BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

NANISIVIK MINE, A DIVISION OF CANZINCO LTD.

2008 ANNUAL GEOTECHNICAL INSPECTION

NANISIVIK MINE, NUNAVUT

FINAL

PROJECT NO.: 0255-017-03
DATE: JANUARY 30, 2009

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Project No. 0255-017-03
January 30, 2009

Mr. Bob Carreau
Vice President, CSR and Sustainability
Breakwater Resources Limited
Suite 950, 95 Wellington Street West
Toronto, ON
M5J 2N7

**RE: 2008 ANNUAL GEOTECHNICAL INSPECTION
NANISIVIK MINE, NUNAVUT**

Dear Bob:

Please find attached our above captioned report on the 2008 Annual Geotechnical Inspection undertaken at Nanisivik Mine. A memo outlining maintenance and monitoring requirements was previously left with Mr. Gary Schnase, acting Site Manager. 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.

Regards,
BGC ENGINEERING INC.
per:

[Original Signed By:]

Geoff Claypool, P.Eng.
Geological Engineer
(direct line 403/250-5185 ext. 104)

Enclosure: Report, Figures, Appendices
GKC/aw

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LIMITATIONS OF REPORT

BGC Engineering Inc. (BGC) prepared this report for the account of CanZinco Ltd., A Division of Breakwater Resources Ltd. The material in it reflects the judgment of BGC staff in light of the information available to BGC at the time of report preparation. Any use which a third party makes of this report, or any reliance on decisions to be based on it are 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 report.

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1.0 INTRODUCTION

Nanisivik Mine is wholly owned and operated by CanZinco Ltd., which is a division of Breakwater Resources Ltd. (Breakwater). Nanisivik Mine is located on the Borden Peninsula on northern Baffin Island, just south of Strathcona Sound, as shown on Figure 1.

Mining operations at Nanisivik ceased in September 2002. Site operations are currently conducted under Nunavut Water Board License NWB1NAN0208 (the License), dated October 1, 2002 which entitles CanZinco (the Licensee) to use water and dispose of waste associated with the closure and reclamation of the mine. Part H, Item 6 of the License states the following:

> "An inspection of the earthworks, the geological regime, and the hydrological regime of the West Twin Disposal Area, East Adit Treatment Facility, and fuel containment berms shall be carried out annually during the summer by a Geotechnical Engineer."

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

> "In addition to the requirements outlined in Part H, item 6, of the License, the Licensee shall include inspection of all portals, adits, 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 (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. Bob Carreau, Vice-President CSR and Sustainability for Breakwater, 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 Dike
	Test Cell Dike
	East Twin Creek Diversion Dike
	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 Dike
	Toe of West Twin Dike
	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
	Lower Adit
	Shale Hill Raise
	Oceanview East and West Raises
	Area 14 Raise
	Former Portal to Mill Foundation
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 dike and channel and the dump containment ponds was provided by Kilborn Engineering Ltd. Golder Associates Ltd. prepared the annual inspection reports for the waste containment dikes in 1998 and 1999, while BGC provided the annual inspection reports for 2000 through 2007. 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 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 Dike, toe of the West Twin Dike 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 Portal, Oceanview Portal, K-Baseline Portal, 17 North Portal, 88 North Portal, 00 Portal and 01 Portal.
- A fill pillar was constructed beneath the 00/01 crown/rib pillar.
- The West Twin Dike 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 a portion of the face of the East Twin Creek Diversion Berm.
- The East Adit Treatment Facility was decommissioned by breaching each of the dikes.
- 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 dismatnled 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.

With the exception of some minor maintenance and ongoing monitoring programs, reclamation of the Nanisivik Mine site is now essentially complete.

3.0 CLIMATE REVIEW

Climatic data has been collected by Environment Canada since 1976 at the Nanisivik Airport, which is located approximately 10 km south of the West Twin Disposal Area and approximately 250 m higher in elevation. The recorded climate data were analysed 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 was (MAAT) estimated to be -15.2°C.
- The mean annual precipitation totals 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.

Figure 2 illustrates the long-term mean monthly temperature values (Nanisivik Airport) versus the monthly values for 2008. Table 2 provides a summary of the climate data recorded at the Nanisivik airport since 2003.

Table 2 - Summary of Climate Data 2003-2008

	Mean Annual Air Temperature (°C)	**Total Annual Precipitation (mm/yr)**
Long Term Averages (1977-2007)	-14.8	282
2003	-13.3	333
2004	-15.7	305
2005	-13.5	502
2006	-12.4	455
2007	-13.0	~250*
2008	-13.7	n/a

*Data record missing data from entire month of December.

