of approximately 2 m.

CanZinco (2004) details the reclamation plan for the facility which involves the following:

- The liner is to be removed and disposed of underground according to the Waste Disposal Plan.
- Hydrocarbon contaminated soils are to be relocated to the underground mine, in accordance with the Underground Waste Disposal Plan.
- The areas which are disturbed during reclamation are to be backfilled and/or contoured to their surroundings.

In 2007, the day tank farm was decommissioned. According to site staff, the tanks, liner and berm were removed and transported to the underground mine workings. Site staff also indicated that some hydrocarbon contaminated soil was excavated and was also transported to the underground mine workings.

Inspection Conditions

The main observation made during the inspection was that the area where the day tank farm used to be was well drained and no ponding of surface water and no erosion of surface materials was observed.

No additional maintenance was recommended for this area, in terms of geotechnical requirements. As documented in SRK (2009), all geo-environmental considerations at the Day Tank farm area have been addressed.

6.1.3. Main Tank Farm Spill Containment Berm

Construction Details

The Main Tank Farm Spill Containment Berm was located adjacent to the loading dock at Strathcona Sound, just west of the concentrate storage building (Drawing 1). The purpose of the berm was to provide contingency storage for fuels should the fuel storage tanks leak or spill.

The berm was approximately 5 m high at its highest point and has a crest width of 1-3 m. The side slopes of the berm are approximately 1.5H:1V to 2H:1V.

Decommissioning of the Main Tank farm was initiated in 2010, with the removal of the tanks and removal of the containment berms completed in 2011. Remnant portions of one arm of the perimeter berms remains to aid in surface drainage control. Remediation of the hydrocarbon impacted soils from beneath the Main Tank farm is ongoing under the direction of SRK, the mine's geo-environmental consultant.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-1). The main observations made during the inspection are summarized by the following:

- No ponding of surface water was noted in the former tank farm area.
- The liner underlying the tank farm was being removed and the hydrocarbon impacted soils were being excavated and screened of coarse material.
- The hydrocarbon impacted soils were being placed in lined biopile cells to permit remediation of these soils. The screened cobble sized material was being stockpiled on the surface of the concrete pad of the former concentrate storage shed.

The remediation of the hydrocarbon impacted soils is being overseen by the project's environmental consultant. Thus, no detailed inspection of these measures was undertaken by BGC.

No additional maintenance was recommended for this area, in terms of geotechnical requirements.

6.2. Water Conveyance Structures

Several water conveyance structures were constructed at Nanisivik Mine, both prior to, and during the reclamation process. These include the following structures:

- West Twin Dyke Spillway
- West Twin Outlet Channel
- East Twin Creek Diversion Berm and Channel.

The following sections provide a summary of the inspection conditions at each of the structures mentioned above.

6.2.1. West Twin Dyke Spillway

Construction Details

The West Twin Dyke Spillway is located at the south end of the Surface Cell, as shown on Drawing 2. The spillway conveys water from the Surface Cell to the Reservoir. The physical details of the spillway are summarized by the following:

- The spillway is approximately 550 m long.
- The bottom of the spillway is approximately 6 m wide.
- The grade of the spillway bottom varies from 0% at the inlet to 7% near the middle of the spillway and 2% at the outlet.
- The bottom of the spillway is founded on rock from the inlet to 100 m down gradient of the access ramp. The remainder of the spillway bottom is comprised of rockfill.
- The side slopes of the spillway vary from near vertical in rock to approximately 3(H):1(V) in soil side slopes.
- Side slopes composed of poor quality rock or soil are armoured with riprap.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-2). The main observations are summarized by the following:

- A small pond was observed at the spillway inlet on the Surface Cell cover. The maximum depth of the pond was estimated to be between 20 and 30 cm. The pond appeared to be slightly larger in size compared to 2012. This is likely attributed to the early timing of the inspection and the increased rainfall amounts at site.
- Surface flow seemed to travel further down the spillway than previous years before going subsurface into the rockfill, indicating that the subgrade is beginning to sand-up / freeze-back.
- The additional grading and armouring applied to the left bank of the spillway in 2012 appeared to be stable during inspection, though some of the area remained under snow cover at the time of the inspection.

It is recommended that the spillway channel continue to be inspected annually for stability of the side slopes and erosion of the channel bottom. Measures to reduce snow accumulation in the bottom of the spillway should also continue to be explored.

6.2.2. West Twin Lake Outlet Channel

Construction Details

The West Twin Lake Outlet Channel is located in the northeast corner of the WTDA, as shown on Drawing 2. The channel conveys water from the Reservoir into Twin Lakes Creek. The channel replaces the former decant station located in the same area. The main design feature of the channel is a steel-reinforced, concrete wall which provides water retention and elevation control for the water level in the Reservoir. The physical details of the channel are summarized by the following:

- The concrete wall is approximately 17 m long and 0.3 m thick.
- The central portion of the wall where the flow occurs is 7 m wide and has an invert elevation of approximately 370.2 m.
- The wall contains sloping side walls (4(H):1(V)) and the elevation of the top of the side walls is approximately 370.8 m.
- The concrete wall is founded into the underlying bedrock via a steel-reinforced, concrete footing.
- The channel is armoured to approximately 370.8 m elevation, upstream and downstream of the wall.
- A plunge pool is located downstream of the wall to provide energy dissipation during flooding events.

In 2007, a geosynthetic clay liner (GCL) was installed upstream of the concrete wall, as suggested in the 2006 inspection report. This was completed in response to observations of declining water levels upstream of the wall during periods of low inflows. The declining water levels were inferred to suggest seepage losses through the foundation of the wall. As such, the GCL approach was suggested as a way to limit the potential for these seepage losses.

In September 2008, the culverts in the East Twin access road that had previously impeded the flow from the Reservoir to the Polishing Pond were removed and the Reservoir is now considered to be a fully flow-through hydraulic system at the normal water level. Due to the limited depth of the breach, the former East Twin access road restricts flow into the former polishing pond area at lower water levels.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-3). The main observations are summarized by the following:

- During the inspection, water was flowing over the invert of the wall with a flow depth of between 1 and 2 cm in the creek.
- Seepage was not observed downstream of the wall as has been observed in previous years. This may indicate that the seepage pathways under the wall remained frozen at the time of the inspection.

- Additional instability was noted along the shoreline of the remnant polishing pond in the form of tension cracks and sinkholes within the pond itself. The instability appeared to be further advanced compared to 2012.

Water level measurements relative to the invert elevation were manually taken by site staff throughout 2013 (Drawing 3). Based on these measurements, the water level upstream of the wall was within approximately 5 cm of the invert elevation between mid-June and late August, though only a limited number of readings were obtained between late-July and late-August. It is also likely that the water levels dropped below the invert of the wall during the early part of September when lower inflows are typically experienced. The water level upstream of the wall was more consistently near the crest of the outlet wall in 2013 compared to water levels recorded in previous years, which are also shown on Drawing 3. This is likely reflective of wetter conditions experienced at site in 2013.

In response to recommendations made in 2011, a water level logger was re-installed in the Reservoir during the July 2013 inspection trip. Between July 12 and September 5, the water levels in the Reservoir were recorded hourly. The logger was removed in early-September prior to the formation of ice on the Reservoir. The data collected from the logger indicates the following:

- Similar to the observations in 2012, water levels in the main part of the Reservoir (upstream of the road breach) are approximately 5 to 10 cm higher than water levels in the remnant polishing pond.
- The water level in the Reservoir fluctuated by approximately 10 to 15 cm during the time it was installed.
- Fluctuations in the water level observed at the outlet wall are reflected in the Reservoir water levels.

It is recommended that the water level logger be re-installed during the 2014 inspection trip to continue to enhance the understanding of the relationship between the water levels in the Reservoir and remnant polishing pond.

The observed seepage losses and stability issues along the edge of the remnant polishing pond are thought to be related to the excavation of sediments from the polishing pond during site reclamation activities in 2005. Excavation of these sediments created a deeper pocket of water upstream of the wall and provided a heat source which likely resulted in thawing of the ground beneath the pond. During the 2013 inspection, water depth measurements were collected in the remnant polishing pond from a small boat. Water depths in the middle of the remnant polishing pond were generally found to range from 2 to 3.5 m deep. This water depth was also noted close to the perimeter of the pond, which has likely contributed to observed instability along the shoreline.

Based on the water quality measurements collected since the East Twin Access Road was breached in 2008, the seepage losses through the foundation of the wall do not appear to be influencing the overall performance of the West Twin Area reclamation measures. As suggested by the water level data discussed previously, the impact of seepage losses on the main water level in the Reservoir is minimized by the various breaches creating flow restrictions between the Reservoir and the remnant Polishing Pond. However, the breaches only act to slow the lowering of the water level and, therefore, should not be considered a permanent solution in mitigating seepage losses from the West Twin Area. In light of continuing seepage losses and increasing slope instability noted along the perimeter of the remnant polishing pond, it is recommended that measures to address these concerns be considered. This likely involves backfilling of the Polishing Pond immediately upstream of the wall. This backfilling would be intended to provide the following benefits with respect to seepage control and stability:

- Enhance stability of slopes along the perimeter of the pond by buttressing these slopes.
- Promote freeze-back of the foundation beneath the pond which would be expected to result in a corresponding reduction in seepage losses.
- Lengthen the seepage pathway to reduce impacts of seepage losses on water levels upstream of the wall.

Detailed design specifications such as fill materials / volumes and surface grades and water management plans will need to be developed prior to implementation of this conceptual plan.

6.2.3. East Twin Creek Diversion Dyke and Channel

Construction Details

The East Twin Creek Diversion Dyke is located along Twin Lakes Creek between East Twin Lake and the West Twin Outlet Channel, as shown on Drawing 2. The diversion dyke and channel deflect flow from East Twin Lake away from its previous drainage course, which drained directly into West Twin Lake (the Reservoir). The flow from the diversion channel combines with the flow from the Reservoir downstream of the West Twin Outlet Channel.

The diversion dyke is approximately 2 m above the adjacent ground level and is comprised of sand, gravel and cobbles derived from the nearby Twin Lakes sand and gravel deposit. A portion of the dyke was re-graded during reclamation construction to be less susceptible to erosion. Additionally, the re-graded portion of the dyke was armoured with riprap to prevent future erosion from occurring.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-4). During the inspection, the area where erosion of the left bank of the channel was observed during previous inspections was reviewed. The erosion was found to have progressed since 2012. The observed erosion at this location may be the result of a similar scenario as the erosion due to freshet in the West Twin Dyke Spillway. It appears that the flow in East Twin Creek was elevated near the crest of the diversion dyke by snow blockage and concentrated flow resulted in erosion of the berm as it re-entered the main channel of East Twin Creek. No remedial action is recommended at this time, but it is recommended that visual observations be recorded during freshet at the East Twin Creek Diversion during the spring of 2014 to confirm this assessment. Additional bank armouring may be considered if this flow condition is confirmed to be the cause of the noted erosion.

It should be noted that a seepage discharge spring was observed at the toe of the left bank of the dyke, as it has been during the inspections undertaken since 2012. The seepage water is likely originating in the polishing pond and is also likely related to excavation of polishing pond sediments during site reclamation. This seepage discharge point should continue to be monitored for increased flow rates during 2014.

6.3. Thermal Covers

The following sections provide information regarding each of the thermal covers constructed at site. Each section provides details regarding the construction of each cover, a summary of the observations made during the 2013 inspection and reviews the monitoring data collected from each area in 2013. A table documenting the instrumentation monitoring schedule undertaken in 2013 is provided in Appendix II. It should be noted that the scheduled quarterly readings were not attempted in December 2013 due to access constraints and limited interpretive value provided by these readings. No additional attempts to collect data are planned prior to July 2014.

An additional note on the interpretation of the geothermal monitoring data; for the purposes of interpretations made in this report, the following assumptions were made:

- In the active layer, ground conditions are considered "thawed" when ground temperatures of 0°C and warmer are observed.
- In the talik, ground conditions are considered "thawed" when ground temperatures of warmer than -0.5°C are observed. This is to account for freezing point depression effects which have been noted in the tailings talik at the site.

6.3.1. Surface Cell Tailings Cover

Construction Details

A thermal cover was constructed over the tailings in the Surface Cell in 2004 and 2005. The thermal cover consists of a 1 m thick layer (minimum thickness) of granular shale overlain by a 0.25 m thick layer (minimum thickness) of armour material comprised of sand, gravel and cobbles. It should be noted that, due to surface grade considerations, significantly increased shale thicknesses (greater than 2 m thick) were applied to approximately 30% of the Surface Cell. Additionally, due to practical construction considerations related to the grain size distribution of the armour materials, the armour layer thickness regularly exceeded 0.25 m. The shale was sourced from the Mt. Fuji and Area 14 borrow areas (Drawing 1). The armour material was sourced from the Twin Lakes Delta deposit (Drawing 1). The Surface Cell tailings cover is drained by a series of swales which convey surface water to the spillway inlet located at the south end of the Surface Cell. The spillway transfers water draining off of the Surface Cell into the Reservoir. It should be noted that surface flow is not regularly observed on the Surface Cell and that the majority of the water flow occurs sub-surface due to the coarse nature of the cover materials.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-5). The main observations are summarized by the following:

- The head pond at the entrance to the spillway at the south end of the cover was observed to be slightly larger than it was in 2012. This is likely due to the early timing of the site inspection (early July 2013 versus late July 2012) and the greater amounts of precipitation at site in 2013 compared to 2012.
- Similar to 2012, some minor thermokarsting was noted along the south shoreline, along the east edge of the main drainage swale and just north of the E/W trench. This localized thermokarsting is not considered to be negatively impacting the overall performance of the cover system. Additionally, the thermokarst features do not appear to be changing with time suggesting they have physically stabilized.
- No erosion of the cover materials was noted, but some minor settlement deformation in the bottom of the main drainage swale was observed closer to the spillway entrance.

No maintenance was recommended for the Surface Cell cover system, though the surface of the cover should continue to be visually inspected for additional deformation.

Monitoring Data

The Surface Cell is instrumented with ten thermistors, seven vibrating wire piezometers, six frost gauges and two monitoring wells. The location of each of these instruments is provided on Drawing 4. Select plots providing the results of the monitoring are provided, for interpretation purposes, on Drawings 5 through 11.

The instrumentation has two main purposes; monitor the depth of the active layer thaw in the cover and monitor the ground temperatures, pore pressures and water quality in the talik during freeze-back.

Drawing 5 provides data from the thermistors installed along the periphery of the Surface Cell talik. The graphs illustrate the following:

- The entire tailings profile along the periphery of the talik appears to be frozen, even at thermistor 03-07 where the tailings profile extends to 25 m depth.
- The tailings profile continues to cool over time. The rate of cooling observed in 2013 appears to have increased compared to 2012, especially at deeper depths.

Drawing 6 provides data from thermistors installed closer to the centre of the talik. The graphs illustrate the following:

- Generally, the upper 18 to 20 m of the ground profile appears to be frozen, as illustrated by data recorded from Thermistors BGC03-09, BGC03-10 and BGC05-05.
- The rate of cooling of the geothermal profile appears to have accelerated compared to previous years, especially at deeper depths.
- Rate of downward progression of the -0.5°C isotherm continues to advance at similar or increased rates compared to previous years, as illustrated by data from Thermistors BGC03-09, 03-10 and 05-05.

Drawing 7 illustrates the downward progression of the freezing front over time in the Surface Cell. The depth of the -0.5°C isotherm from various thermistors is plotted against the distance from the crest of the West Twin Dyke. As can be seen, the data suggests the -0.5°C isotherm has migrated between 3 and 15 m downwards since the cover system was completed in 2005. The data also illustrates how the thickness of frozen ground increases with proximity to the West Twin Dyke.

Drawing 7 also illustrates that the freeze-back of the Surface Cell talik is generally proceeding quicker than anticipated, compared to the results of the geothermal analysis documented in BGC (2004a). This is illustrated by comparing the observed depth of the -0.2°C isotherm with the freeze-back envelope predicted by the original geothermal modeling. The -0.2°C isotherm was used for this comparison as it was the freezing point depression assumed during the original geothermal modelling completed as part of the talik freeze-back assessment (BGC 2004a).

Drawing 8 provides data collected from the piezometers installed in the Surface Cell talik. The graphs indicate the following:

- In 2013, Piezometer BGC03-32 was the only piezometer that remained non-frozen in the Surface Cell. No data was collected at BGC05-06 as the instrument was observed to be malfunctioning throughout 2013.
- Piezometer BGC03-32 indicates that pore pressures within the Surface Cell talik are generally about 10 m artesian and continue to increase with time. Elevated pore pressures were expected based on the pre-reclamation studies that were undertaken and are related to the freeze-back process in the talik.
- The elevated pore pressures observed at depth in the remaining thawed piezometer in the Surface Cell remain well below the trigger levels established in BGC (2009c) and are not considered to negatively impact the stability of the West Twin Dyke.
- The temperature of the unfrozen pore water continues to remain colder than 0°C, confirming that the talik pore water exhibits a freezing point depression of approximately -0.9°C.
- Piezometers BGC05-10, BGC05-07, BGC05-13 and BGC 03-35 have frozen back and no longer provide information on pore pressures within the talik. They continue to be monitored to collect additional geothermal data from the piezometer tip.

Drawing 9 illustrates the relationship between talik pore pressures and downward migration of the freezing front. As can be seen, as the freezing front migrates downwards, the pore pressure within the remnant and shrinking talik increases.

Drawings 10 and 11 provide data collected from thermistors and frost gauges important to monitoring active layer thaw and interpreting overall cover performance. The graphs indicate the following:

- The depth of active layer thaw was generally confined within the cover materials or the very top of the tailings throughout 2013.
- The geothermal performance of the cover in 2013 was improved compared to previous years. While the tailings generally remain frozen throughout the year, the active layer thickness in 2013 was similar to, or slightly decreased, compared to previous years.

It should be noted that the frost gauges were installed to provide visual evidence of shallow ground temperature behaviour for monitoring personnel, inspectors, or community residents. As such, they should not be considered precision ground temperature monitoring instruments, as this task is accomplished by the thermistor monitoring network.

The results of water quality testing undertaken on samples collected at the inlet of the West Twin Dyke Spillway are also provided on Drawing 11. As can be seen, the total zinc concentration in the water draining off the Surface Cell continued to be low (less than 0.02 mg/L) in samples collected in 2013. Similar results have been observed since 2010. Additionally, similar reductions in the total sulphate concentrations have also been observed since 2010. The water quality monitoring data suggests that the improved geothermal performance of the Surface Cell cover system observed since 2007 has had beneficial effects on the quality of the surface water runoff.

No water samples were collected from the monitoring wells installed in the Surface Cell (BGC05-11 and BGC05-12) in 2013. These monitoring wells are no longer functioning and water sample collection from them is no longer possible. Considering that the piezometric monitoring results suggest that the talik pore water is hydraulically confined, the water quality in the Surface Cell talik is not expected to impact the water quality in the Reservoir. Thus replacement of the monitoring wells to monitor water quality in the Surface Cell talik is not considered necessary at this time.

6.3.2. West Twin Dyke

Construction Details

The West Twin Dyke is a frozen core, upstream constructed, earth fill dyke that separates the Surface Cell and the Reservoir (Drawing 2). The dyke is constructed of frozen, compacted shale and founded on frozen, settled tailings. The dyke is approximately 14 m high and the downstream face slopes at an angle of approximately 15°. The downstream face of the dyke was surfaced with a 0.25 m thick layer (minimum thickness) of sand, gravel and cobbles sourced from the Twin Lakes Delta.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-6). The main observations made during the inspection are summarized by the following:

- No settlement or cracking of the crest was noted
- The downstream face of the dyke shows no indications of erosion or settlement
- No seepage was noted on the face of the dyke or at the toe of the dyke.

In general, the dyke appeared to be in a satisfactory condition and no maintenance was recommended.

Monitoring Data

The West Twin Dyke is instrumented with five thermocouple cables installed within the dyke, four thermistors and one vibrating wire piezometer installed from the crest of the dyke. The location of each of these instruments is provided on Drawings 4 and 12. Select plots providing the results of the monitoring, for interpretation purposes, are provided on Drawings 13 and 14.

Drawing 13 provides data from Thermistors BGC03-33 and BGC03-34, which provide a continuous geothermal monitoring profile from 5 m below the crest of the dyke to approximately 24 m bgs, approximately 6 m below the base of the dyke. The data indicates the following:

- The entire depth profile continues to cool. The rate of cooling appears to have accelerated in 2013, especially at depths below 18 m bgs.
- The small zone of tailings between 22 and 24 m bgs previously considered to be thawed was shown to be cooler than -2.0^{o}C, continuing the cooling trend that has been observed in recent years.

Drawing 14 provides data from additional thermistors installed from the crest of the dyke, as well as one vibrating wire piezometer installed within a thawed zone at depth. The data indicates the following:

- The profile immediately upstream of the dyke is frozen (cooler than -0.5°C) to at least 23 m bgs (approximately 5 m below base of dyke).
- The geothermal profile continues to cool with time.
- At piezometer 05-17, the pore pressures within the small thawed zone at approximately 24.5 m bgs (approximately 6.5 m below the base of the dyke) are approximately 9 m artesian and have increased slightly since 2012. The elevated pore pressures observed at depth remain well below the trigger levels established in BGC (2009c) and are not considered to negatively impact the stability of the West Twin Dyke.

- The piezometric tip temperature suggests a freezing point depression of between 0.4 and 0.5°C.

No thermocouple data has been collected in 2013 due to the very erratic nature of the data collected from these instruments in previous years. These instruments are well over 10 years old and are no longer able to provide useful data. Given the current geothermal characterization of the dyke and dyke foundation, replacement of these instruments is not considered necessary.

6.3.3. Test Cell Area

Construction Details

The Test Cell area consists of the Test Cell, former Test Cell Dyke and Toe of Test Cell Dyke. These areas were discussed separately in previous annual inspection reports but have now been combined into one section for the sake of efficiency.

A thermal cover was constructed over the Test Cell area in 2004 and 2005. The thermal cover consists of a 1 m thick layer (minimum thickness) of granular shale overlain by a 0.25 m thick layer (minimum thickness) of armour material comprised of sand, gravel and cobbles. It should be noted that, due to surface grade considerations, significantly increased shale thicknesses (greater than 2 m) were applied to approximately 20% of the Test Cell. Additionally, due to practical construction considerations related to the grain size distribution of the armour materials, the armour layer thickness regularly exceeded 0.25 m. The shale was sourced from the Mt. Fuji, East Twin and Area 14 borrow areas (Drawing 1). The armour material was sourced from the Twin Lakes Delta deposit (Drawing 1). The Test Cell tailings cover is drained by a main swale which conveys surface water directly into the Reservoir.

The Test Cell Dyke is an earth fill dyke that separates the Test Cell and the Reservoir (Drawing 2). The dyke is constructed of frozen, compacted shale and founded on frozen, settled tailings. The dyke was approximately 4 m high. During reclamation, the top 2 m of shale material in the dyke was removed and placed in the Test Cell as cover material. The remnant dyke was surfaced with a layer of armour material, approximately 0.25 m thick. As such, the dyke is now essentially integrated into the Test Cell cover.

A thermal cover was constructed over the tailings at the toe of the Test Cell Dyke in 2005. The thermal cover consists of a 1 m thick (minimal thickness) layer of granular shale overlain by a 0.25 m thick layer (minimal thickness) of armour material comprised of sand, gravel and cobbles. It should be noted that, due to surface grade considerations, shale fill thickness in excess of the 1 m minimum thickness was applied to the tailings beach at the toe of Test Cell Dyke, especially immediately adjacent to the remnant Test Cell dyke. The shale was sourced from the Mt. Fuji and Area 14 borrow areas (Drawing 1). The armour material was sourced from the Twin Lakes Delta deposit (Drawing 1). The riprap was sourced from the dolostone outcrop at the south end of the West Twin Dyke.

Inspection Conditions

Select photos from the inspection of the Test Cell and Test Cell Dyke are provided in Appendix I (Drawing I-7). The main observations are summarized by the following:

- No erosion of the cover was observed.
- No ponding on the cover was observed.
- Similar to previous inspection observations, the north south arm of the Test Cell dyke, and the Test Cell cover just inside of the dyke, remains undulating suggesting some amount of thaw settlement of the cover materials has occurred. The cover is overbuilt in this area and surface erosion is unlikely due to the limited potential for surface water. Thus, the undulating nature of the cover has not changed greatly in the last several years. As such, this area is not of concern.

Select photos from the inspection of the cover along the toe of the Test Cell Dyke are provided in Appendix I (Drawing I-8). The main observations are summarized by the following:

- No erosion of the cover was observed
- No erosion or disturbance due to ice plucking of the riprap was observed

In general, the tailings cover in the Test Cell area appears to be in satisfactory condition. As such, no maintenance was recommended.

Monitoring Data

The Test Cell area is instrumented with seven thermistors, five vibrating wire piezometers, four frost gauges and two monitoring wells. The location of each of these instruments is provided on Drawing 12. Select plots providing the results of the monitoring are provided on Drawings 15 through 18.

Drawing 15 provides geothermal and piezometric monitoring data collected from the Test Cell in 2013. The data indicates the following:

- The subsurface profile between 1.5 and 15 m depth in the Test Cell at the base of the West Twin Dyke (BGC05-04) is colder than -0.5^{o}C and is presumed to be frozen. The geothermal profile continues to cool with time.
- As suggested by Thermistor BGC05-29, the subsurface profile just inside the former location of the Test Cell dyke is frozen (colder than -0.5°C) to approximately 20 m bgs.
- The data collected from thermistor BGC05-19, indicates cooling of the geothermal profile near the centre of the talik, especially at depths between 5 and 10 m bgs.
- Thermistor 05-19 also suggests that the centre of the Test Cell talik has frozen back to between 10 and 12 m bgs.
- A minor amount of warming was observed in thermistor 05-29 below 20 m bgs; this may be reflective of the warm air temperatures at site in 2009 and 2010. The time lag between the warm air temperatures in 2009 and 2010 and the warming ground

temperatures at depth observed in 2013 illustrates the impact of warm air temperatures on the temporal trends of geothermal cooling.

- The pore water pressures measured at 20 to 25 m bgs in the Test Cell talik generally range from 2 to 3 m bgs. Only a nominal change in pore pressure (< 0.5 m) was observed in 2013, compared to 2012.
- The temperature of the unfrozen pore water is generally between -0.2˚C and -0.5˚C and is relatively stable. Minimal cooling of the recorded pore water temperature has been observed since installation in 2005.

Drawing 16 provides data collected from thermistors and frost gauges important to monitoring active layer thaw in the Test Cell and interpreting overall cover performance. The graphs indicate the following:

- The active layer thaw was generally confined within the cover materials throughout 2013.
- The geothermal performance of the cover in 2013 was improved compared to previous years, as indicated by near surface data collected from frost gauges FG7 and FG8 as well as Thermistor BGC05-04.

Select plots providing the results of the monitoring of the Test Cell Dyke are provided on Drawing 17. The monitoring data indicates the following:

- Data from thermistor BGC03-22 suggests that the dyke and foundation beneath the dyke was frozen to approximately 20 m bgs throughout the year and the geothermal profile continues to cool with time.
- The vibrating wire piezometer (BC05-24) installed approximately 20 m bgs beneath the dyke has frozen back as indicated by the tip temperature below -3°C and the corresponding variability in pore pressures. The recorded pore pressure is considered to be localized and associated with the freeze-back of the piezometer tip and is not considered to be representative of pore water pressures throughout the Test Cell talik.

Select plots providing the results of the monitoring of the tailings cover at the toe of the Test Cell Dyke are provided on Drawing 18. The graphs indicate the following:

- The subsurface profile at the toe of the Test Cell Dyke (BGC05-27) between 3 and 20 m bgs is colder than -0.5˚C and is assumed to be frozen. The geothermal profile continues to cool with time. The monitoring data demonstrates that the upper 20 m of the subsurface profile is frozen, despite being along a shoreline which was periodically submerged in water during operations of the tailings disposal area. The fact that permafrost exists at this location, to the extent it does, is considered beneficial to the overall Test Cell talik freeze-back. This is because it exceeds expectations and assumptions made in the contaminant loading model (CanZinco 2004) which assumed a completely thawed tailings profile adjacent to the water.
- The monitoring data from Piezometer BGC05-28 indicates piezometric elevation of approximately 370 m. This is nominally the elevation of the water level in the Reservoir. This suggests that the hydraulic connectivity between the tailings at depth

and the Reservoir remains intact. The pore water temperature measured at the piezometer tip has cooled to approximately -0.7°C in 2013. It is likely this piezometer will become frozen in over the next couple of years.

No water samples were collected from the monitoring wells in the Test Cell in 2013 due to operational difficulties with the heat trace contained within the wells. These wells are no longer functioning and water samples can no longer be collected from them. Given the positive water quality monitoring results from the WTDA, replacement of these instruments is not considered necessary at this time.

6.3.4. Toe of West Twin Dyke Tailings Cover

Construction Details

A thermal cover was constructed over the tailings at the toe of the West Twin Dyke in 2005. The thermal cover consists of a 1 m thick layer (minimum thickness) of granular shale overlain by a 0.25 m thick layer (minimum thickness) of armour material comprised of sand, gravel and cobbles. The shale was sourced from the Mt. Fuji and Area 14 borrow areas (Drawing 1). The armour material was sourced from the Twin Lakes Delta deposit (Drawing 1). The riprap was sourced from the dolostone outcrop at the south end of the West Twin Dyke.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-9). The main observations are summarized by the following:

- No erosion of the cover was observed.
- As observed during previous inspections, some minor thermokarsting was observed, but was not seen to be negatively impacting the overall performance of the cover system.
- No erosion or ice plucking of the riprap along the shoreline was observed.

No additional maintenance items were recommended.

Monitoring Data

The tailings cover at the toe of the West Twin Dyke is instrumented with two thermistors. The location of each of these instruments is provided on Drawing 12. Select plots providing the results of the monitoring are provided on Drawing 19. The graphs indicate the following:

- As illustrated by the data collected from Thermistor BGC05-26, the subsurface profile below 4 m is colder than -4°C and is presumed to be frozen to at least 24 m bgs, the depth of the bottom of the instrument. The bottom 15 m of the instrument is measuring ground temperatures in the bedrock, demonstrating the frozen nature of the bedrock near the base of the West Twin Dyke.

- As illustrated by the data collected from Thermistor BGC03-19, the subsurface profile below 3 m is colder than -2˚C and is presumed to be frozen to at least 11 m bgs, the depth of the bottom of the instrument.

West Twin Disposal Area Water Quality

As required in the current Water License, water quality sampling and testing were undertaken at the West Twin Outlet Channel throughout the open water period in 2013. This channel is considered the final discharge point for water from the WTDA before entering the environment in Twin Lakes Creek. Samples were collected bi-weekly and subsequently forwarded to a laboratory for a variety of tests. Water samples were tested for pH, conductivity, Total Suspended Solids (TSS), sulphate, total metal concentrations, and ammonia (NH_3). The total zinc, total lead, total cadmium and sulphate concentrations observed at the West Twin Outlet Channel throughout 2013 are illustrated on Drawing 20. As can be seen, the total zinc, lead and cadmium concentrations observed throughout 2013 met discharge criteria, as they have since the covers were completed in 2005. Zinc concentrations recorded in 2013 are the lowest in terms of peak and average concentration since the covers were completed. Sulphate concentration also continued the downward trend observed in recent years. The low and reducing metals and sulphate concentrations suggest that the thermal covers, and the water cover in the Reservoir, are effective in limiting metal loading to the water in the Reservoir.

It should be noted that the TSS values obtained from the samples collected throughout 2013 were slightly higher than what was observed in the last three years, though well below discharge criteria and well within the historical range. These TSS values generally indicate an improvement over values recorded prior to breaching of the East Twin access road. Hence, the results suggest that excessive amounts of solids are not being carried in the outflow from the WTDA.

Stantec (2014) should be referenced for a detailed review of the results of the water quality monitoring program undertaken in 2013.

6.3.5. Landfill Cover

Construction Details

A thermal cover was constructed over the Nanisivik Landfill in 2005. The thermal cover consists of a 2 m thick layer (minimum thickness) of granular shale overlain by a 0.25 m thick layer (minimum thickness) of armour material comprised of sand, gravel and cobbles. The shale was sourced from the Townsite Shale borrow area. The armour material was sourced from the Twin Lakes Delta deposit. The face of the landfill is sloped at approximately 3(H):1(V).

It should be noted that the thermal cover constructed at the Landfill was built over an existing surficial shale cover that was continuously placed and maintained during operations as part of the on-going landfill operating procedures (for pest control and protection against wind transport). No attempts were made during construction of the thermal cover in 2005 to verify the existing cover thickness and thereby reduce the fill requirements. Therefore, it can be assumed that the thermal cover is thicker than just the material placed in 2005.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-10). The main observations are summarized by the following:

- No erosion of the cover was observed, either on the upper flatter portion of the cover or on the sloping face of the Landfill.
- No seepage was observed at the toe of cover during the time of the inspection.
- Some exposed shale was observed on the lower portion of the west face. This is due to an insufficient amount of armour material available for covering and is not related to erosion. Previous attempts undertaken to spread the armour over the exposed shale were determined to be impractical from a construction standpoint. Considering the observed stability of the area since construction, additional maintenance is not considered necessary.
- Some minor cracking and thermokarsting was observed along the upslope water deflection berm. This has resulted in a minor amount of surface water running along the west edge of the cover system. This is not considered to be negatively affecting the performance of the adjacent landfill cover system and no maintenance is considered necessary at this time.
- No areas of settlement or thermokarst features were observed on the surface of the landfill cover system.

No maintenance items were recommended.

Monitoring Data

The Landfill cover is instrumented with one thermistor and one frost gauge. The location of each of these instruments is provided on Drawing 21. Select plots providing the results of the monitoring are provided on Drawing 22. The graphs indicate the following:

- The landfill debris underlying the cover remained frozen throughout the year.
- The geothermal profile within the underlying landfill debris continues to cool over time.
- The active layer thaw did not penetrate into the underlying waste material throughout 2013.
- The geothermal performance of the landfill cover in 2013 was observed to be slightly improved compared to previous years. This is inferred from both the frost gauge and thermistor data provided on Drawing 22. The frost gauge data indicates the active layer thickness in 2013 reached a maximum depth of approximately 1.7 m bgs. Additionally, the maximum temperature recorded at the thermistor node located at 2.3 m bgs, near the cover/landfill debris interface, was approximately -2.0°C.

6.3.6. West Open Pit Waste Rock Cover

Construction Details

A thermal cover was constructed over the West Open Pit in 2006. The thermal cover consists of a 2 m thick layer (minimum thickness) of granular shale overlain by a 0.35 m thick layer (minimum thickness) of armour material comprised of sand, gravel and cobbles. The shale was sourced from the Townsite Shale borrow area. The armour material was sourced from the local borrow source located along the road between the 09S portal and the 17 North Portal. The face of the West Open Pit cover is sloped at a maximum angle of approximately 3(H):1(V).

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-11). The main observations are summarized by the following:

- No erosion of the armour surface was noted.
- No areas of settlement or thermokarst features were observed during the 2012 inspection.
- No seepage water was observed at the toe of the cover.
- Similar to previous inspection observations, a small crack (1-3 cm wide) was observed in the crown pillar area. The size of the crack is consistent with previous years.

No additional maintenance items are recommended.

Monitoring Data

The West Open Pit cover is instrumented with one thermistor (BGC08-01). The purpose of the thermistor is to monitor the freeze-back of the underlying backfill materials as well as the active layer thaw within the cover materials. The location of this instrument is provided on Drawing 23. The results of the monitoring undertaken in 2013 are provided on Drawing 24. The graphs indicate the following:

- The waste rock used to backfill the open pit has frozen back.
- The active layer thaw was confined within the cover materials throughout 2013. This is improved from the cover performance observed in, and previous to, 2012.
- The geothermal profile within the waste rock observed in 2013 was slightly cooler than what was observed in 2012.
- The cooling trend within the underlying waste rock continued in 2013, at an accelerated rate compared to previous years.

6.3.7. East Open Pit Waste Rock Cover

Construction Details

A thermal cover was constructed over the East Open Pit in 2005. The thermal cover consists of a 2 m thick layer (minimum thickness) of granular shale overlain by a 0.35 m thick layer (minimum thickness) of armour material comprised of sand, gravel and cobbles. The shale was sourced from the Shale Hill shale borrow area. The armour material was sourced from the local borrow source located along the road between the K-Baseline Portal and Kuhulu Lake. The face of the East Open Pit cover is sloped at a maximum angle of approximately 3(H):1(V). A remnant highwall exists along the south edge of the pit area. The remnant highwall ranges from 1 to 5 m high and is sloped back at an angle of approximately 60°. A bench exists between a portion of the remnant highwall and the main portion of the cover system.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-12). The main observations are summarized by the following:

- Some minor surface (rill) erosion was noted on the surface of the cover. The erosion did not appear to have progressed over the past several years.
- Some minor cracking was noted on the surface of the cover. This cracking is thought to be related to thermal expansion and contraction of the cover materials.
- No areas of settlement or thermokarst features were observed on the surface of the cover.

The cracking in the crown pillar at the East Open Pit was not observed to have progressed since 2012. As previously noted, the cracking coincides with the mined out rib pillar and the area of the 39 Portal. As in previous years, no opening to the underground was observed during the inspection. As such, the cracking was not seen to be of immediate concern especially given the lack of progression over the past several years. Accordingly, no maintenance was recommended, but the crown pillar should continue to be visually monitored for additional deformation.

The minor erosion noted on the surface of the cover was anticipated. The armour material at this location contains a fine grained fraction that was expected to wash away with time leaving behind the coarse grained fraction, a process known as self-armouring. As such, the armour thickness at this location, and many others where alternative armour materials were used, was increased to 0.35 m. The coarse grained fraction of the armour material is expected to limit the amount of erosion that can occur, without negatively impacting the geothermal performance of the cover.

Monitoring Data

The East Open Pit Waste Rock cover is instrumented with two thermistors and two frost gauges. The location of each of these instruments is provided on Drawing 25. Select plots providing the results of the monitoring are provided on Drawing 26. The graphs indicate the following:

- Data from Thermistor BGC05-02, installed in the area with a thin layer of waste rock backfill (approximately 3 m thick), indicates the waste rock has frozen back and continues to cool with time at a similar rate as observed in previous years.
- Data from Thermistor BGC05-03, installed in the area with a thick layer of waste rock backfill (approximately 9 m thick), indicates the waste rock, and hydrocarbon contaminated soil buried at depth, has frozen back. The geothermal profile continues to cool at a comparable rate to last year.
- The active layer monitoring data from Thermistor BGC05-03 and BGC05-02 indicates that the active layer was confined within the cover materials throughout 2013. The thermal performance of the cover continues to improve with time, suggesting that ice-saturation at the base of the cover is occurring.

No data was collected from the two frost gauges in 2013 due to the gauges being frozen into the pvc casings.

6.3.8. East Trench Waste Rock Cover

Construction Details

A thermal cover was constructed over the East Trench in 2005. The thermal cover consists of a 2 m thick layer (minimum thickness) of granular shale overlain by a 0.35 m thick layer (minimum thickness) of armour material comprised of sand, gravel and cobbles. The shale was sourced from the Shale Hill shale borrow area. The armour material was sourced from the local borrow source located along the road between the K-Baseline Portal and Kuhulu Lake. The face of the East Trench cover is sloped at an angle ranging between 4(H):1(V) and 6(H):1(V).

Inspection Conditions

The main observations are summarized by the following:

- As noted in previous inspections, minor surface erosion was observed near the upslope edge of the cover where seepage water periodically discharges from natural rock outcrops onto the surface of the cover. No progression of this erosion was noted in 2013.
- No seepage was observed at the toe of the cover.

In general, the East Trench cover appears to be in satisfactory condition. As such, no maintenance was recommended.

6.3.9. Oceanview Open Pit Waste Rock Cover

Construction Details

A thermal cover was constructed over the Oceanview Open Pit in 2005. The thermal cover consists of a 2 m thick layer (minimum thickness) of granular shale overlain by a 0.35 m thick layer (minimum thickness) of armour material comprised of sand, gravel and cobbles. The shale was sourced from the Shale Hill borrow area (Drawing 1). The armour material was sourced from the Chris Creek "A" borrow area (Drawing 1). The face of the Oceanview Open Pit cover is sloped at a maximum angle of approximately 3(H):1(V). The surface of the cover in the bottom of the pit slopes to the north at a grade of approximately 3%.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-13). The main observations are summarized by the following:

- No ponded water was observed on the surface of the cover.
- The upslope water deflection berm appeared to be effective in directing surface water away from the cover. This was inferred from visual observations indicating surface water flow along the upslope edge of the berm.
- Minor surface erosion was noted along the backslope at the south end of the cover, as has been noted during previous inspections. The erosion appears to be slowly progressing, based on visual observations, but is not expected to impact the overall performance of the cover system. Self armouring of the erosion areas is occurring as the coarser particles within the armour layer are exposed and concentrated at surface, as anticipated.
- Some seepage was noted at the toe of the cover. Seepage has been noted in this area previously and its likely source is infiltration water that is running along the ice saturated base of the cover before existing at the toe.
- Some acid rock drainage staining was observed on the east edge of the cover. The stained area appeared to originate upslope of the extent of the cover and appeared to cover a similar extent to what has been observed in previous inspections.

In general, the Oceanview Open Pit cover appears to be in satisfactory condition. As such, no maintenance was recommended. The surficial erosion should continue to be visually monitored for additional progression.

As discussed previously, minor erosion of the surface of the cover was anticipated. Similar to the East Open Pit cover, the armour material at this location contains a fine grained fraction that was expected to wash away with time. As such, the armour thickness was increased to 0.35 m. The coarse grained fraction of the armour material, which can be observed in photos on Drawing I-15, is expected to limit the amount of erosion that can occur, without negatively affecting the geothermal performance of the cover.

Monitoring Data

The Oceanview Pit Waste Rock cover is instrumented with one thermistor and one frost gauge. The location of each of these instruments is provided on Drawing 27. Select plots providing the results of the monitoring are provided on Drawing 28. The graphs indicate the following:

- The active layer was confined within the cover materials throughout 2013.
- The waste rock underlying the cover has frozen back and remained completely frozen throughout 2013.
- The geothermal profile within the waste rock is relatively stable exhibiting only minor cooling over the past 3 years.
- Based on the thermistor data collected from BGC05-01 the geothermal performance of the cover in 2013 was similar to the performance observed since 2010. The maximum active layer thaw depth indicated by Thermistor BGC05-01 was estimated to be approximately 1.4 m bgs, which is approximately 0.9 m above the base of the cover.

Only one data point from the frost gauge was collected in 2013 (mid-August) due to being frozen into the bottom of the pvc casing. On August 13, 2013, the active layer thaw was measured to be approximately 1.2 m bgs. This is 0.1 m less than the active layer thaw depth measured at the same time in 2013. This suggests improved cover performance in 2013.

6.3.10. Area 14 Waste Rock Cover

Construction Details

Area 14 is a satellite ore body situated on a west-facing slope, approximately 1 km to the east of East Twin Lake (Drawing 1). A waste rock pile was created outside the portal during mining operations. In 1988, the waste rock pile was flattened and a thermal cover was constructed over the top of the waste rock pile, but the face was left exposed.

In 2005, the thermal cover at the Area 14 waste rock pile was completed by constructing a cover over the exposed face and armouring the entire surface of the cover. The thermal cover consists of a 2 m thick layer (minimum thickness) of granular shale overlain by a 0.35 m thick layer (minimum thickness) of armour material comprised of sand, gravel and cobbles. All shale was sourced from the Area 14 shale borrow area (Drawing 1). All armouring material was sourced from the hill side immediately north of the Area 14 portal.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-14). The main observations are summarized by the following:

- No erosion of the cover materials was observed.
- No areas of settlement or thermokarst features were observed on the surface of the cover.

- No seepage was noted at the toe of the cover.

In general, the Area 14 waste rock cover appears to be in satisfactory condition. As such, no maintenance was recommended.

Monitoring Data

The Area 14 Waste Rock cover is instrumented with one thermocouple and one frost gauge; locations for each of these instruments are provided on Drawing 29. Select plots providing the results of the monitoring are provided on Drawing 30. The graphs indicate the following:

- The active layer thaw was limited to the upper 1.1 m of the cover and did not penetrate into the underlying waste rock in 2013.
- The geothermal performance of the cover in 2013 was improved in comparison to the performance measured since 2006 considering the reduced maximum thaw depths observed.

No thermocouple data was collected in 2013 from the Area 14 Waste Rock cover instrument. Reading of this instrument has been discontinued due to the erratic nature of the results.

6.3.11. Upper Dump Pond Tailings Cover

Construction Details

The upper dump pond was an emergency tailings storage containment cell located between the water tank and the West Twin Disposal Area, as shown on Drawing 1. A thermal cover was constructed over the tailings in the Upper Dump Pond in 2005. The thermal cover consists of a 2 m thick (minimal thickness) layer of granular shale overlain by a 0.25 m thick layer (minimal thickness) of armour material comprised of sand, gravel and cobbles. The shale was sourced from the Townsite shale borrow area (Drawing 1). The armour material was sourced from the Twin Lakes Delta deposit (Drawing 1).

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-15). The main observations from the inspection are summarized by the following:

- No erosion of the surface of the cover was observed.
- No seepage was noted at the toe of the cover.
- No areas of settlement or thermokarst features were observed on the surface of the cover.

In general, the Upper Dump Pond tailings cover appears to be in a satisfactory state. As such, no maintenance was recommended.

Monitoring Data

The Upper Dump Pond tailings cover is instrumented with one frost gauge. The location of this instrument is provided on Drawing 31. Select plots providing the results of the monitoring are provided on Drawing 32. The graph indicates the following:

- The active layer thaw was limited to the upper 1.5 m of the cover and did not penetrate into the underlying tailings in 2013.
- The geothermal performance of the cover in 2013 was improved compared to the observed performance since 2008 based on the observed depth of active layer thaw.

6.3.12. Industrial Complex Foundation Cover

Construction Details

The Industrial Complex is located approximately 1 km north of the town site (Drawing 1). The Industrial Complex housed the concentrator, DMS circuit, power plant, maintenance shops, warehouse, administration and technical offices and associated facilities. The facility was built on bedrock and a reinforced concrete foundation.

The Industrial Complex was dismantled between 2005 and 2006 and the remnant foundation was backfilled with metals contaminated soils. In 2008, a thermal cover was constructed over the backfilled foundation. The thermal cover consists of a 2 m thick layer (minimum thickness) of granular shale overlain by a 0.35 m thick layer (minimum thickness) of armour material. The shale was sourced from the Mill Area deposit and the armour materials were locally sourced. The sloping face of the cover is approximately 3(H):1(V).

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-16). The main observations made during the inspection are summarized by the following:

- No erosion of the surface of the cover was observed.
- No settlement or thermokarst features were observed on the surface of the cover.
- No seepage was observed at the toe of the cover.

In general, the Industrial Complex cover appears to be in satisfactory condition. As such, no maintenance was recommended.

Monitoring Data

The Industrial Complex Foundation cover is instrumented with one thermistor. The location of this instrument is provided on Drawing 33. Select plots providing the results of the monitoring are provided on Drawing 34. The graph indicates the following:

- The metals contaminated soils used to backfill the foundation footprint have frozen back.
- The active layer thaw (approximately 2 m) was confined within the cover materials throughout 2013 and the cover performance appears to have improved over time.

- The geothermal profile beneath the cover appears to be cooling with time at the same pace as in recent years.

6.4. Mine Openings

6.4.1. 00/01 Portals and Crown Pillar

Construction Details

00 Portal

The 00 Portal is located at the edge of the West Open Pit at the western end of the mine, as illustrated on Drawing 1. The 00 Portal was the principal access at the western extremity of the mine. The portal measured approximately 5 by 5 m in cross section. The brow immediately above the portal was approximately 4 to 5 m high.

In 2005, the portal was backfilled with waste rock. The backfill was placed approximately to within 1 m of the top of the portal and into the portal approximately 5 m from the entrance. The backfill extended outside the portal face and was sloped at an angle of approximately 3(H):1(V) and graded into the overall backfill of the West Open Pit. A thermal cover was subsequently constructed over the waste rock as part of the West Open Pit thermal cover.

01 Portal

The 01 Portal was located at the western end of the mine, as shown on Drawing 1. The 01 Portal housed the main ventilation fans during mining operations which were mounted in a plate steel bulkhead. The portal opening was approximately 22 m wide and 4 m high. The brow immediately above the portal was approximately 4 to 5 m high.

In 2005, the portal was backfilled with waste rock. The backfill was placed approximately to within 1 m of the top of the portal and into the portal up to the face of the bulkhead. The backfill extended outside the portal face and was sloped at an angle of approximately 3(H):1(V) and graded into the overall backfill of the West Open Pit. A thermal cover was subsequently constructed over the waste rock as part of the West Open Pit thermal cover.

00/01 Crown Pillar

A stope connecting the 00 and 01 portals was located approximately 5 m behind the West Open Pit highwall. A portion of the rock between the 00 and 01 portals, known as the 00/01 rib pillar, was removed during later stages of mine development as part of the pillar recovery program. After the recovery of a portion of the rib pillar, a crack developed in the crown pillar above the area that had been mined. In 2005, a fill pillar was constructed beneath the cracked portion of the crown pillar to provide additional support and prevent development of an opening into the mine workings if the pillar were to collapse. The pillar was constructed out of waste rock and was constructed approximately to within 1 m of the top of the opening.

Inspection Conditions

The area of the West Open Pit cover where the portals had existed was inspected in July 2013. The observations are summarized by the following:

- No indications of surface deformation were observed.
- No indications of seepage from the mine workings were observed.

No maintenance of the portal plugs or the cover over the portal plugs was recommended.

The crown pillar was also inspected from surface. The observations are summarized by the following:

- No additional cracking was observed.
- Based on visual observations, the existing cracking did not seem to dilate further since 2012.
- No visually distinguishable deformation was observed in the crown pillar.

In general, the portal plugs constructed for the 00 and 01 portals and the 00/01 crown pillar appear to be in satisfactory condition. It is recommended that the crown pillar area continue to be visually monitored to check for further propagation of the cracking.

6.4.2. 17 North Portal

Construction Details

The 17 North Portal was a culverted portal giving access to the Main Ore Zone. The location of the portal is illustrated on Drawing 1. The 17 North Decline was approximately 5 by 5 m in cross section and the culvert was half round with a diameter of 5 m and a length of 28 m. The culvert was supported by a 0.25 m thick by 2 m high concrete wall on either side and it extended 5 m inside the dolostone bedrock of the drift.

In 2005, the culvert was removed and the portal was backfilled with granular shale derived from the Shale Hill borrow area. The backfill was placed to within 1 m of the top of the portal and extended into the portal for approximately 4 m. The backfill extended outside the portal face and was sloped at an angle ranging between 4(H):1(V) and 7H:1V and graded into the surrounding topography. A 0.35 m thick layer of armour material, derived from the Kuhulu Lake borrow area, was then applied to the surface of the shale backfill.

Inspection Conditions

The main observations are summarized by the following:

- No erosion of the surface of the cover was observed.
- No seepage was observed at the toe of the cover.

In general, the 17 North Portal cover appears to be physically stable and in satisfactory condition. As such, no maintenance was recommended.

6.4.3. Oceanview Portal

Construction Details

The Oceanview Portal was a bare rock entrance into the north side of the Oceanview underground workings. The location of the portal is illustrated on Drawing 1. The Oceanview decline had a cross section of approximately 5 by 5 m. The brow of the portal was approximately 5 m in height.