It should be noted that the weather station at the Nanisivik Airport operated by Environment Canada was replaced in 2008 and no longer is capable of recording precipitation amounts.

As indicated in Table 2, 2008 was an above average year for air temperature but was the coolest year since the reclamation covers were completed in 2005. The MAAT was approximately 1.1°C warmer in 2008 than the long term average. The mean monthly temperature recorded in February, March, September and December were observed to be cooler than the long term monthly average. The remainder of the months had mean monthly temperatures equal to, or warmer than, the long term average for that month.

It should also be noted that although 2008 was observed to be warmer than average, the observed air temperatures were still significantly cooler than the “High Sensitivity” estimate for global warming, -10.1°C, used in the thermal cover design, as documented in BGC (2004b).

To further assess the thaw season climate data, the average monthly temperatures and thaw degree days between May and September for 2003 through 2008 are provided in Table 3.

Table 3 - Summary of Thaw Season Climate Data 2003-2008

Parameter	Average Monthly Air Temperatures (°C)					Average Air Temperature From May to September (°C)	Air Thawing Index (°C x Days)*
	May	June	July	August	September		
Monthly Average (1977-2007)	-10.3	-0.2	5.1	1.8	-5.3	-1.8	293
2003	-8.6	0.0	6.3	0.3	-5.1	-1.4	309
2004	-9.2	-1.8	2.8	1.2	-4.8	-2.4	154
2005	-11.3	1.4	4.6	4.1	-4.8	-1.2	337
2006	-6.1	-1.7	5.7	4.7	-1.9	+0.1	352
2007	-12.4	0.7	9.4	5.2	-5.4	-0.5	507
2008	-5.2	1.2	6.9	2.5	-5.8	-0.1	390

* Thaw Degree Day values were calculated using mean daily temperatures.

The data indicates that the average monthly temperature between May and September in 2008 was -0.1°C, approximately 1.7°C warmer than the long term average and 0.4°C warmer than the average temperature recorded over the same time period in 2007. However, when the thaw season air temperatures are converted to air thawing indices (ATI), it is apparent that the summer months in 2008 were cooler than 2007. Because of its focus on the air temperatures during the thaw season, ATI are considered to be a better parameter to characterize thawing potential for each individual year than MAAT values. Figure 3 provides the ATI for the years 1977 through 2008. As can be seen, since 1998 only two years (2002 and 2004) have experienced ATI lower than the long term average.

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 location of each mining area is illustrated on Figure 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 Figure 4. The Surface Cell and Reservoir are separated by the West Twin Dike, a frozen-core, rockfill dike. Prior to construction of the West Twin Dike, tailings were deposited throughout the original West Twin Lake. After construction of the dike, 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 Dike, 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 REVIEW OF 2007 MAINTENANCE RECOMMENDATIONS

The 2007 Annual Geotechnical Inspection Report (BGC 2008a) outlined a number of maintenance recommendations. These recommendations, and their status, as observed during the 2007 inspection, are provided in Table 4.

Table 4 - Summary and Status of 2007 Maintenance Recommendations

Inspection Item	Recommended Maintenance	2008 Comments/ Actions
East Adit Treatment Area	• Dikes were breached in 2006, no dike maintenance required. • Improve drainage through Retention Pond.	• Action cannot be completed due to practical construction considerations. Area will be visually monitored to assess if further remedial actions are necessary.
Main Tank Farm spill containment berm	• Repair the area of the containment berm affected during the adjacent hydrocarbon soils excavation. • Cover areas of exposed liner and repair any observed tears in the liner.	• Some activity undertaken subsequent to 2008 inspection, to be reviewed during 2009 inspection.
West Twin Dike Spillway	• Re-level access road. • Fix settlement area near spillway outlet. • Re-grade area near deflection berms. • Apply additional armour to edge of south side access ramp. • General grading and rockfill placement may be undertaken to improve long term stability of the spillway channel.	• Some activity undertaken subsequent to 2008 inspection, to be reviewed during 2009 inspection.
Surface Cell Tailings Cover	• Backfill thermokarst feature observed along south edge of cover.	• No action yet undertaken.
Test Cell/ Test Cell Dike Cover	• Place rip rap lower on the slope at the shoreline at the Test Cell outlet. • Apply additional compactive effort along north-south arm of Test Cell Dike.	• Some activity undertaken subsequent to 2008 inspection, to be reviewed during 2009 inspection.

Inspection Item	Recommended Maintenance	2008 Comments/ Actions
Toe of West Twin Dike/ Toe of Test Cell Dike	• Backfill thermokarst features observed at toe of West Twin Dike. • Spread rip rap currently stockpiled at shoreline at Toe of West Twin Dike.	• Thermokarst features were backfilled at time of inspection. • Some activity undertaken subsequent to 2008 inspection, to be reviewed during 2009 inspection.
Landfill Cover	• Complete spreading of armour on west face. • Compact the armour surface.	• Some activity undertaken subsequent to 2008 inspection, to be reviewed during 2009 inspection.
West Open Pit Waste Rock Cover	• Apply armour to access road area at the front of the pit.	• Some activity undertaken subsequent to 2008 inspection, to be reviewed during 2009 inspection.
Oceanview Pit Waste Rock Cover	• Backfill small thermokarst feature observed in southeast corner of pit.	• Thermokarst features were backfilled at time of inspection.
17 N Portal	• Backfill thermokarst feature.	• Some activity undertaken subsequent to 2008 inspection, to be reviewed during 2009 inspection.
Oceanview Portal	• Repair settlement in SW corner. • Improve grade behind surface water deflection berm to prevent ponding.	• No action yet undertaken.
Area 14 Raise	• Construct surface mound.	• No action yet undertaken. Given stable performance over 20 years, additional remedial action no longer considered necessary and area will continue to be monitored.
Townsite Shale Borrow Area	• Re-slope crest of pit (portion which remains near vertical). • Re-grade floor of pit	• Some activity undertaken subsequent to 2008 inspection, to be reviewed during 2009

Inspection Item	Recommended Maintenance	2008 Comments/ Actions
	when material removal complete.	inspection.
Area 14 Armour Borrow Area	• Re-grade thermokarst area.	• No action yet undertaken. Given stabilization of area observed since 2006, remedial action no longer considered necessary and area will continue to be visually monitored.
Former Portal to Mill Foundation	• Armour surface of portal plug.	• Some activity undertaken subsequent to 2008 inspection, to be reviewed during 2009 inspection.
Instrumentation/ Monitoring	• Replace Frost Gauge 9 in the Test Cell. • Replace Frost Gauges 13 and 14 in the East Open Pit. • Add more methyl blue solution to frost gauges that require it. • Install frost gauges and a thermistor at the West Open Pit. • Install frost gauges and a thermistor at the Industrial Complex. • Obtain more water quality samples for metals testing at the toe of the East Open Pit cover.	• Frost gauge maintenance planned for spring 2009. • Boreholes for thermistors drilled in 2008, instruments to be installed prior to spring 2009 monitoring season. • Water quality included as larger site monitoring program.

As noted in Table 4, many maintenance items were addressed subsequent to the 2008 inspection. These activities will be reviewed during the 2009 inspection to confirm if any additional maintenance is required. Any maintenance items identified in previous inspections that have yet to be addressed, or have only been partially addressed, have been carried forward as recommendations for 2008. More information regarding the 2008 maintenance requirements is provided in Section 6.

6.0 2008 INSPECTION CONDITIONS

Mr. Geoff Claypool, P.Eng., conducted the geotechnical site inspection between July 14 through 16, 2008. Each of the elements from Table 1 were inspected on foot. Pertinent observations concerning the physical condition of each element were recorded by photograph. The photographs and field notes constitute the field record which provides the basis for this formal report.

After completion of the site inspection tour, a memo (attached in Appendix I) was forwarded to Mr. Gary Schnase, acting Site Manager, summarizing the conditions observed and the resulting recommendations.

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 Dike,
- Test Cell Dike,
- East Adit Treatment Pond Dike,
- East Adit Retention Pond Dike,
- 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 Dike and Test Cell Dike 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 Dikes

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 Figure 1. The facility was comprised of a Treatment Pond and a Retention Pond, both of which employed earthen dikes 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 dikes 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 Dike is approximately 5 m above the surrounding ground surface. The Retention Pond Dike 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 dikes 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 dikes at an angle of approximately 3(H):1(V).

Inspection Conditions

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

- Some ponding of water was noted in the East Adit Retention Pond.
- Some channelization of remnant sediments was observed in the East Adit Treatment Pond.