Prior to 2004, the portal had been backfilled with waste rock and covered over with locally derived overburden materials. In 2005, a thermal cover was constructed over the existing portal plug. The cover consisted of a 2.0 m thick layer (minimum thickness) of granular shale overlain by a 0.35 m thick layer of armour material consisting of sand, gravel and cobbles. The shale was derived from the Shale Hill borrow area. The armour material was derived from the Chris Creek “A” deposit. The thermal cover was extended to the east and north of the portal entrance in an old ore stockpile area. Additionally, a water deflection berm was constructed upslope of the cover extension to prevent concentrated surface water from flowing over the cover area.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-17). The main observations from the inspection are summarized by the following:

- A small area of surficial settlement was observed near the southwest corner of the portal cover. The settlement area appears to have stabilized as it has not changed significantly since it was first observed in 2006.
- Some minor cracking was noted along the east edge of the portal cover, as has been noticed in previous inspections. The condition of the cracking does not appear to have changed in several years.
- No seepage was observed at the toe of the cover.
- The surface water deflection berm appeared to be effective in diverting water around the cover extension.

In general, the Oceanview Portal cover appears to be physically stable and in satisfactory condition. As such, no maintenance was recommended.

6.4.4. K-Baseline Portal

Construction Details

The K-Baseline portal was a culverted entry used to access the K-Baseline ore body. The location of the portal is illustrated on Drawing 1. The K-Baseline decline was approximately 5 m by 5 m in cross section and the culvert was half round with a diameter of 5 m and a length of 28 m. The culvert was supported by two concrete pony walls, 1 m wide by 2.4 m high, on both sides. The concrete pony walls extended 3 m inside the dolostone bedrock of the drift.

In 2004, the culvert was removed and the portal was backfilled with waste rock. In 2005, a thermal cover was constructed over the waste rock portal plug. The cover consisted of a 2.0 m thick layer (minimum thickness) of granular shale overlain by a 0.35 m thick layer of armour material consisting of sand, gravel and cobbles. The shale was derived from the Shale Hill borrow area. The armour material was derived from the Chris Creek “A” deposit. An additional thermal cover was constructed over the area below the road immediately outside the portal where mineralized soils and additional waste rock were located. A surficial cover of shale was also constructed adjacent to the thermal cover to improve drainage conditions.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-18). The main observations are summarized by the following:

- No erosion of the cover was observed.
- No seepage was noted at the toe of the cover.
- No areas of significant settlement were observed in the cover.
- Some minor cracking was noted on the surface of the cover, likely related to thermal expansion and contraction of the cover materials.

In general, the K-Baseline portal appears to be in satisfactory condition. As such, no maintenance was recommended.

6.4.5. Area 14 Portal

Construction Details

The Area 14 Portal was a bare rock portal that provided access to the Area 14 underground workings. The location of the portal is illustrated on Drawing 1. Mining ceased in this area around 1987 and the portal was backfilled with waste. The waste was covered and contoured with shale in 1987 and 1988.

In 2005, locally derived armour material was stockpiled adjacent to the portal cover for construction of the final armour layer. In late 2006, the stockpiled armour materials were spread over the portal area.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-19).

The portal surface remained covered in snow during the 2013 inspection. Based on inspection observations over the past several years, it is likely that the Area 14 portal remains in satisfactory condition. As such, no maintenance was recommended.

6.4.6. 09 South Portal

Construction Details

The 09 South Portal is located at the western end of the mine, as shown on Drawing 1. The 09 South Portal is a culverted entry giving access to the Main Ore Zone. The 09 South drift is approximately 5 m by 5 m in cross section. The culvert is round with a diameter of 5 m and a length of 28 m. The bottom of the culvert is filled with rockfill to provide a smooth floor. The culvert extends approximately 13 m inside the shale bedrock of 09 south drift, leaving 15 m exposed on surface, a portion of which is covered with talus from the slope above.

The 09 South Portal remained open until the fall of 2008 to provide access to the underground workings during the underground waste disposal program. Once the underground waste disposal program was complete in September 2008, work on permanent closure of the 09 South Portal began.

In 2008, the culvert was removed and the portal was backfilled with granular shale derived from the Mill Area deposit. The backfill was placed to within 0.5 m of the top of the portal and extended into the portal for approximately 5 m. The backfill extended outside the portal face and was sloped at an angle of approximately 4(H):1(V) and graded into the surrounding topography. A 0.25 m (minimum thickness) layer of locally derived armour material was then applied to the surface of the shale backfill.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-20). The main observations are summarized by the following:

- No erosion of the cover was observed.
- No seepage was noted at the toe of the cover.
- Some minor cracking and deformation of the cover was noted, in a similar condition as was observed in 2012. The area appears to have stabilized.

In general, the 09 South Portal cover appears to be physically stable and in satisfactory condition. As such, no maintenance was recommended.

6.4.7. Lower Adit

Construction Details

The Lower Adit is located at the western end of the mine near the Industrial Complex, as illustrated on Drawing 1. The Lower Adit provided the main access into the underground crusher and fine ore bin, as well as secondary access to the Main Ore Zone.

The Lower Adit Portal remained open until the fall of 2008 to provide ventilation to the underground workings during the underground waste disposal program. Once the underground waste disposal program was complete in September 2008, work on permanent closure of the Lower Adit Portal began.

In 2008, the portal was backfilled with granular shale derived from the Mill Area deposit. The backfill was placed to within 0.5 m of the top of the portal and extended into the portal for approximately 5 m. The backfill extended outside the portal face and was sloped at an angle of approximately 4(H):1(V) and graded into the surrounding topography. A 0.25 m (minimum thickness) layer of locally derived armour material was then applied to the surface of the shale backfill.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-21). The main observations are summarized by the following:

- No erosion of the cover was observed.
- No seepage was noted at the toe of the cover.
- No cracking or deformation of the cover was noted.

In general, the Lower Adit portal plug appears to be in satisfactory condition. As such, no maintenance was recommended.

6.4.8. Portal to Mill Foundation

Construction Details

A portal was driven beneath the Mill building in 1980 as part of emergency repair operations for the Mill. The portal is located approximately 70 m south of the Mill, adjacent to Twin Lakes Creek. The portal provided access to an ice lens which was present beneath the mill building. As part of the repair operations, the ice lens was mined out and concrete pillars were constructed to provide additional support for the Mill. After the repair operations were complete, the portal was plugged with shale rock fill.

Inspection Conditions

The main inspection observations are summarized by the following:

- No erosion of the armoured portal plug was observed.
- No seepage was noted at the toe of the portal plug.

In general, the portal plug appears to be physically stable. No additional maintenance was recommended.

6.4.9. Shale Hill Raise

Construction Details

The Shale Hill Raise provided ventilation for the underground workings in the Shale Hill area. The location of the raise (E582524, N8107427, UTM NAD 83 Zone 16) is illustrated on Drawing 1. The 3 m diameter raise was approximately 47 m deep. During mining operations, the raise was sealed with a 3 m diameter steel tank with the bottom cut out and with two adaptors in the top for 36-inch ventilation fans. The tank was fixed to a cemented collar at the top of the raise.

Prior to 2005, the surface structure was removed and, according to mine site records, the Shale Hill raise was backfilled with waste rock. A mound of shale was constructed at surface with side slopes of approximately 3(H):1(V). In 2005, a 0.35 m thick layer of locally derived armour material was applied to the surface of the mound to complete the remediation of this raise.

Inspection Conditions

During the inspection, the armour surface appeared to be stable with no visual indications of erosion or surface deformation. As such, no maintenance was recommended.

6.4.10. Oceanview East Raise

Construction Details

The Oceanview East Raise was situated at the extreme east end of the Oceanview underground workings. The location of the raise (E585123, N8107506, UTM NAD 83 Zone 16) is illustrated on Drawing 1. The 4 by 4 m raise was approximately 10 m deep and provided ventilation for the underground workings in the Oceanview area. During mining operations, the raise was covered with a wooden wind deflector with a locked door.

In 2002, the wooden deflector was removed and, according to mine site records, the raise was backfilled with waste rock. During backfilling, it was noted that an ice plug was present in the raise at a depth of approximately 1.5 m below ground surface. As such, waste rock was placed only to this depth. A 3 m high mound was placed on top of the raise to accommodate for possible future settlement of the ice plug. The mound was constructed of shale and surfaced with coarse rock.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-22). During the inspection, the armour surface appeared to be stable with no visual indications of erosion or surface deformation. As such, no maintenance was recommended.

6.4.11. Oceanview West Raise

Construction Details

The Oceanview West raise was located near the west end of the Oceanview underground workings (E584851, N8107466, UTM NAD 83 Zone 16), as shown on Drawing 1. The 3 m diameter raise is approximately 26 m deep and provided ventilation for the underground workings. The raise was covered by a steel enclosure with a locked wooden cover.

In 2002, the steel enclosure was removed and, according to mine site records, the raise was backfilled with waste rock as part of the progressive reclamation of the mine site. During backfilling, it was noted that an ice plug was present in the raise at a depth of approximately 1.5 m below ground surface. As such, waste rock was placed only to this depth. A 3 m mound was placed on top of the raise to accommodate for possible future settlement of the ice plug. The mound was constructed of shale and surfaced with coarse rock.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Drawing I-22). During the inspection, the armour surface appeared to be stable with no visual indications of erosion or surface deformation. As such, no maintenance was recommended.

6.4.12. Area 14 Raise

Construction Details

The location of the Area 14 Raise (E584187, N8105663, UTM NAD 83 Zone 16) is illustrated on Drawing 1. The raise had a cross section of 5 m by 5 m and an approximate depth of 8 m. Mining ceased in this area around 1987 and the raise was completely backfilled to the floor of the underground workings. Backfilling was completed with waste rock and the surface was then covered and contoured with shale in the summer of 1987 and 1988.

Inspection Conditions

During the inspection no settlement of the area surrounding the former raise was observed. As such, no maintenance was recommended.

6.5. Shale and Armour Borrow Areas

6.5.1. Shale Borrow Areas

Several shale borrow areas were developed during the reclamation process to provide material for construction of the thermal covers. The borrow areas include the following:

- Mt. Fuji
- Area 14
- West Twin
- East Twin
- Shale Hill
- Townsite

The borrow areas were reclaimed once no longer required. The reclamation efforts included re-grading of slopes for stability and sufficient grading of the floor of each borrow area to provide for positive drainage of surface water.

Select photos from the inspection are provided in Appendix I (Drawing I-23). The main observations are summarized by the following:

- Mt. Fuji
    - The benches remained partially covered in snow at the time of the inspection.

- Based on areas not covered in snow, the benches are continuing to slowly fill in from the raveling of the remaining bench faces and are expected to eventually form a stable slope at the natural angle of repose.
- The floor had no ponded water and is considered well drained.
- No issues requiring maintenance were observed.

- Area 14
  - The area was partially covered in snow at the time of the inspection.
  - In general, the re-graded pit walls appear to be stable.
  - One area of erosion has occurred at the north end of the borrow area where natural surface water periodically discharge occurs into the pit, typically during freshet. At this location, the overburden material has been eroded down to the top of the bedrock and has been deposited into the floor of the pit. This area was observed to have stabilized during recent inspections as down-cutting of these materials no longer appears to be occurring.
  - No ponding of water was observed at the time of the inspection, but there has been significant thermokarsting at the entrance to the pit. As such, it is likely that this impedes drainage at some point in the year. The material is sufficiently fractured that any ponded water likely drains when the ground thaws.
- West Twin
  - In general, the re-graded pit walls appear to be stable.
  - No ponding was observed in the floor of the pit.
  - No issues requiring maintenance were observed.
- East Twin
  - In general, the re-graded pit walls appear to be stable.
  - No ponding was observed in the floor of the pit.
  - Some thermokarsting was noted on some of the remnant benches within the interior of the pit. This thermokarsting has resulted in some ponding within the interior benches of the pit.
  - No issues requiring maintenance were observed.
- Shale Hill
  - In general, the re-graded pit walls appear to be stable.
  - No ponding was observed in the floor of the pit.
  - No issues requiring maintenance were observed.
- Townsite
  - In general, the re-graded pit walls appear to be stable.
  - No ponding was observed in the floor of the pit.
  - No issues requiring maintenance were observed.

6.5.2. Armour Borrow Areas

Several armour borrow areas were developed during the reclamation process to provide material for construction of the thermal covers. The borrow areas include the following:

- Twin Lakes Delta deposit
- Chris Creek “A” and “B” deposits
- Kuhulu Lake Road deposit
- 09S/17N Road deposit
- Area 14

The borrow areas were reclaimed once no longer required. The reclamation efforts included sufficient grading of the floor of each borrow area to provide for positive drainage of surface water.

The main observations are summarized by the following:

- Twin Lakes Delta deposit
    - The floor of the quarry was, in general, well drained. The surface water flows to the north edge of the borrow area and then proceeds to flow west to the Reservoir.
    - Only isolated thermokarsting was observed in the floor of the quarry.
    - No issues requiring maintenance were observed.
- Chris Creek “A” and “B” deposits
    - The floor of the quarry was observed to be well drained.
    - Some minor thermokarsting was observed in the floor of the quarry.
    - No issues requiring maintenance were observed.
- Kuhulu Lake Road deposit
    - The floor of the borrow area was graded in late 2006 in response to thermokarsting identified during the 2006 inspection. Since the grading in 2006, some additional thermokarsting has occurred, but the area appears to be well drained due to the pervious nature of the ground in this area. No additional maintenance was recommended.
- 09S/17N deposit
    - The face of the borrow area did not exhibit any indications of erosion or thermokarsting.
    - No issues requiring maintenance were observed.
- Area 14 deposit
    - Some minor thermokarsting was observed in the borrow area.
    - Given the stability exhibited by the area over the past few years, additional grading is no longer considered necessary but the area should continue to be monitored.

6.6. Other Areas

6.6.1. Concentrate Storage Shed

Construction Details

Dismantling of the Concentrate Storage Shed was completed in 2007. The concrete floor slab was left in-place and covered with a surficial cover of locally derived materials. According to mine site staff, the cover is approximately 30 cm thick, although this was not confirmed during the site inspection. The area adjacent to the Concentrate Storage Shed foundation, where metals contaminated soils had been excavated, was also backfilled and re-sloped to prevent ponding.

Inspection Conditions

The main observations made during the inspection are summarized by the following:

- Most of the surficial cover over the remnant concrete pad was removed previously by the Coast Guard.
- A building has been erected on the surface of the cleared concrete pad by Department of National Defence.
- A portion of the cleared concrete pad was being used to stockpile coarse rock screened out of the contaminated soil excavation from the main tank farm foundation. The rock stockpile was surrounded by a soil berm to limit interaction of the stockpile with any surface water running along the surface of the concrete pad.
- No erosion of the remaining cover was observed.
- No seepage from the cover area was noted.
- No ponding was noted on the surface of the cover or any areas immediately adjacent to the cover. Though the remaining cover over the lower portion of the pad has the potential to impede drainage and create ponding during spring melt or precipitation events.

No maintenance of the Concentrate Storage Shed concrete pad was recommended.

6.7. Summary of 2013 Maintenance Recommendations

The maintenance items recommended throughout Section 6 are summarized in Table 4.

Table 4. Recommended 2013 Maintenance and Action Items.

Inspection Item	Recommended Maintenance Action Items
West Twin Dyke Spillway	The area should continue to be visually monitored for any signs of erosion or permafrost degradation induced deformation of the side slopes. Review feasibility of methods to reduce quantity of snow in spillway.
West Twin Outlet Channel	Monitor the water elevation in the Reservoir. Consider seepage control measures such as backfill polishing pond upstream of the wall.
East Twin Creek Diversion Channel	No immediate maintenance required. Additional armouring may be required at some point to address noted erosion. Monitor creek flows during freshet to assess causes of erosion. Monitor seepage discharge point at toe of dyke.
Surface Cell Tailings Cover	No maintenance required. Continue to monitor thermokarst areas for additional deformation.
East Open Pit/ East Trench Waste Rock Cover	No maintenance required. Continue to visually monitor cracking in EOP crown pillar and minor surficial erosion of EOP and East Trench covers.
Oceanview Pit Waste Rock Cover	No maintenance required. Continue to visually monitor surficial erosion along backslope.
00/01 Portals and crown pillar	No maintenance required. Continue to visually monitor cracking in WOP crown pillar.
Instrumentation/ Monitoring	Re-install water level logger in Reservoir during 2014 inspection.

No maintenance was recommended at other areas not specifically noted in Table 4.

6.8. 2014 – 2018 Monitoring Recommendations

As part of the Water License renewal process, BGC undertook a review of the geotechnical monitoring requirements for the Nanisivik Mine site. The intent of the review was to develop a revised monitoring schedule for the term of the next Water License, which is assumed to be for a five year duration (2014-2018). The results of this review are documented in a project memorandum (BGC 2013b) included in Appendix III. Based on the results of the monitoring program undertaken to date, it was considered appropriate to reduce the monitoring schedule for the term of the next Water License. In summary, geotechnical instrumentation (thermistors, piezometers, frost gauges) will be undertaken as per the proposed schedule between July 1 and September 1. Additionally, the reclamation measures will continue to be inspected on an annual basis throughout the term of the next Water License by a qualified Geotechnical Engineer.

7.0 CONCLUSIONS AND RECOMMENDATIONS

The following paragraphs provide a summary of the significant observations, conclusions and recommendations based on the results of the 2013 Geotechnical Inspection Program undertaken at the Nanisivik Mine site.

Embankments

The breaches in the remnant dykes at the East Adit Treatment Facility continue to permit natural drainage of the area with only limited ponding in the Retention Pond. The size of this ponding is gradually decreasing with time as the low spots in the pond area backfill with natural sediment transported from upslope areas. The Main Tank Farm berm was nearly completely removed at the time of the inspection and no ponding was occurring in the area. The West Twin Dyke was physically stable with no signs of erosion or seepage.

Hydraulic Structures

The West Twin Dyke Spillway continues to effectively drain surface water from the Surface Cell cover into the Reservoir and is generally functioning as intended. Some erosion of the side wall was noted in the past, likely in response to elevated flows during freshet. Re-sloping and placement of additional armour in erosion areas was completed during the 2012 inspection. The remediation work was reviewed during the 2013 inspection and was noted to be in good condition.

As observed during previous inspections, a small head pond developed on the Surface Cell cover at the spillway inlet. The presence of the head pond is not considered to negatively impact the overall cover performance; hence the elimination of the head pond is not considered necessary. Reduction in pond size may continue over time as the intact rock in the base of the spillway inlet becomes more permeable due to freeze thaw effects.

Seepage losses continued at the West Twin Outlet wall in 2013. Despite these seepage losses, the water level in the remnant polishing pond upstream of the wall remained near the invert of the outlet wall throughout the open water season in 2013. The stable water level in the Reservoir is thought to reflect the generally wetter than normal conditions at site in 2013 as opposed to being indicative of reduction in seepage losses. Increased instability in the shoreline of the polishing pond was also noted in 2013. Based on the water quality measurements collected since the East Twin Lake access road was breached in 2008, the seepage losses through the foundation of the wall do not appear to be affecting the overall performance of the West Twin Area reclamation measures. The seepage losses at the wall should continue to be monitored and additional seepage control measures should be considered.

Some erosion at the East Twin Diversion Dyke was noted during the inspection. The erosion was likely due to elevated flows during freshet in combination with snow blockage in the channel. The erosion appeared to be more advanced in 2013 compared to 2012. In general the dyke remains in stable condition. However, it is recommended that visual observations of flow during freshet be recorded in 2014. Seepage was observed at the toe of the East Twin Diversion Dyke in 2013 upstream of the convergence of flow from West Twin. This seepage is likely originating in the remnant polishing pond. There is no concern with respect to the integrity of the dyke due to the presence of this seepage. However, it is recommended that this seepage point be monitored for increased flows in 2014.

Thermal Covers

The thermal covers were generally performing well in 2013 and in most cases, the thermal performance was the best since the completion of the covers. Only minor erosion, cracking and thermokarsting were observed which were not seen to negatively impact the thermal performance nor the water quality in the surrounding areas. Many of these features have been noted previously and have been observed to be physically stable for the past several years. For the most part, the active layer thaw was contained within the thermal cover at most locations. Continued improvement has also been observed in the quality of the surface water runoff from the Surface Cell cover system. This is an indication of the beneficial impacts related to improved geothermal performance of the cover system. Additionally, the water quality observed at the final discharge point for the West Twin Disposal Area has also been observed to remain well below the discharge criteria.

It is anticipated that, over time, the ice saturation will continue to progress within the base of the cover materials. As this occurs, the geothermal performance of the covers will continue to improve, further confining the active layer thaw within the cover. No maintenance is required for the thermal covers at this time; however, visual monitoring is recommended to check for additional surface deformation.

Talik Freeze-back

Freeze-back of the talik in the Surface Cell and Test Cell appears to be proceeding at anticipated rates. Cooling of the entire geothermal profile was observed in most instruments at similar or accelerated rates of cooling compared to recent years.

The pore pressures in the Surface Cell talik continue to increase, as expected, due to continued freeze-back of the tailings, but have been shown to be lowest near the dyke and highest in the centre of the talik. The piezometers in the Test Cell have demonstrated that the Test Cell talik and Reservoir are hydraulically connected. This was expected based on the available information on the Test Cell talik (BGC 2004a) and was assumed during the development of the contaminant loading model (CanZinco 2004).

Mine Openings, Crown Pillars and Raises

The covers constructed over the mine openings generally appear to be physically stable. Cracking at the East Open Pit crown pillar does not appear to have progressed since 2011. No maintenance is recommended, but continued visual inspection is warranted.

Shale and Armour Borrow Areas

In general, the shale and armour borrow areas appear to be physically stable and are not causing any significant ponding to occur. No maintenance was recommended at any of the borrow areas.

8.0 CLOSURE

This report provides a performance assessment of numerous structures at the Nanisivik Mine, based on visual observations recorded during the site inspection and a review of monitoring data collected from various instruments throughout 2013.

We trust the information provided herein meets your present requirements. Thank you for allowing BGC to be of service, once again, to Nanisivik Mine. If you have any questions or require additional details, please contact the undersigned.

Respectfully submitted,

BGC ENGINEERING INC.
per:

ISSUED AS DIGITAL DOCUMENT.
SIGNED HARDCOPY ON FILE WITH
BGC ENGINEERING INC.

Geoff Claypool, M.Eng., P.Eng.
Senior Geological Engineer

Mitchell Latimer, B.Sc., E.I.T
Geoenvironmental Engineer

Reviewed by:

James W. Cassie, M.Sc., P.Eng.
Vice President / Senior Geotechnical Engineer

GC/ML/jc/sr

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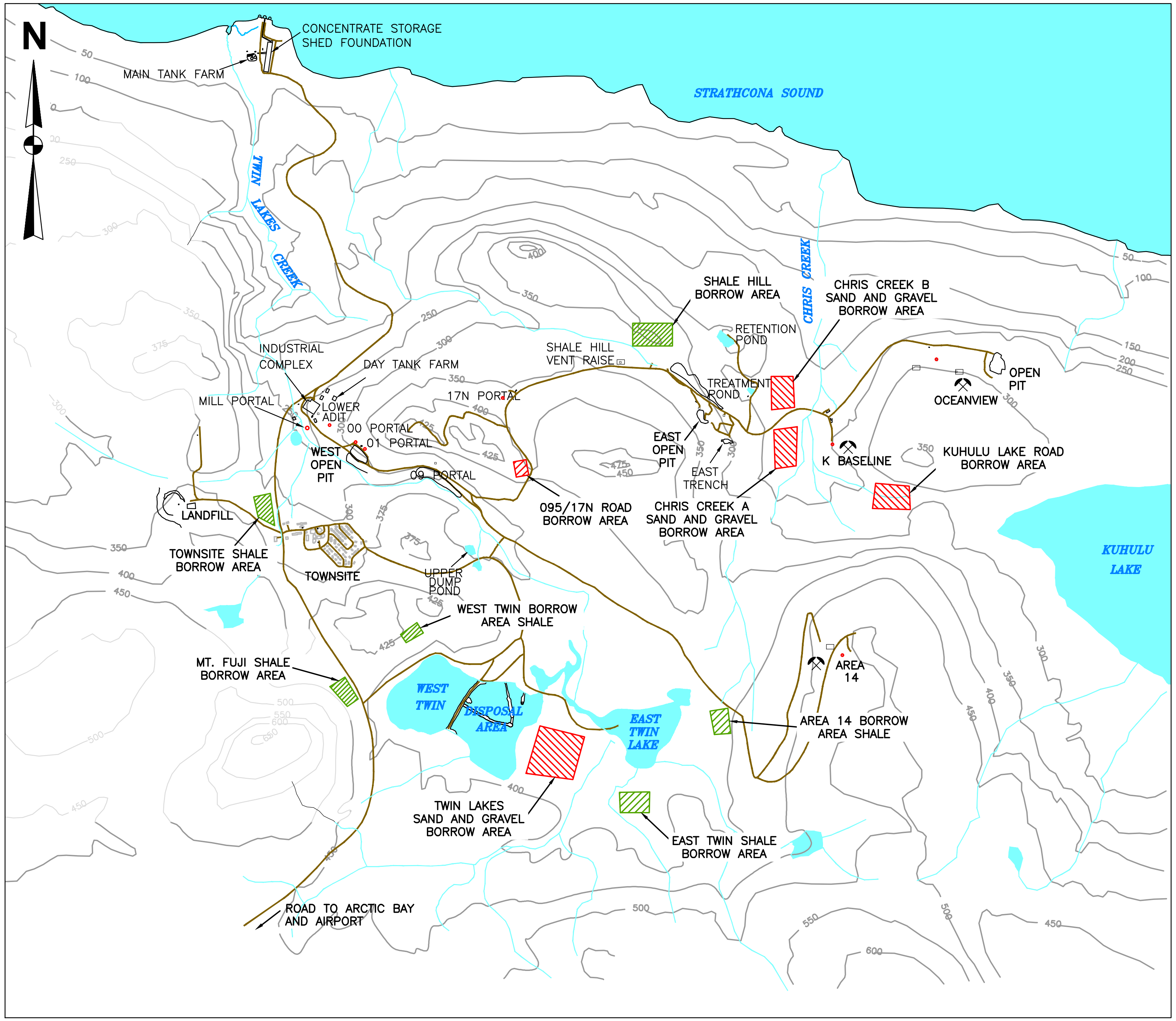
DRAWINGS



LEGEND

- ROAD
- GROUND CONTOUR (50 m INTERVAL)
- CREEKS, DRAINAGE, STREAMS, SHORELINE
- RAISE
- PORTAL

Scale 1:40000

800 0 800 1600 2400

metres

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PROJECT: NANISIVIK MINE 2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: SITE LOCATION PLAN

PROJECT No.: 0255-023-03

DWG No. 01

REV.:

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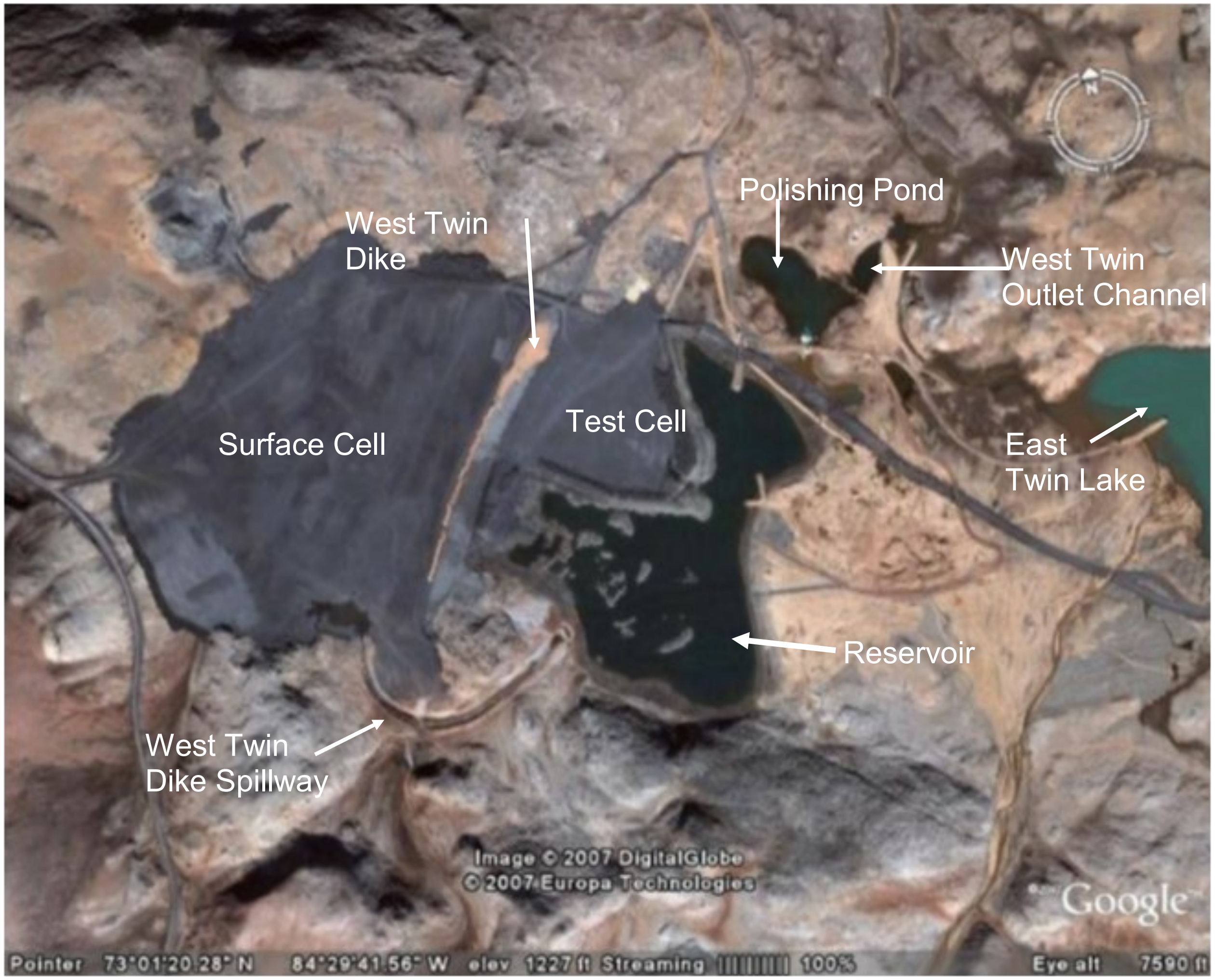

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1. Photo derived from Google Earth January 10, 2008
2. Approximate date of photo is July 2005.

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CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: COMPONENTS OF WEST TWIN DISPOSAL AREA

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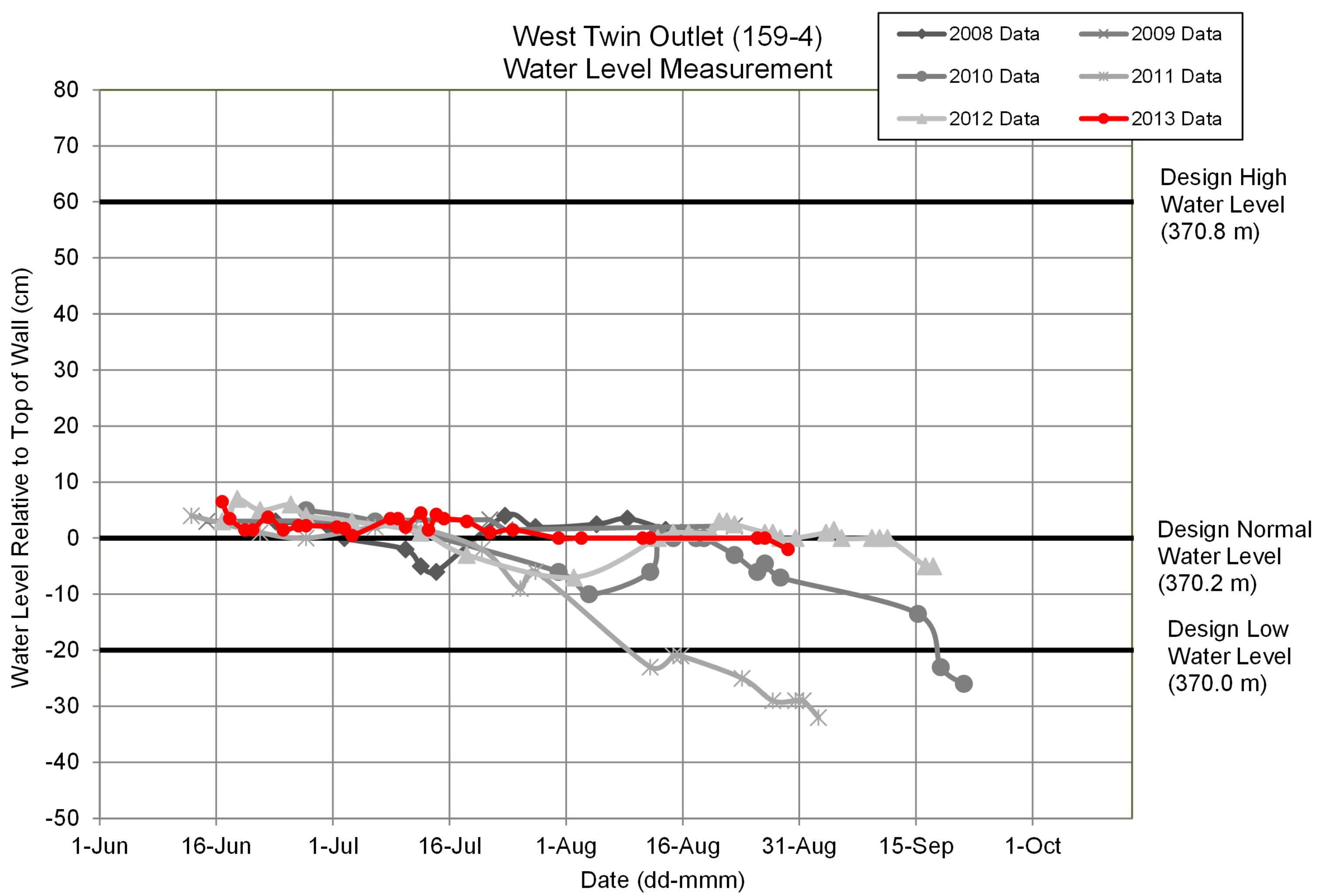

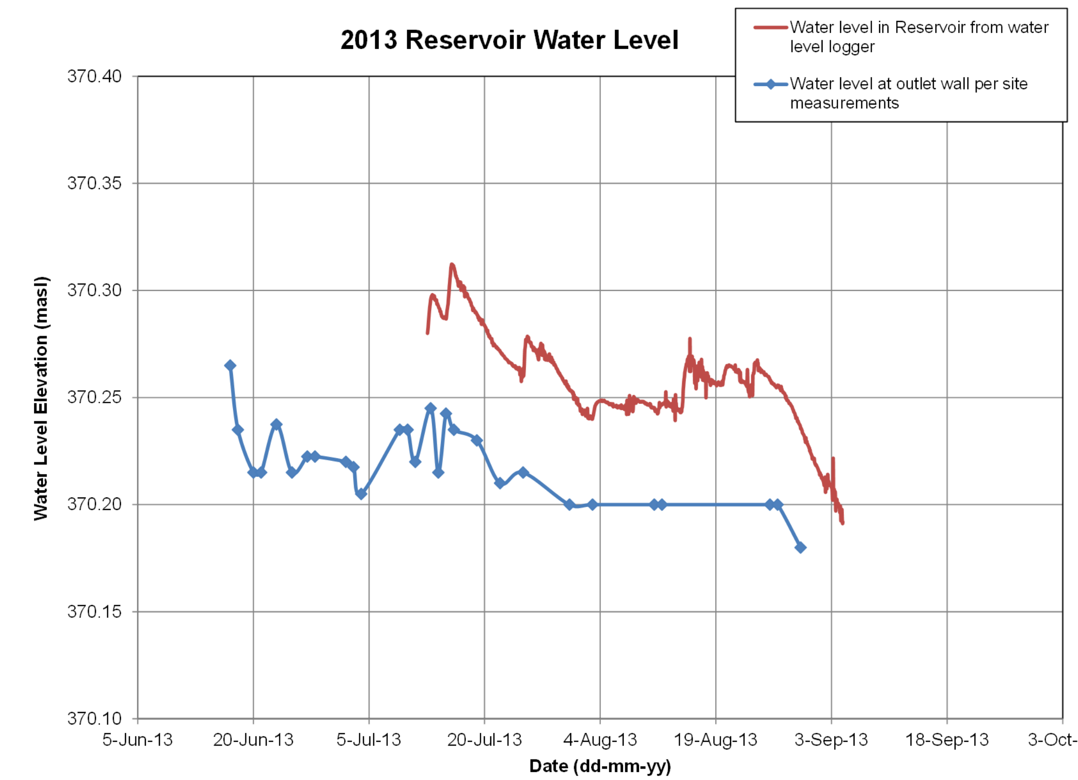

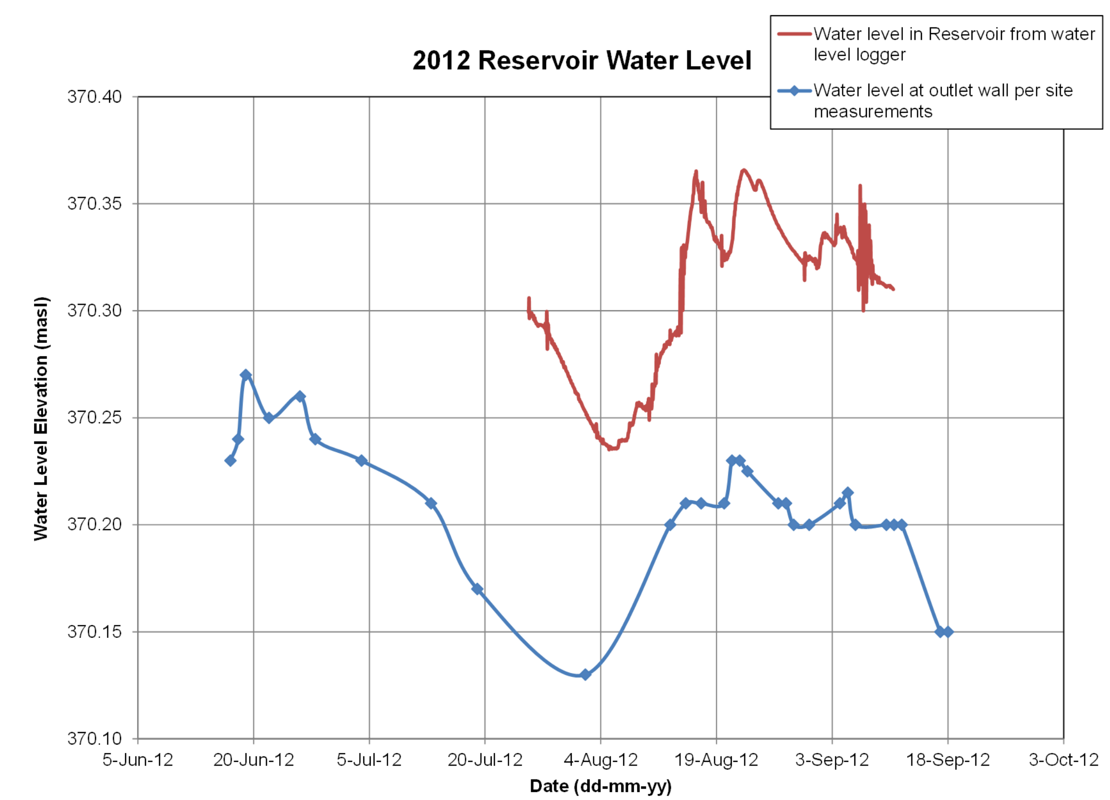

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PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: WATER LEVELS IN RESERVOIR AND AT WEST TWIN OUTLET WALL

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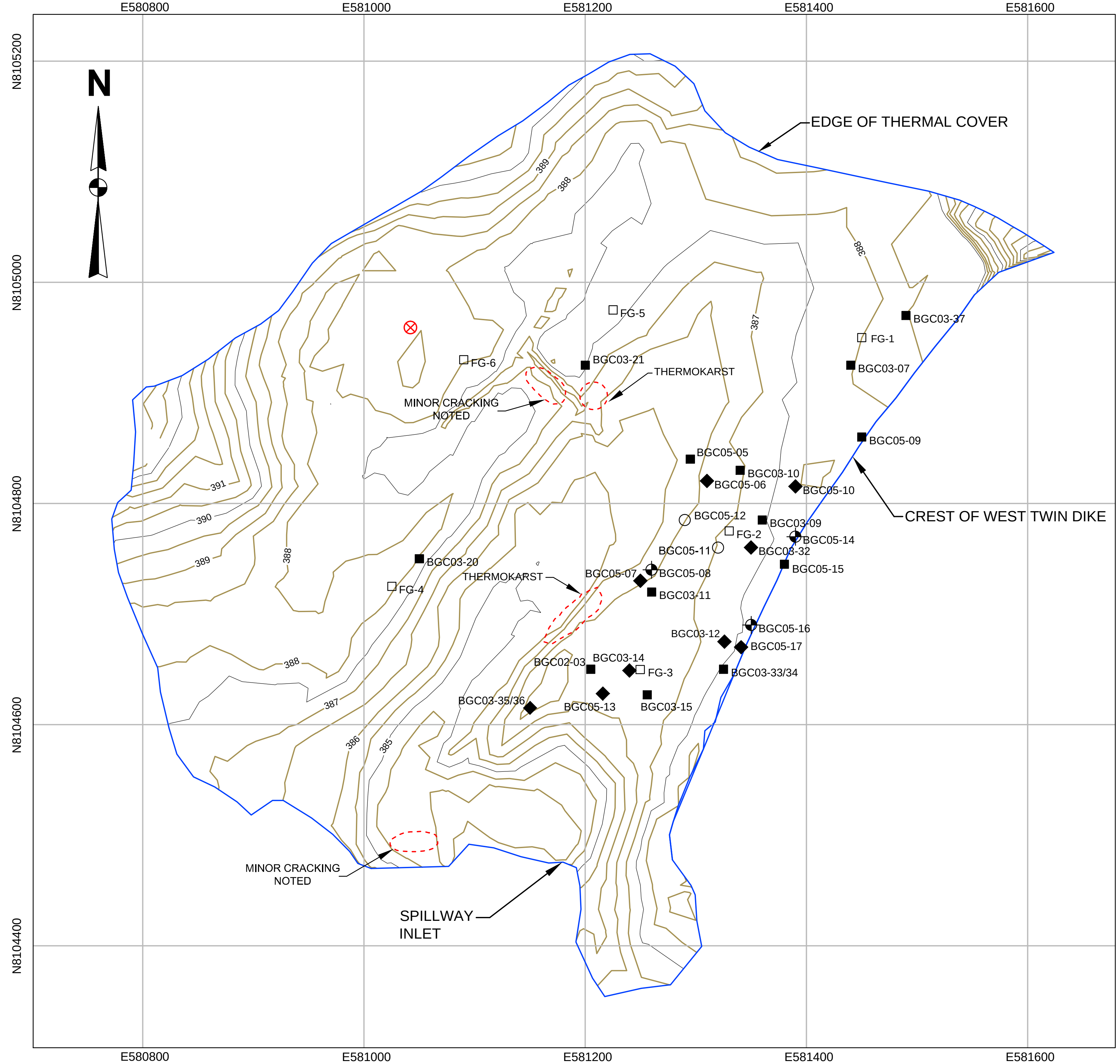

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metres

NOTES:

1. GRID BASED ON UTM NAD 83, ZONE 16 COORDINATES.
2. ELEVATIONS ARE IN METRES.
3. CONTOUR INTERVAL IS = 0.5 m.
4. SCALE IS APPROXIMATE.

LEGEND:

- THERMISTOR/ THERMOCOUPLE
- FROST GAUGE
- MONITORING WELL
- VW PIEZOMETER
- CONTINGENCY BOREHOLE
- AIR TEMPERATURE PROBE/RAIN GAUGE

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PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: SURFACE CELL TAILINGS COVER

PROJECT No.: 0255-023-03
DWG No.: 04
REV.:

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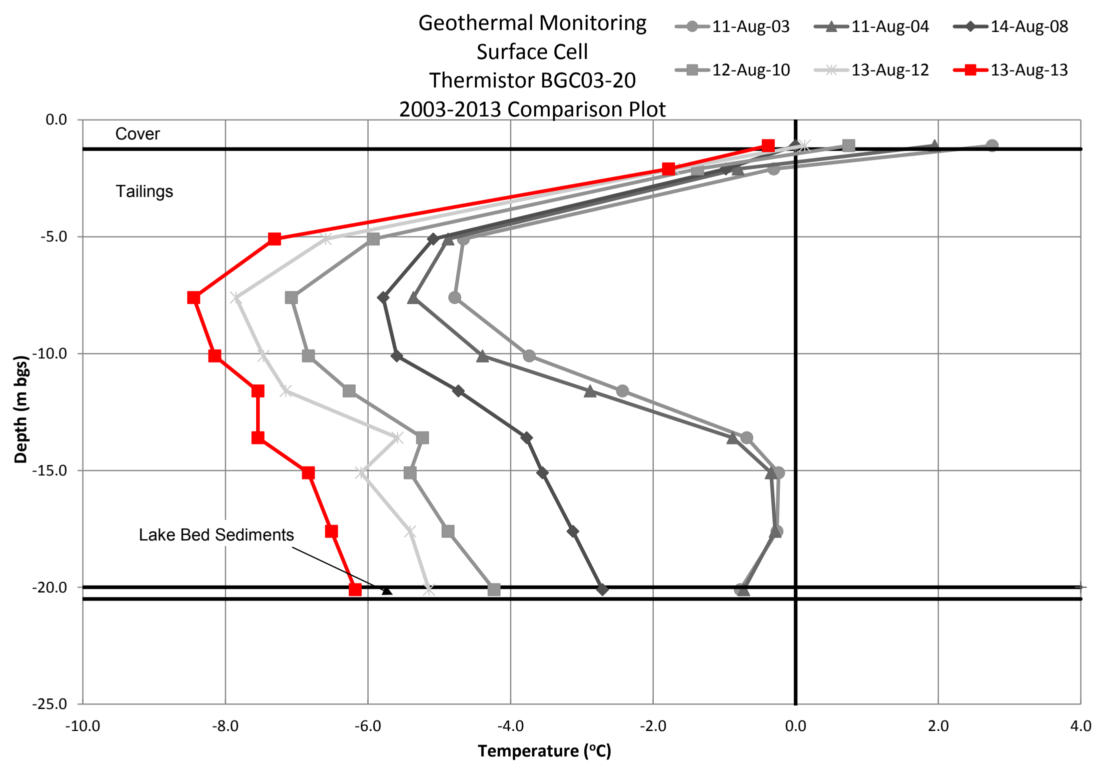

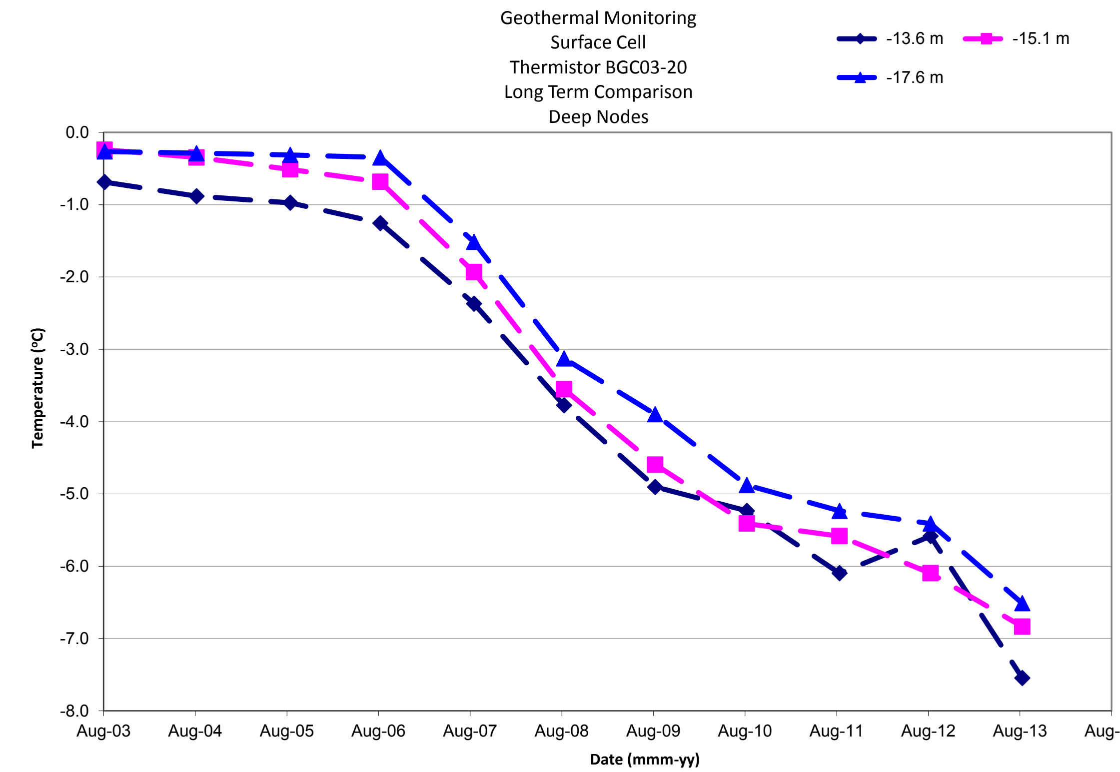

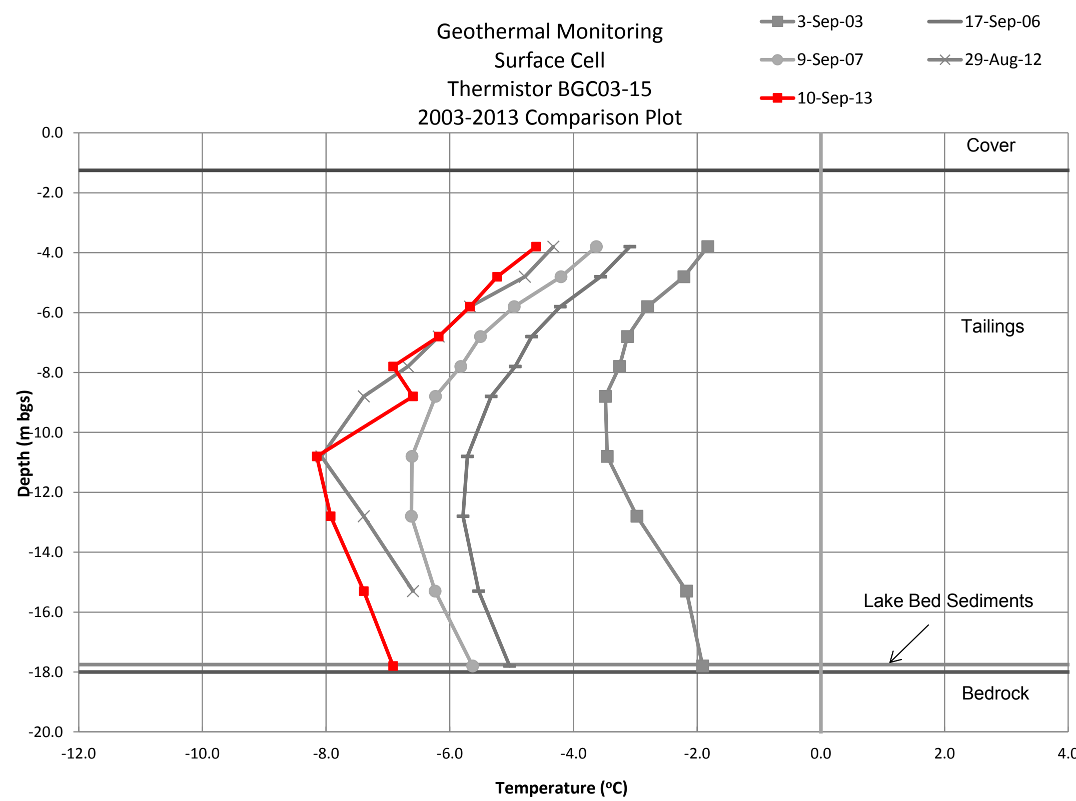

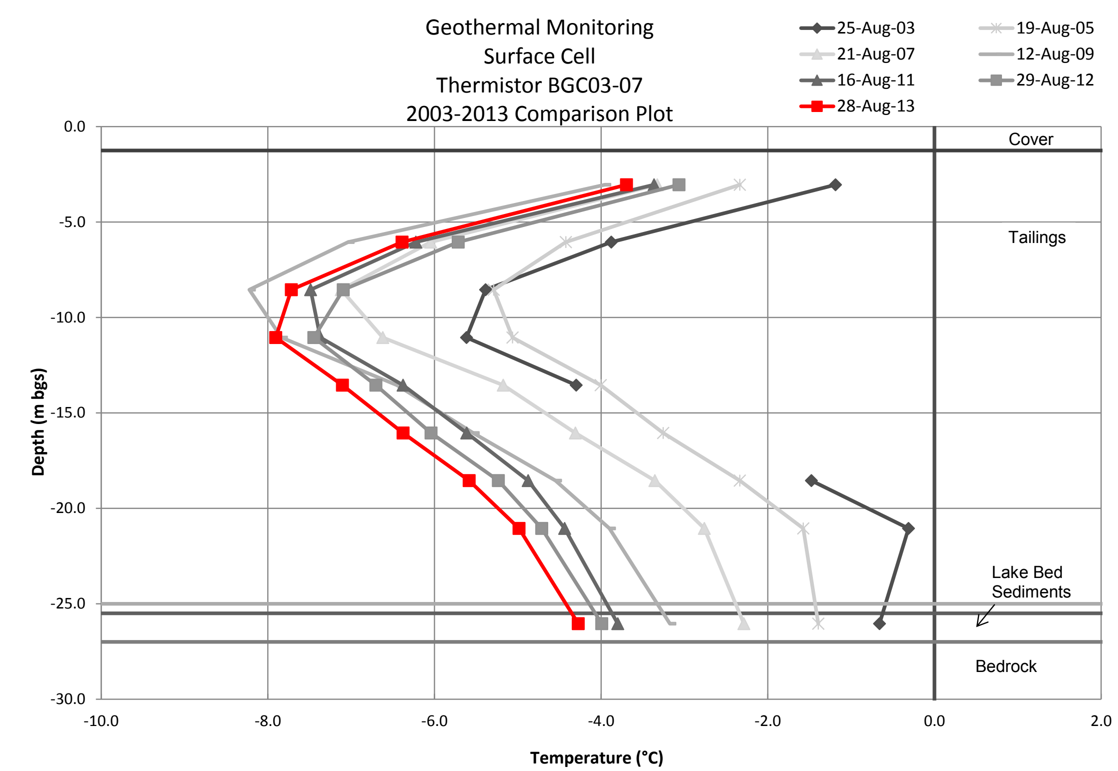

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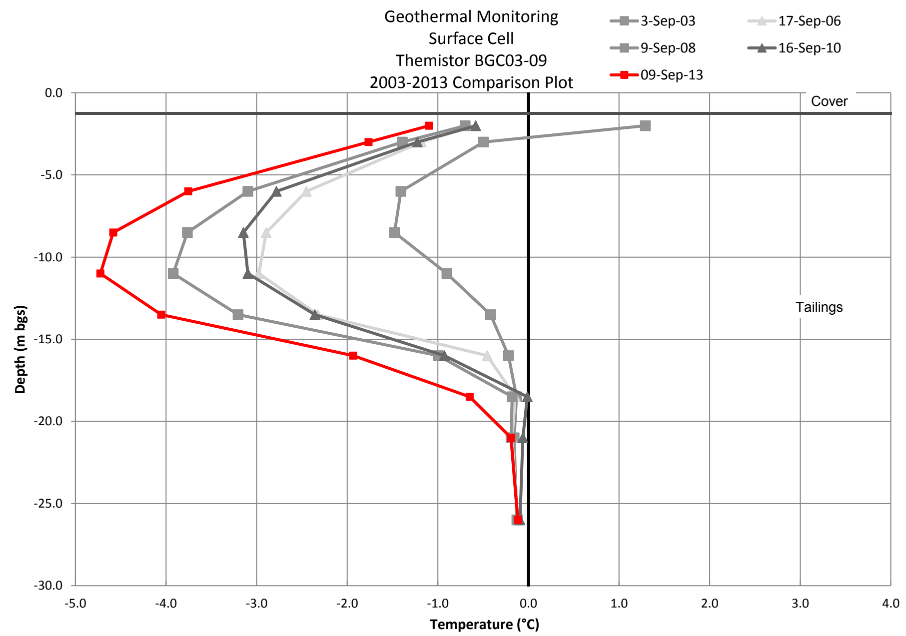