Additional grading could be done at the former Retention Pond to further reduce the size of the remaining shallow pond although the soft ground conditions in the area may prevent this action due to practical construction considerations. It should be noted that this pond does not appear to be creating a negative environmental impact and the small depression that contains the pond will likely fill with sediment over time eventually eliminating the pond. As such, additional remedial actions at the EATF 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 Figure 1. The berm provided contingency storage for fuels should 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

Select photos from the inspection are provided in Appendix II (Figure II-2). The main observations made during the inspection are summarized by the following:

- The liner, berm and tanks had been completely removed as part of reclamation efforts.
- The area where the day tank farm used to be was well drained and no ponding of surface water was observed.

No additional maintenance was recommended for this area, in terms of geotechnical requirements. It is assumed that any and all geo-environmental considerations have been addressed by other parties.

6.1.3 Main Tank Farm Spill Containment Berm

Construction Details

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

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

Inspection Conditions

Select photos from the inspection are provided in Appendix II (Figure II-3). The main observations made during the inspection are summarized by the following:

- No seepage was observed at the toe of the berm.
- No erosion or sloughing of either the upstream or downstream face of the berm was observed.
- A portion of the berm was removed adjacent to the hydrocarbon soils excavation outside the containment facility.
- The liner is exposed at several locations on the inside of the containment berm.

During the excavation of hydrocarbon contaminated soils in the dock area between 2006 and 2008, a portion of the main tank farm spill containment berm was affected. The affected area was approximately 20 m long (lateral distance along the berm), from the crest to the toe of the berm. The excavation has resulted in an oversteepening of the berm face and exposure of the GCL liner.

In general, the berm appears to be in a satisfactory condition, except for the area affected during excavation of nearby hydrocarbon soils. The affected area should be re-sloped to match the grade of the adjacent slopes and the GCL liner should be re-buried to prevent damage to the liner. It is also recommended that any area of exposed liner within the berm be covered to prevent damage from occurring. Also, any torn portions of the liner should be repaired. Based on information from site, it is understood that some of this work was undertaken after the inspection in 2008. This work will be reviewed as part of the 2009 inspection.

It should be noted that the inspection of the Main Tank Farm area was limited to surficial observations of the dike. Due to practical limitations, no assessment of the integrity or effectiveness of the buried, internal liner was undertaken.

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 Dike Spillway;
- West Twin Outlet Channel; and
- 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 Dike Spillway

Construction Details

The West Twin Dike Spillway is located at the south end of the Surface Cell, as show on Figure 4. 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 rip rap.

Inspection Conditions

Select photos from the inspection are provided in Appendix II (Figure II-4). 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.
- Some minor erosion was occurring along the edge of the access ramp on the southwest side of the spillway.
- One settlement area was noted within the bottom of the spillway near the outlet.

- No slope debris was noted in the bottom of the channel as it had been during previous inspections. This may suggest the weathered diabase area is beginning to reach thermal equilibrium and the additional armouring applied to the north side of the channel has increased stability of this area.

The following maintenance items were recommended:

- Re-level the access road along the edge of the spillway channel to prevent ponding and improve long term stability.
- Place additional rockfill in the settlement area near the spillway outlet.
- Re-grade the rutted area near the up-slope water deflection berms.
- Apply additional armour to the edge of the south side of the access ramp where erosion has been noted.
- General grading of the spillway area may be undertaken to improve the long term stability of the spillway channel.

Based on information from site, it is understood that this work was undertaken after the inspection in 2008. This work will be reviewed as part of the 2009 inspection.

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 show on Figure 4. 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 wide 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 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.

Based on observations made throughout the open water season in 2008, the response to installation of the GCL has been favourable. Water was observed to be flowing over the outlet wall for much of the open water season. During times of low inflows into the Reservoir, such as the time of the inspection in early July, the water level upstream of the wall was generally maintained to within 5 cm of the invert of the wall.

It should be noted that the culverts in the East Twin access road that had previously impeded the flow from the Reservoir to the Polishing Pond were removed in September 2008. As a result, the Reservoir is now considered to be a fully flow-through hydraulic system. As such, the performance of the wall in maintaining the elevation of the water level in the Reservoir can, for the first time, be fully assessed during the open water season in 2009. The necessity of any additional remedial actions to reduce seepage losses will be determined after the 2009 inspection.

Inspection Conditions

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

- No new cracks were observed in the exposed portion of the wall.
- The water level upstream of the wall was approximately 3 cm below the crest of the wall. The culverts in the East Twin Lake access road were still impeding flow from the Reservoir into the Polishing Pond at the time of the inspection.