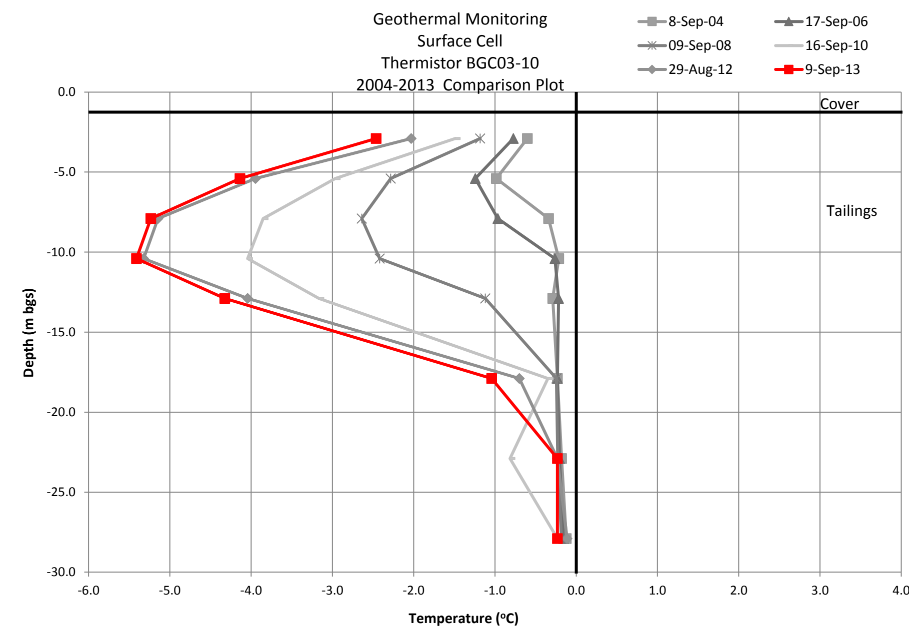

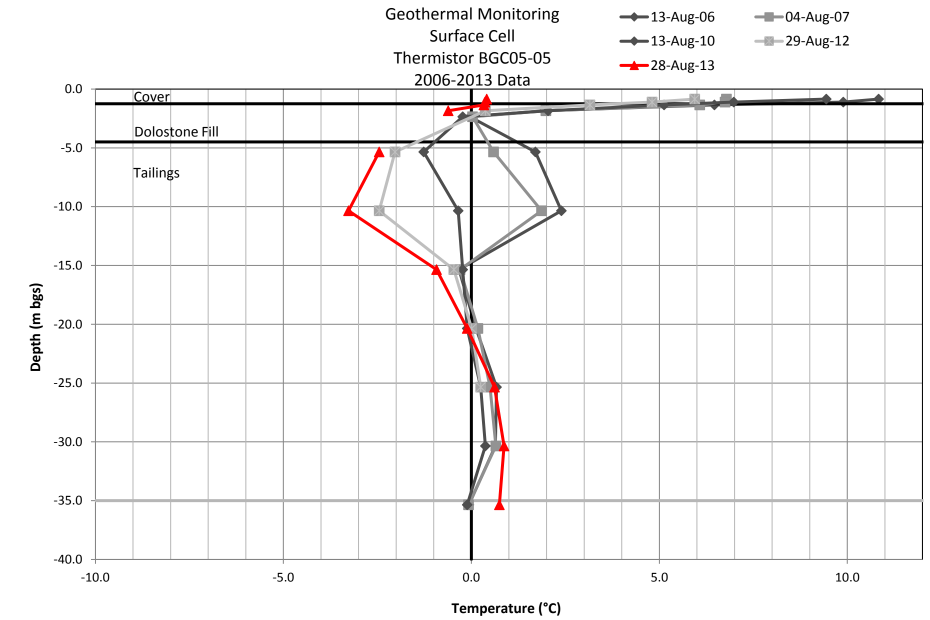

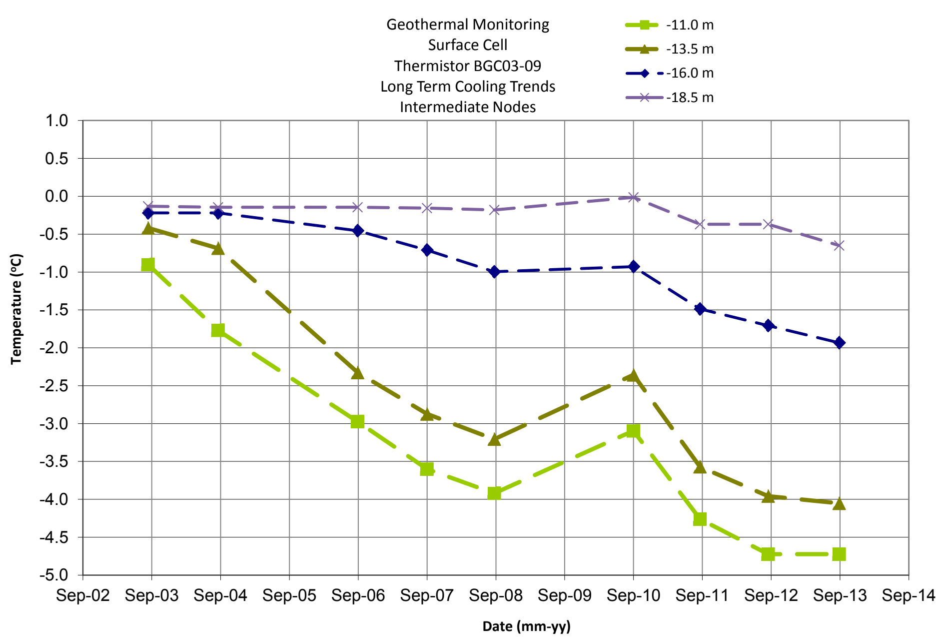

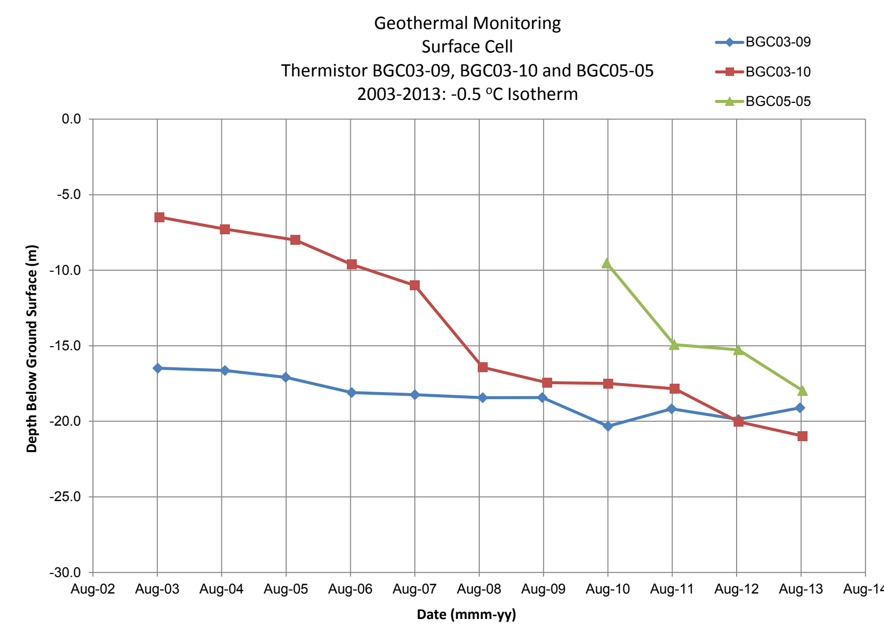

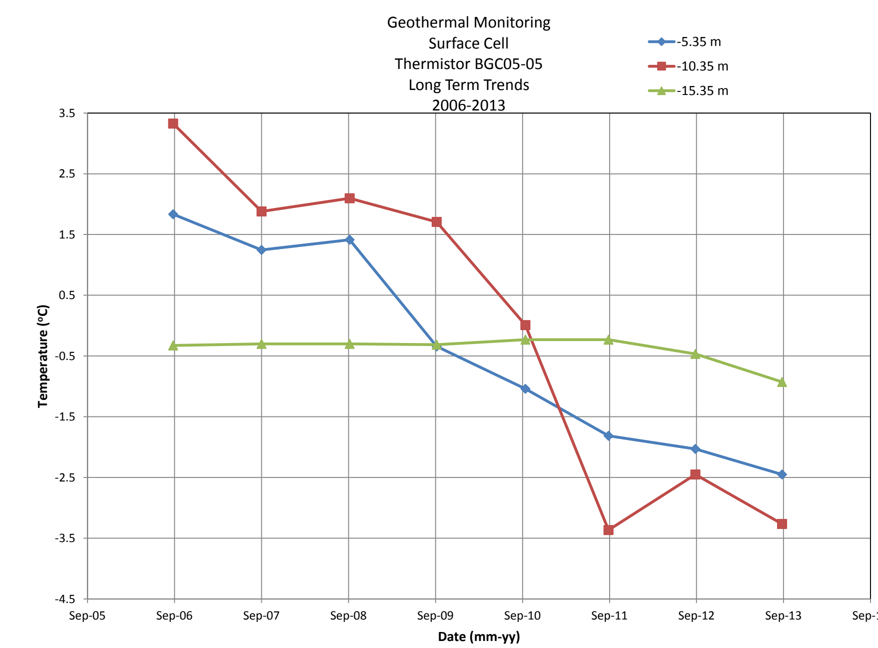

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PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

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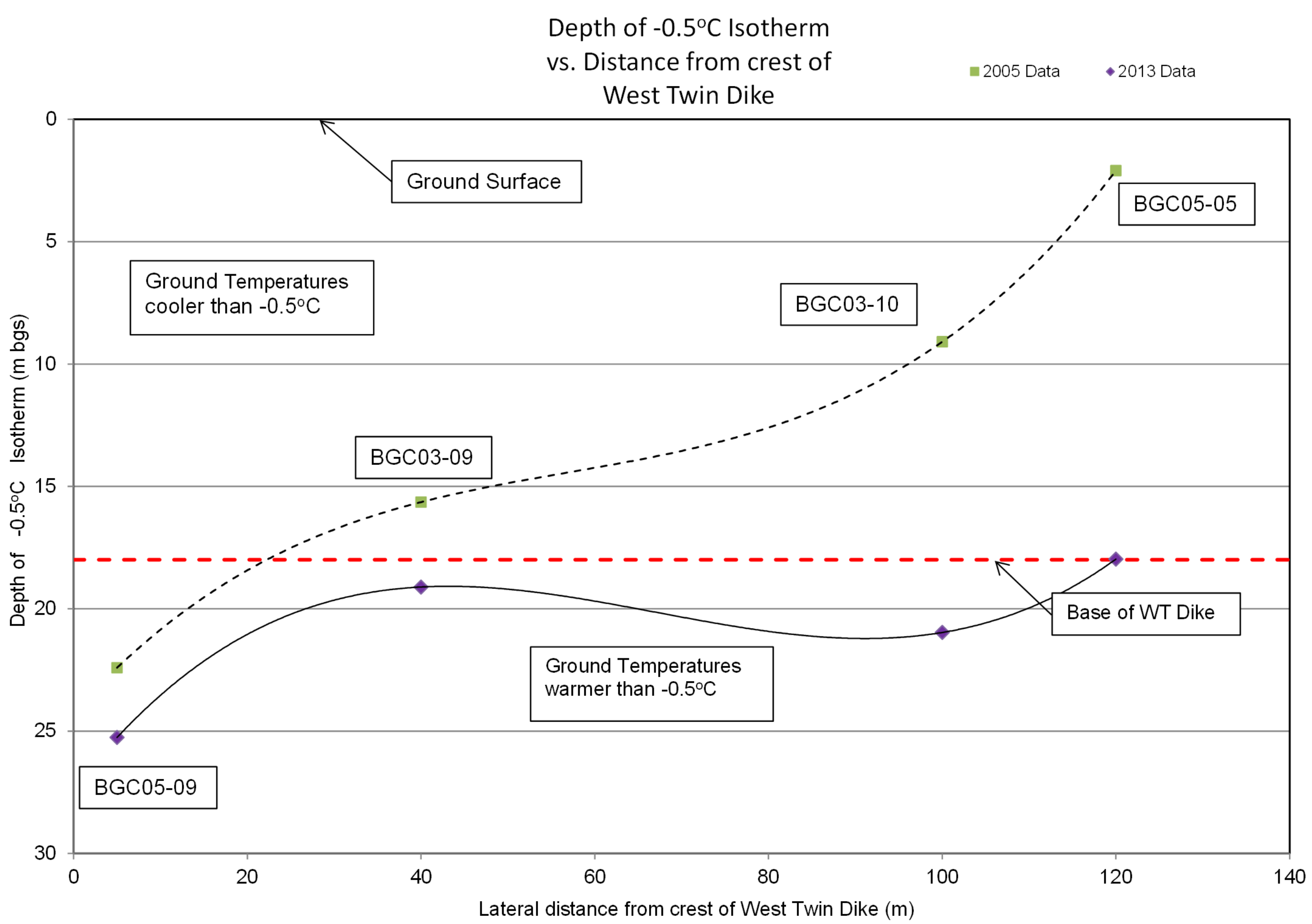

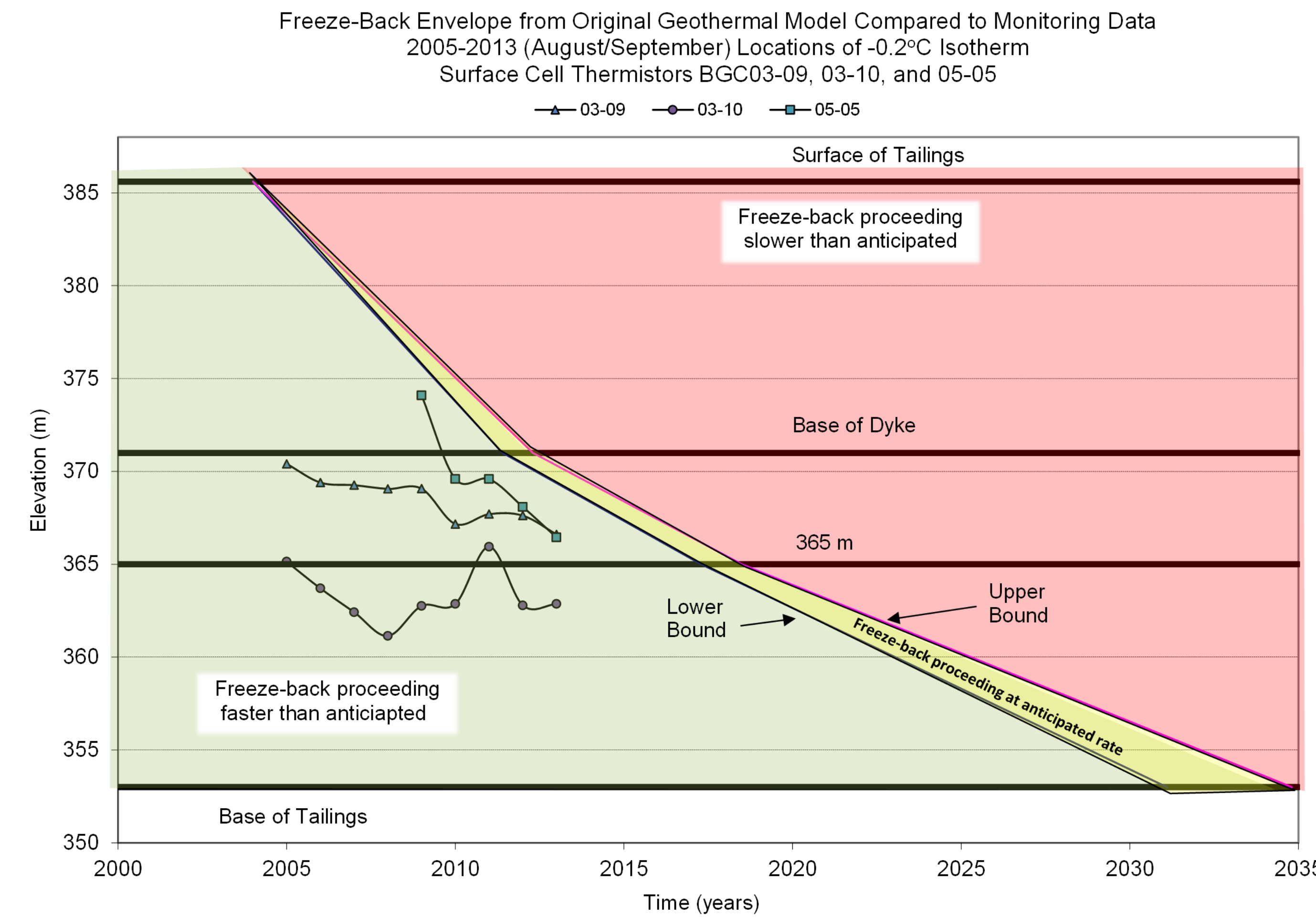

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2013 ANNUAL GEOTECHNICAL INSPECTION

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GEOTECHNICAL MONITORING DATA 3

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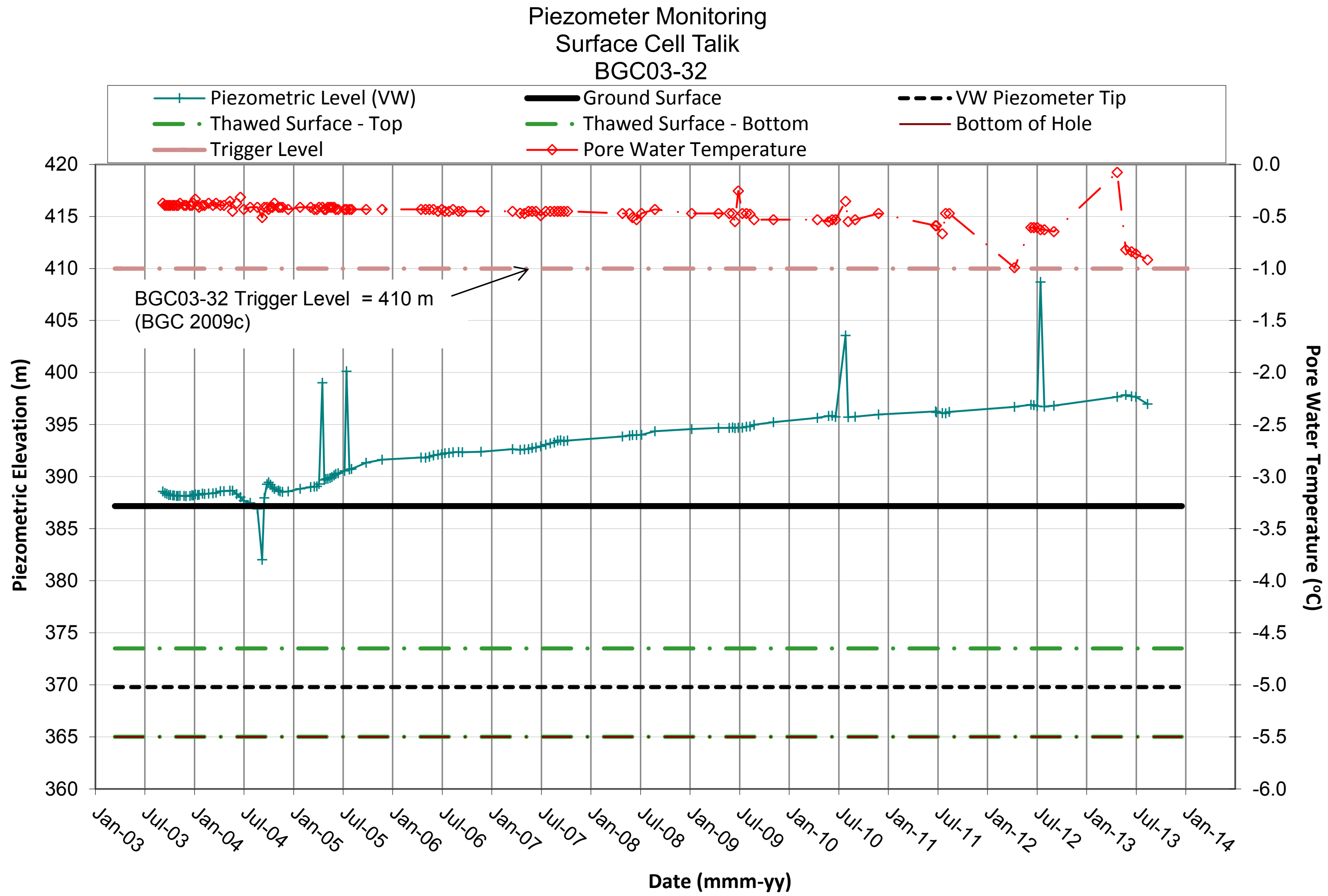

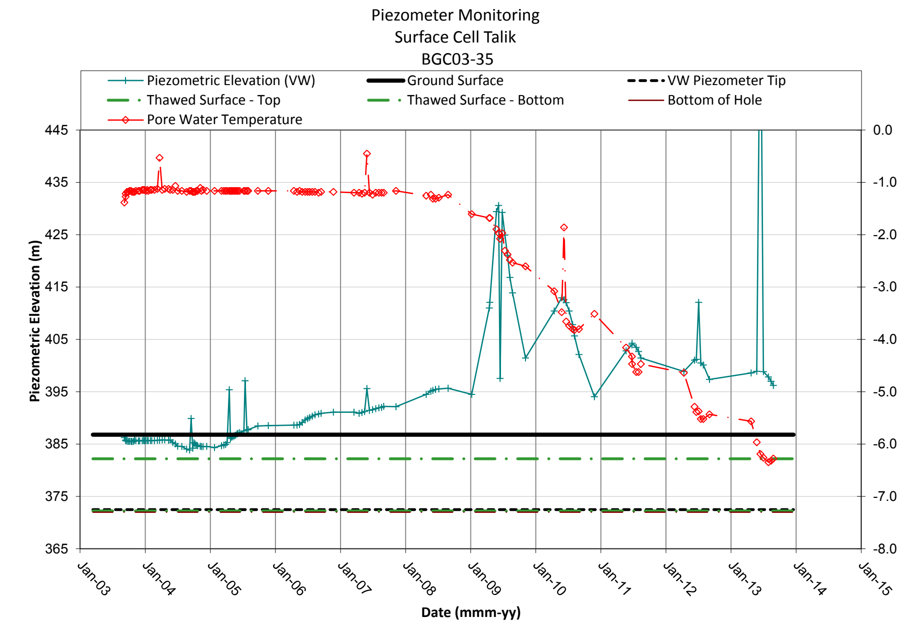

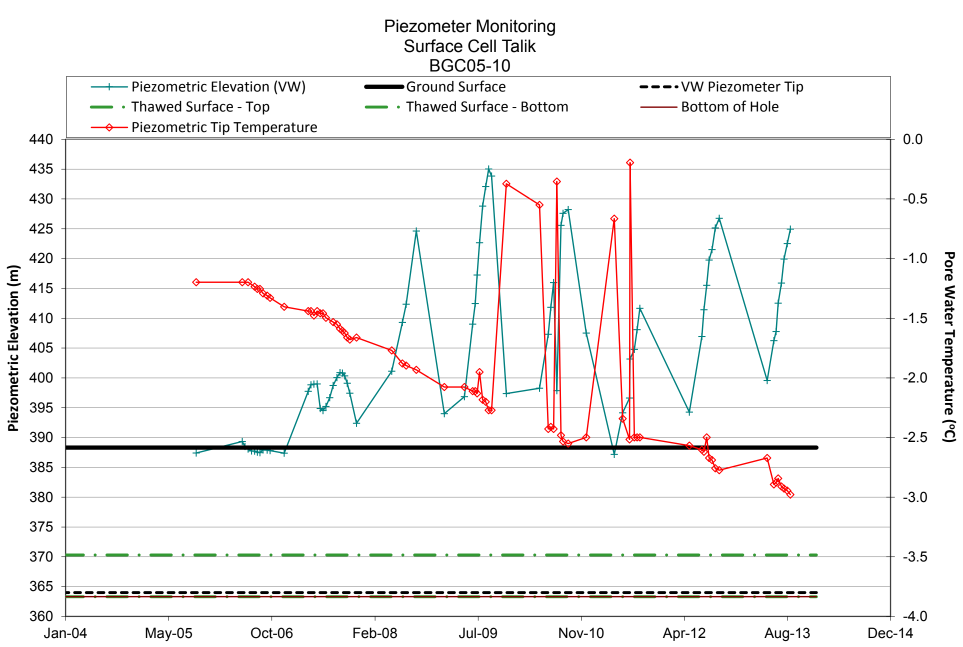

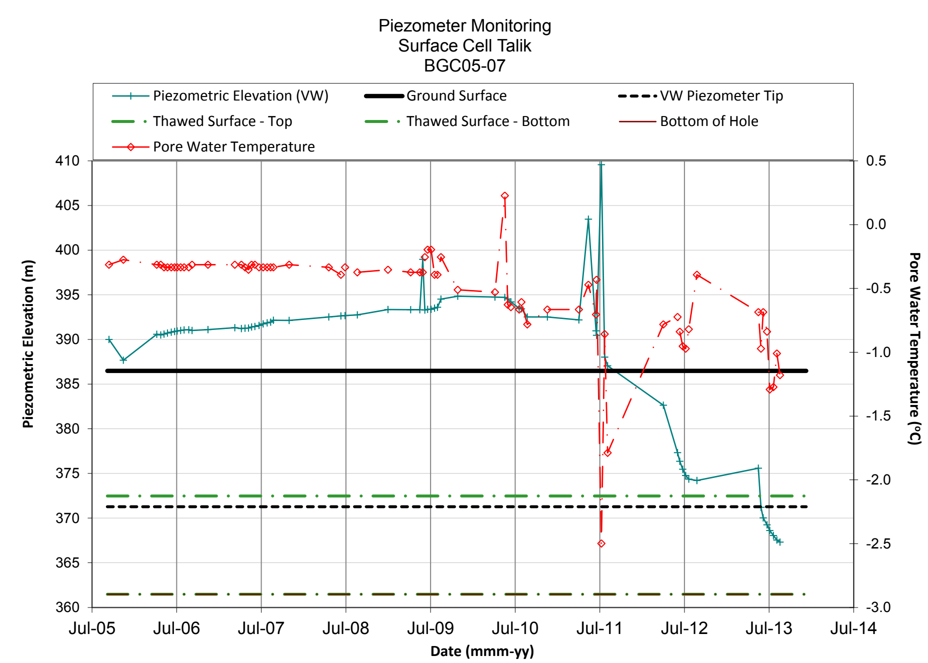

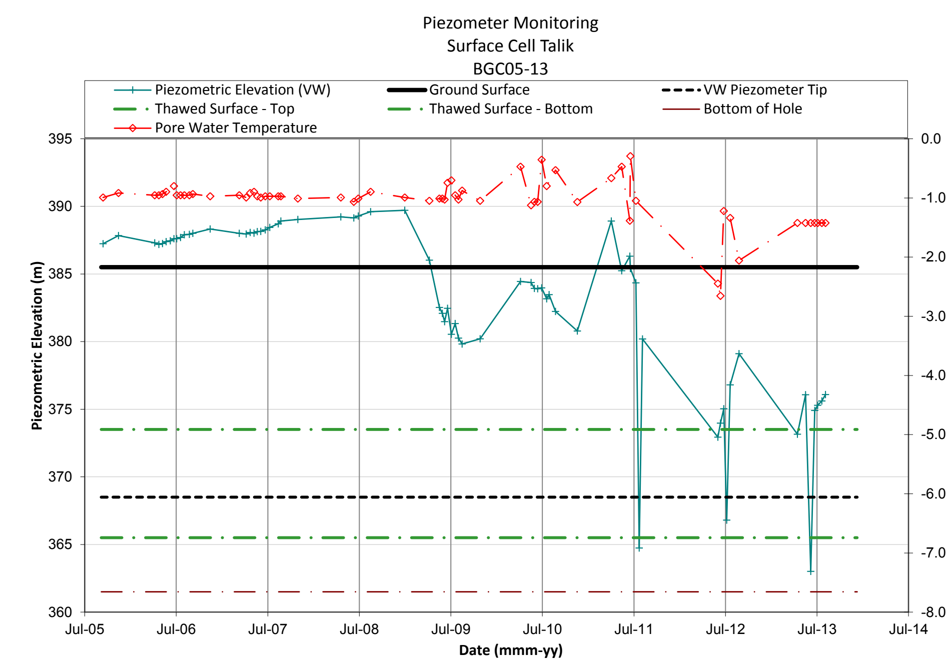

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2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: SURFACE CELL TAILINGS COVER
GEOTECHNICAL MONITORING DATA 4

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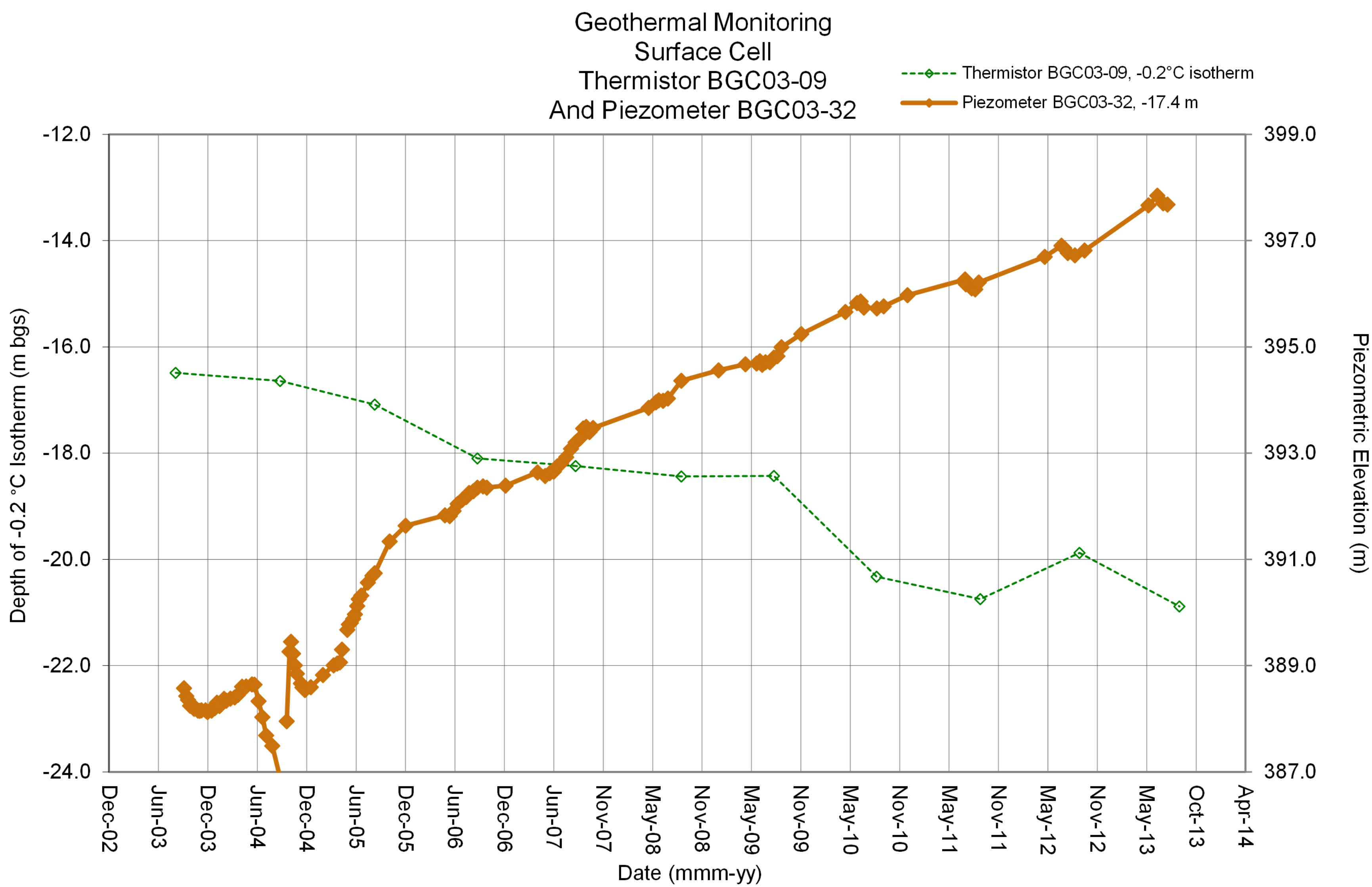

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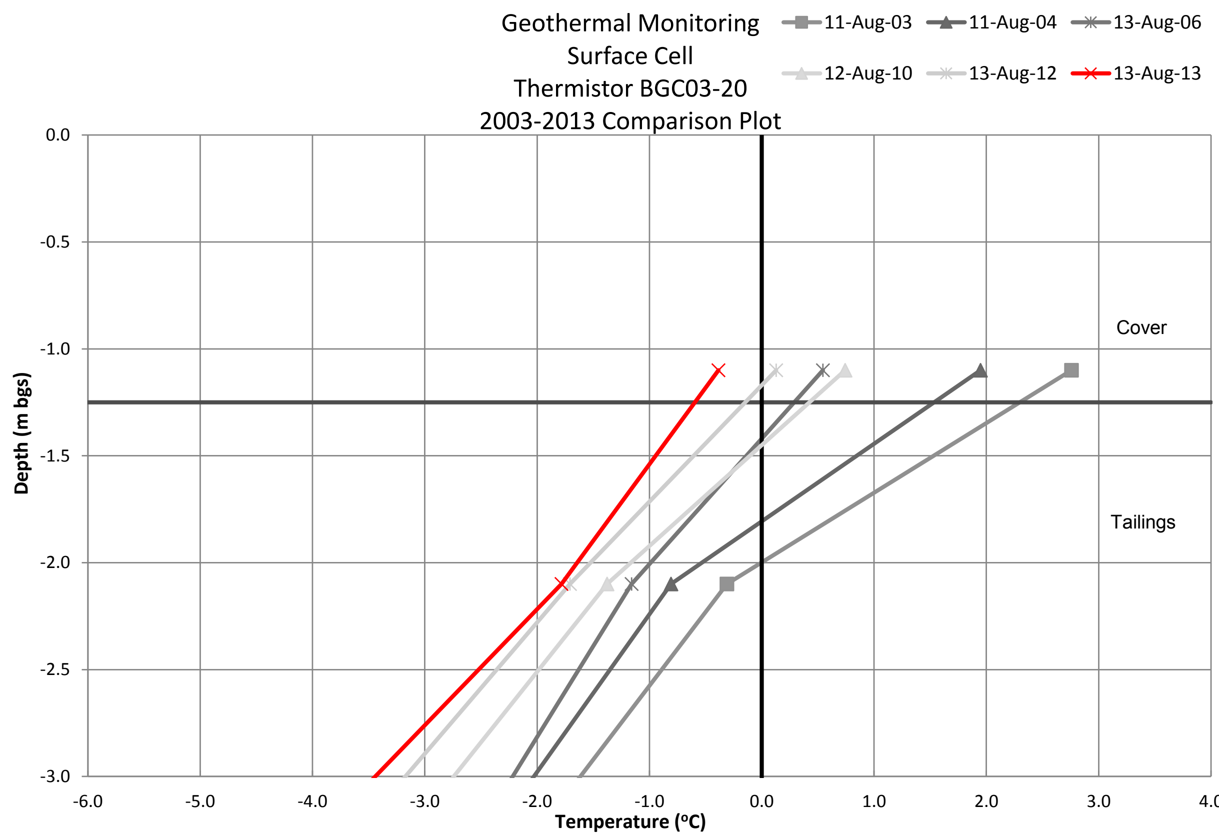
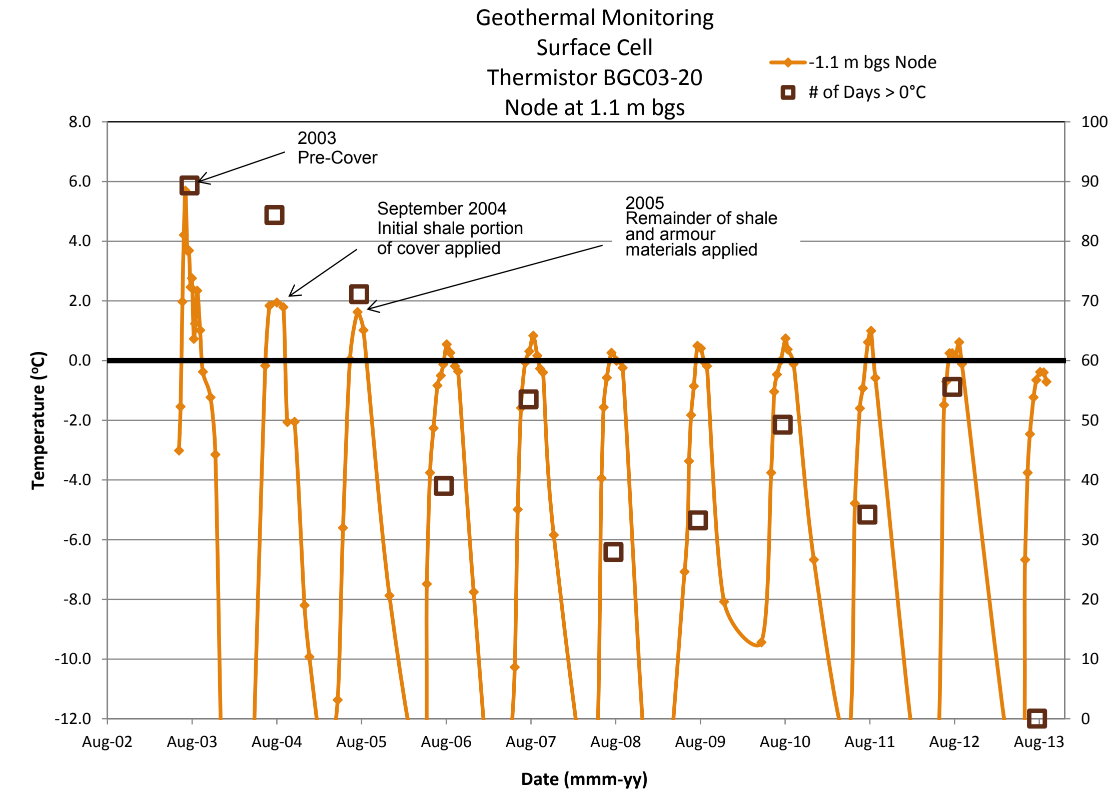
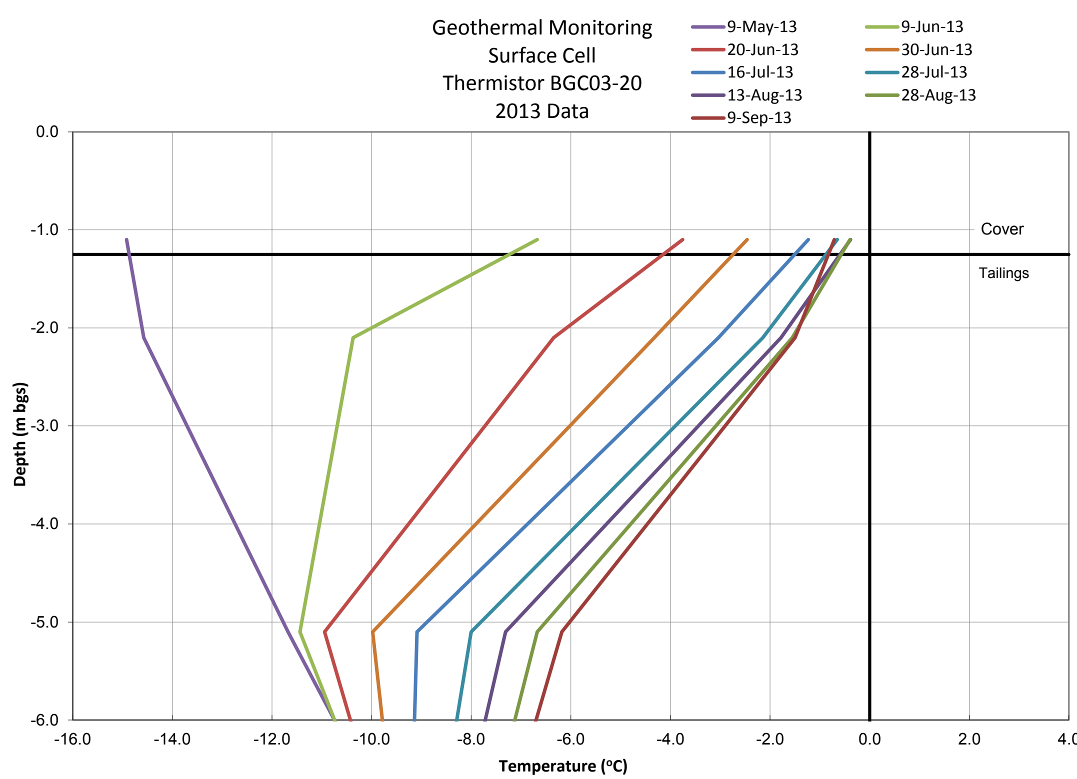
PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: SURFACE CELL TAILINGS COVER
GEOTECHNICAL MONITORING DATA 5

DWG No.:	PROJ No.:	REV:
9	0255-023-03	







DWG TO BE READ WITH BGC REPORT TITLED: "NANISIVIK MINE 2013 GEOTECHNICAL INSPECTION", FEB 2014

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

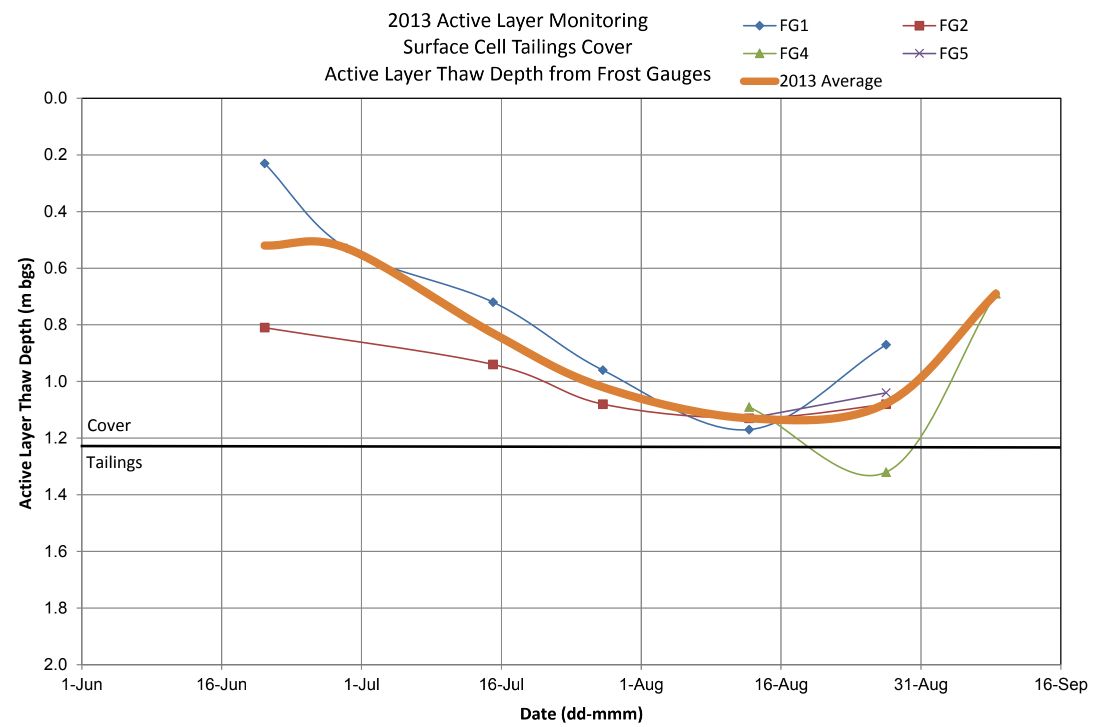
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

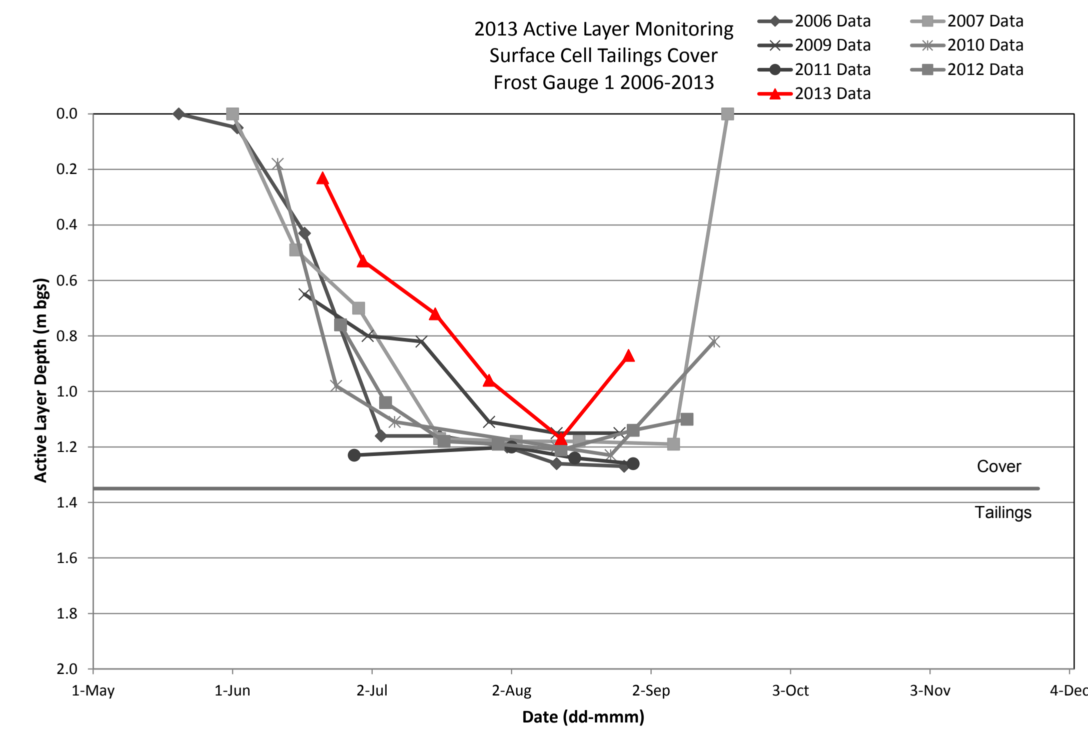
CLIENT: nyrstar

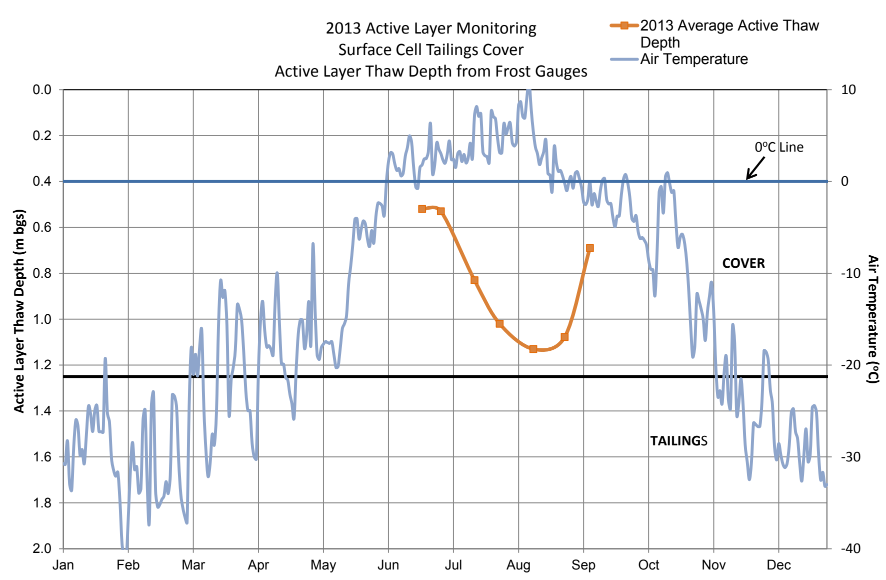
PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: SURFACE CELL TAILINGS COVER
GEOTECHNICAL MONITORING DATA 6

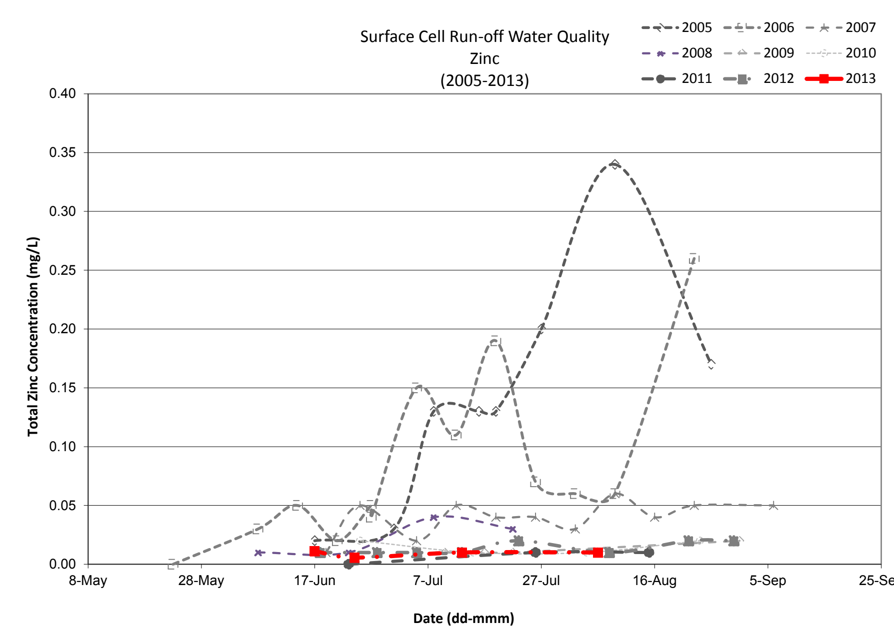
DWG No.:	PROJ No.:	REV:
10	0255-023-03	

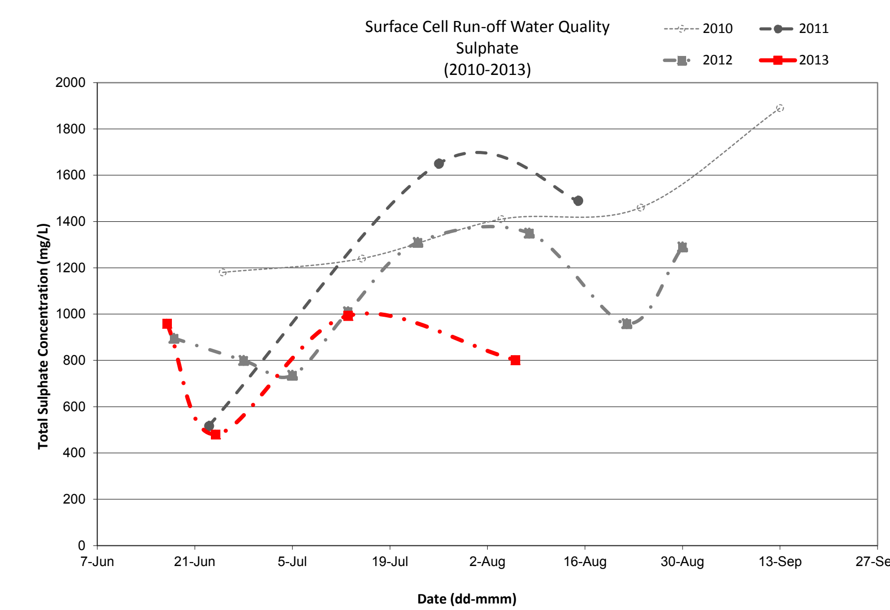






*2012-2013 Mean Daily Air Temperatures taken from the Arctic Bay weather station





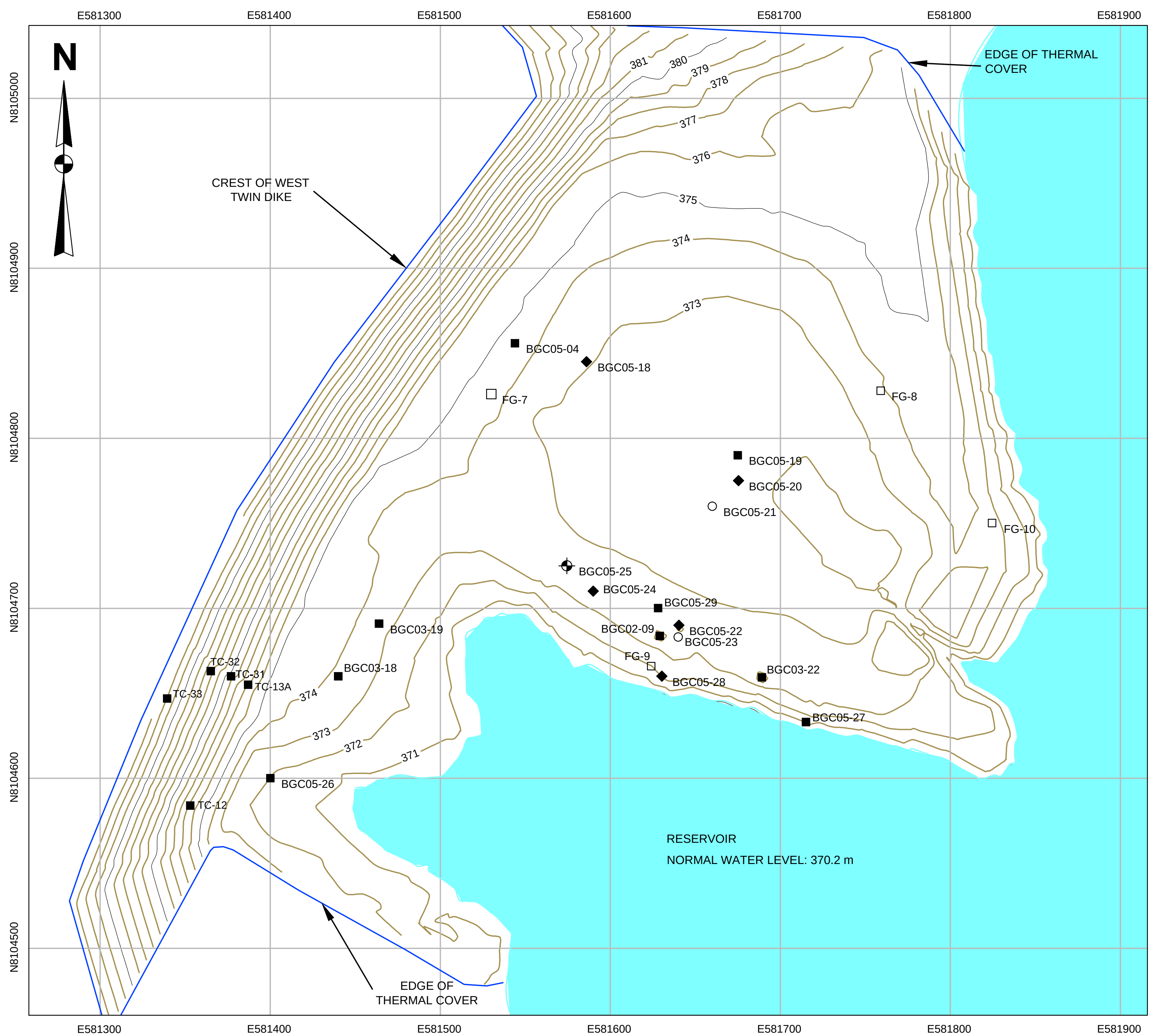
DWG TO BE READ WITH BGC REPORT TITLED: "NANISIVIK MINE 2013 GEOTECHNICAL INSPECTION", FEB 2014

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT:	NANISIVIK MINE 2013 ANNUAL GEOTECHNICAL INSPECTION
TITLE:	SURFACE CELL TAILINGS COVER GEOTECHNICAL MONITORING DATA 7
DWG No.:	11
PROJ No.:	0255-023-03
REV:	



Scale 1:3000

60 0 60 120 180

metres

NOTES:

1. GRID BASED ON UTM NAD 83, ZONE 16 COORDINATES.
2. ELEVATIONS ARE IN METRES.
3. CONTOUR INTERVAL IS = 1.0 m.
4. SCALE IS APPROXIMATE.
5. THERMOCOUPLE LOCATIONS ARE APPROXIMATE.

LEGEND:

- THERMISTOR/ THERMOCOUPLE
- FROST GAUGE
- MONITORING WELL
- VW PIEZOMETER
- CONTINGENCY BOREHOLE

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	AS SHOWN
DATE:	FEB 2014
DRAWN:	JL
DESIGNED:	GKC
CHECKED:	JWC
APPROVED:	GKC

PROFESSIONAL SEAL:

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

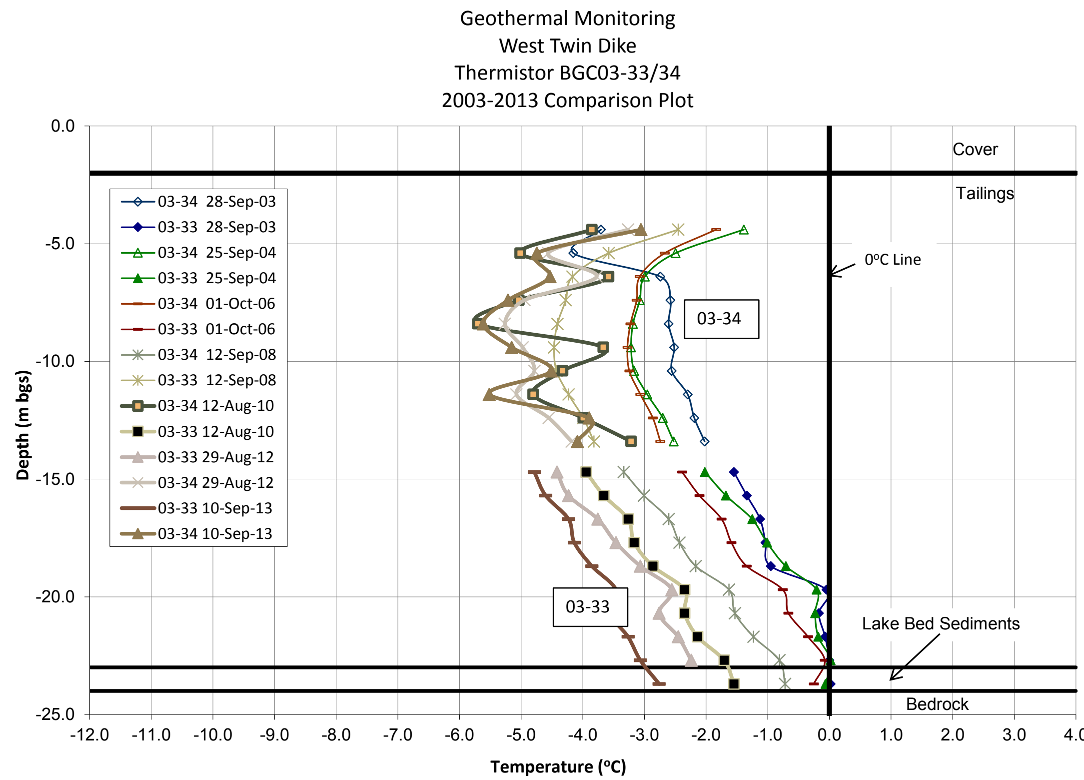
PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

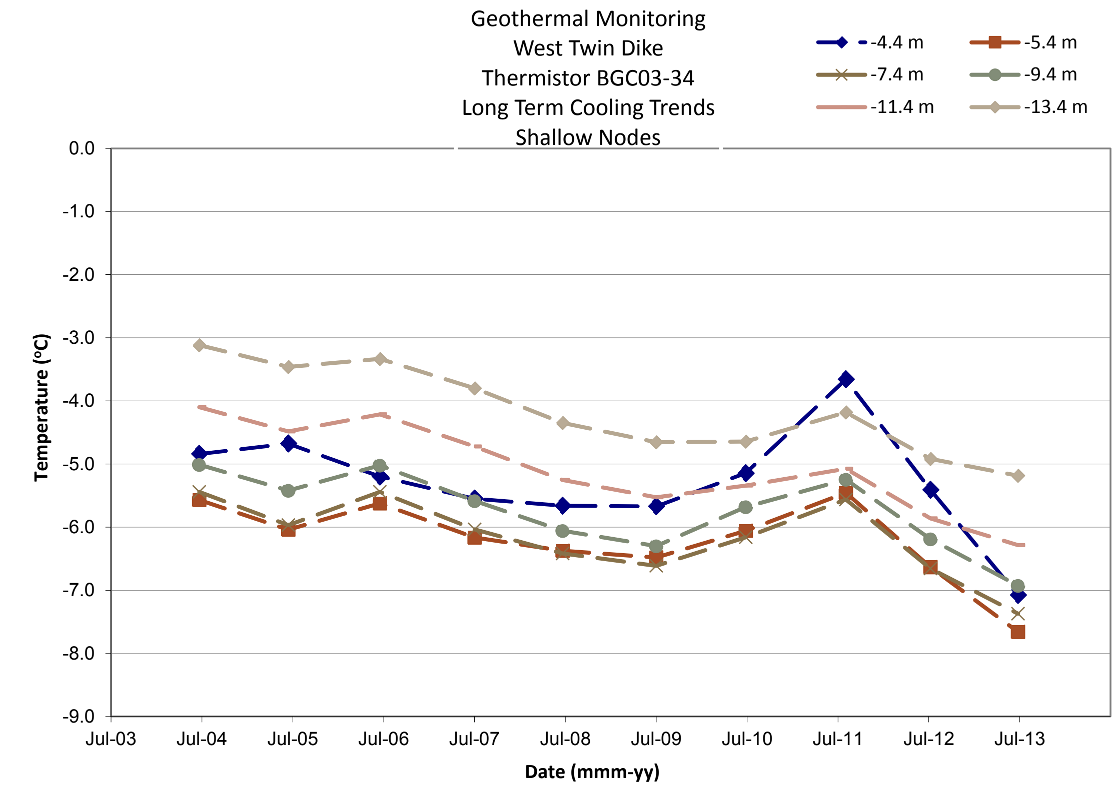
TITLE: TEST CELL TAILINGS COVER

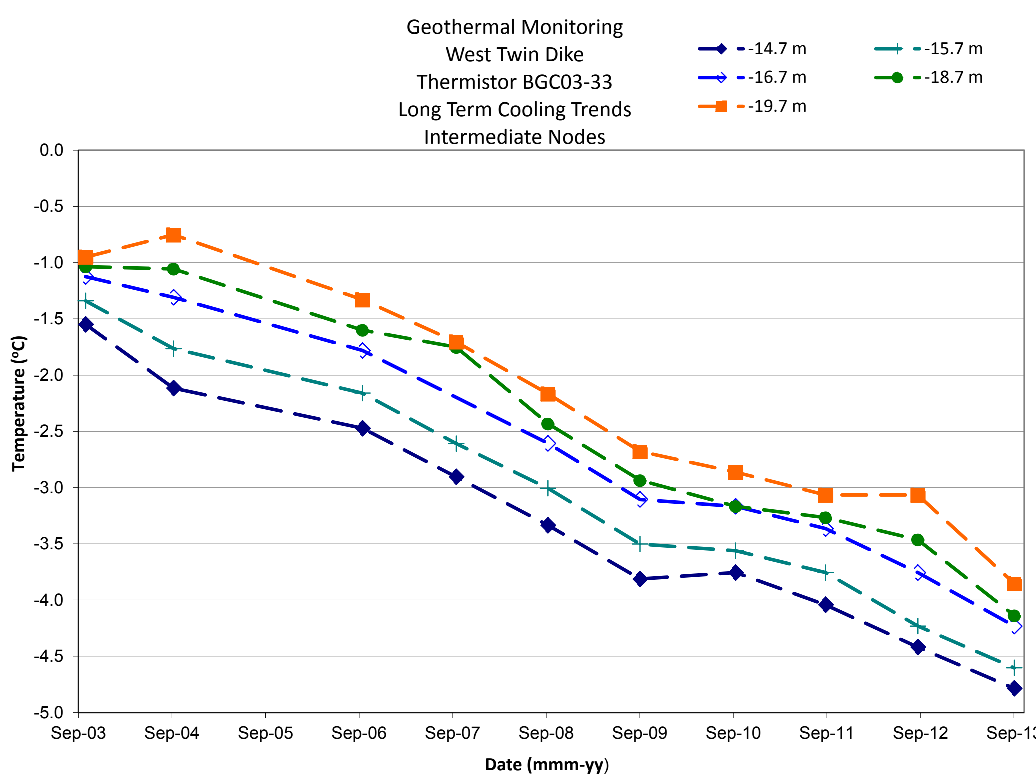
PROJECT No.:	DWG No.	REV.:
0255-023-03	12	

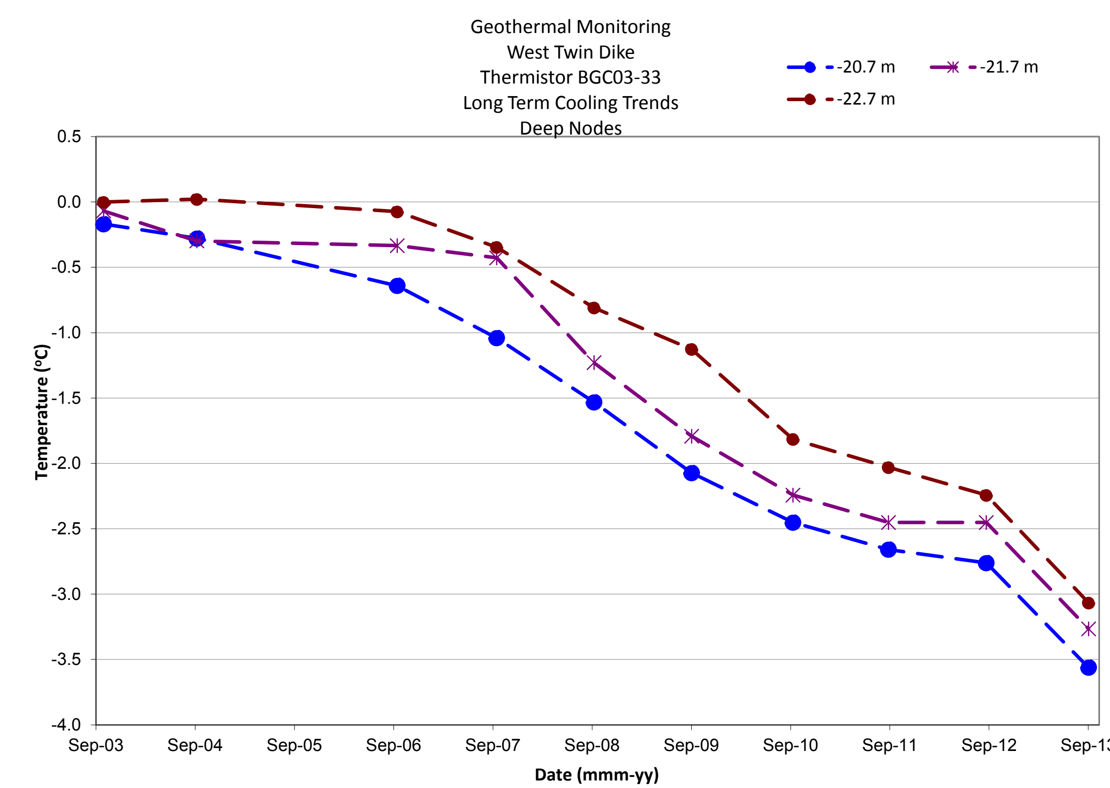
X:\Projects\0255\023\Workspace\20140207_NANISIVIK_MINE_2013_ANNUAL_GEOTECHNICAL_INSPECTION\12_TEST_CELL_TAILINGS_COVER.dwg Layout: 12 Plot Date Feb 27 14 Time: 9:50 AM

DWG TO BE READ WITH BGC REPORT TITLED "NANISIVIK MINE 2013 ANNUAL GEOTECHNICAL INSPECTION" DATED FEBRUARY 2014









DWG TO BE READ WITH BGC REPORT TITLED: "NANISVIK MINE 2013 GEOTECHNICAL INSPECTION", FEB 2014

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

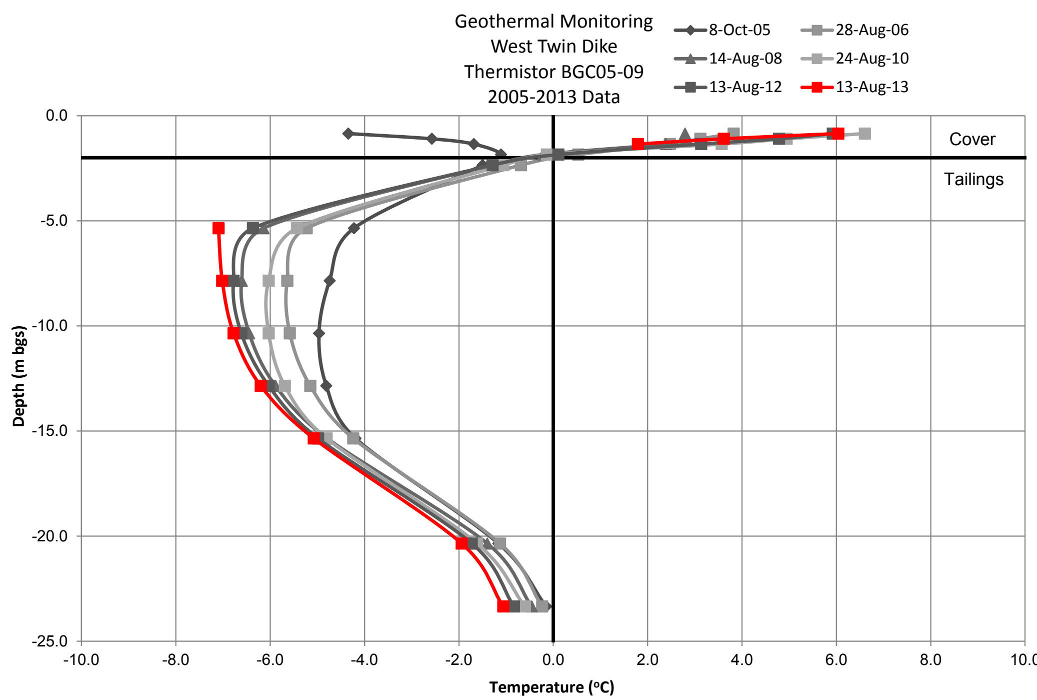
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

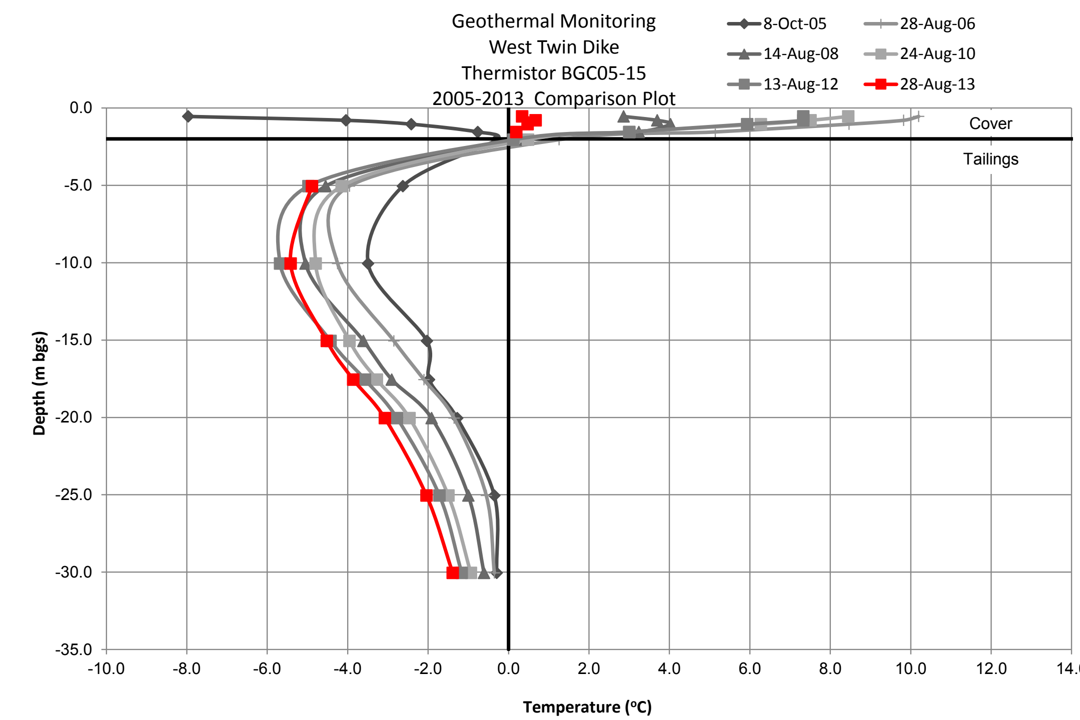
CLIENT: nyrstar

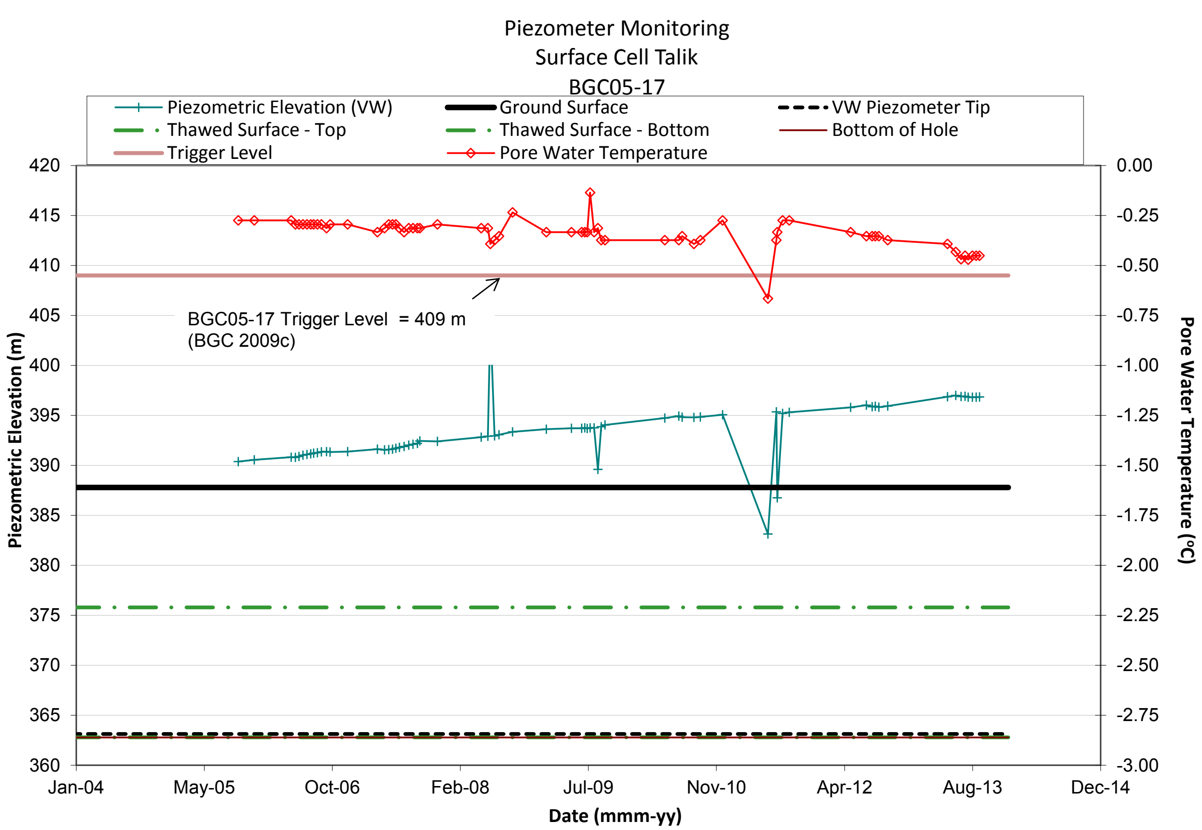
PROJECT: NANISVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

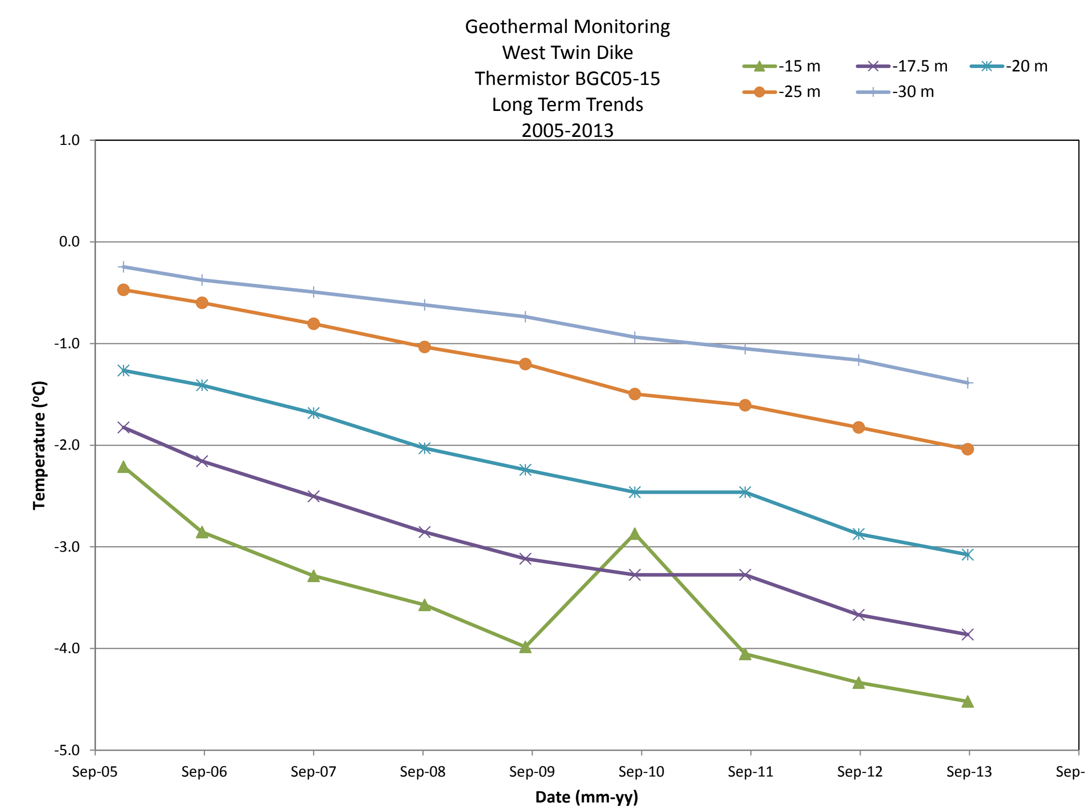
TITLE: WEST TWIN DIKE
GEOTECHNICAL MONITORING DATA 1

DWG No.:	PROJ No.:	REV:
13	0255-023-03	









DWG TO BE READ WITH BGC REPORT TITLED: "NANISIVIK MINE 2013 GEOTECHNICAL INSPECTION", FEB 2014

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

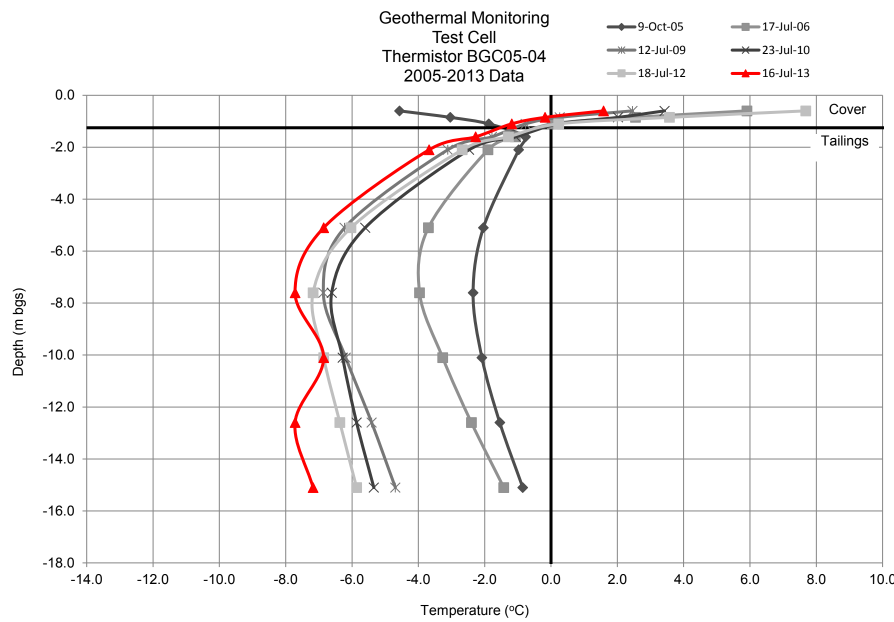
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

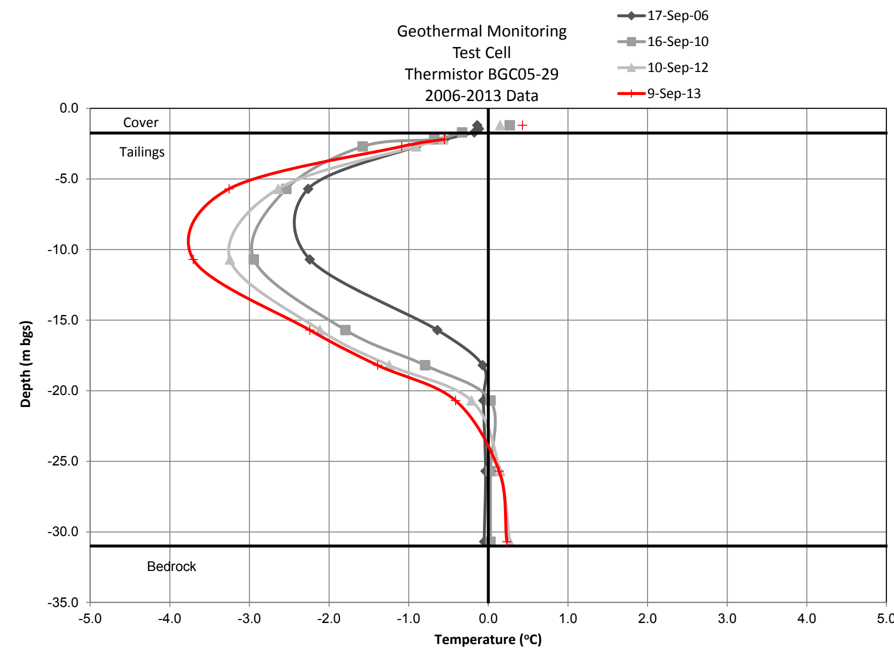
CLIENT: nyrstar

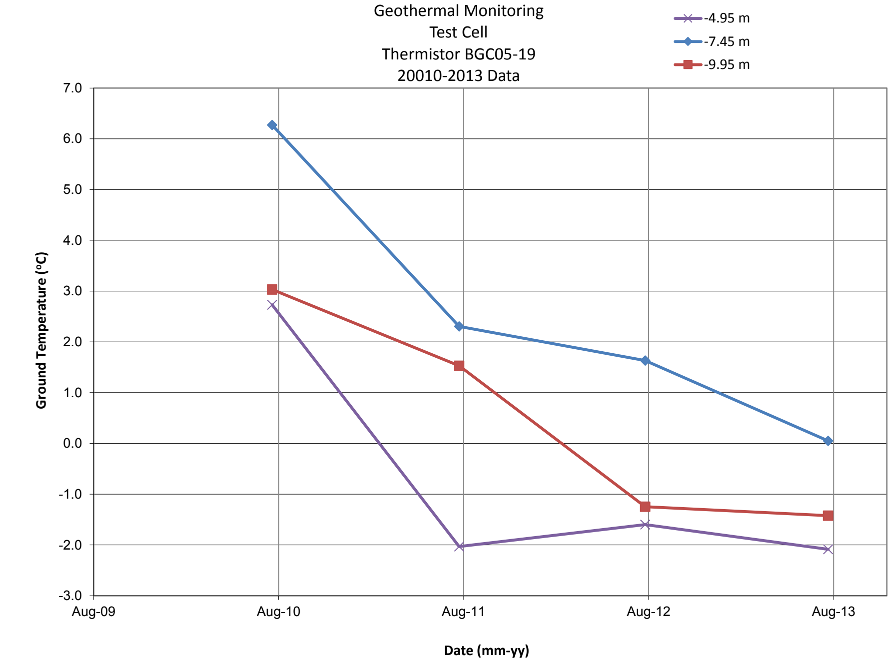
PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

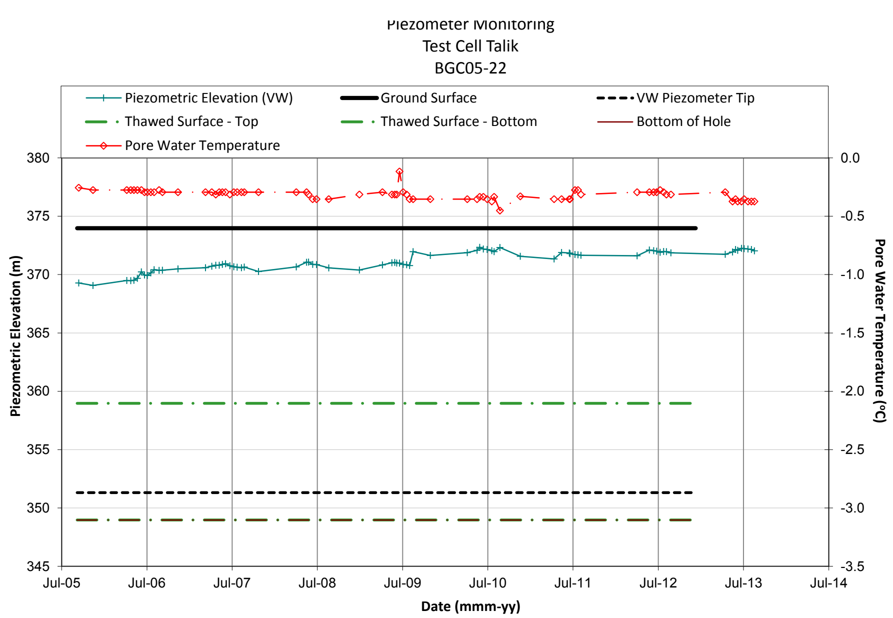
TITLE: WEST TWIN DIKE
GEOTECHNICAL MONITORING DATA 2

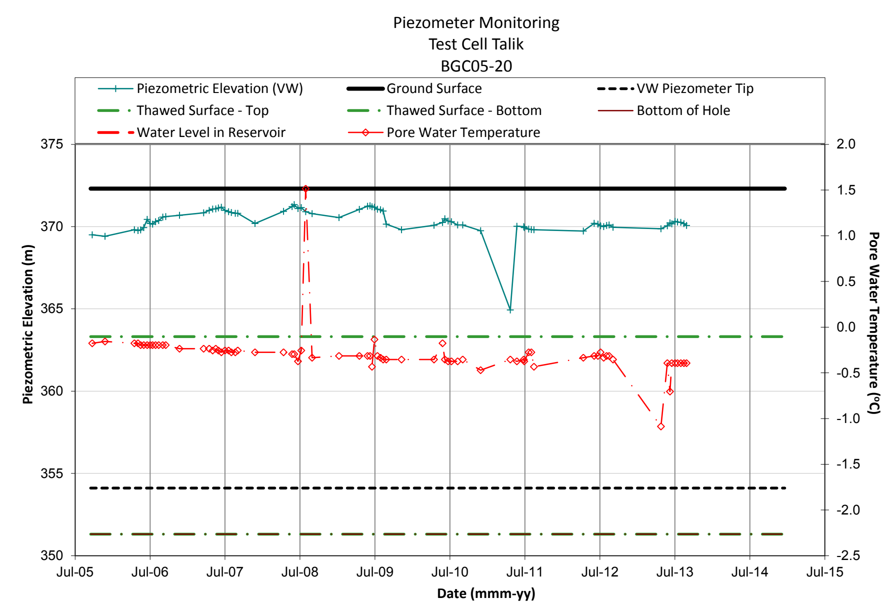
DWG No.:	PROJ No.:	REV:
14	0255-023-03	

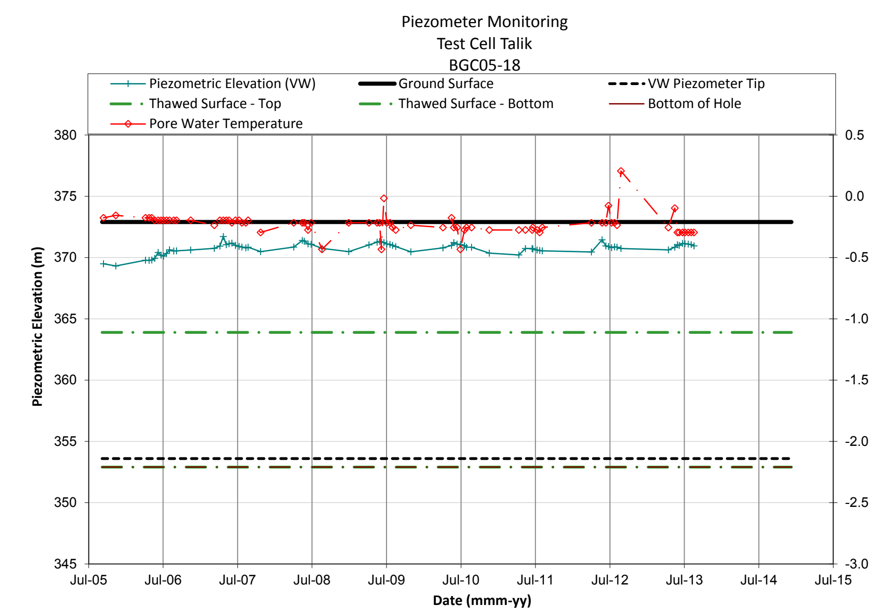












DWG TO BE READ WITH BGC REPORT TITLED: "NANISIVIK MINE 2013 GEOTECHNICAL INSPECTION", FEB 2014

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

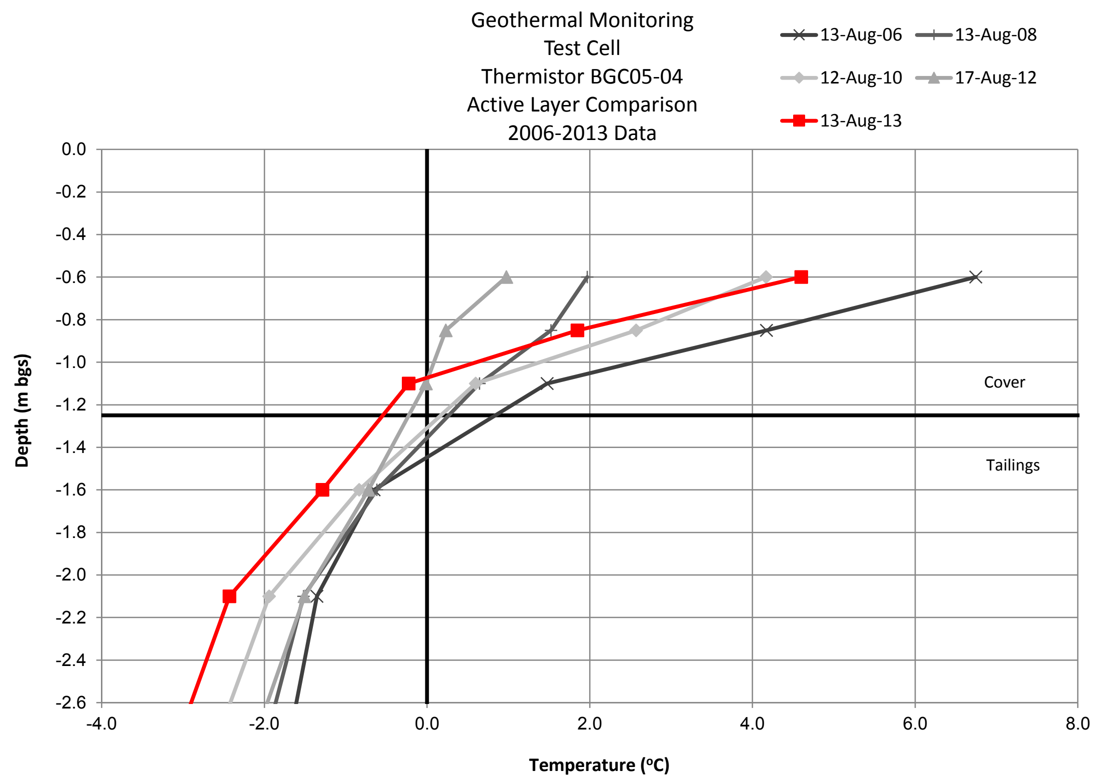
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

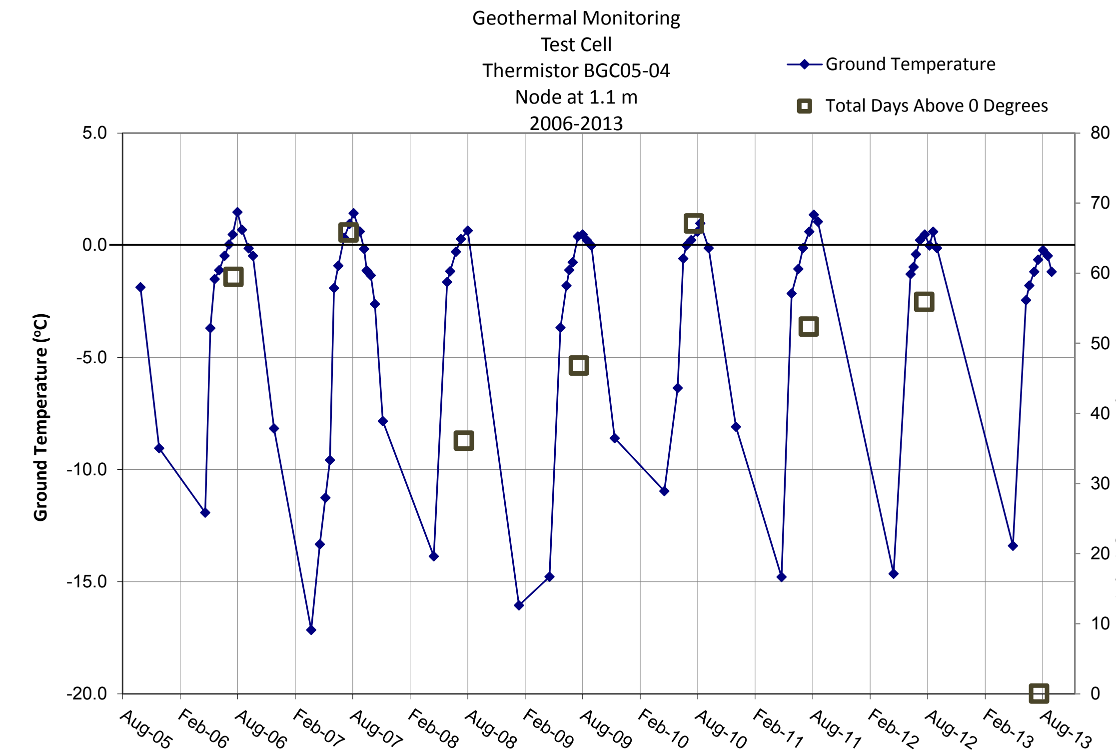
CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

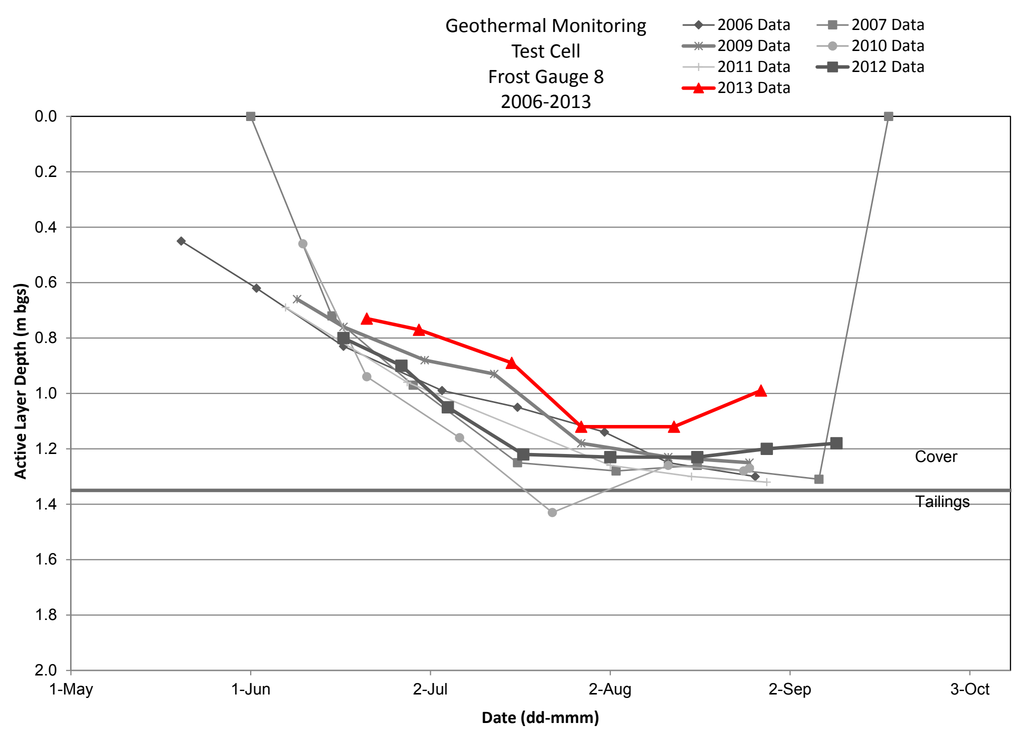
TITLE: TEST CELL TAILINGS COVER
GEOTECHNICAL MONITORING DATA 1

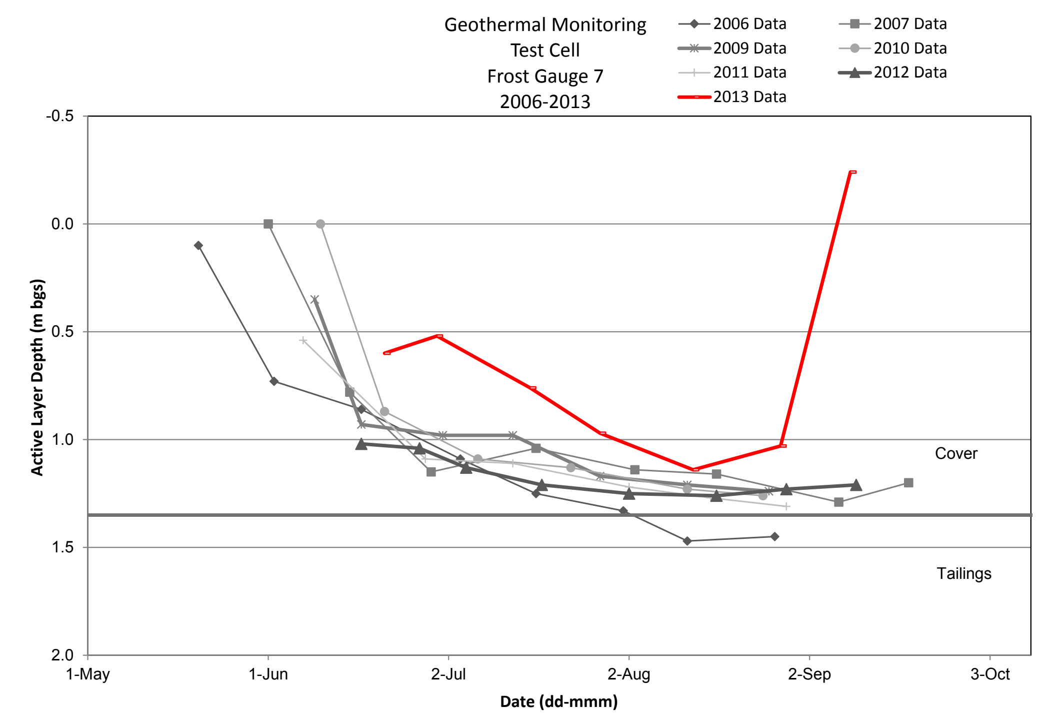
DWG No.:	PROJ No.:	REV:
15	0255-023-03	





Note: The value for annual number of days above freezing in 2011 was estimated using a combination of geothermal monitoring and climate data.





DWG TO BE READ WITH BGC REPORT TITLED: "NANISIVIK MINE 2013 GEOTECHNICAL INSPECTION", FEB 2014

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

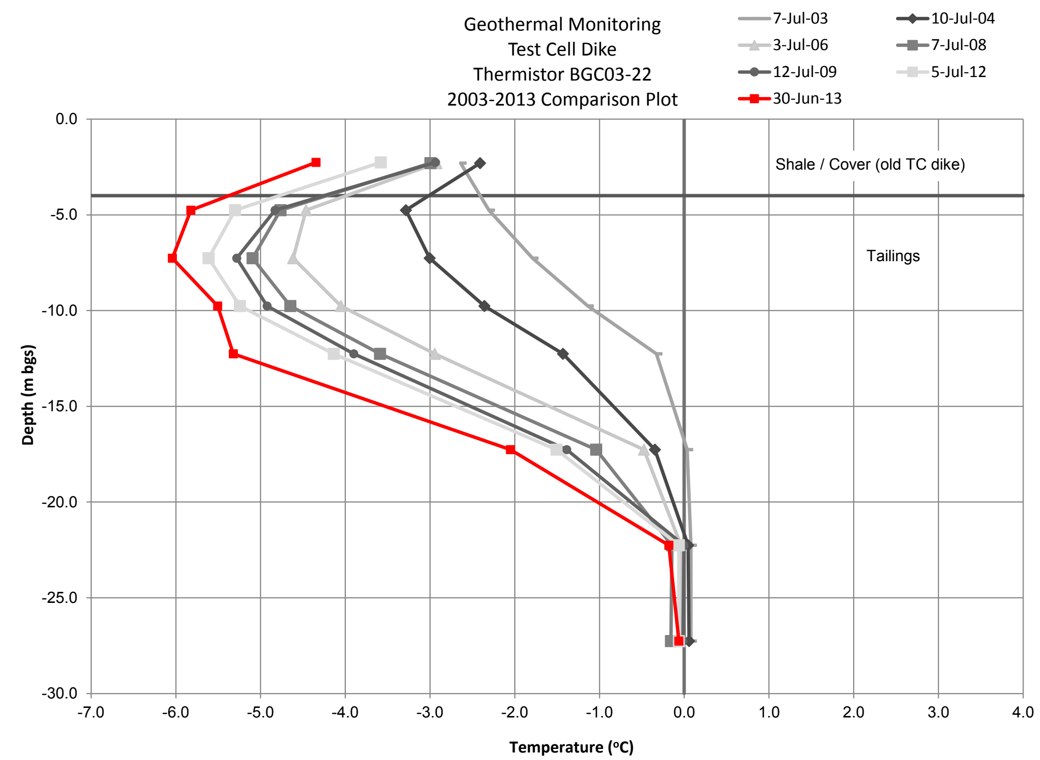
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

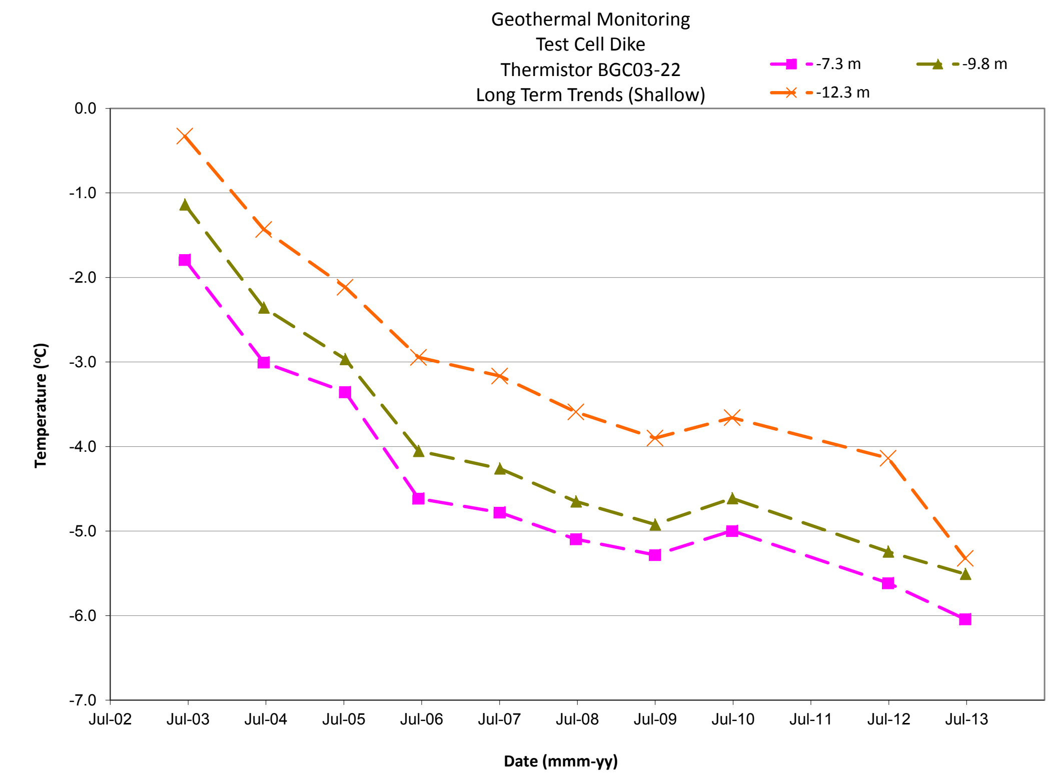
CLIENT: nyrstar

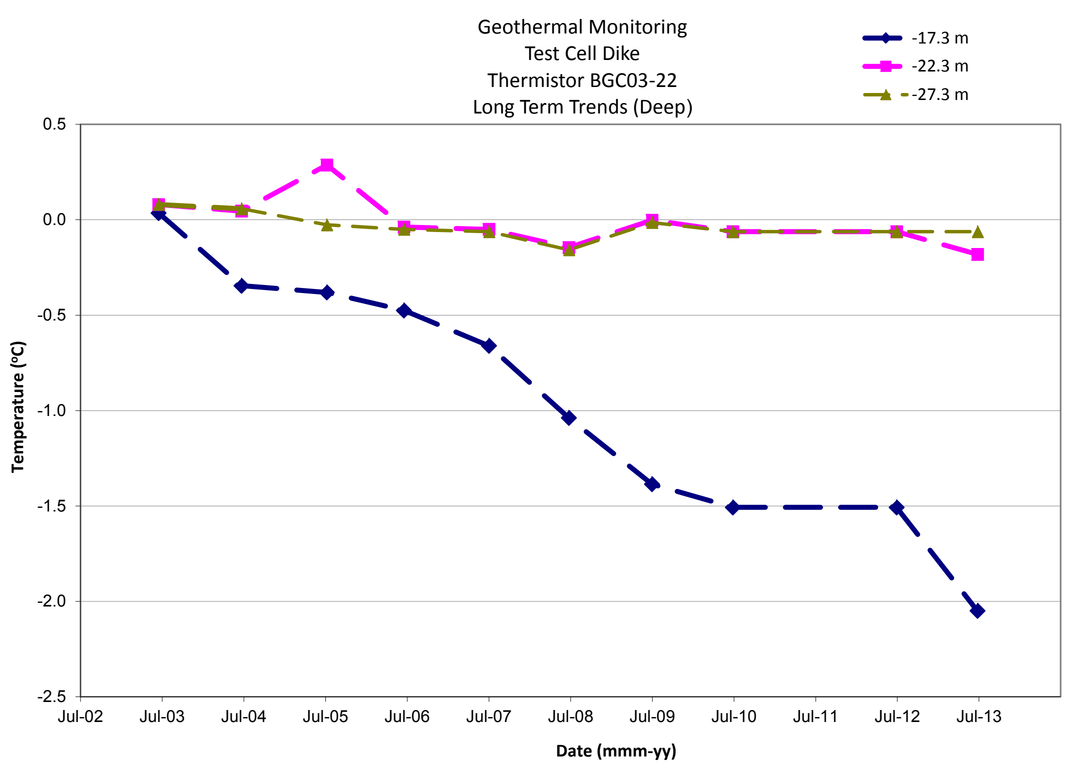
PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

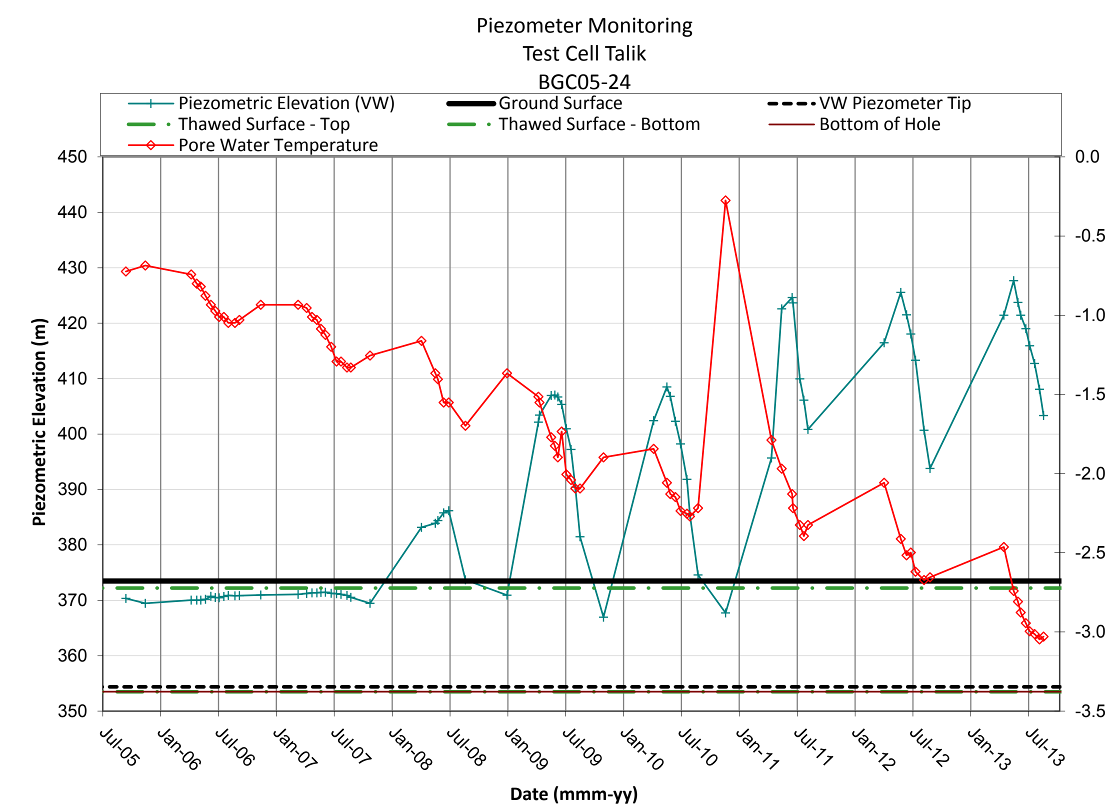
TITLE: TEST CELL TAILINGS COVER
GEOTECHNICAL MONITORING DATA 2

DWG No.:	PROJ No.:	REV:
16	0255-023-03	









DWG TO BE READ WITH BGC REPORT TITLED: "NANISIVIK MINE 2013 GEOTECHNICAL INSPECTION", FEB 2014

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

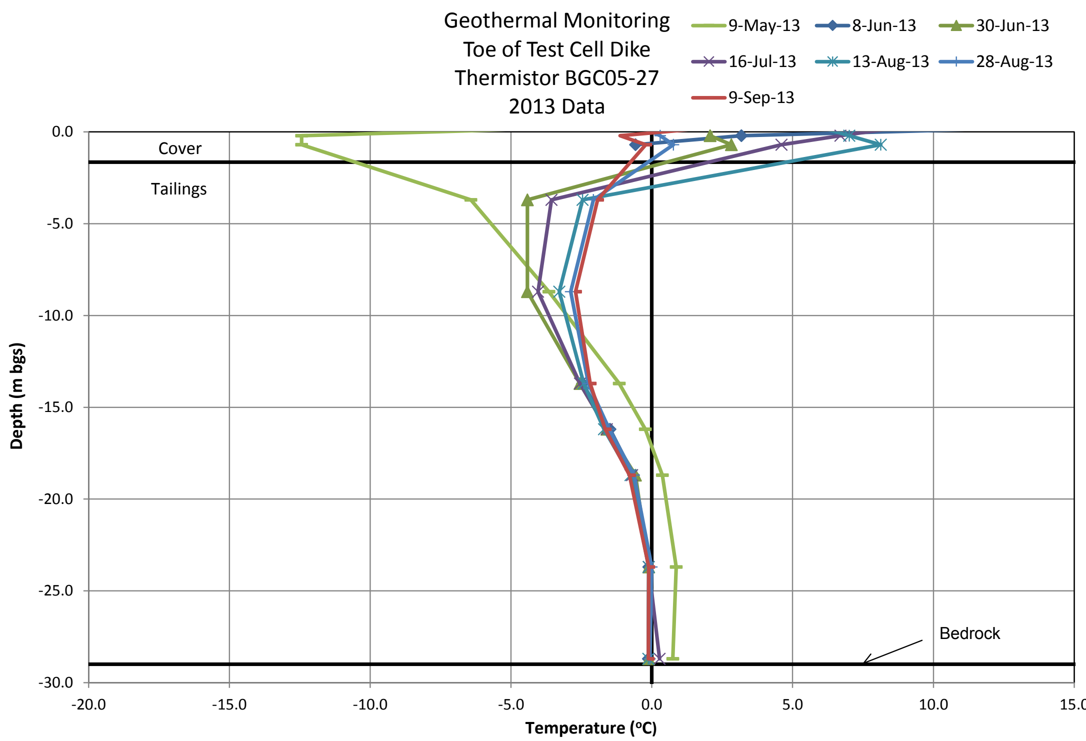
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

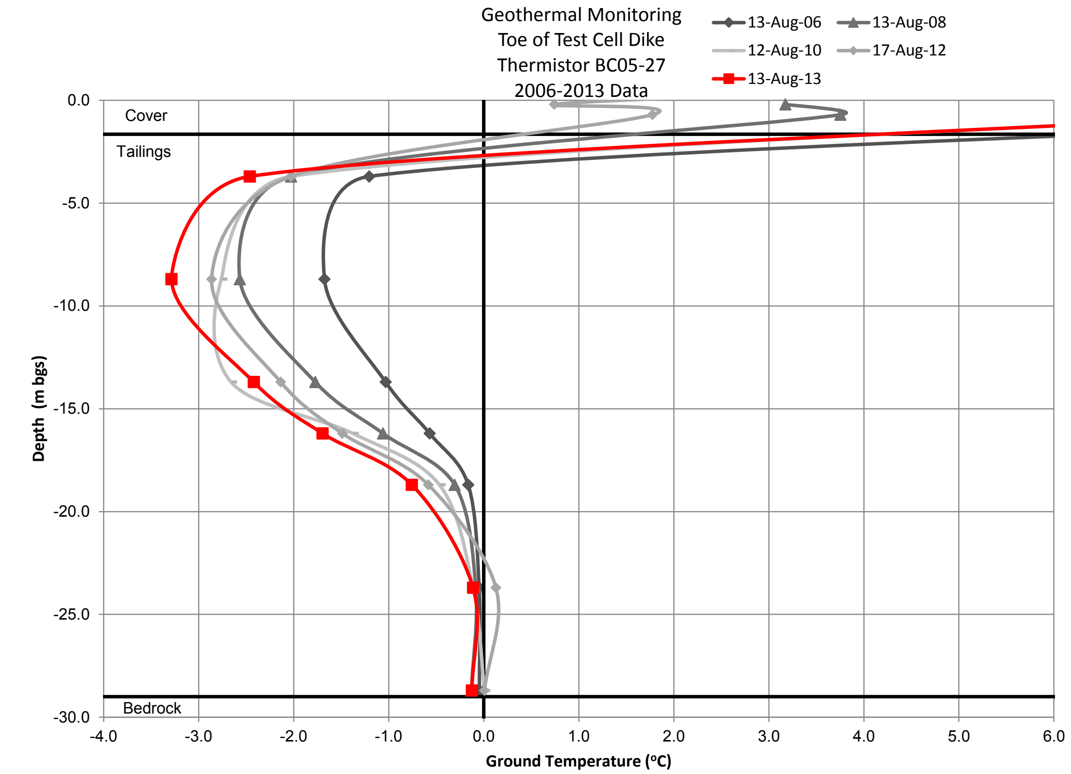
CLIENT: nyrstar

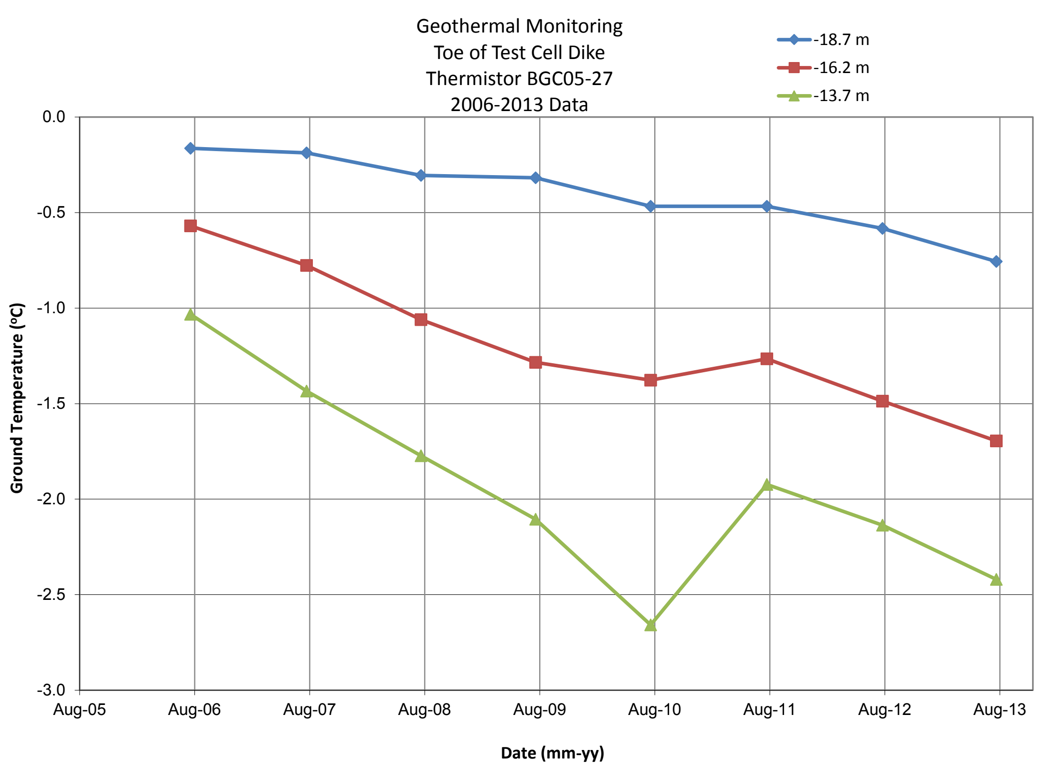
PROJECT: NANISIVIK MINE 2013 ANNUAL GEOTECHNICAL INSPECTION

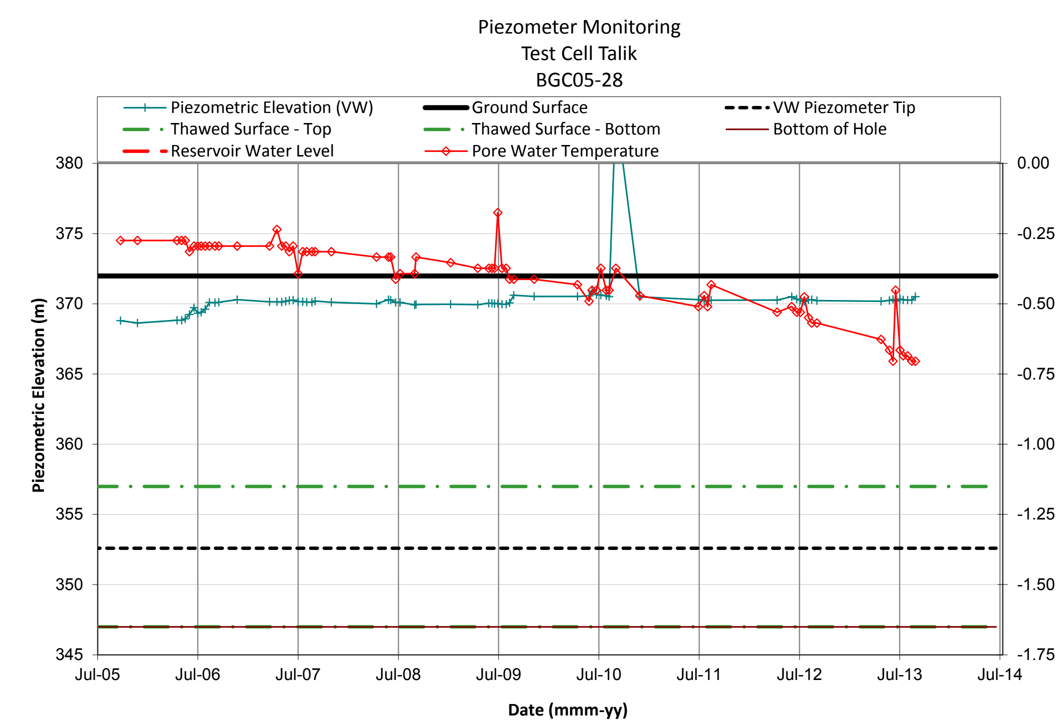
TITLE: TEST CELL DIKE GEOTECHNICAL MONITORING DATA

DWG No.:	PROJ No.:	REV:
17	0255-023-03	









DWG TO BE READ WITH BGC REPORT TITLED: "NANISVIK MINE 2013 GEOTECHNICAL INSPECTION", FEB 2014

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

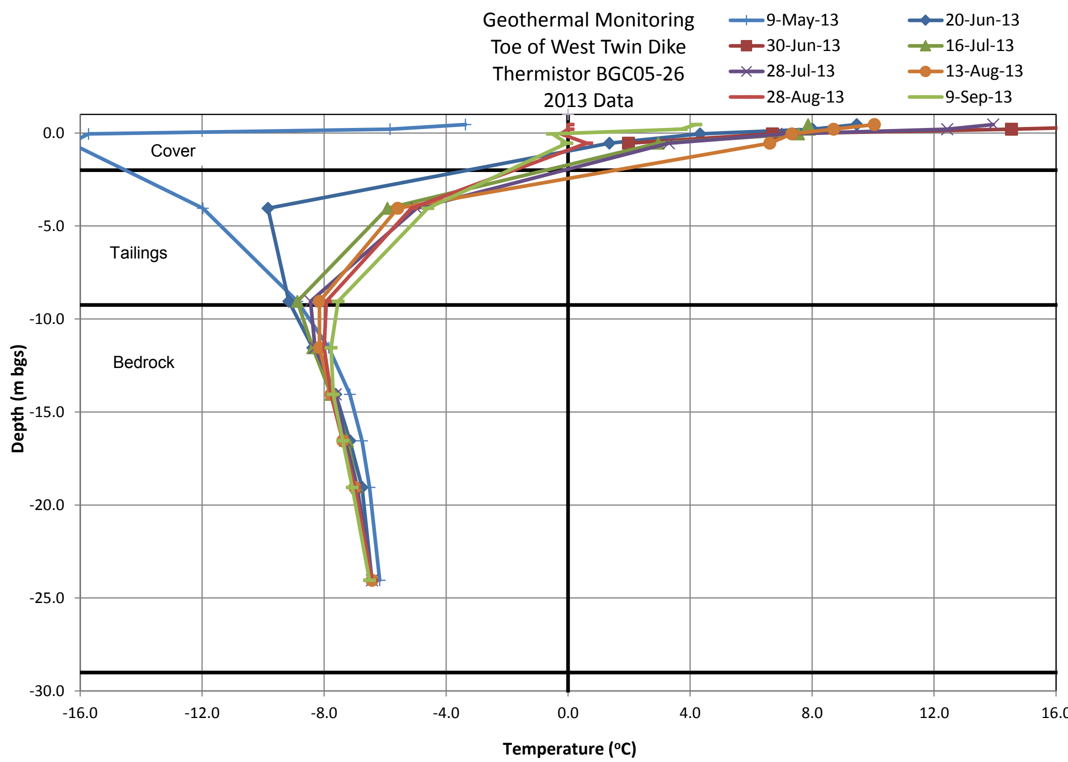
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

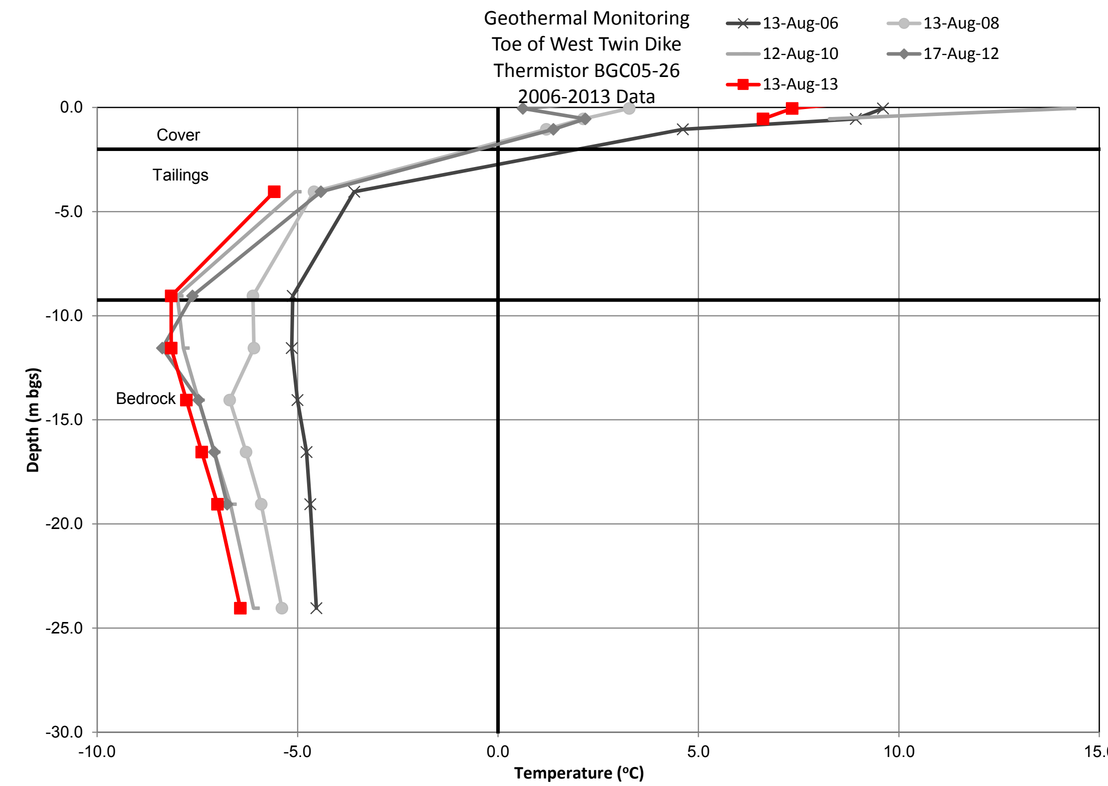
CLIENT: nyrstar

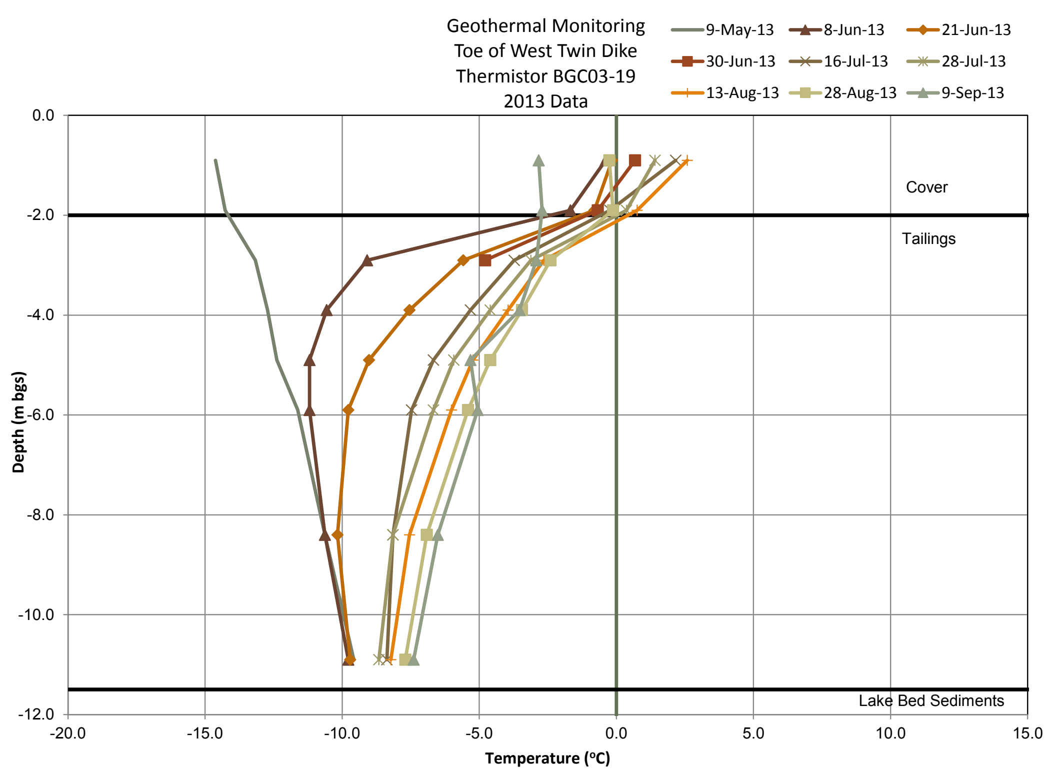
PROJECT: NANISVIK MINE 2013 ANNUAL GEOTECHNICAL INSPECTION

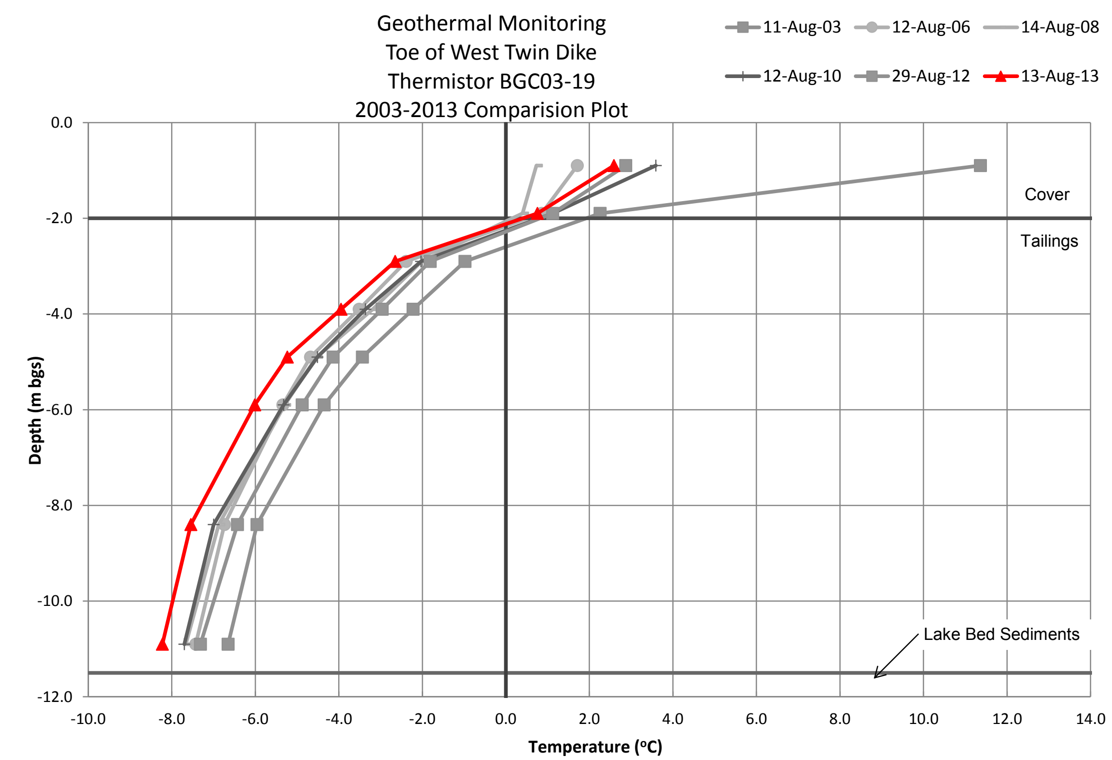
TITLE: TOE OF TEST CELL DIKE TAILINGS COVER GEOTECHNICAL MONITORING DATA

DWG No.:	PROJ No.:	REV:
18	0255-023-03	









DWG TO BE READ WITH BGC REPORT TITLED: "NANISVIK MINE 2013 GEOTECHNICAL INSPECTION", FEB 2014

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

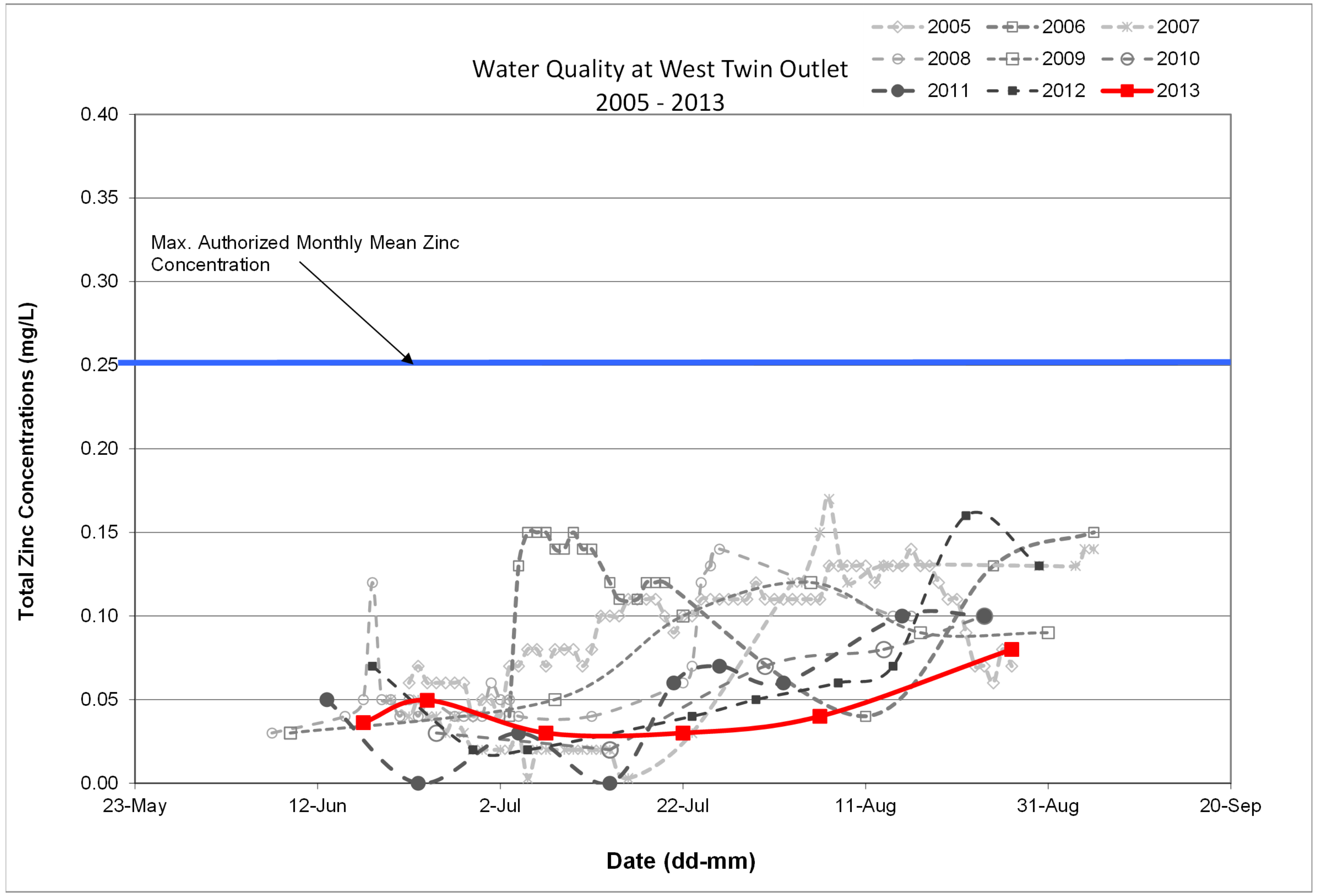
PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

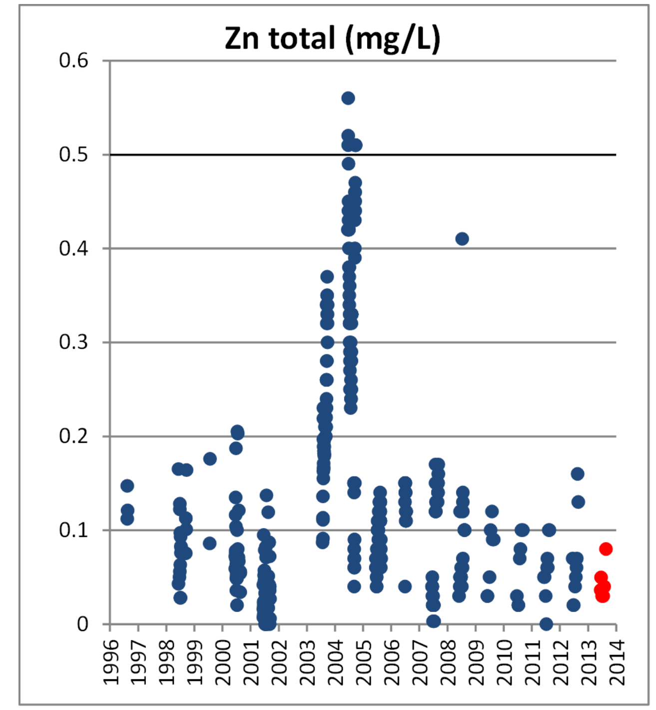
TITLE: TOE OF WEST TWIN DIKE TAILINGS COVER
GEOTECHNICAL MONITORING DATA

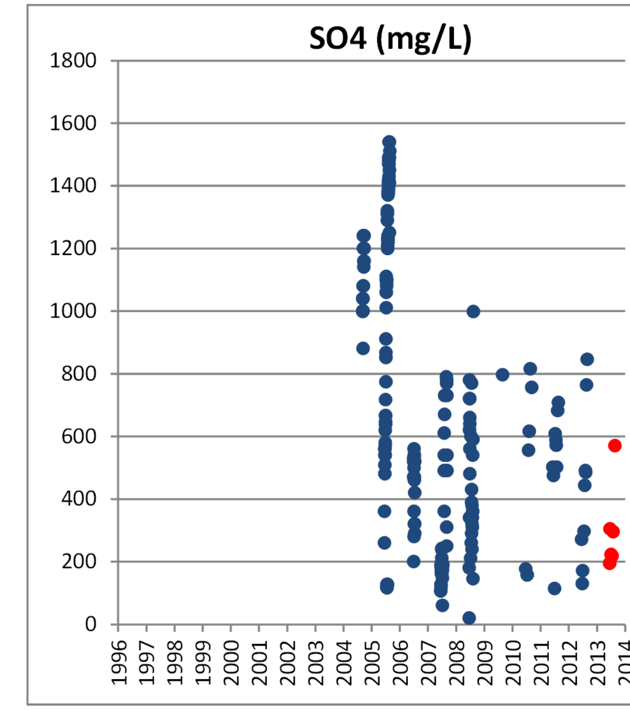
DWG No.: 19

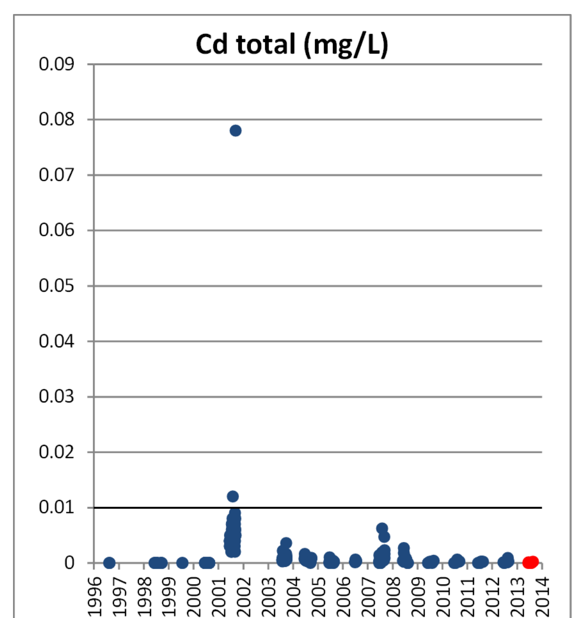
PROJ No.: 0255-023-03

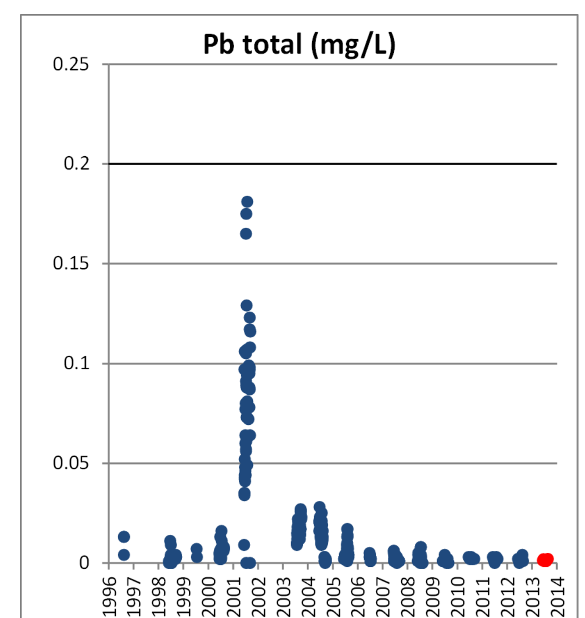
REV:

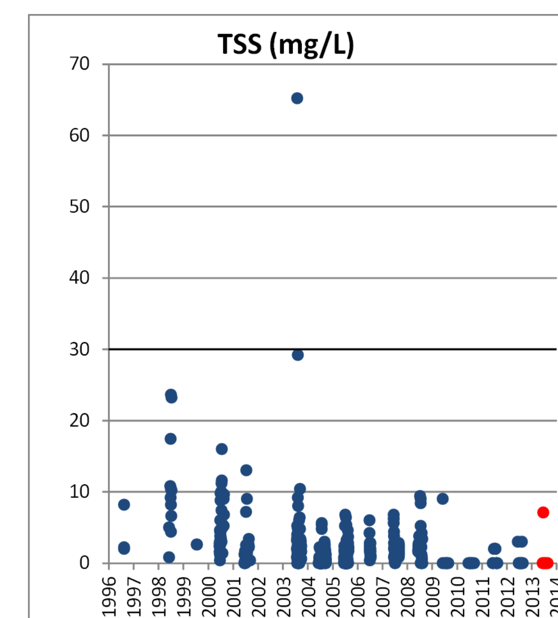












Water Quality data obtained from the Stantec annual water quality report (Stantec 2014) [currently in progress]

DWG TO BE READ WITH BGC REPORT TITLED: "NANISIVIK MINE 2013 GEOTECHNICAL INSPECTION", FEB 2014

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

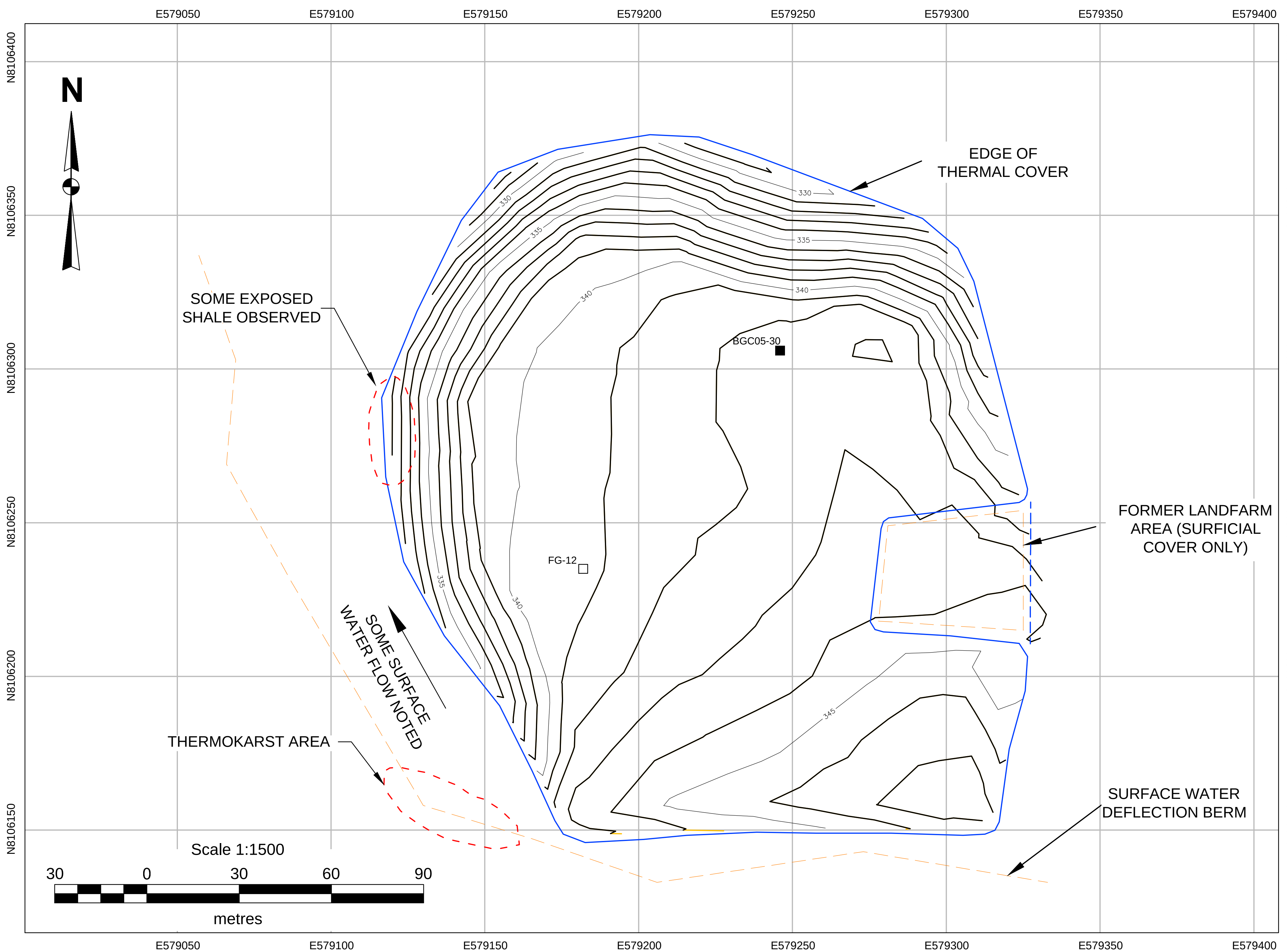
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: WEST TWIN DISPOSAL AREA
WATER QUALITY DATA

DWG No.:	PROJ No.:	REV:
20	0255-023-03	



NOTES:

1. GRID BASED ON UTM NAD 83, ZONE 16 COORDINATES.
2. ELEVATIONS ARE IN METRES.
3. CONTOUR INTERVAL IS = 1.0 m.
4. SCALE IS APPROXIMATE.

LEGEND:

■ THERMISTOR

□ FROST GAUGE

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	AS SHOWN
DATE:	FEB 204
DRAWN:	JL
DESIGNED:	GKC
CHECKED:	JWC
APPROVED:	GKC

PROFESSIONAL SEAL:

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

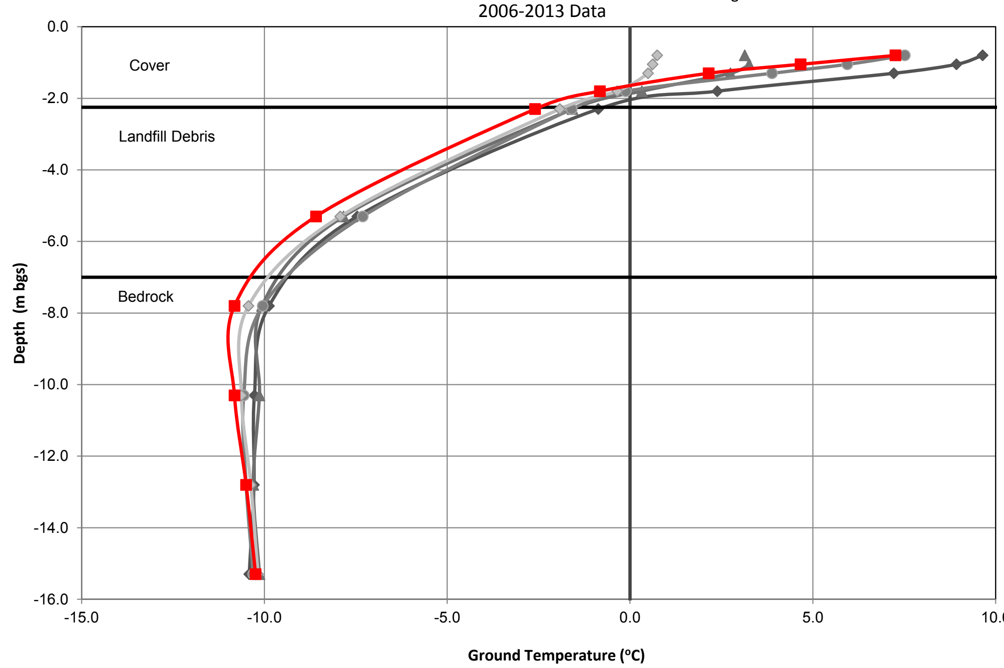
CLIENT: nyrstar

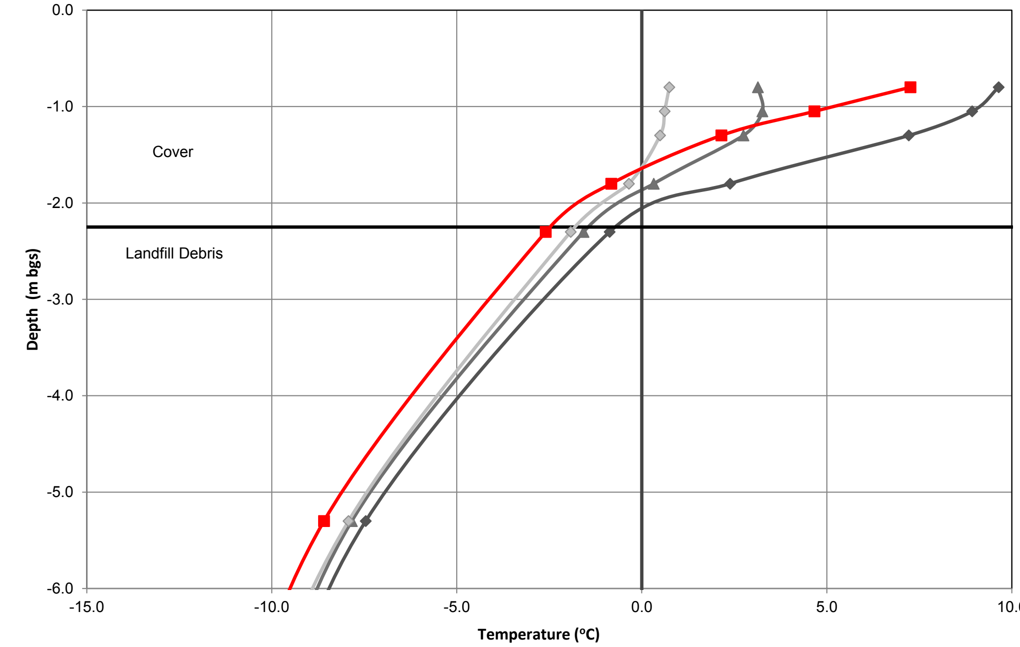
PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

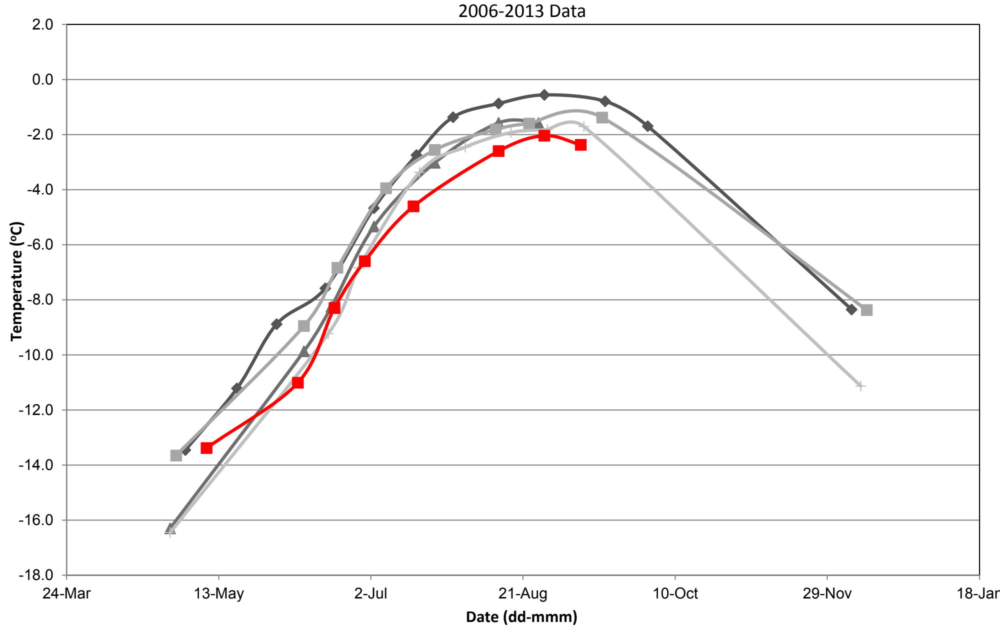
TITLE: LANDFILL COVER

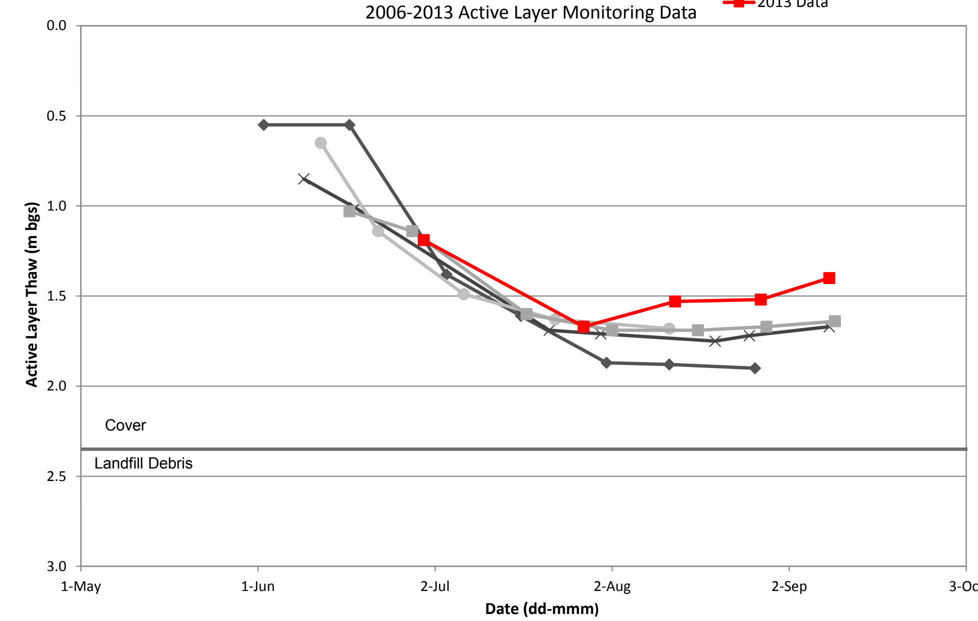
PROJECT No.:	DWG No.	REV.:
0255-023-03	21	

DWG TO BE READ WITH BGC REPORT TITLED "NANISIVIK MINE 2013 ANNUAL GEOTECHNICAL INSPECTION" DATED FEBRUARY 2014









DWG TO BE READ WITH BGC REPORT TITLED: "NANISIVIK MINE 2013 GEOTECHNICAL INSPECTION", FEB 2014

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

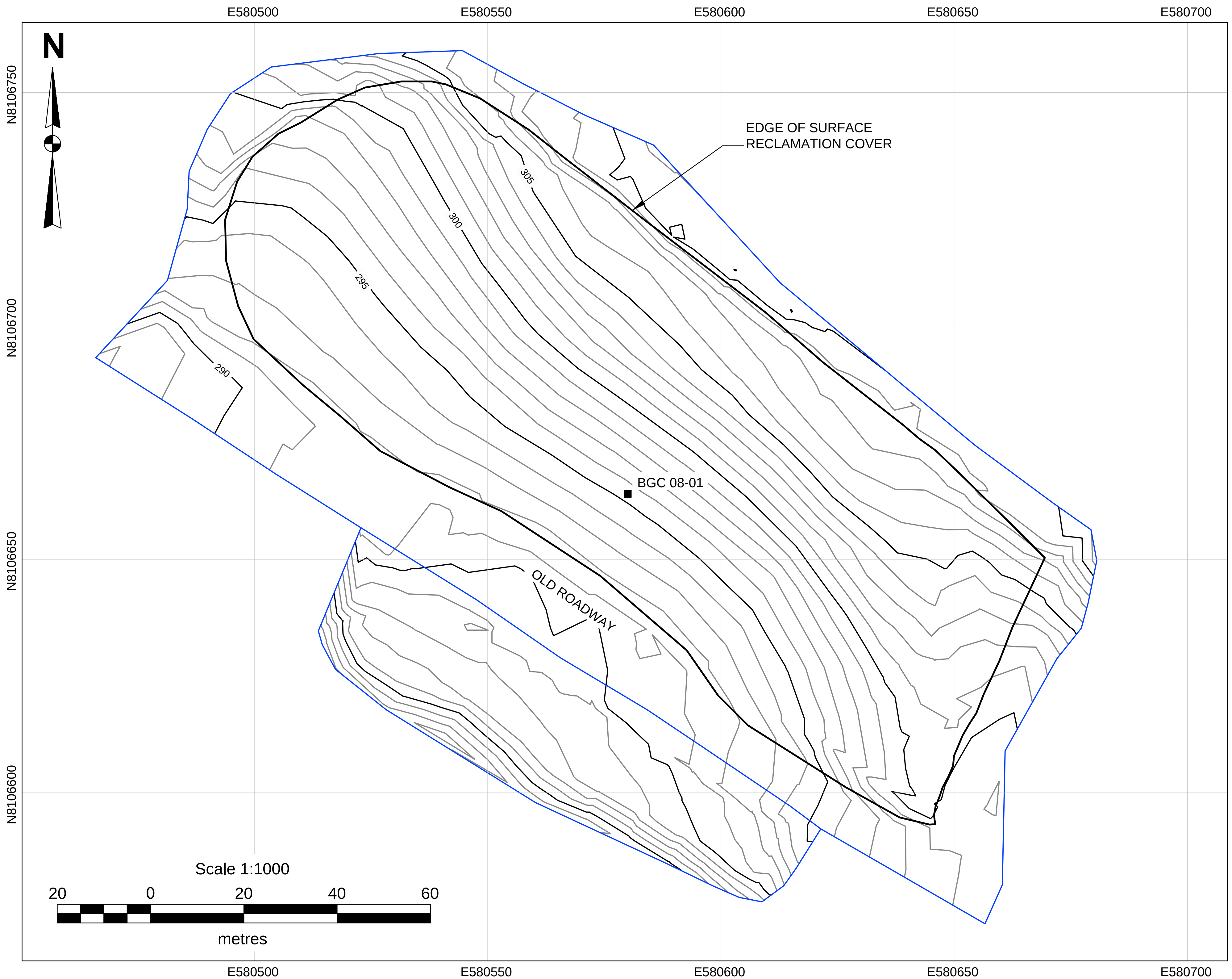
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: LANDFILL COVER
GEOTECHNICAL MONITORING DATA

DWG No.:	PROJ No.:	REV:
22	0255-023-03	



LEGEND:

■ THERMISTOR INSTALLATION

NOTES:

1. GRID BASED ON UTM, NAD 83, ZONE 16 COORDINATES.
2. ELEVATIONS ARE IN METRES.
3. CONTOUR INTERVAL IS = 1.0 m.
4. SCALE IS APPROXIMATE.

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	AS SHOWN
DATE:	FEB 2014
DRAWN:	JL
DESIGNED:	GKC
CHECKED:	JWC
APPROVED:	GKC

PROFESSIONAL SEAL:

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: WEST OPEN PIT
WASTE ROCK COVER

PROJECT No.:	DWG No.	REV.:
0255-023-03	23	

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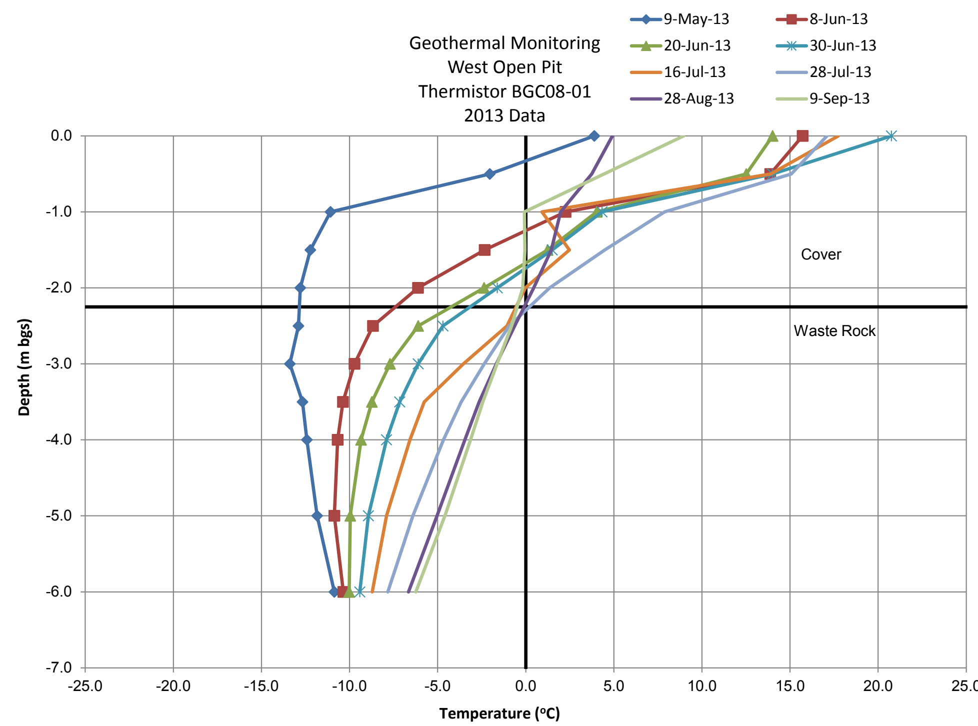

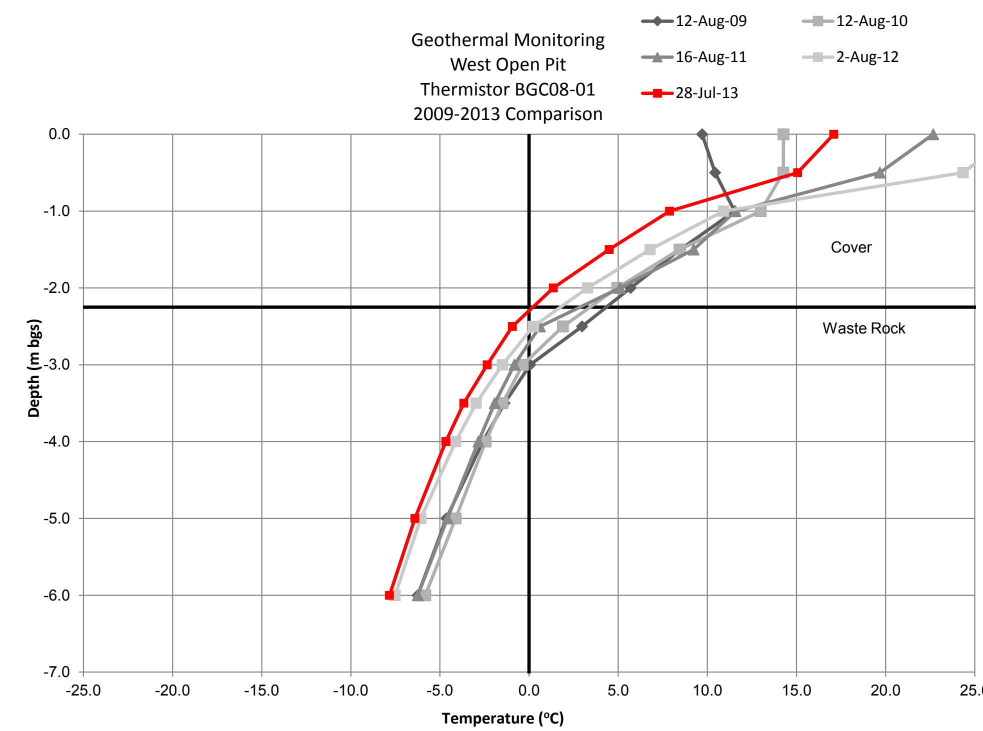

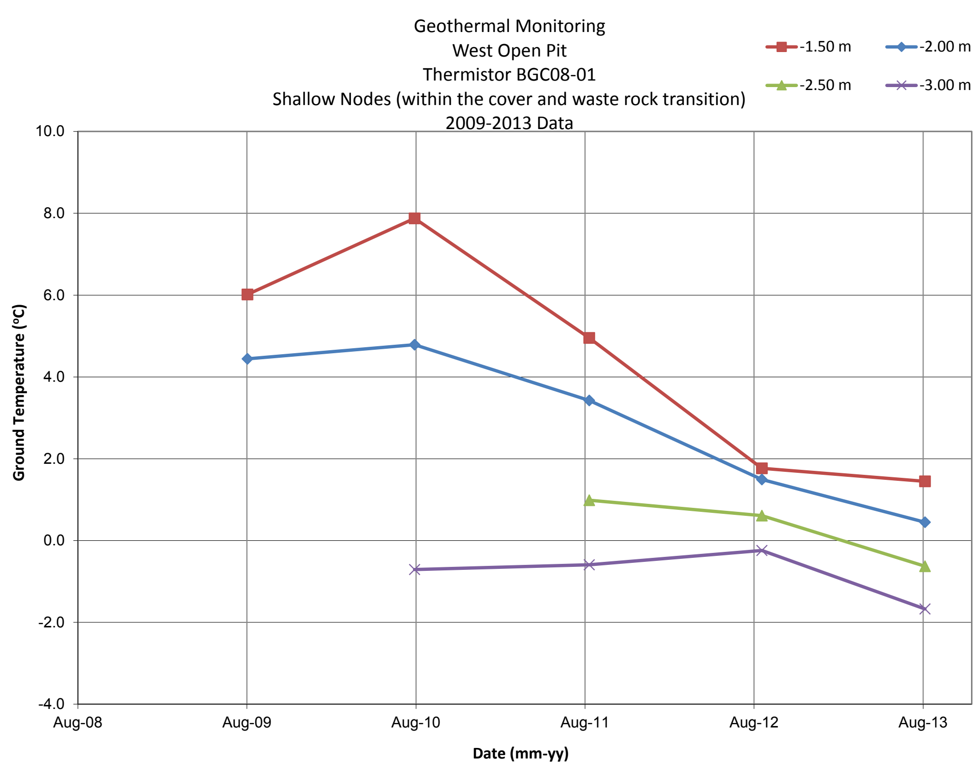

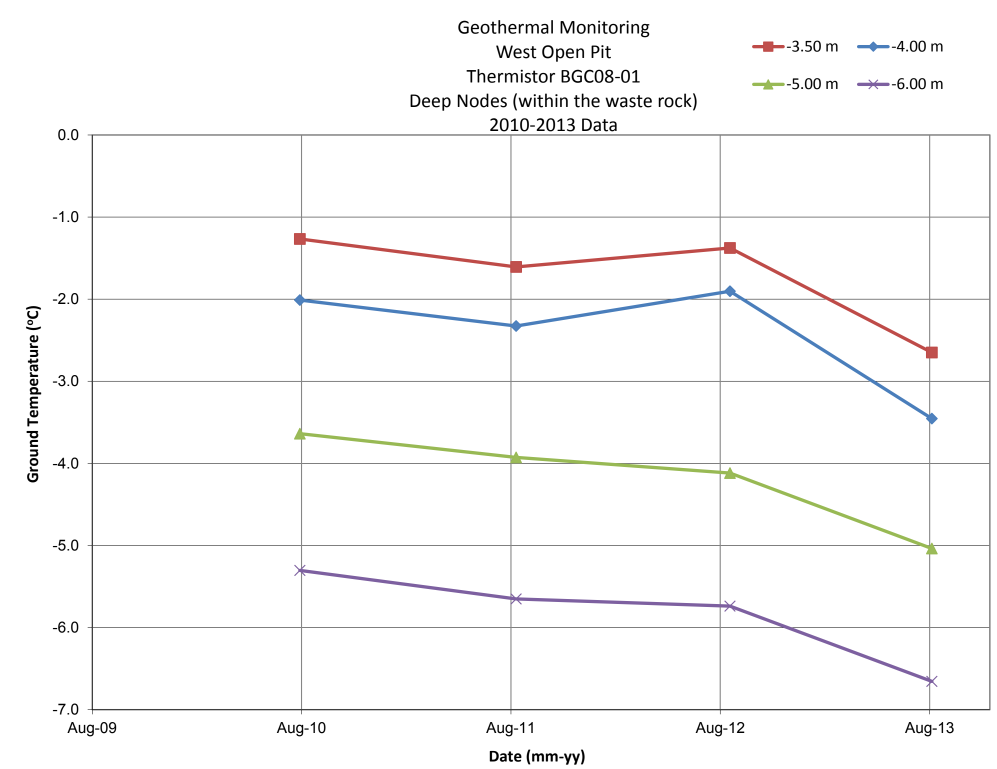

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SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

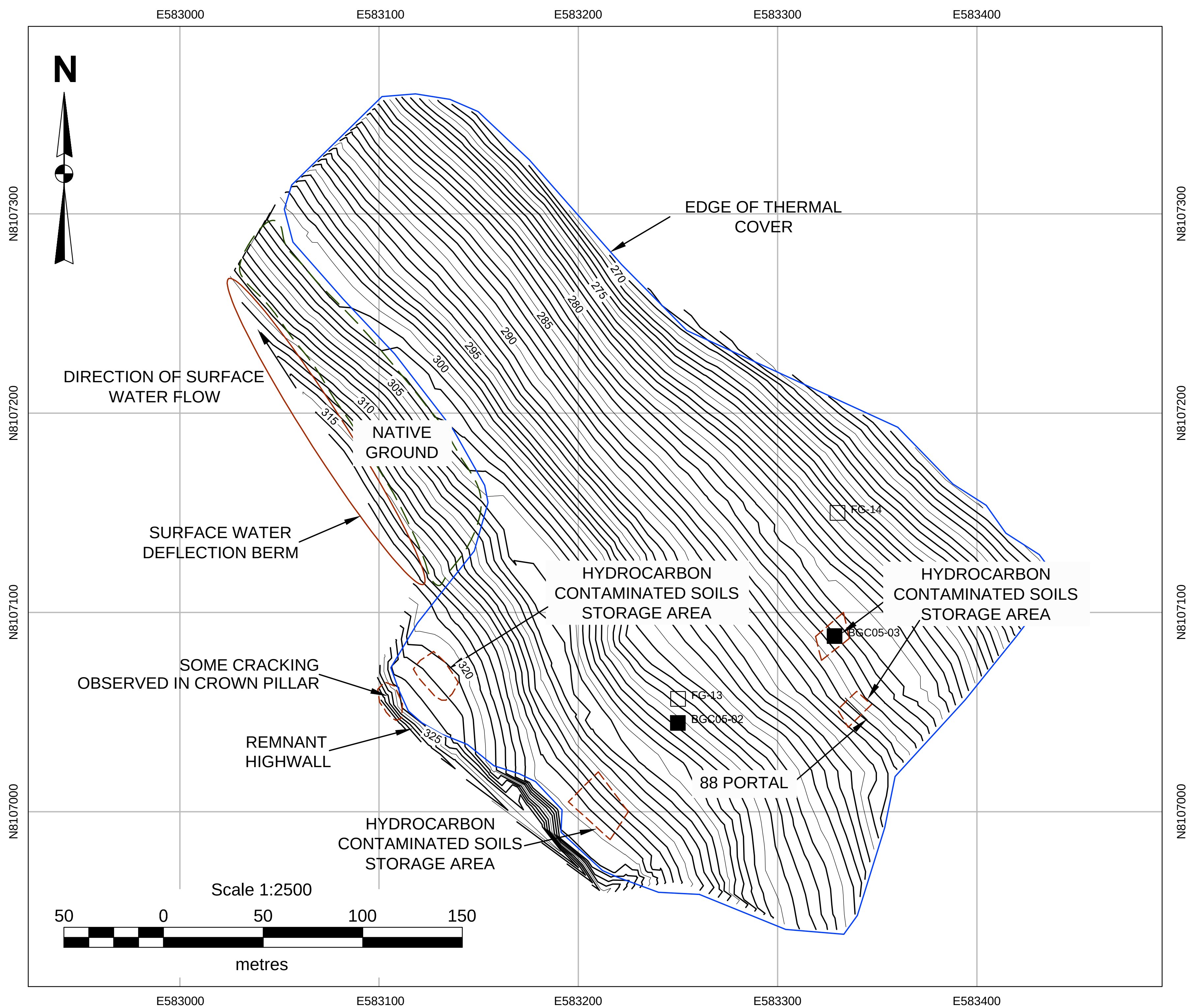
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: WEST OPEN PIT WASTE ROCK COVER
GEOTECHNICAL MONITORING DATA

DWG No.:	PROJ No.:	REV:
24	0255-023-03	



NOTES:

1. GRID BASED ON UTM NAD 83, ZONE 16 COORDINATES.
2. ELEVATIONS ARE IN METRES.
3. CONTOUR INTERVAL IS = 1.0 m.
4. SCALE IS APPROXIMATE.

LEGEND:

■	THERMISTOR
□	FROST GAUGE

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	AS SHOWN
DATE:	FEB 2014
DRAWN:	JL
DESIGNED:	GKC
CHECKED:	JWC
APPROVED:	GKC

PROFESSIONAL SEAL:

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT:
NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE:
EAST OPEN PIT WASTE ROCK COVER

PROJECT No.:	DWG No.	REV.:
0255-023-03	25	

DWG TO BE READ WITH BGC REPORT TITLED "NANISIVIK MINE 2013 ANNUAL GEOTECHNICAL INSPECTION" DATED FEBRUARY 2014

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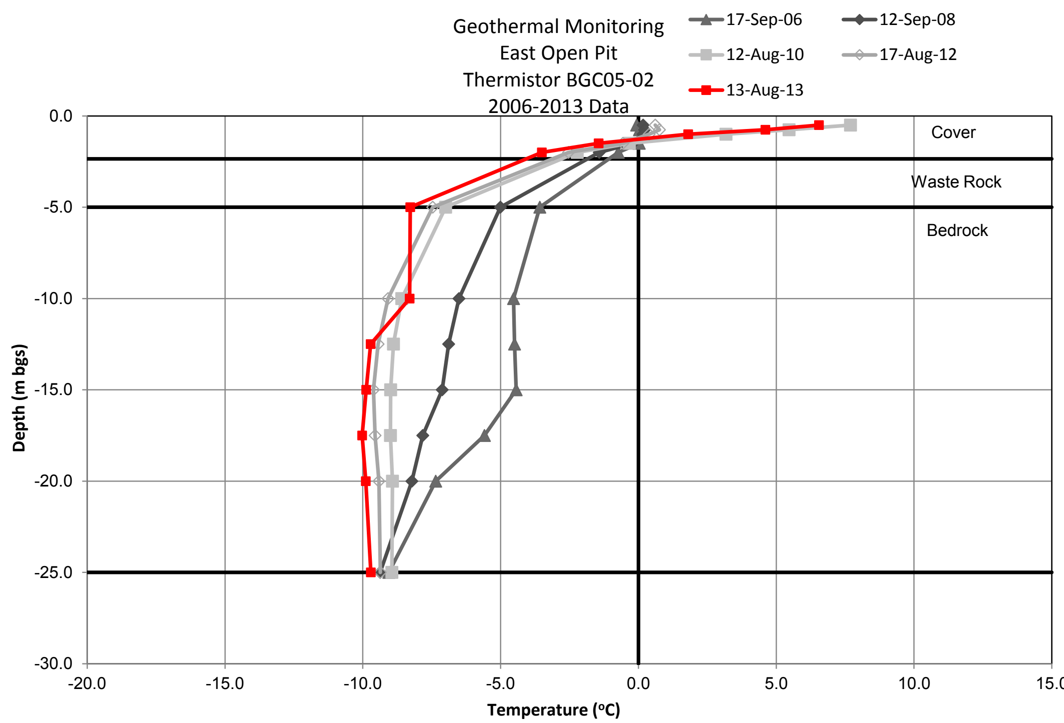

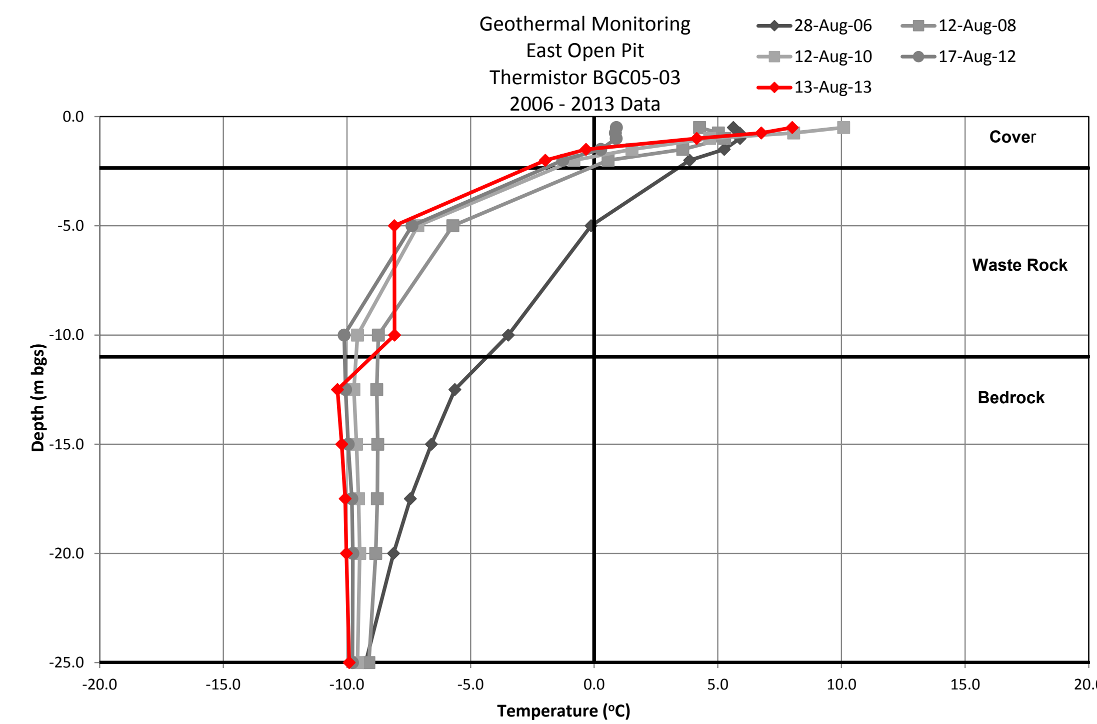

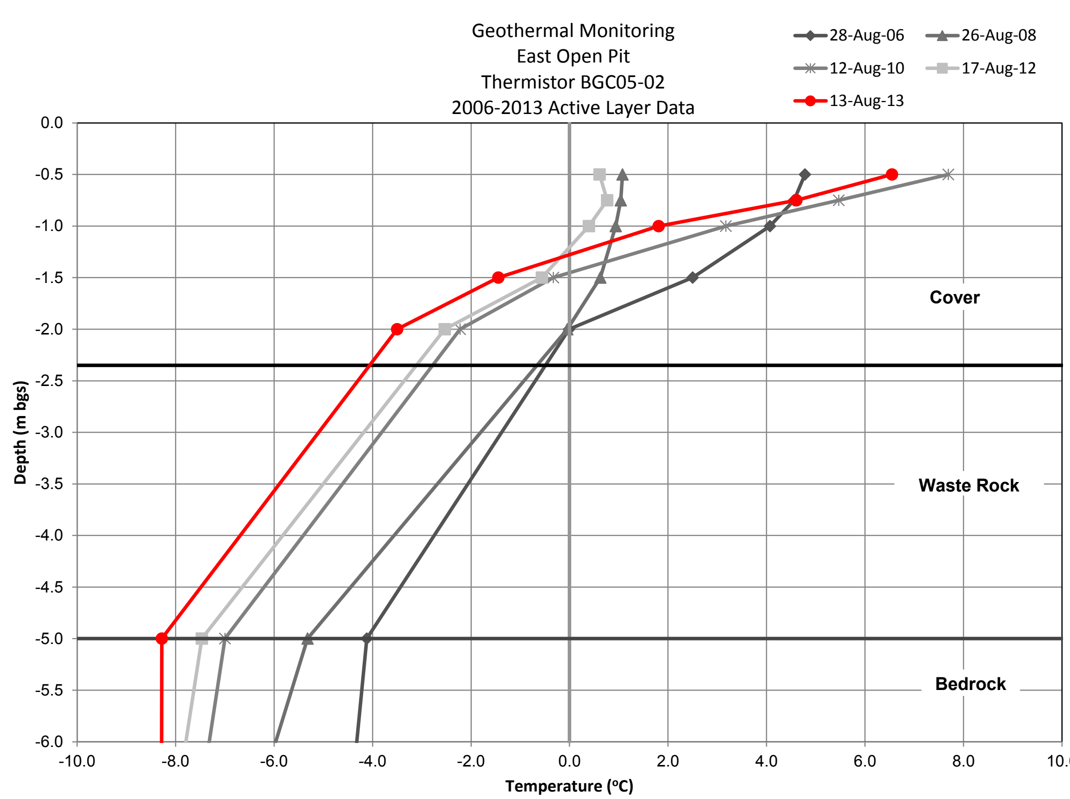

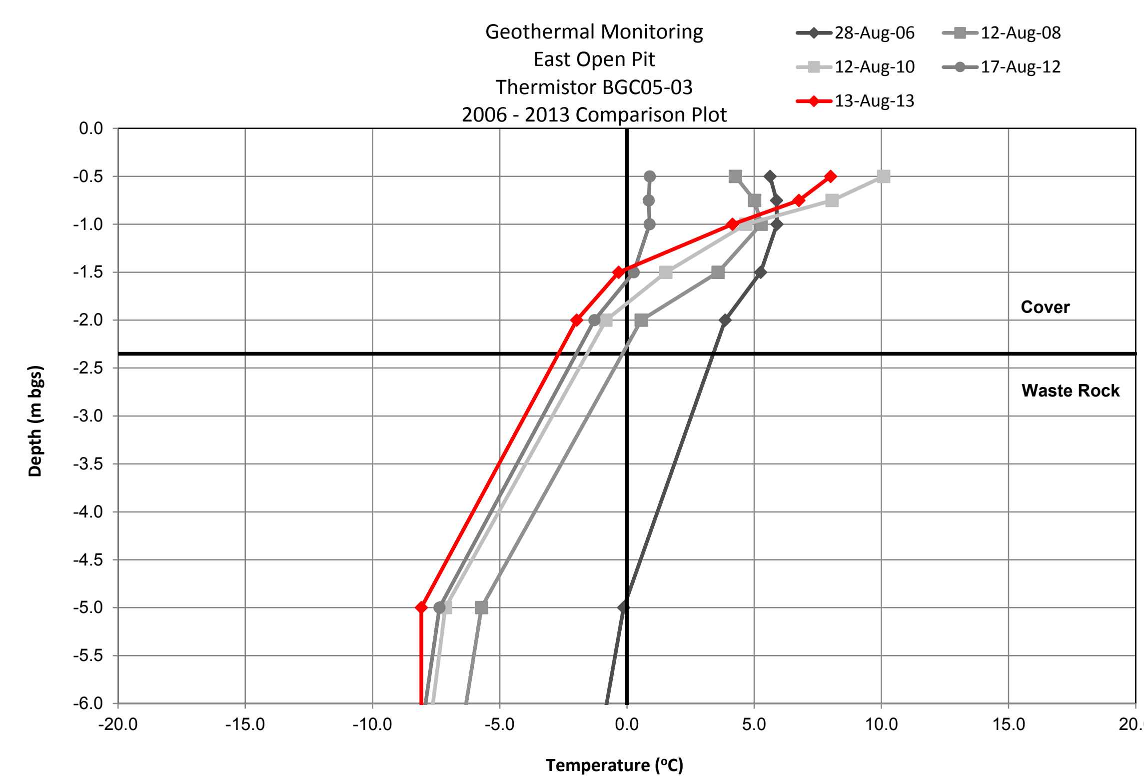

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DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

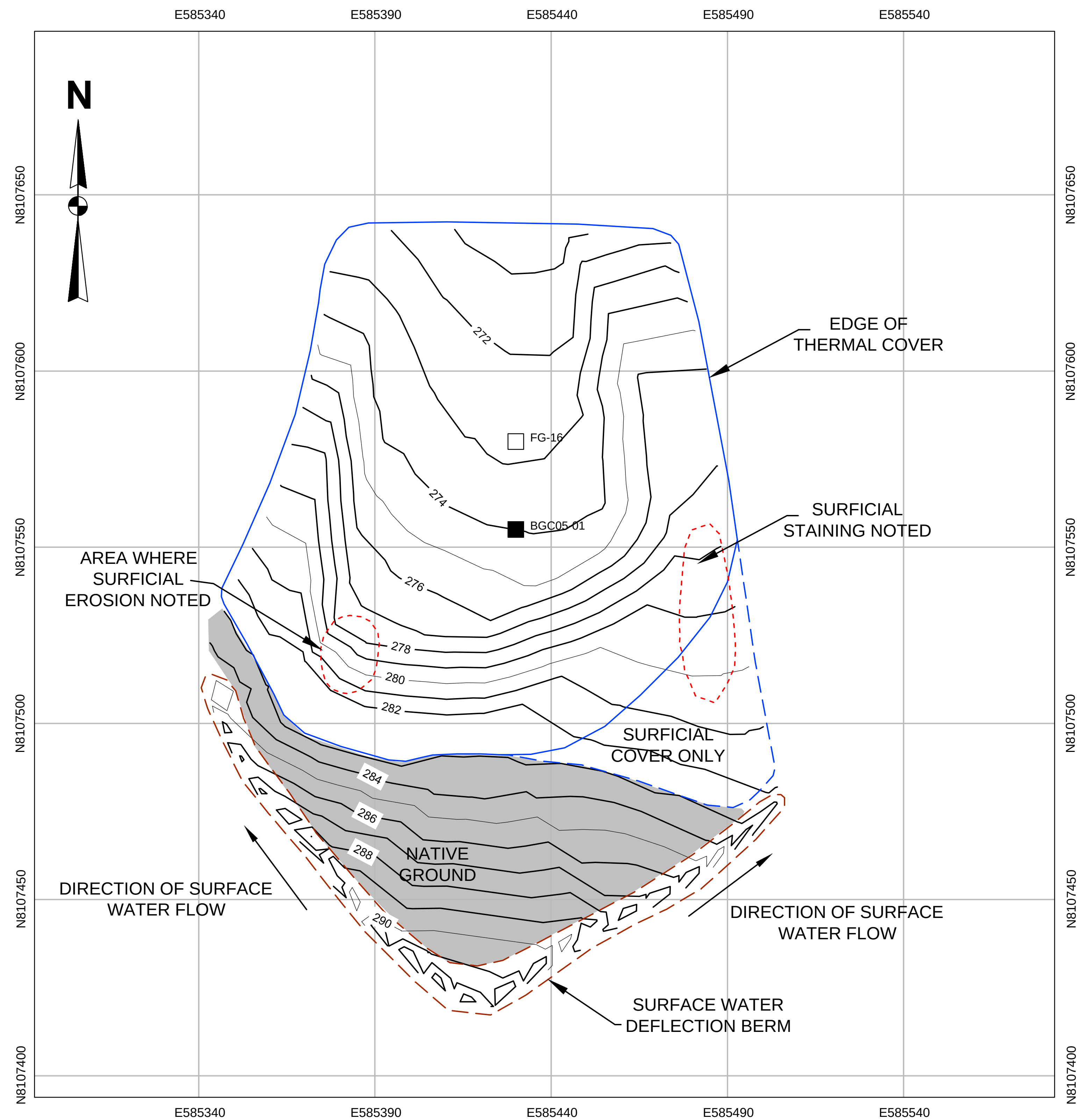
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: EAST OPEN PIT WASTE ROCK COVER
GEOTECHNICAL MONITORING DATA

DWG No.:	PROJ No.:	REV:
26	0255-023-03	



Scale 1:1500

30 0 30 60 90

metres

NOTES:

1. GRID BASED ON UTM NAD 83, ZONE 16 COORDINATES.
2. ELEVATIONS ARE IN METRES.
3. CONTOUR INTERVAL IS = 1.0 m.
4. SCALE IS APPROXIMATE.

LEGEND:

■ THERMISTOR

□ FROST GAUGE

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	AS SHOWN
DATE:	FEB 2014
DRAWN:	JL
DESIGNED:	GKC
CHECKED:	JWC
APPROVED:	GKC

PROFESSIONAL SEAL:

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE 2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: OCEANVIEW OPEN PIT WASTE ROCK COVER

PROJECT No.:	DWG No.	REV.:
0255-023-03	27	

DWG TO BE READ WITH BGC REPORT TITLED "NANISIVIK MINE 2013 ANNUAL GEOTECHNICAL INSPECTION" DATED FEBRUARY 2014

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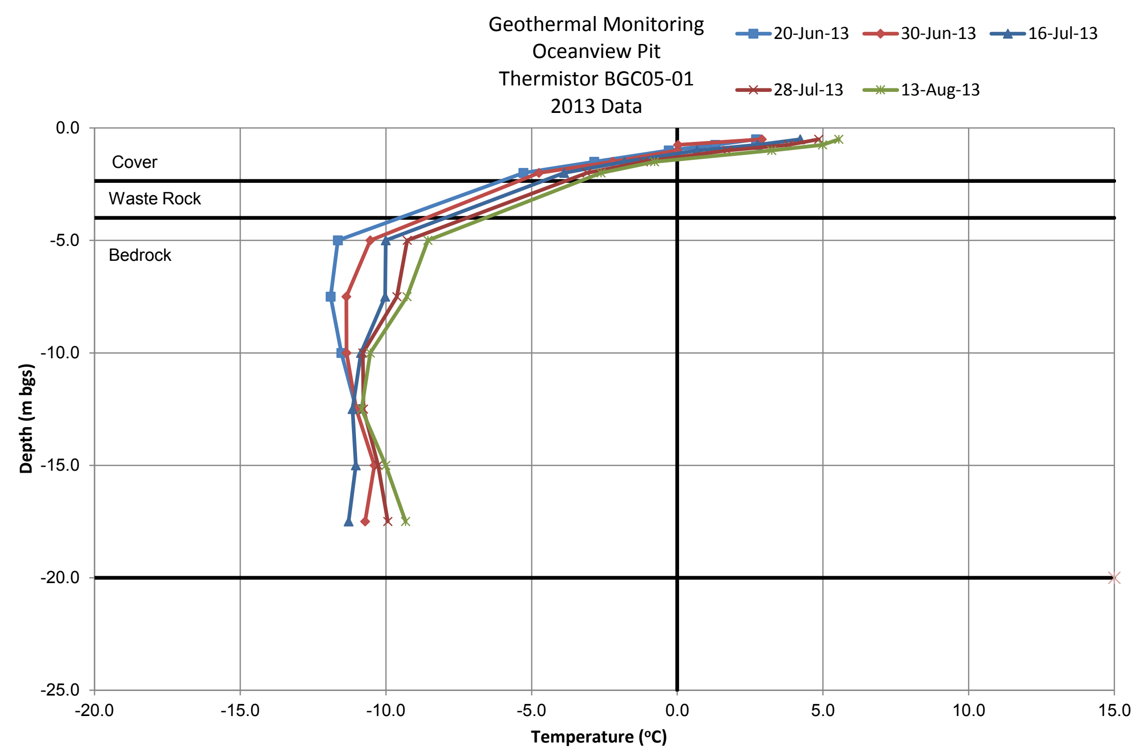

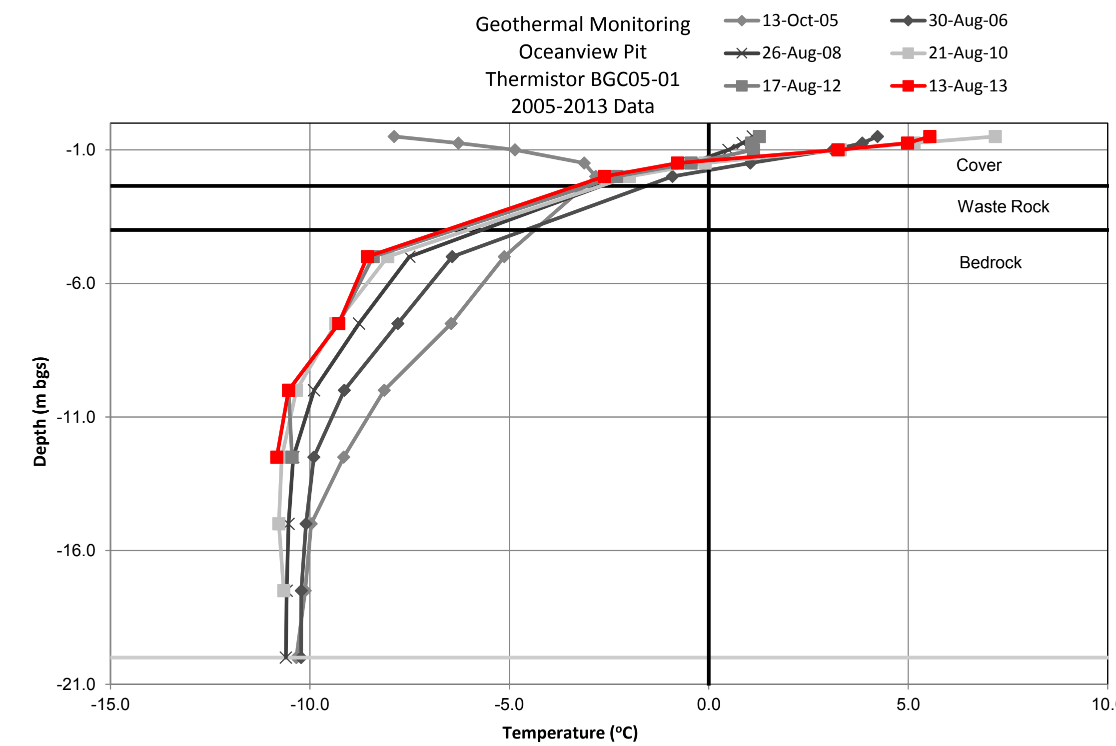

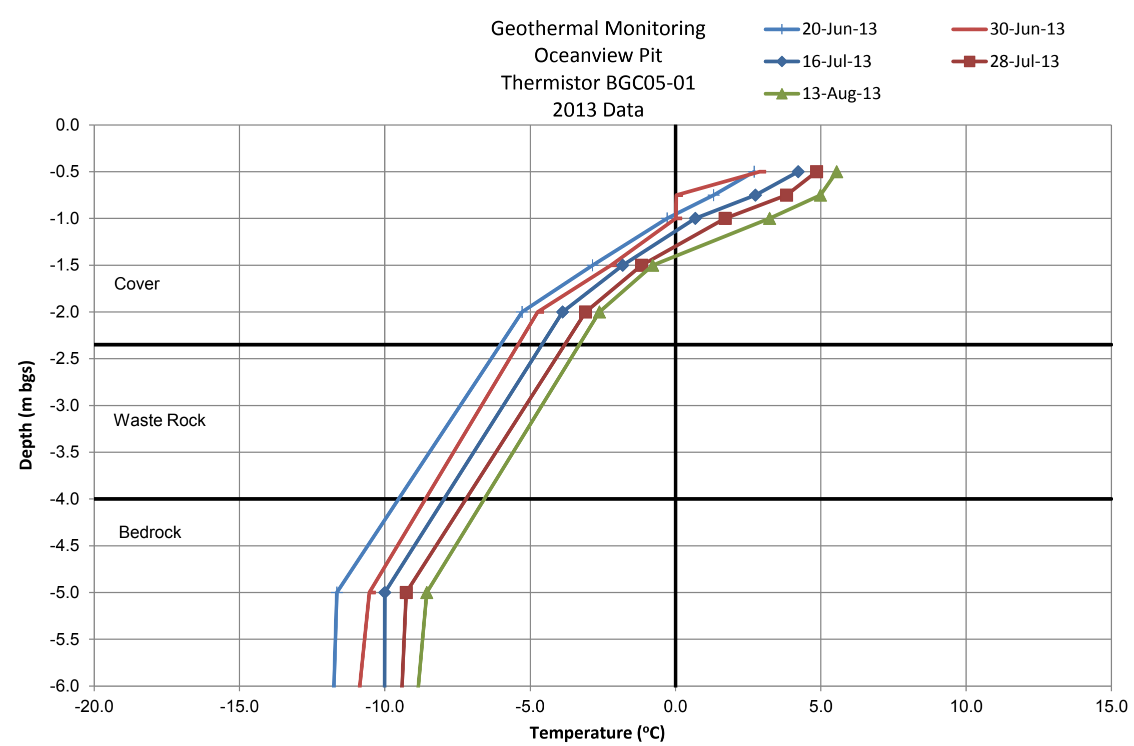

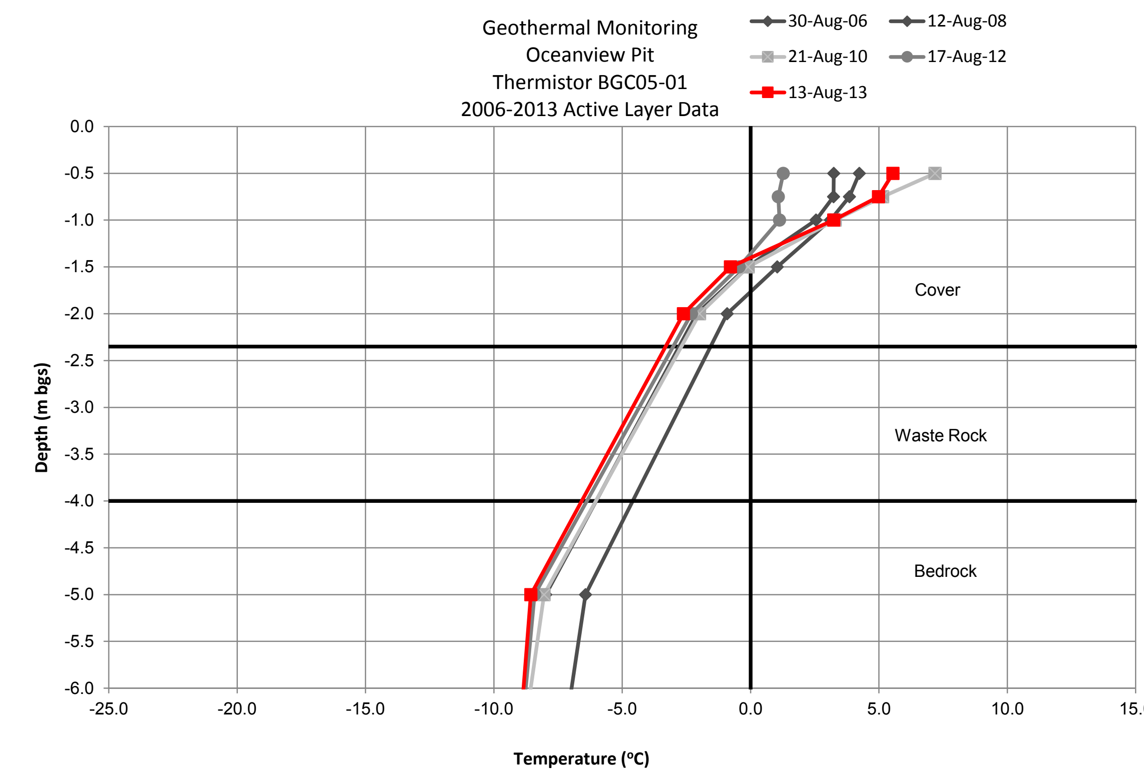

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DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

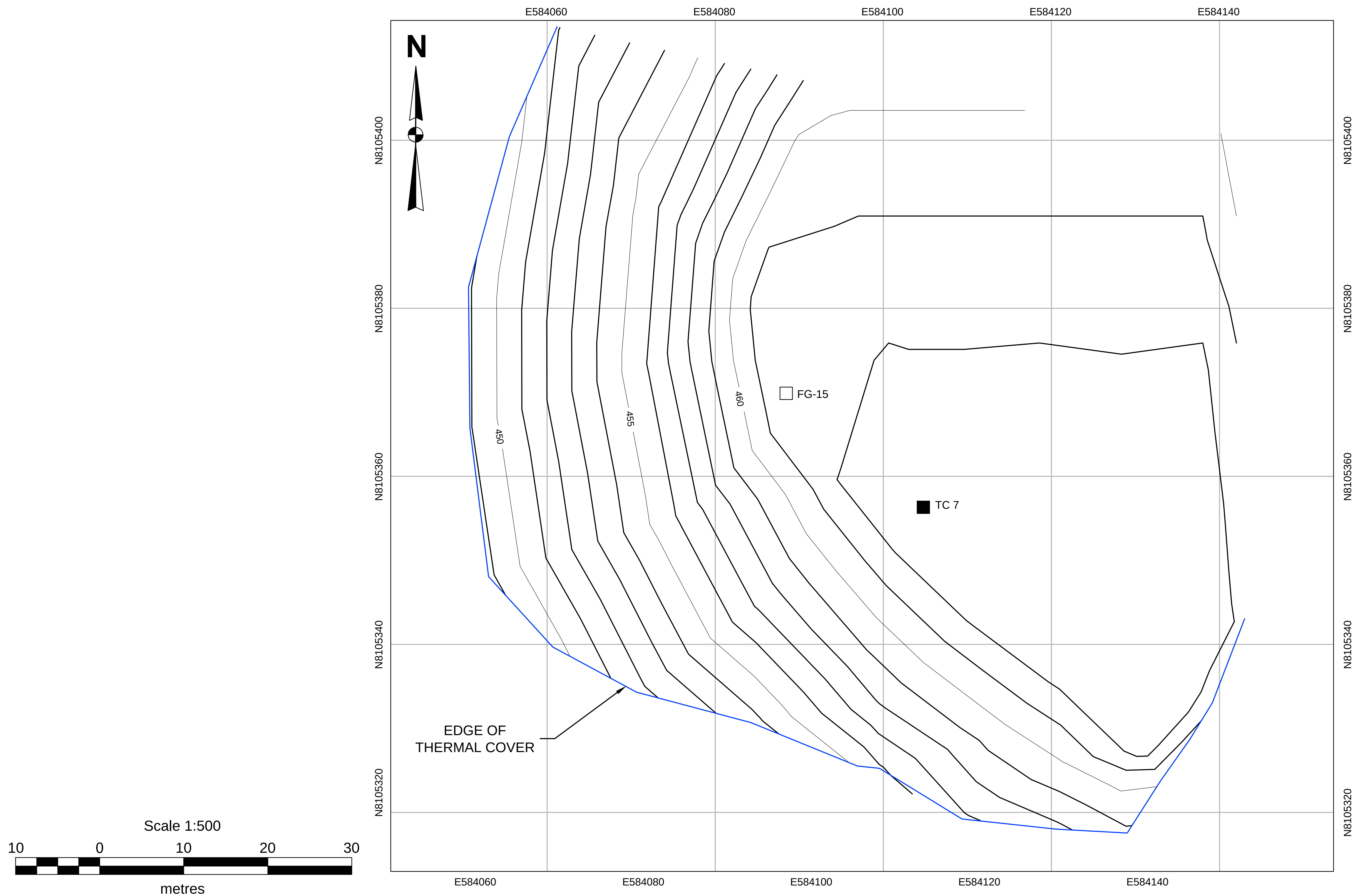
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: OCEANVIEW PIT WASTE ROCK COVER
GEOTECHNICAL MONITORING DATA

DWG No.:	PROJ No.:	REV:
28	0255-023-03	



NOTES:

1. GRID BASED ON UTM NAD 83, ZONE 16 COORDINATES.
2. ELEVATIONS ARE IN METRES.
3. CONTOUR INTERVAL IS = 1.0 m.
4. SCALE IS APPROXIMATE.

LEGEND:	
■	THERMOCOUPLE
□	FROST GAUGE

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	AS SHOWN
DATE:	FEB 2014
DRAWN:	JL
DESIGNED:	GKC
CHECKED:	JWC
APPROVED:	GKC

PROFESSIONAL SEAL:

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: AREA 14 WASTE ROCK COVER

PROJECT No.:	DWG No.	REV.:
0255-023-03	29	

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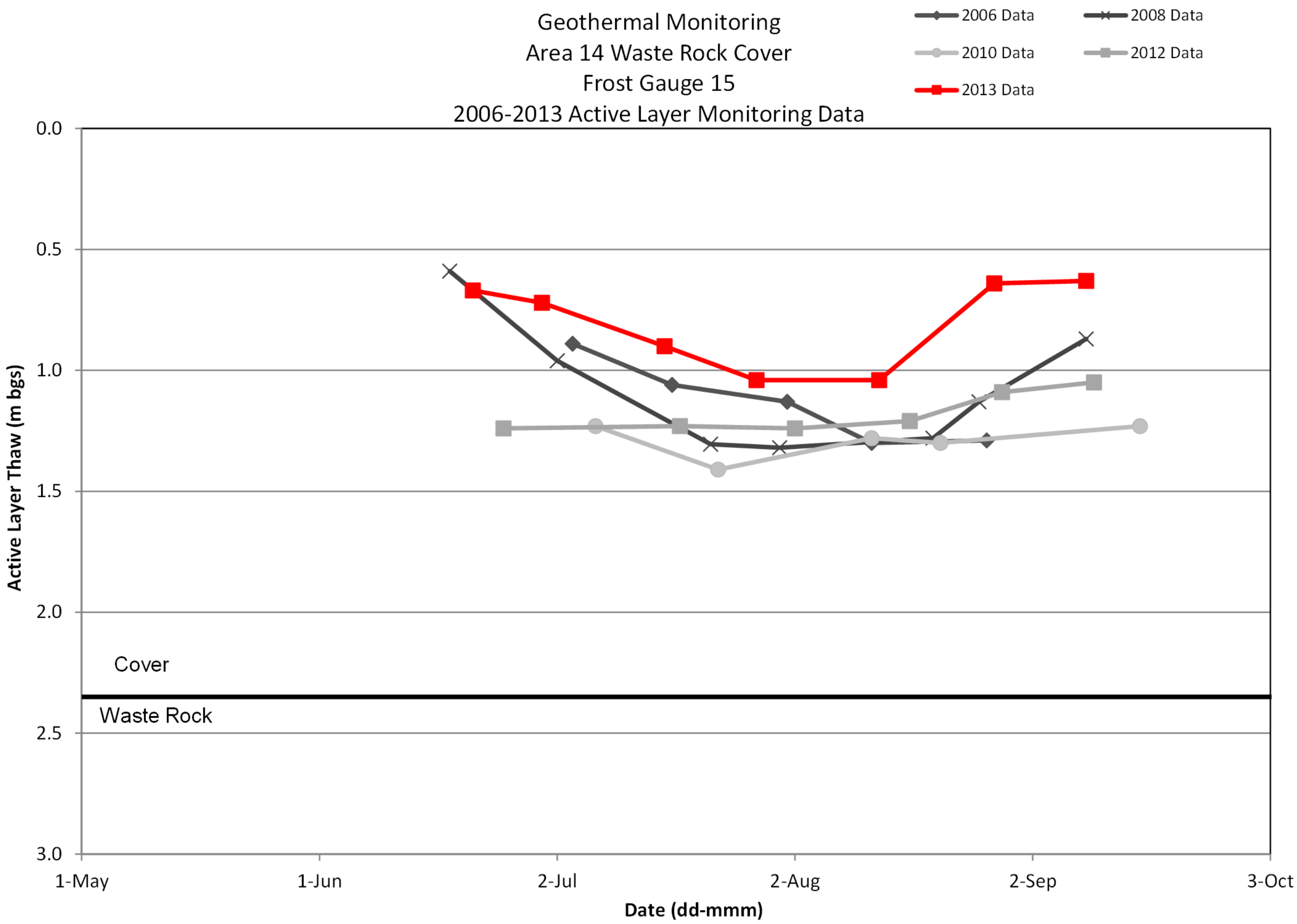

DWG TO BE READ WITH BGC REPORT TITLED: "NANISVIK MINE 2013 GEOTECHNICAL INSPECTION", FEB 2014

SCALE:	AS SHOWN	DRAWN:	MCL
DATE:	FEB 2014	CHECKED:	JWC
DESIGNED:	GKC	APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: NANISVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: AREA 14 WASTE ROCK COVER
GEOTECHNICAL MONITORING DATA

CLIENT: nyrstar

DWG No.: 30	PROJ No.: 0255-023-03	REV:

NOTES:

1. GRID BASED ON UTM, NAD 83, ZONE 16 COORDINATES.
2. ELEVATIONS ARE IN METRES.
3. CONTOUR INTERVAL IS = 0.2 m.
4. SCALE IS APPROXIMATE.

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	AS SHOWN
DATE:	FEB 2014
DRAWN:	JL
DESIGNED:	GKC
CHECKED:	JWC
APPROVED:	GKC

PROFESSIONAL SEAL:

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE RECLAMATION
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: UPPER DUMP POND TAILINGS COVER

PROJECT No.:	DWG No.	REV.:
0255-023-03	31	

DWG TO BE READ WITH BGC REPORT TITLED "NANISIVIK MINE 2013 ANNUAL GEOTECHNICAL INSPECTION" DATED FEBRUARY 2014

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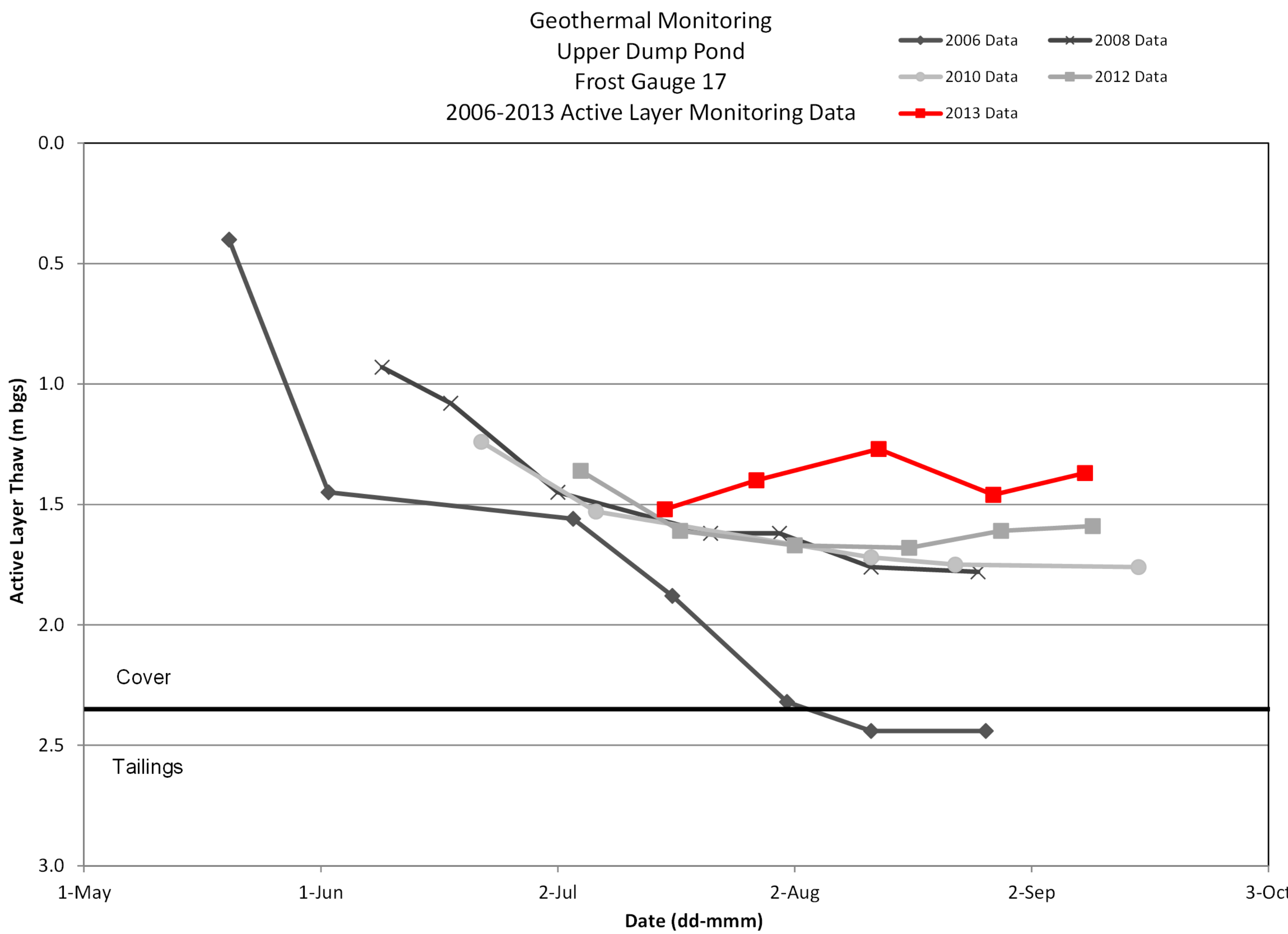


DWG TO BE READ WITH BGC REPORT TITLED: "NANISVIK MINE 2013 GEOTECHNICAL INSPECTION", FEB 2014

SCALE:	AS SHOWN
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

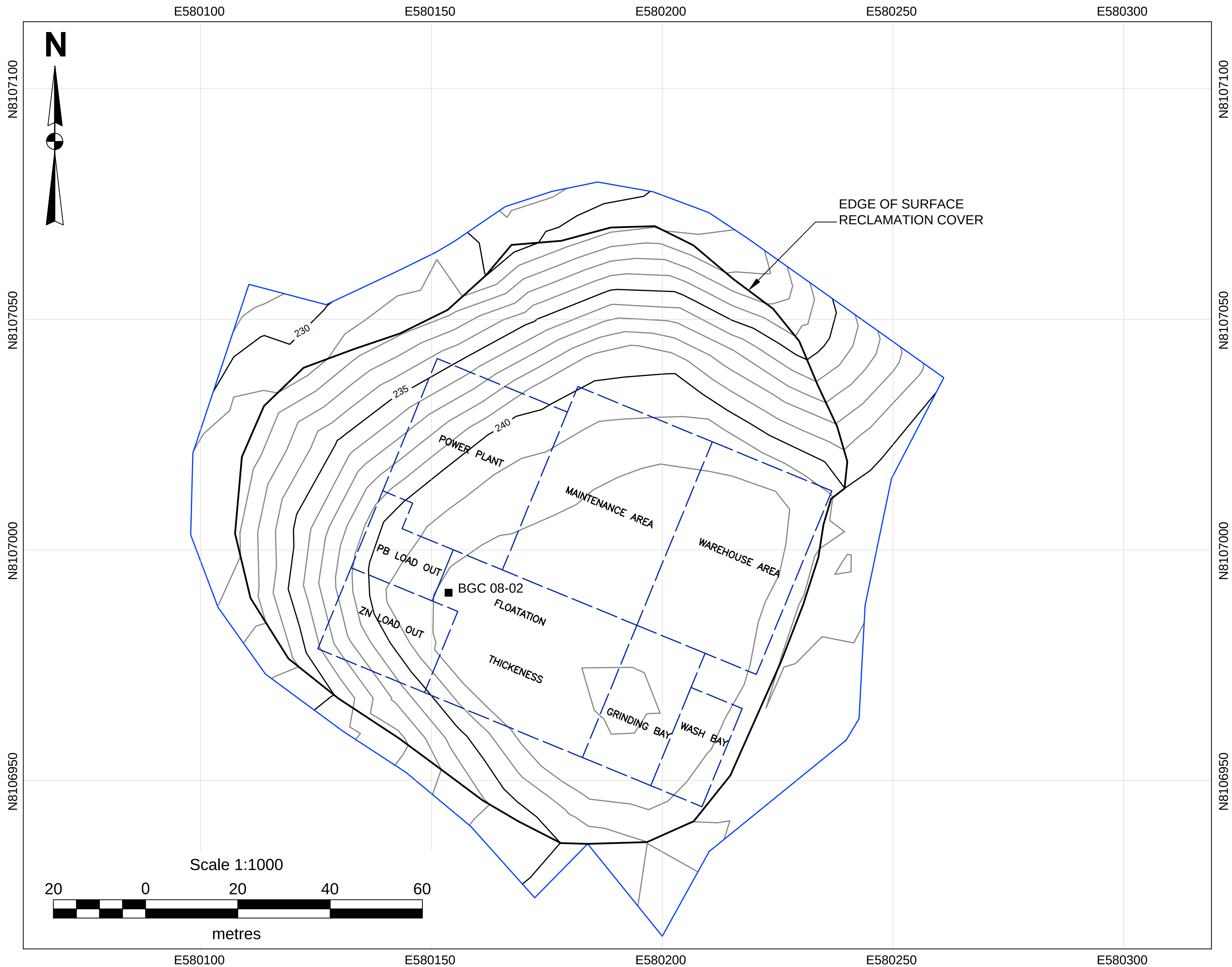
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: UPPER DUMP POND TAILINGS COVER
GEOTECHNICAL MONITORING DATA

DWG No.:	PROJ No.:	REV:
32	0255-023-03	



NOTES:

1. GRID BASED ON UTM, NAD 83, ZONE 16 COORDINATES.
2. ELEVATIONS ARE IN METRES.
3. CONTOUR INTERVAL IS = 1.0 m.
4. SCALE IS APPROXIMATE.
5. FLOOR PLAN OF INDUSTRIAL COMPLEX DERIVED FROM MINE SITE RECORDS AND IS CONSIDERED TO BE APPROXIMATE.

LEGEND:

■ THERMISTOR INSTALLATION

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	AS SHOWN
DATE:	FEB 2014
DRAWN:	JL
DESIGNED:	GKC
CHECKED:	JWC
APPROVED:	GKC

PROFESSIONAL SEAL:

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: INDUSTRIAL COMPLEX COVER

PROJECT No.:	DWG NO.:	REV.:
0255-023-03	33	

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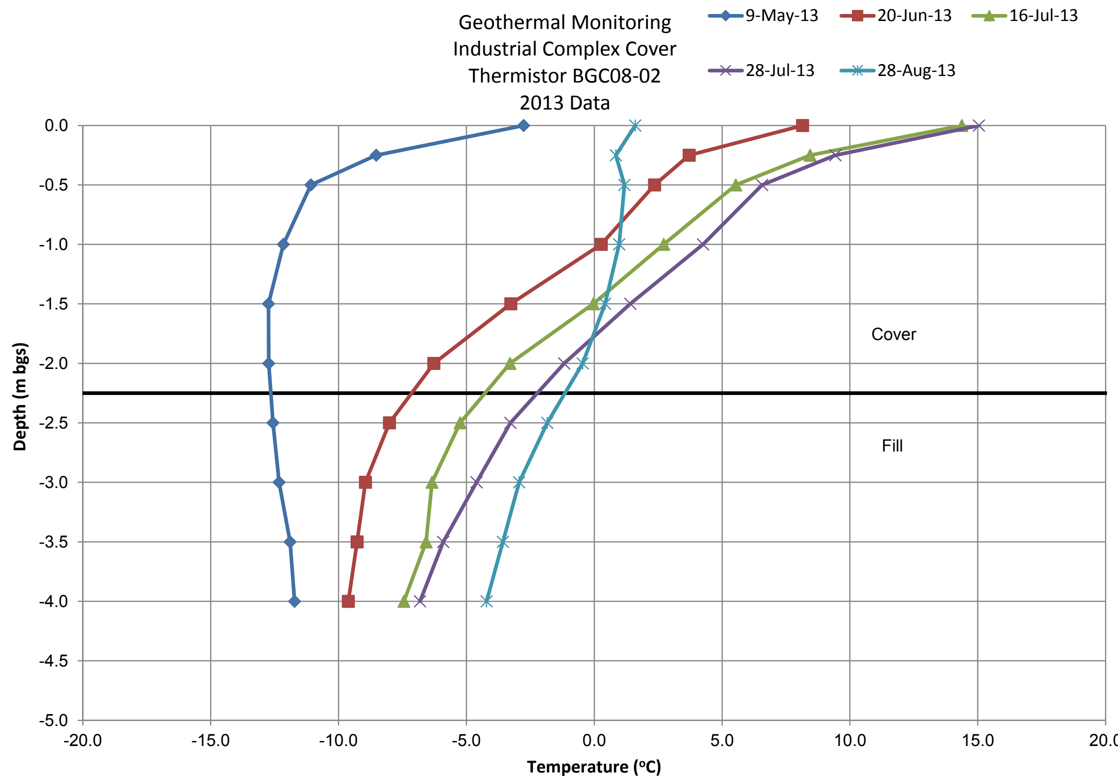

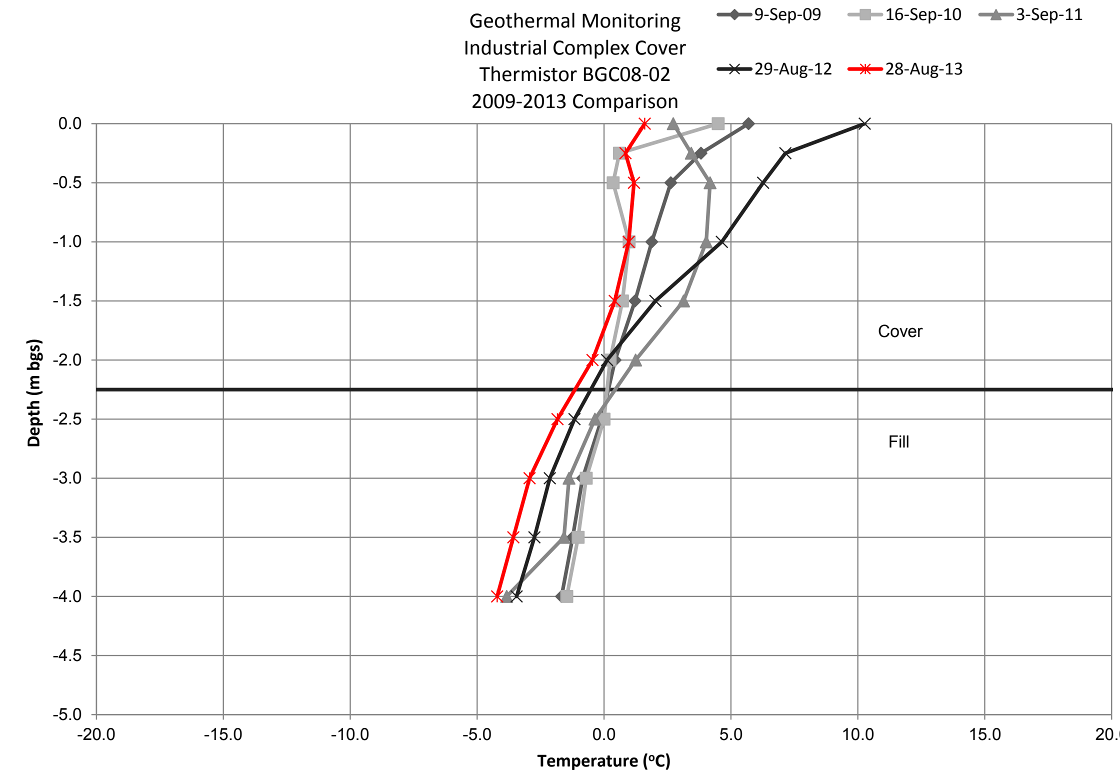

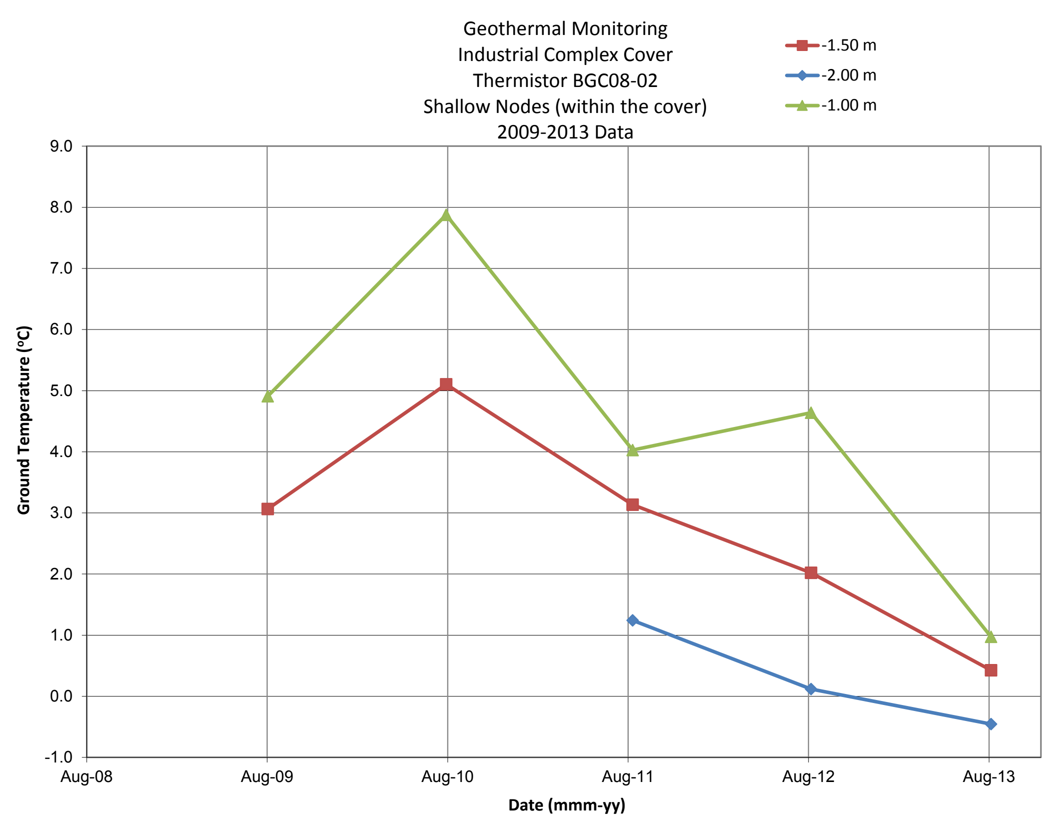

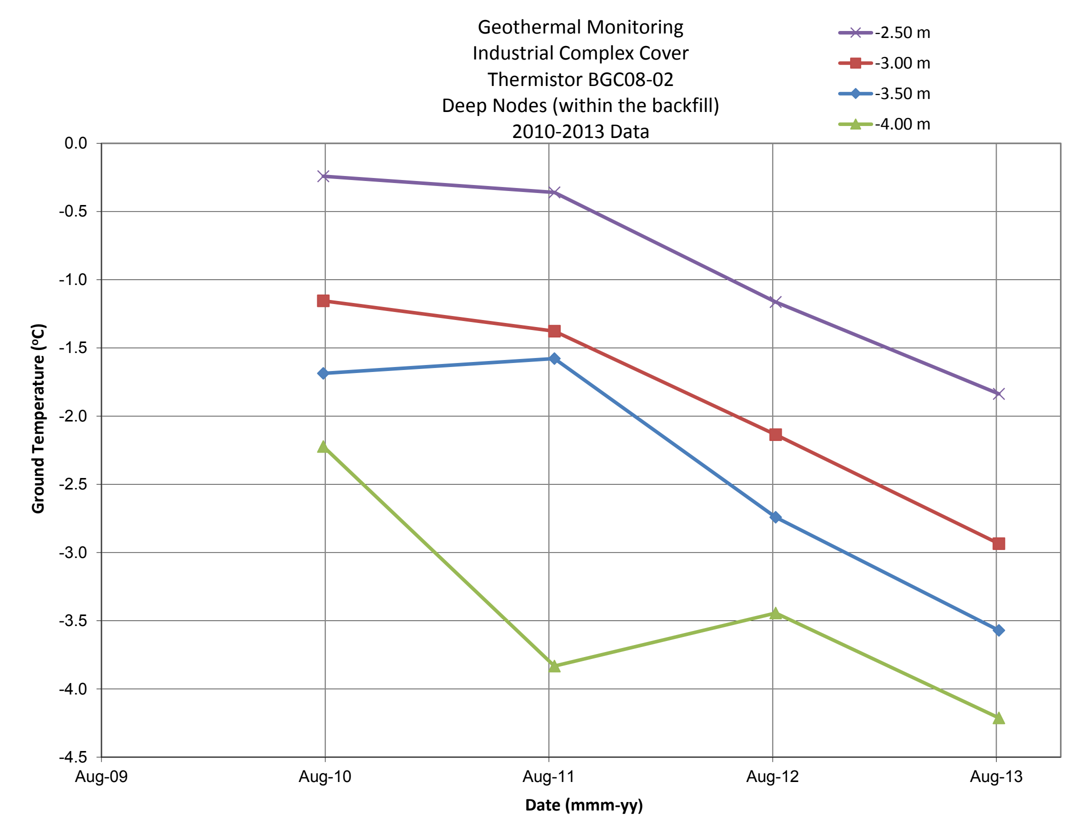

DWG TO BE READ WITH BGC REPORT TITLED: "NANISIVIK MINE 2013 GEOTECHNICAL INSPECTION", FEB 2014

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: INDUSTRIAL COMPLEX COVER
GEOTECHNICAL MONITORING DATA

DWG No.:	PROJ No.:	REV:
34	0255-023-03	

APPENDIX I
INSPECTION PHOTOS

LIST OF APPENDIX I INSPECTION PHOTOS

Photo 1. Main Tank Farm—As seen from road up to townsite.

Photo 2. Main Tank Farm—Remnant perimeter dyke in location of old water retention pond.

Photo 3. Main Tank Farm and excavation spill pile.

Photo 4. Main Tank Farm—Stockpiles of soil excavated from tank farm foundation.

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: MAIN TANK FARM
SPILL CONTAINMENT BERM

APPENDIX No.:	PROJ No.:	REV:
I-1	0255-023-03	

Photo 5. West Twin Dyke Spillway—Ramp into the bottom of the West Twin Dyke Spillway.

Photo 6. West Twin Dyke Spillway—Looking up gradient.

Photo 7. West Twin Dyke Spillway—Looking down gradient.

Photo 8. West Twin Dyke Spillway—Outlet.

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: WEST TWIN DYKE SPILLWAY

APPENDIX No.:	PROJ No.:	REV:
I-2	0255-023-03	

Photo 9. West Twin Outlet Channel—Note water running over wall.

Photo 10. West Twin Outlet Channel—Looking upstream.

Photo 11. West Twin Outlet Channel—Slumping and thermokarst along shoreline of polishing pond.

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: WEST TWIN LAKE OUTLET CHANNEL

APPENDIX No.:	PROJ No.:	REV:
I-3	0255-023-03	

Photo 12. East Twin Creek Diversion Channel—View looking up gradient.

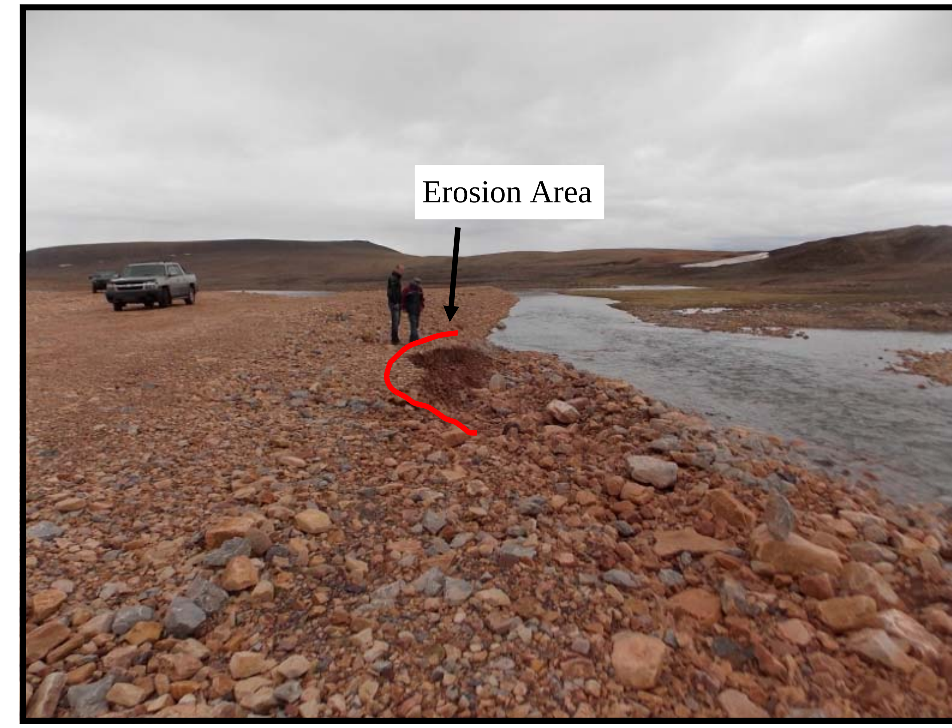

Photo 13. East Twin Creek Diversion Channel– Erosion area noted above seepage discharge point.

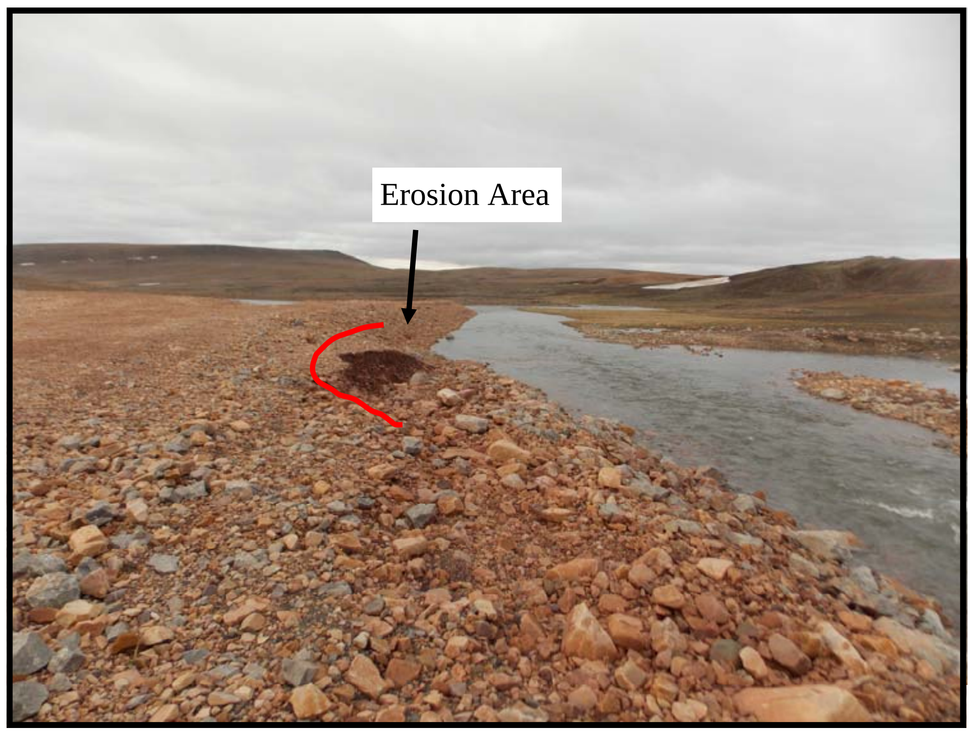

Photo 14. East Twin Creek Diversion Channel– Erosion area noted above seepage discharge point. Erosion is further advanced compared to 2012.

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: EAST TWIN LAKE CREEK DIVERSION DYKE

APPENDIX No.:	PROJ No.:	REV:
I-4	0255-023-03	

Photo 15. Surface Cell—General spillway entrance from crest of right bank on spillway.

Photo 16. Surface Cell—Settlement area just north of E/W drainage swale.

Photo 17. Surface Cell—Cover System.

Photo 18. Surface Cell—E/W drainage channel on Surface Cell cover. View looking west.

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: SURFACE CELL TAILINGS COVER

APPENDIX No.:	PROJ No.:	REV:
I-5	0255-023-03	

Photo 19. West Twin Dyke—As seen from right (south) abutment.

Photo 20. West Twin Dyke—View along crest of dyke looking north.

SCALE:	AS SHOWN	DRAWN:	MCL
DATE:	FEB 2014	CHECKED:	JWC
DESIGNED:	GKC	APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: WEST TWIN DYKE

CLIENT: nyrstar

APPENDIX No.:	PROJ No.:	REV:
I-6	0255-023-03	

Photo 21. Test Cell—Surface of Test Cell cover.

Photo 22. Test Cell—Surface of Test Cell cover.

SCALE:	AS SHOWN	DRAWN:	MCL
DATE:	FEB 2014	CHECKED:	JWC
DESIGNED:	GKC	APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: TEST CELL TAILINGS COVER

CLIENT: nyrstar

APPENDIX No.: I-7	PROJ No.: 0255-023-03	REV:

Photo 23. Toe of Test Cell Dyke—At Reservoir edge. Note ice pan on Reservoir.

Photo 24. Toe of Test Cell Dyke—Armour along shoreline of cover at toe of Test Cell Dyke. East/West arm, view looking west.

Photo 25. Toe of Test Cell Dyke—North/South arm, view looking south.

Photo 26. Toe of Test Cell Dyke—Outlet of Test Cell Cover

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: TOE OF TEST CELL DYKE TAILINGS COVER

APPENDIX No.:	PROJ No.:	REV:
I-8	0255-023-03	

Photo 27. Toe of West Twin Dyke.

Photo 28. Toe of West Twin Dyke—Armour along shoreline of cover at toe of West Twin Dyke.

SCALE:	AS SHOWN	DRAWN:	MCL
DATE:	FEB 2014	CHECKED:	JWC
DESIGNED:	GKC	APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: TOE OF WEST TWIN DYKE TAILINGS COVER

CLIENT: nyrstar

APPENDIX No.: I-9	PROJ No.: 0255-023-03	REV:

Photo 29. Landfill—Surface of landfill cover.

Photo 30. Landfill—Sloping face of cover.

Photo 31. Landfill— Surface of landfill cover.

Photo 32. Landfill—Face of landfill cover.

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: LANDFILL COVER

APPENDIX No.:	PROJ No.:	REV:
I-10	0255-023-03	

Photo 33. West Open Pit—Crack in crown pillar.

Photo 34. West Open Pit—Crack in crown pillar.

Photo 35. West Open Pit—View west along remnant highwall.

Photo 36. West Open Pit—View looking west along surface of cover.

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT:	NANISIVIK MINE 2013 ANNUAL GEOTECHNICAL INSPECTION
TITLE:	WEST OPEN PIT WASTE ROCK COVER
APPENDIX No.:	I-11
PROJ No.:	0255-023-03
REV:	

Photo 37. East Open Pit—Sloping upper surface of cover system.

Photo 38. East Open Pit—Remnant highwall.

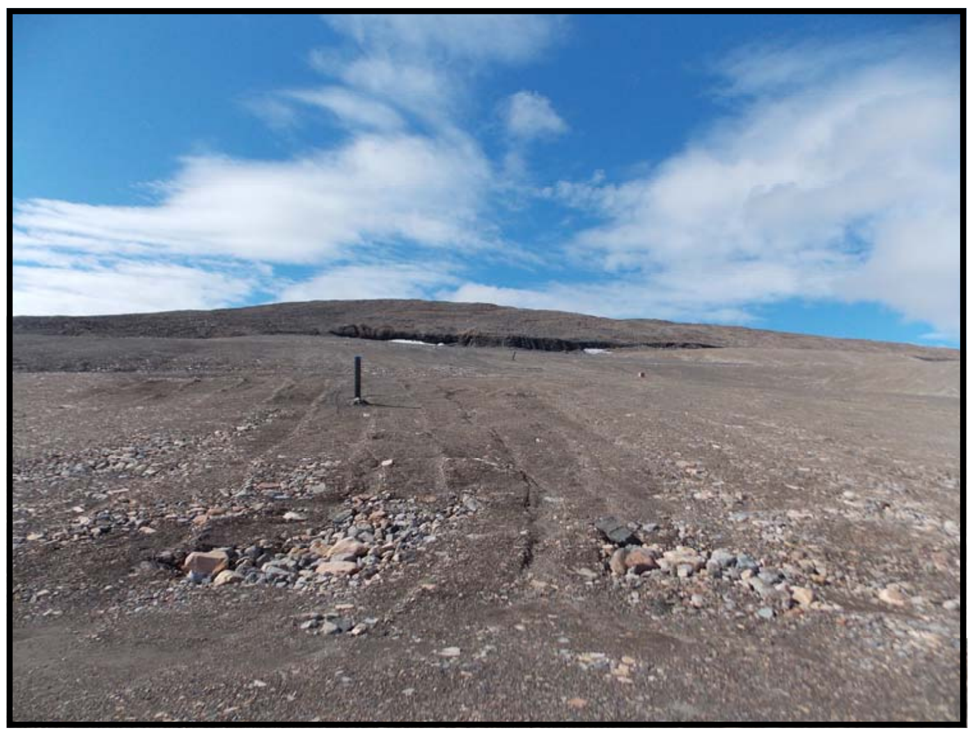

Photo 39. East Open Pit—Looking upslope along surface of cover. Note minor rill erosion.

Photo 40. East Open Pit—Cracking in crown pillar. Similar condition to 2012.

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: EAST OPEN PIT WASTE ROCK COVER

APPENDIX No.:	PROJ No.:	REV:
I-12	0255-023-03	

Photo 41. Oceanview Open Pit—Toe area.

Photo 42. Oceanview Open Pit—Rill erosion along sloping face of cover at SW corner of pit.

Photo 43. Oceanview Open Pit— Surface of pit cover area.

Photo 44. Oceanview Open Pit—Note minor rill erosion.

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: OCEANVIEW OPEN PIT WASTE ROCK COVER

APPENDIX No.:	PROJ No.:	REV:
I-13	0255-023-03	

Photo 45. Area 14—Surface of cover.

Photo 46. Area 14—General view of cover as seen from Area 14 raise.

SCALE:	AS SHOWN	DRAWN:	MCL
DATE:	FEB 2014	CHECKED:	JWC
DESIGNED:	GKC	APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: AREA 14 WASTE ROCK COVER

CLIENT: nyrstar

APPENDIX No.: I-14	PROJ No.: 0255-023-03	REV:

Photo 47. Upper Dump Pond—Sloping face of cover.

Photo 48. Upper Dump Pond—Monitoring on the surface of cover.

SCALE:	AS SHOWN	DRAWN:	MCL
DATE:	FEB 2014	CHECKED:	JWC
DESIGNED:	GKC	APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: UPPER DUMP POND TAILINGS COVER

CLIENT: nyrstar

APPENDIX No.: I-15	PROJ No.: 0255-023-03	REV:

Photo 49. Industrial Complex Cover—View across upper flat portion of cover.

Photo 50. Industrial Complex Cover—Toe of sloping face of cover.

Photo 51. Industrial Complex Cover—View looking from on top of cover.

Photo 52. Industrial Complex Cover—Sloping face of cover.

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: INDUSTRIAL COMPLEX COVER

APPENDIX No.:	PROJ No.:	REV:
I-16	0255-023-03	

Photo 53. Oceanview Portal—Looking downslope along surface of portal cover.

Photo 54. Oceanview Portal—Settlement area along west edge of cover. Nothing active noted.

SCALE:	AS SHOWN	DRAWN:	MCL
DATE:	FEB 2014	CHECKED:	JWC
DESIGNED:	GKC	APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: OCEANVIEW PORTAL COVER

CLIENT: nyrstar

APPENDIX No.: I-17	PROJ No.: 0255-023-03	REV:

Photo 55. K-Baseline Portal—Surface of cover as seen from East Open Pit

Photo 56. K-Baseline Portal—Upper flatter portion of cover.

SCALE:	AS SHOWN	DRAWN:	MCL
DATE:	FEB 2014	CHECKED:	JWC
DESIGNED:	GKC	APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: K-BASELINE PORTAL COVER

CLIENT: nyrstar

APPENDIX No.: I-18	PROJ No.: 0255-023-03	REV:

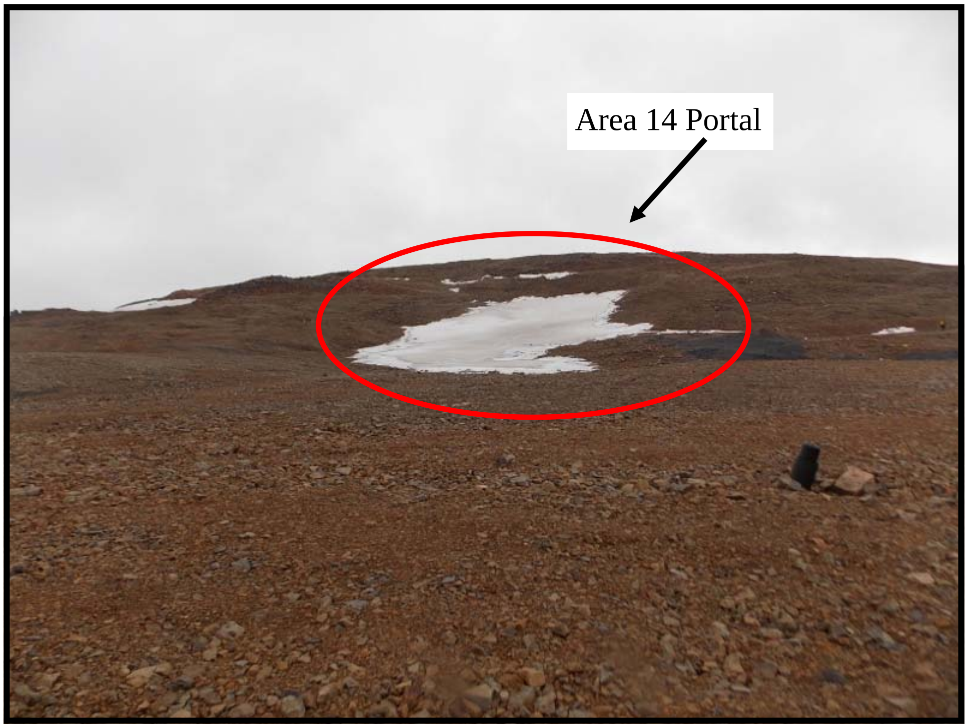

Photo 57. Area 14 Waste Rock cover and Portal.

SCALE:	AS SHOWN	DRAWN:	MCL
DATE:	FEB 2014	CHECKED:	JWC
DESIGNED:	GKC	APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: AREA 14 PORTAL COVER

CLIENT: nyrstar

APPENDIX No.: I-19	PROJ No.: 0255-023-03	REV:

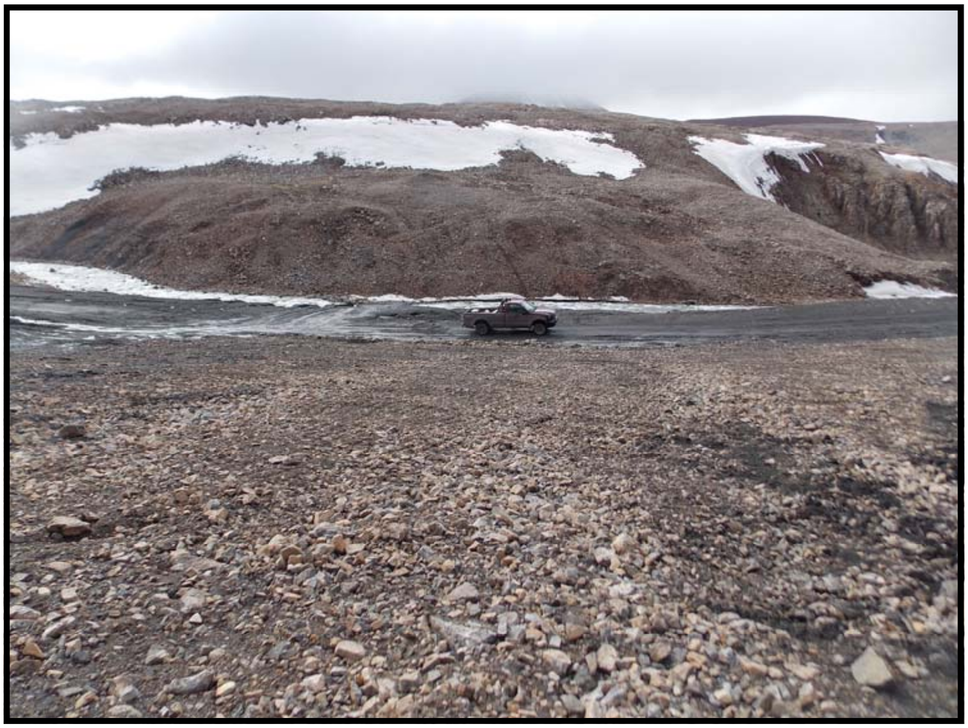

Photo 58. 09S Portal—Looking downslope along surface of cover.

Photo 59. 09S Portal—Looking upslope along surface of cover.

SCALE:	AS SHOWN	DRAWN:	MCL
DATE:	FEB 2014	CHECKED:	JWC
DESIGNED:	GKC	APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: 09S PORTAL COVER

CLIENT: nyrstar

APPENDIX No.:	PROJ No.:	REV:
I-20	0255-023-03	

Photo 60. Lower Adit—View looking upslope along surface of cover.

Photo 61. Lower Adit—As seen from top of Industrial Complex cover.

SCALE:	AS SHOWN	DRAWN:	MCL
DATE:	FEB 2014	CHECKED:	JWC
DESIGNED:	GKC	APPROVED:	GKC

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: LOWER ADIT COVER

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

APPENDIX No.: I-21	PROJ No.: 0255-023-03	REV:

Photo 62. Oceanview West Raise.

Photo 63. Oceanview East Raise.

SCALE:	AS SHOWN	DRAWN:	MCL
DATE:	FEB 2014	CHECKED:	JWC
DESIGNED:	GKC	APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: MINE RAISE COVER

CLIENT: nyrstar

APPENDIX No.: I-22	PROJ No.: 0255-023-03	REV:

Photo 64. Area 14 Shale Quarry.

Photo 65. East Twin Shale Quarry—As seen from Area 14 shale quarry.

Photo 66. Mt. Fuji Shale Quarry.

Photo 67. Surface of Twin Lakes sand and gravel quarry.

SCALE:	N/A
DATE:	FEB 2014
DESIGNED:	GKC
DRAWN:	MCL
CHECKED:	JWC
APPROVED:	GKC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: nyrstar

PROJECT: NANISIVIK MINE
2013 ANNUAL GEOTECHNICAL INSPECTION

TITLE: SHALE BORROW AREAS

APPENDIX No.:	PROJ No.:	REV:
I-23	0255-023-03	

APPENDIX II
2013 GEOTECHNICAL MONITORING SCHEDULE

2013 Geothechnical and Geothermal Instrument Reading Schedule

BGC Engineering Inc.

		1-Jan	1-Feb	1-Mar	7-Apr	21-Apr	5-May	19-May	26-May	2-Jun	9-Jun	16-Jun	23-Jun	30-Jun	7-Jul	14-Jul	21-Jul	28-Jul	4-Aug	11-Aug	18-Aug	25-Aug	1-Sep	8-Sep	15-Sep	22-Sep	29-Sep	6-Oct	3-Nov	1-Dec	8-Dec	15-Dec	22-Dec	29-Dec
West Twin Dyke																																		
TC12	Thermocouple	Not functioning																																
TC13A	Thermocouple	Not functioning																																
TC31	Thermocouple	Not functioning																																
TC32	Thermocouple	Not functioning																																
TC33	Thermocouple	Not functioning																																
BGC03-33	Thermistor																																	
BGC03-34	Thermistor																																	
BGC05-09	Thermistor																																	
BGC05-15	Thermistor																																	
BGC05-17	VW Piezo.																																	
Surface Cell																																		
BGC02-03	Thermistor	Not functioning																																
BGC03-07	Thermistor																																	
BGC03-09	Thermistor																																	
BGC03-10	Thermistor																																	
BGC03-11	Thermistor	Not functioning																																
BGC03-12	Vibrating Wire																																	
BGC03-14	Vibrating Wire																																	
BGC03-15	Thermistor																																	
BGC03-20	Thermistor																																	
BGC03-21	Thermistor	Not functioning																																
BGC03-32	Vibrating Wire																																	
BGC03-35	Vibrating Wire																																	
BGC03-36	Thermocouple																																	
BGC03-37	Thermistor	Not functioning																																
BGC05-05	Thermistor																																	
BGC05-06	VW Piezo.																																	
BGC05-07	VW Piezo.																																	
BGC05-08	Contingency																																	
BGC05-10	VW Piezo.																																	
BGC05-11	Monitoring Well																																	
BGC05-12	Monitoring Well	Not functioning																																
BGC05-13	VW Piezo.																																	
BGC05-14	Contingency																																	
BGC05-16	Contingency																																	
FG-1	Frost Gauge																																	
FG-2	Frost Gauge																																	
FG-3	Frost Gauge																																	
FG-4	Frost Gauge																																	
FG-5	Frost Gauge																																	
FG-6	Frost Gauge																																	

Weekly Reading

Quarterly Reading

Bi-Weekly Reading

2013 Geothechnical and Geothermal Instrument Reading Schedule

		1-Jan	1-Feb	1-Mar	7-Apr	21-Apr	5-May	19-May	26-May	2-Jun	9-Jun	16-Jun	23-Jun	30-Jun	7-Jul	14-Jul	21-Jul	28-Jul	4-Aug	11-Aug	18-Aug	25-Aug	1-Sep	8-Sep	15-Sep	22-Sep	29-Sep	6-Oct	3-Nov	1-Dec	8-Dec	15-Dec	22-Dec	29-Dec
Toe of West Twin Dyke																																		
BGC03-18	Thermocouple	Not functioning																																
BGC03-19	Thermistor																																	
BGC05-26	Thermistor																																	
Test Cell																																		
BGC05-04	Thermistor																																	
BGC05-18	VW Piezo.																																	
BGC05-19	Thermistor																																	
BGC05-20	VW Piezo.																																	
BGC05-21	Monitoring Well	Not functioning																																
BGC05-22	VW Piezo.																																	
BGC05-23	Monitoring Well	Not functioning																																
BGC05-24	VW Piezo.																																	
BGC05-25	Contingency																																	
FG-7	Frost Gauge																																	
FG-8	Frost Gauge																																	
Test Cell Dyke																																		
BGC02-09	Thermistor	Not functioning																																
BGC03-22	Thermistor																																	
BGC05-29	Thermistor																																	
Toe of Test Cell Dyke																																		
BGC05-27	Thermistor																																	
BGC05-28	VW Piezo.																																	
FG-9	Frost Gauge																																	
FG-10	Frost Gauge																																	
Oceanview Pit																																		
BGC05-01	Thermistor																																	
FG-16	Frost Gauge																																	
East Open Pit																																		
BGC05-02	Thermistor																																	
BGC05-03	Thermistor																																	
FG-13	Frost Gauge																																	
FG-14	Frost Gauge																																	
Landfill																																		
BGC05-30	Thermistor																																	
FG-11	Frost Gauge																																	
Area 14																																		
TC7	Thermocouple																																	
FG-15	Frost Gauge																																	
Upper Dump Road																																		
FG-17	Frost Gauge																																	
West Open Pit																																		
BGC08-01	Thermistor																																	
Mill Cover																																		
BGC08-02	Thermistor																																	
Water Quality / Levels																																		
159-4	Water Level																																	
159-4	Water Quality																																	
Spillway Inlet	Water Quality																																	

- Weekly Reading
- Quarterly Reading
- Bi-Weekly Reading

APPENDIX III
2014 - 2018 GEOTECHNICAL MONITORING PROGRAM SCHEDULE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Suite 200 - 1121 Centre St. NW, Calgary, AB Canada T2E 7K6
Telephone (403) 250-5185 Fax (403) 250-5330

BGC Project Memorandum

To:	**Nyrstar**	**Doc. No.:**	
Attention:	**Johan Skoglund**	**cc:**	
From:	**Geoff Claypool**	**Date:**	**September 16, 2013**
Subject:	**2014-2018 Geotechnical Monitoring Schedule Nanisivik Mine, NU**		
Project No.:	**0255-023-04**		

Dear Johan,

As per your request, BGC Engineering Inc. (BGC) has undertaken a review of the geotechnical monitoring requirements for the now reclaimed Nanisivik Mine site. This review is being conducted in support of the application for the new Water License, which is anticipated to be in place in time for the 2014 monitoring season. This memorandum provides the following information:

- A description of the monitoring program implemented since completion of the majority of reclamation construction activities (2006 through 2012);
- A brief review of the results of the monitoring program, and their significance with respect to performance of the reclamation measures and assumptions and analyses undertaken during the development of the reclamation plan; and,
- A proposed monitoring schedule for the term of the next Water License, which is assumed to be for a five year duration (2014-2018).

As per the Nanisivik Mine Reclamation and Closure Monitoring Plan (GLL 2004)[1], the various surface reclamation covers constructed around the Nanisivik Mine site were instrumented, both pre- and post-construction, to assess the effectiveness of the reclamation measures and to validate the results of various analyses undertaken while developing the reclamation

[1] Gartner Lee Limited. 2004. Nanisivik Mine Reclamation and Closure Monitoring Plan. Prepared for CanZinco Ltd. February 2004.

plan. A conceptual monitoring plan was included in GLL (2004) outlining the monitoring schedule during the Reclamation and Closure periods. The majority of the instrumentation was installed in 2005 and the monitoring plan was implemented in 2006, although monitoring of previously installed instruments continued throughout the construction period in 2004 and 2005. Since 2009, geotechnical monitoring has been conducted as per the schedule included in the current Water License (1AR-NAN0914) which was based on the monitoring schedule proposed in BGC (2008)[2]. Most instruments have been monitored on a bi-weekly basis between June and September with additional quarterly readings obtained typically in April and December or January. The monitoring data is reviewed in an ongoing basis by BGC and a comprehensive assessment of the monitoring data, and its significance with respect to the performance of the reclamation measures, is included in the Annual Geotechnical Inspection report submitted to Nyrstar. The most recent comprehensive review of the geotechnical and geothermal monitoring data was provided in BGC (2013)[3]. This Annual Geotechnical Inspection report is subsequently submitted by Nyrstar to the Nunavut Water Board as a component of the annual report required in the Water License.

Based on the monitoring data collected since the majority of the permafrost aggradation covers were completed in 2005, the following main conclusions are drawn:

- The surface reclamation covers are performing as anticipated. The geothermal monitoring data collected to-date indicates that the covers are generally achieving their design objectives by confining the active layer within the cover and maintaining the underlying tailings in a frozen state (see Figure 1). The monitoring data indicates that performance of the covers continues to improve with time, despite the warmer than average climate conditions experienced by the site since the covers were constructed.
- Freeze-back of the Surface Cell and Test Cell taliks is occurring as expected. The monitoring data collected to-date indicates that cooling of the subsurface profile is continuing. In the Surface Cell, the upper 15 to 20 m of the subsurface profile is frozen back in most areas (see Figures 2 and 3). The monitoring data collected to date validates the results of the talik freeze-back modeling undertaken during the development of the West Twin Disposal Area (WTDA) reclamation plan (see Figure 4).
- In the Test Cell, the freeze-back is also occurring, with at least the upper 10 m of the subsurface profile frozen in the centre of the talik (see Figure 5).
- The freeze-back of the Surface Cell talik has resulted in elevated pore pressures in the centre of the talik (see Figure 6). This was expected and validates the

[2] BGC Engineering Inc. 2008. Proposed 2008-2012 Geotechnical Monitoring Schedule. Prepared for Breakwater Resources Ltd. May, 2008.
[3] BGC Engineering Inc. 2013. 2012 Annual Geotechnical Inspection, Nanisivik Mine, NU. Prepared for Nyrstar, February, 2013.

assumptions made regarding talik pore pressures in the Surface Cell during the development of the reclamation plan. The increasing pore pressures are not considered to negatively impact the stability of the West Twin Dike due to the continued downward advancement of the freezing front and the confinement of the pore pressures within the centre of the talik, away from the dike. The pore pressures remain well below trigger levels previously developed as illustrated on Figure 6. The trigger levels signify pore pressures which may be of concern with respect to dyke stability.

- The freeze-back of the Test Cell talik has resulted in only minor increases in pore pressures within the Test Cell talik (see Figure 7). The piezometric data from the Test Cell suggests hydrogeologic connection exists between the Test Cell talik and the Reservoir. This validates the assumptions made during the development of the contaminant loading model component of the WTDA reclamation plan.
- The West Twin Dike and its foundation remain in a perennially frozen state and no indications of instability have been observed (see Figure 8).
- The landfill has frozen back and the cover confines the annual active layer thaw from migrating into the underlying waste materials (see Figure 9). Similar observations with respect to freeze-back of underlying waste and backfill materials and cover performance have been noted at the Industrial Complex.
- The East Open Pit waste rock backfill has frozen back and the cover confines the annual active layer thaw from migrating into the underlying waste materials (see Figure 10). Similar observations with respect to freeze-back of underlying mine wastes and cover performance have been noted at the Oceanview and West Open Pits.

Given the encouraging results of the monitoring program and the positive performance of the reclamation measures observed to-date, it is considered appropriate to reduce the monitoring schedule for the term of the next Water License. A proposed geotechnical monitoring schedule for the term of the next Water License is provided in Table 1 and is summarized below:

- Thermistors will be monitored bi-weekly or monthly between July 1 and September 1, based on the following rationale:
  - Data will be collected bi-weekly from thermistors providing information from the active layer between July 1 and September 1.
  - Data will be collected monthly from thermistors providing information only on freeze-back of the underlying mine waste.
- Vibrating wire piezometers will be monitored on a monthly basis, between July 1 and September 1.
- Frost gauges will be monitored on a bi-weekly basis between July 1 and September 1.
- Water levels at the West Twin Outlet Wall should be recorded on a weekly basis between July 1 and September 1.

- No data collection is proposed to be undertaken outside the July 1 to September 1 window. Data collected from thermistors previously during this time period has shown to be consistently cooling and typically only yields geothermal information when the geothermal profile is at its coolest, especially in the upper 15 m of the depth profile. As such, it is recommended that the quarterly readings typically undertaken during December and April be discontinued.
- Thermocouples will no longer be monitored since many are malfunctioning and the data collected in recent years has been shown to be inconsistent and unreliable. This should be expected given the age of the instruments, many of which were installed more than 20 years ago. Also, the thermocouples are located in areas that have been frozen back for many years. Hence, the data collected from these sites are of limited value.
- No samples will be collected from the groundwater monitoring wells installed in the Surface Cell and Test Cell taliks. All of the monitoring wells are currently inoperable due to malfunctioning heat trace and blocked or bent well casings. Given the encouraging water quality of both the Surface Cell discharge and the outflow from the Reservoir, the water quality in the taliks is not considered to be of critical importance at this time. Should water quality in either the Surface Cell or the outflow from the Reservoir decline in the future, the need for groundwater monitoring may be re-visited.
- The air temperature probe installed on the Surface Cell in 2012 should continue to collect site specific air temperature data for the duration of the next Water License. This data will supplement climate data collected at the Arctic Bay airport.

Monitoring data will continue to be forwarded to BGC immediately after collection for review and assessment. Additionally, the reclamation measures will continue to be inspected on an annual basis throughout the remainder of the Closure Period by a qualified geotechnical engineer. The inspection observations and the monitoring data will be included in the Annual Geotechnical Monitoring Report, along with a comprehensive assessment of the significance of the data with respect to the reclamation measures.

It should be noted that the monitoring schedule proposed herein is based on the expectation that the reclamation measures will continue their current trend of good and improving performance. In the unlikely event that performance is observed to be not as expected, the monitoring schedule may be altered accordingly.

CLOSURE

BGC Engineering Inc. (BGC) prepared this document for the account of Nyrstar. The material in it reflects the judgment of BGC staff in light of the information available to BGC at the time of document preparation. Any use which a third party makes of this document or any reliance on decisions to be based on it is the responsibility of such third parties. BGC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this document.

As a mutual protection to our client, the public, and ourselves, all documents and drawings are submitted for the confidential information of our client for a specific project. Authorization for any use and/or publication of this document or any data, statements, conclusions or abstracts from or regarding our documents and drawings, through any form of print or electronic media, including without limitation, posting or reproduction of same on any website, is reserved pending BGC's written approval. If this document is issued in an electronic format, an original paper copy is on file at BGC and that copy is the primary reference with precedence over any electronic copy of the document, or any extracts from our documents published by others.

This memorandum presents a proposed geotechnical instrument monitoring schedule for the Nanisivik Mine, NU for the term of the next Water License. We trust the information provided herein meets your requirements and expectations. Should you have any questions or comments regarding the information provided herein, please contact the undersigned at your convenience.

Respectfully submitted,

BGC Engineering Inc.
Per:

Original Signed By

Geoff Claypool, M.Eng., P.Eng.
Senior Geological Engineer

Reviewed by:

Original Signed By

James W. Cassie M.Sc., P.Eng.
Vice President, Specialist Geotechnical Engineer

TABLES

Table 1 -
Recommended 2014-2018 Geothechnical and Geothermal Instrument Reading Schedule

							1-Jul	8-Jul	15-Jul	23-Jul	1-Aug	8-Aug	15-Aug	22-Aug	1-Sep
West Twin Dyke															
TC12	Thermocouple		Not functioning												
TC13A	Thermocouple		Not functioning												
TC31	Thermocouple		Not functioning												
TC32	Thermocouple		Not functioning												
TC33	Thermocouple		Not functioning												
BGC03-33	Thermistor	Monthly													
BGC03-34	Thermistor	Monthly													
BGC05-09	Thermistor	Bi-weekly													
BGC05-15	Thermistor	Bi-weekly													
BGC05-17	VW Piezo.	Monthly													
Surface Cell															
BGC02-03	Thermistor		Not functioning												
BGC03-07	Thermistor	Monthly													
BGC03-09	Thermistor	Monthly													
BGC03-10	Thermistor	Bi-weekly													
BGC03-11	Thermistor		Not functioning												
BGC03-12	Vibrating Wire Piezometer	Monthly													
BGC03-14	Vibrating Wire Piezometer	Monthly													
BGC03-15	Thermistor	Bi-weekly													
BGC03-20	Thermistor	Bi-weekly													
BGC03-21	Thermistor		Not functioning												
BGC03-32	Vibrating Wire Piezometer	Monthly													
BGC03-35	Vibrating Wire Piezometer	Monthly													
BGC03-36	Thermocouple	Monthly													
BGC03-37	Thermistor		Not functioning												
BGC05-05	Thermistor	Monthly													
BGC05-06	VW Piezo.	Monthly													
BGC05-07	VW Piezo.	Monthly													
BGC05-08	Contingency														
BGC05-10	VW Piezo.	Monthly													
BGC05-11	Monitoring Well		Not functioning												
BGC05-12	Monitoring Well		Not functioning												
BGC05-13	VW Piezo.	Monthly													
BGC05-14	Contingency														
BGC05-16	Contingency														
FG-1	Frost Gauge	Bi-weekly													
FG-2	Frost Gauge	Bi-weekly													
FG-3	Frost Gauge	Bi-weekly													
FG-4	Frost Gauge	Bi-weekly													
FG-5	Frost Gauge	Bi-weekly													
FG-6	Frost Gauge	Bi-weekly													

Weekly Reading

Monthly

Bi-Weekly Reading

Table 1 - Recommended 2014-2018 Geotechnical and Geothermal Instrument Reading Schedule

							1-Jul	8-Jul	15-Jul	23-Jul	1-Aug	8-Aug	15-Aug	22-Aug	1-Sep
Toe of West Twin Dyke															
BGC03-18	Thermocouple		Not functioning												
BGC03-19	Thermistor	Bi-weekly													
BGC05-26	Thermistor	Bi-weekly													
Test Cell															
BGC05-04	Thermistor	Bi-weekly													
BGC05-18	VW Piezo.	Monthly													
BGC05-19	Thermistor	Bi-weekly													
BGC05-20	VW Piezo.	Monthly													
BGC05-21	Monitoring Well		Not functioning												
BGC05-22	VW Piezo.	Monthly													
BGC05-23	Monitoring Well		Not functioning												
BGC05-24	VW Piezo.	Monthly													
BGC05-25	Contingency														
FG-7	Frost Gauge	Bi-weekly													
FG-8	Frost Gauge	Bi-weekly													
Test Cell Dyke															
BGC02-09	Thermistor		Not functioning												
BGC03-22	Thermistor	Monthly													
BGC05-29	Thermistor	Bi-weekly													
Toe of Test Cell Dyke															
BGC05-27	Thermistor	Bi-weekly													
BGC05-28	VW Piezo.	Monthly													
FG-9	Frost Gauge	Bi-weekly													
FG-10	Frost Gauge	Bi-weekly													
Oceanview Pit															
BGC05-01	Thermistor	Bi-weekly													
FG-16	Frost Gauge	Bi-weekly													
East Open Pit															
BGC05-02	Thermistor	Bi-weekly													
BGC05-03	Thermistor	Bi-weekly													
FG-13	Frost Gauge	Bi-weekly													
FG-14	Frost Gauge	Bi-weekly													
Landfill															
BGC05-30	Thermistor	Bi-weekly													
FG-11	Frost Gauge	Bi-weekly													
Area 14															
TC7	Thermocouple	Monthly													
FG-15	Frost Gauge	Bi-weekly													
Upper Dump Road															
FG-17	Frost Gauge	Bi-weekly													
West Open Pit															
BGC08-01	Thermistor	Bi-weekly													
Mill Cover															
BGC08-02	Thermistor	Bi-weekly													
Water Quality / Levels															
159-4	Water Level	Weekly													
159-4	Water Quality	Bi-weekly													
Spillway Inlet	Water Quality	Bi-weekly													

- Weekly Reading
- Monthly Reading
- Bi-Weekly Reading

FIGURES

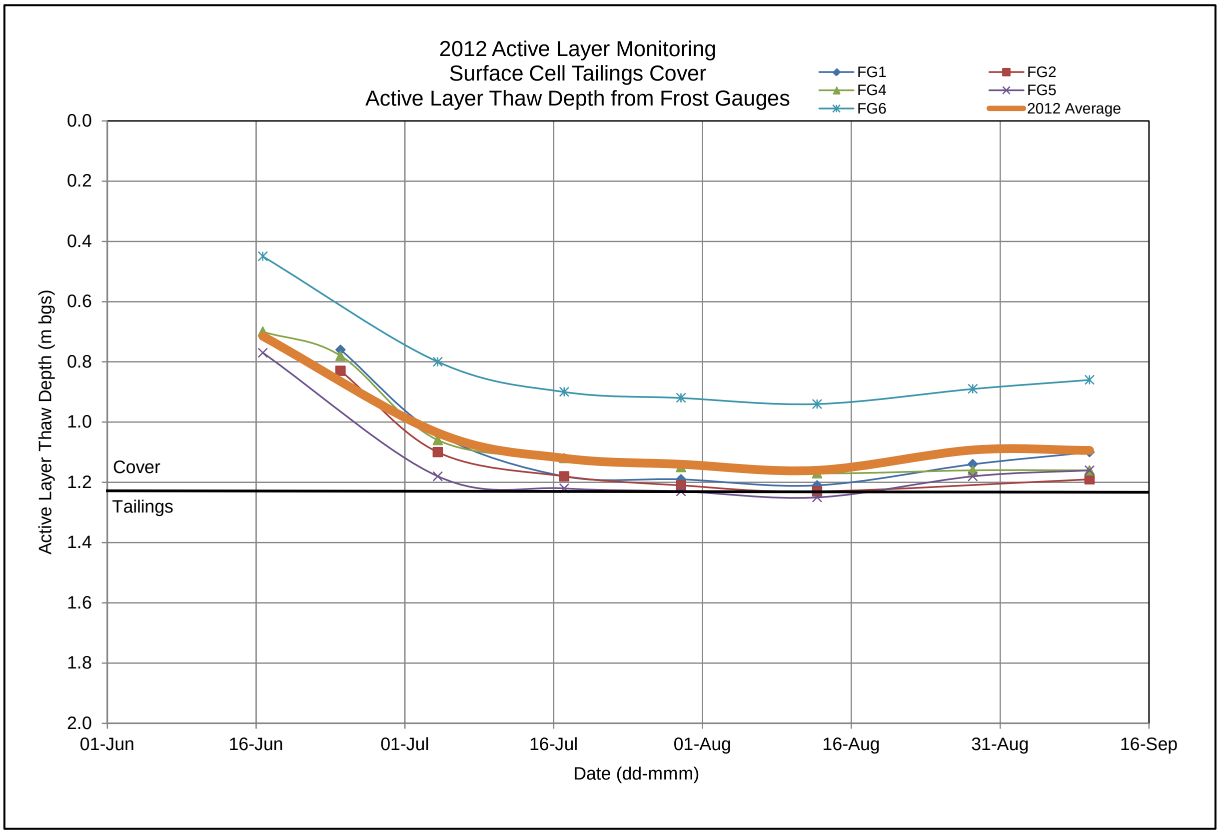

Figure 1. Cover Performance – 2012 Frost Gauge Plot from Surface Cell.

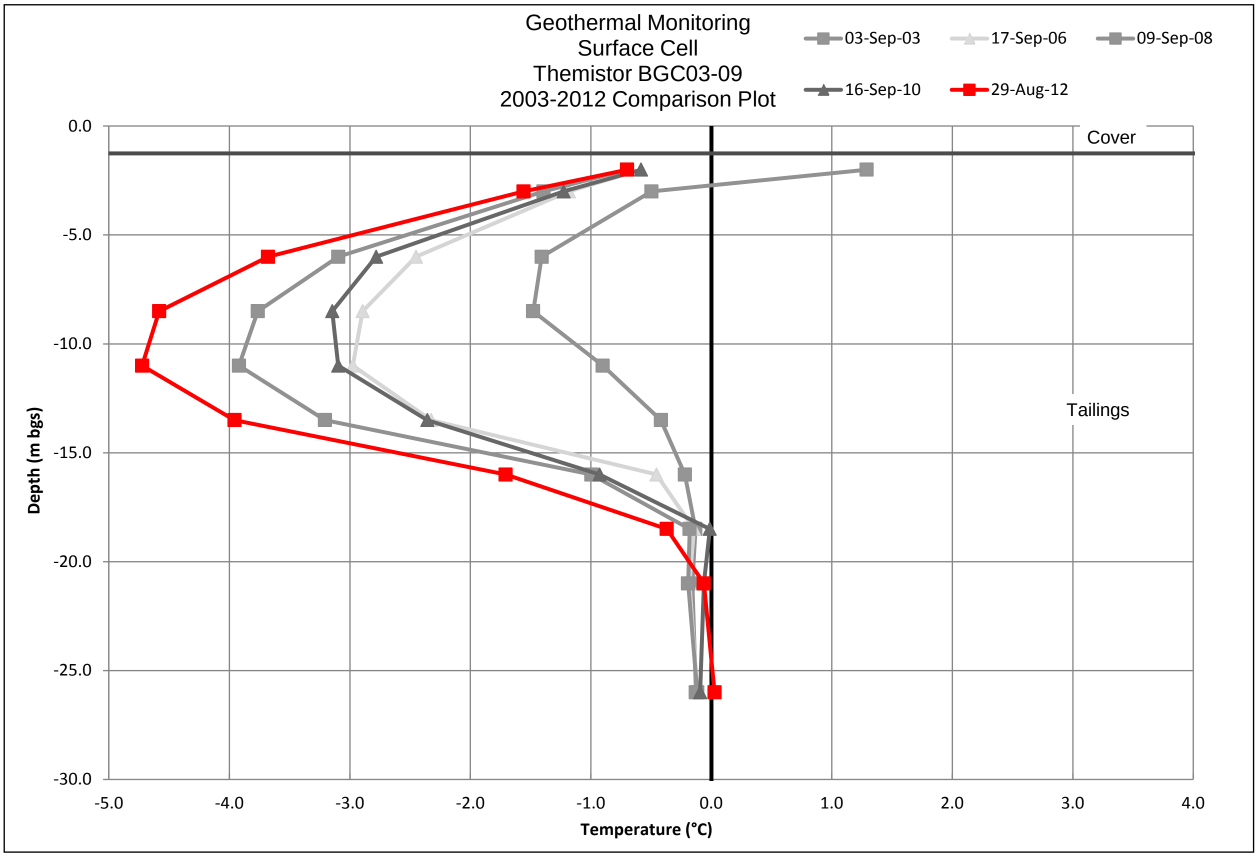

Figure 2. Surface Cell Talik Freeze-back – Thermistor 05-05 near Centre of Surface Cell Talik.

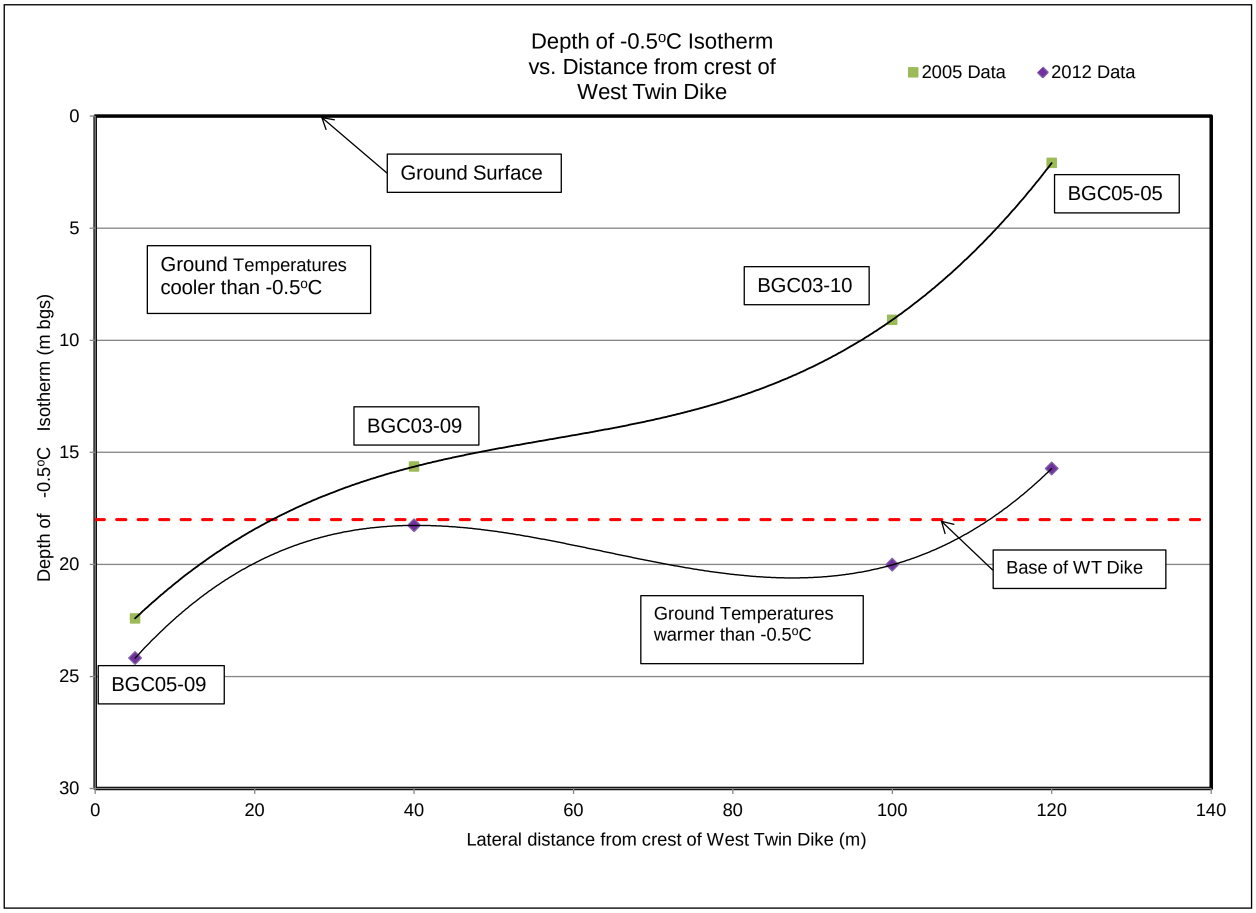

Figure 3. Surface Cell Talik Freeze-back – Downward progression of freeze-back with time and proximity to West Twin Dyke.

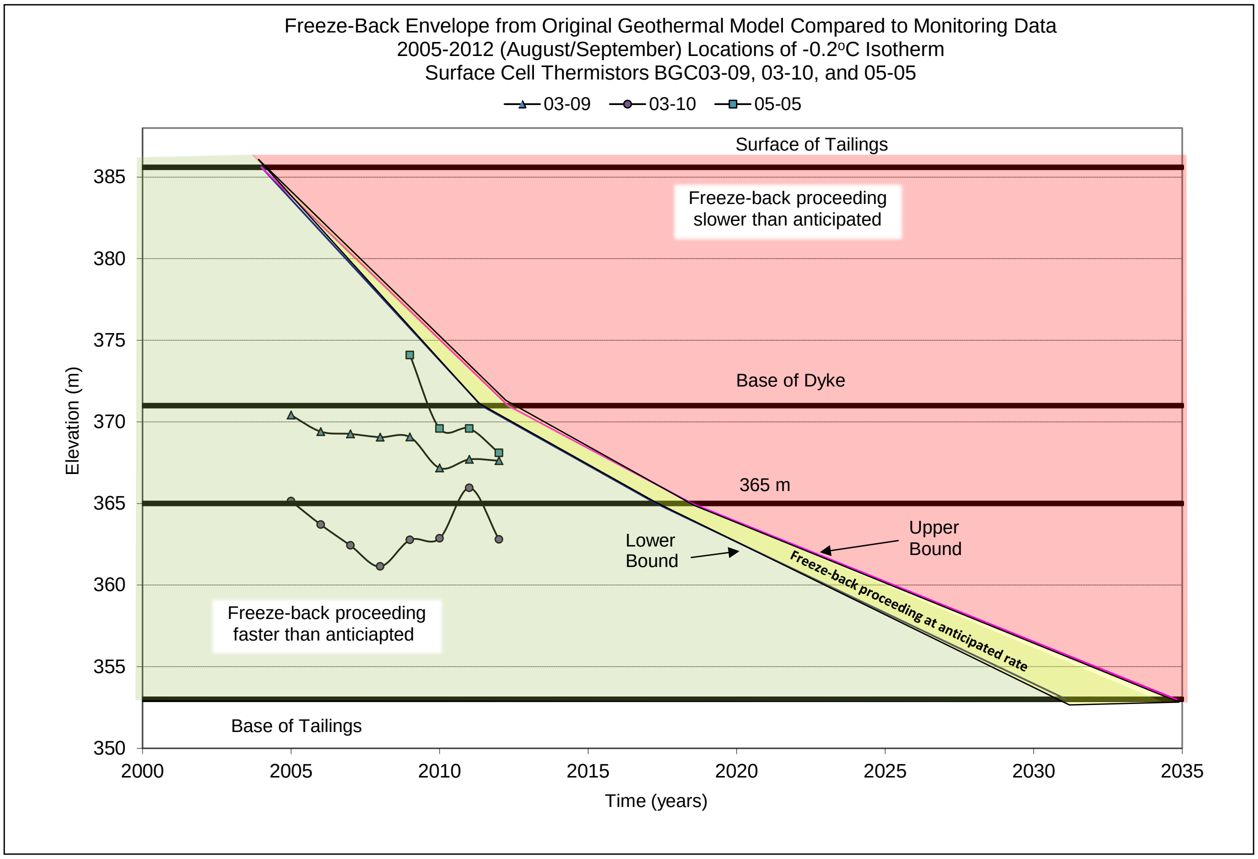

Figure 4. Surface Cell Talik Freeze-back – Comparison of observed freeze-back with previous model results.

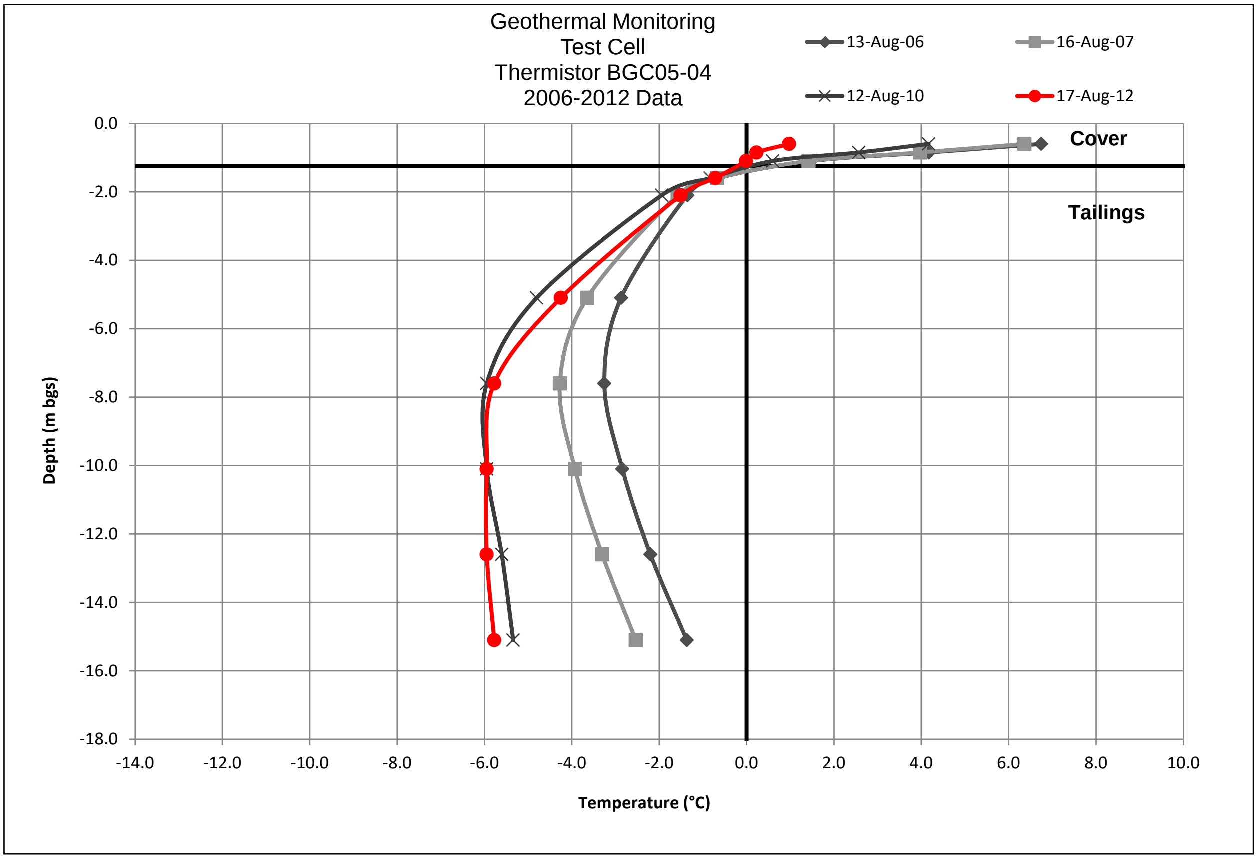

Figure 5. Test Cell Talik Freeze-back – Thermistor 05-19 near Centre of Test Cell Talik.

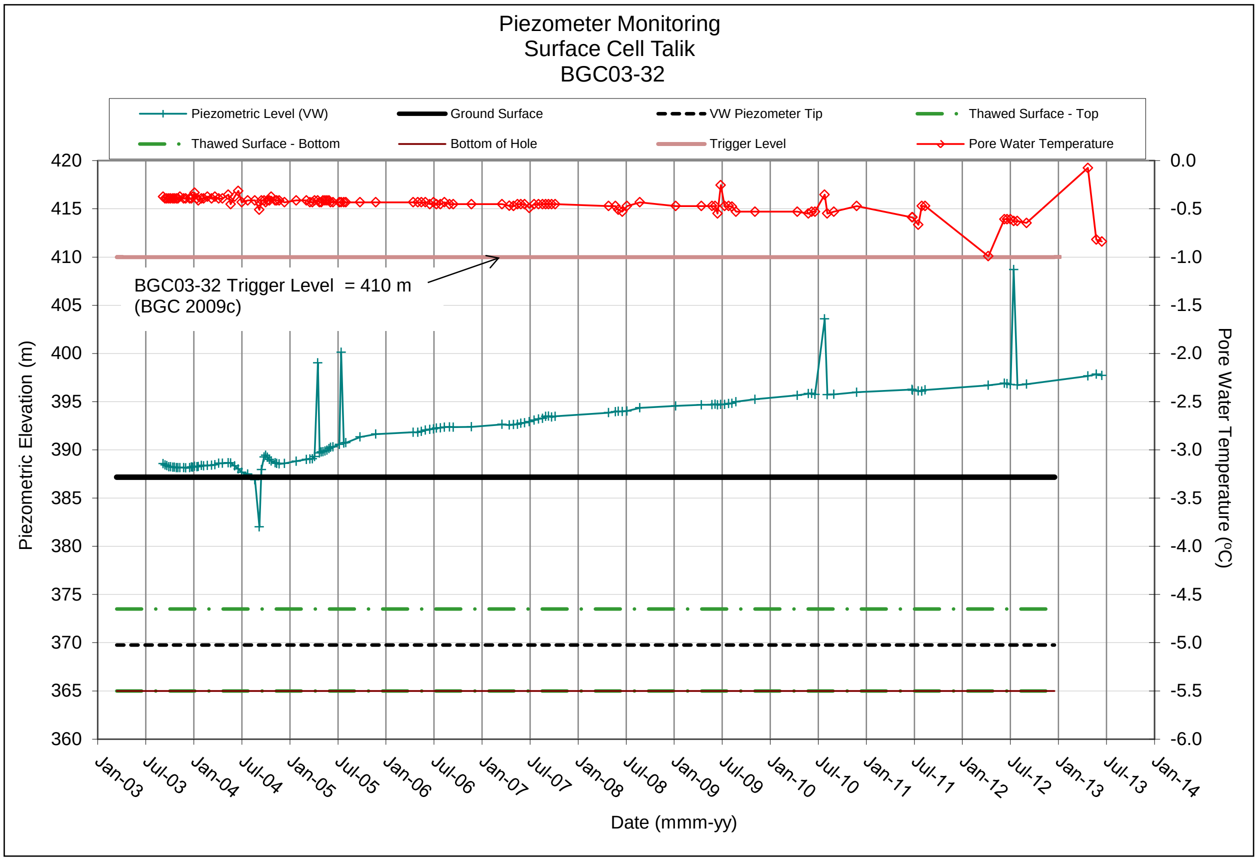

Figure 6. Pore Pressures in Surface Cell Talik.

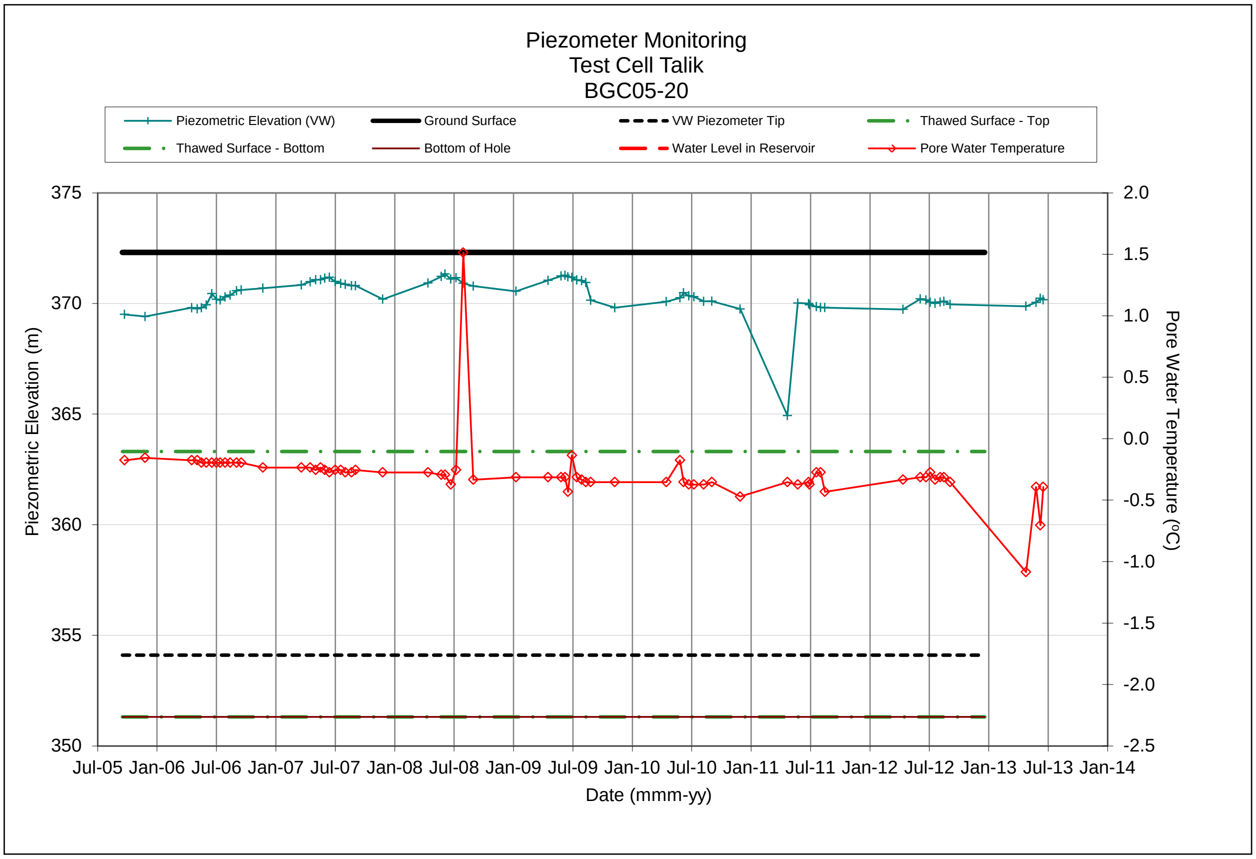

Figure 7. Pore Pressures in Test Cell Talik.

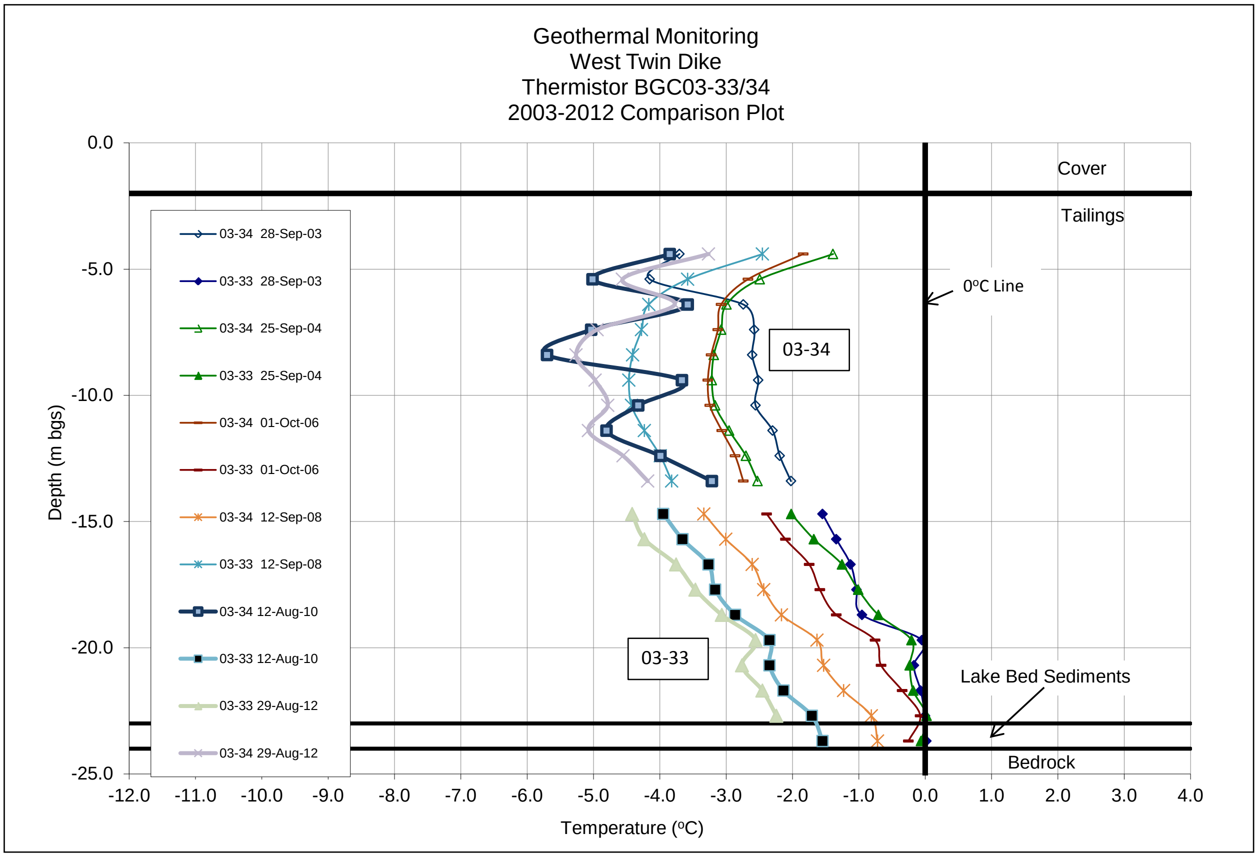

Figure 8. Freeze-back of West Twin Dyke Foundation – Thermistor 03-33/34.

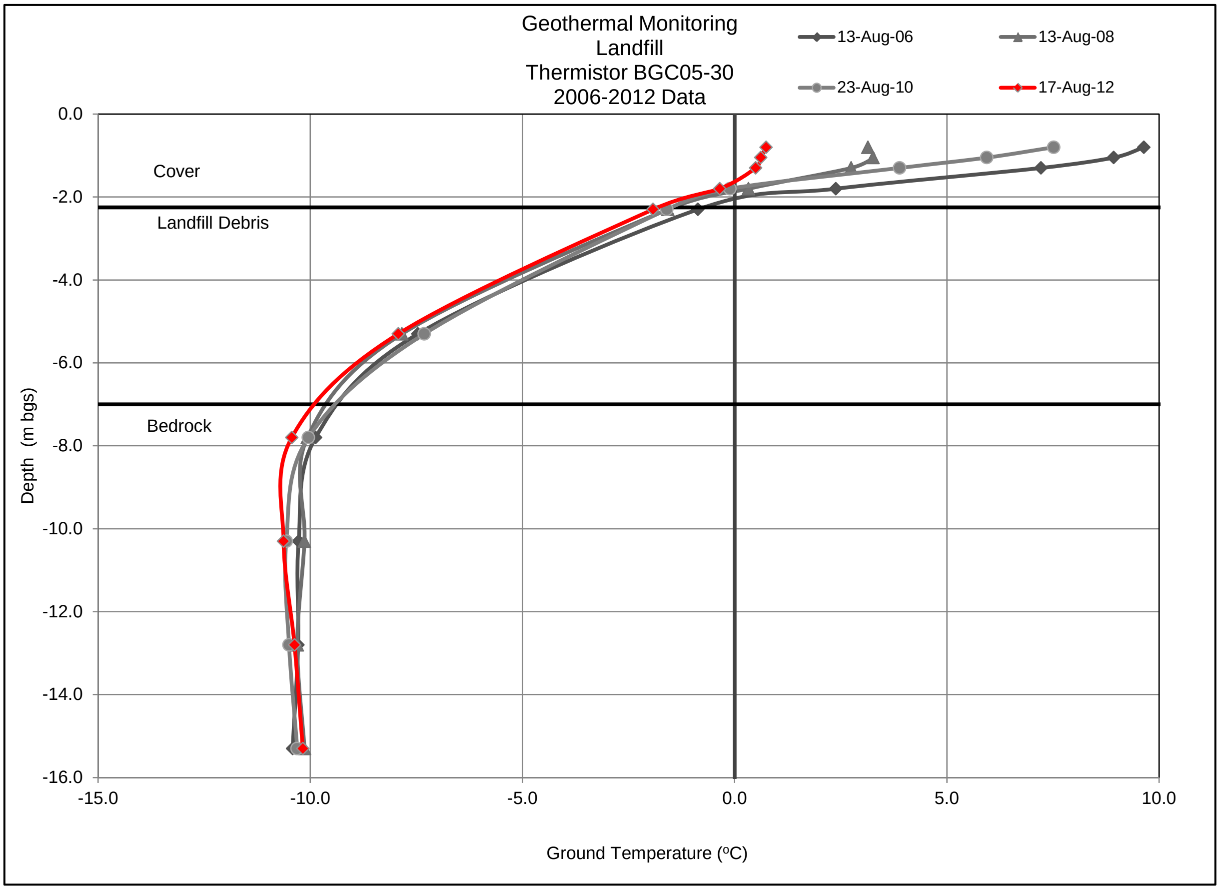

Figure 9. Freeze-back of Landfill – Thermistor 05-30.

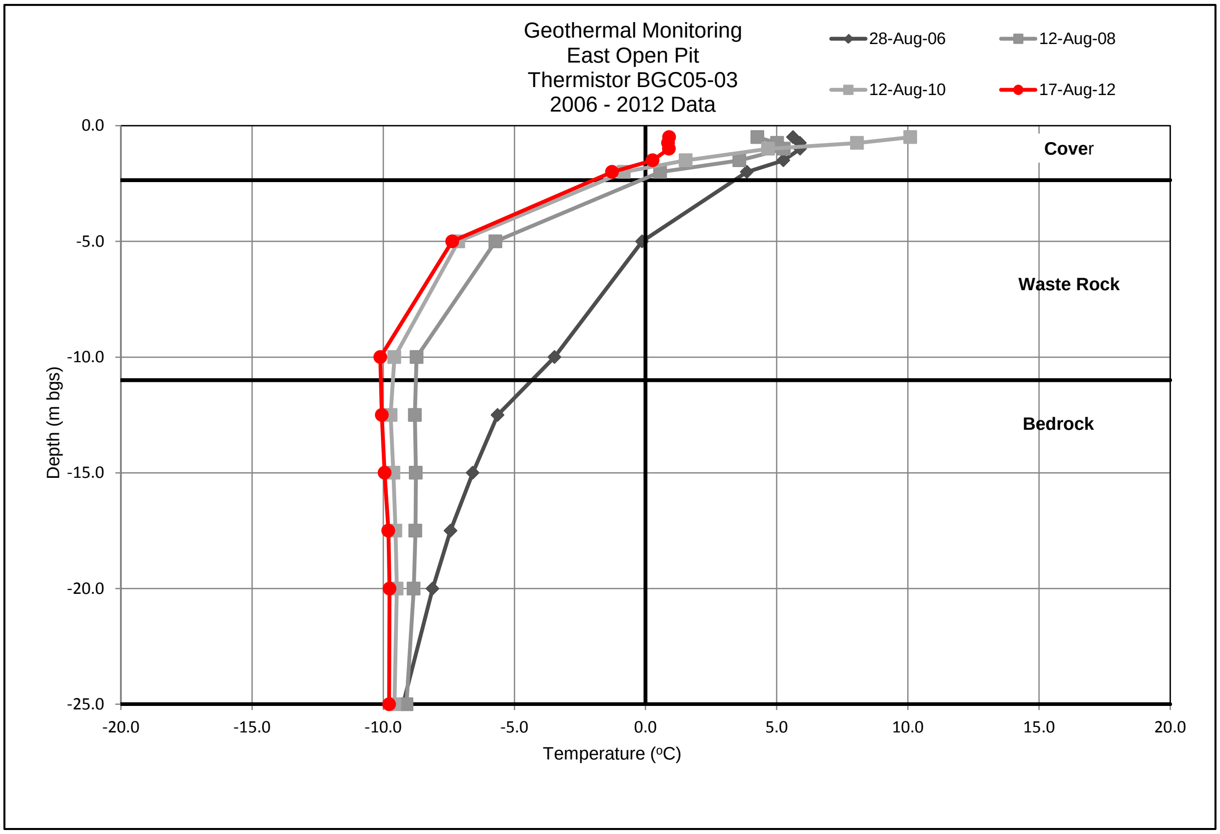

Figure 10. Freeze-back of East Open Pit Waste Rock Backfill – Thermistor 05-03.