The following maintenance items were recommended:

- Continue to inspect the wall for further cracking.
- Monitor the water level upstream of the wall to assess continued seepage losses.

6.2.3 East Twin Creek Diversion Dike and Channel

Construction Details

The East Twin Creek Diversion Dike is located along Twin Lakes Creek between East Twin Lake and the West Twin Outlet Channel, as shown on Figure 4. The diversion dike 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 dike 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 dike was regraded during reclamation construction to be less susceptible to erosion. Additionally, the regraded portion of the dike was armoured with riprap to prevent future erosion from occurring.

Inspection Conditions

Select photos from the inspection are provided in Appendix II (Figure II-6). No indications of erosion of the dike were observed. The armoured portion of the dike was inspected and observed to be in satisfactory condition. No additional maintenance was recommended.

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 2008 inspection and reviews the monitoring data collected from each area in 2008.

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 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 (Figure 1). The armour material was sourced from the Twin Lakes Delta deposit (Figure 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 II (Figure II-7). The main observations are summarized by the following:

- Some cracking of the cover along the east/west trench was observed, approximately to the same degree, as was observed in 2007.

- A small pond was present at the spillway inlet, as it was in 2007. The maximum depth of water was approximately 20 to 30 cm.
- Some small thermokarst features were observed along the south edge of the cover.
- No erosion of the cover materials was noted.

The following maintenance items were recommended:

- Backfill the thermokarst features observed near the south edge of the cover.

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 Figure 5. Select plots providing the results of the monitoring are provided, for interpretation purposes, on Figures 6 through 12.

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

Figure 6 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 (cooler than -0.5°C).
- Cooling of ground temperatures continues throughout the entire profile, even at depth (i.e. 25 m at 03-07, 20 m at 03-20 and 18 m at 03-15).
- The rate of cooling in 2008 appeared to be at the same increased rate as was observed in 2007 (i.e. 03-20).

Figure 7 provides data from thermistors installed near the centre of the talik. The graphs illustrate the following:

- The upper 12 to 18 m of the ground profile appears to be frozen (cooler than -0.5°C).
- The ground profile continues to cool with time.
- The -0.5°C isotherm continues a downward progression with time.

Figure 8 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 Dike. As can be seen, the data suggests the -0.5°C isotherm has migrated between 4 and 7 m downwards since pre-reclamation conditions observed in 2003. The data also illustrates how the thickness of frozen ground (cooler than -0.5°C) increases with proximity to the West Twin Dike.

Figure 9 provides data collected from some of the piezometers installed in the Surface Cell talik. The graphs indicate the following:

- The piezometers indicate that pore pressures within the Surface Cell talik are generally 7 to 10 m artesian. However, higher pore pressures have been periodically observed in piezometer BGC05-10. The effect of the elevated pore pressures observed at depth in the Surface Cell on the stability of the West Twin Dike was assessed in BGC (2007). Based on the results of the analysis, the pore pressures are not considered to negatively impact the stability of the West Twin Dike.
- The high pore pressures observed at piezometer BGC05-10 are attributed to continued freezing of the pore water immediately surrounding the piezometer tip. As can be seen, the piezometer tip temperature is approximately -2°C. As such, the pore pressures recorded at piezometer BGC05-10 are not considered to be reflective of pore pressures widely distributed within the Surface Cell talik and thus are not considered to negatively impact the stability of the West Twin Dike.
- In general, the pore pressures within the talik are continuing to increase with time.
- The temperature of the unfrozen pore water continues to cool below 0^{o}C, confirming that the talik pore water exhibits a freezing point depression.

Figure 10 illustrates the relationship between talik pore pressures and downward migration of the freezing front. As can be seen, the pore pressures are observed to be somewhat cyclic in nature with periods of increases followed by periods where the pore pressures remain relatively stable. On Figure 10, the pore pressure data from piezometer BGC03-35 is plotted against geothermal data from nearby thermistor BGC03-15. The geothermal data is taken from the thermistor node located at approximately the same depth as the piezometer (~16 to 18 m bgs). Based on this plot, the periods of pore pressure increase appear to correspond to the period of geothermal cooling at depth. Additionally, the periods when the pore pressures are observed to be stable appear to correspond to the period of geothermal warming at depth. This intuitively makes sense, since the pore pressures increases are observed when freezing front migrates downwards, essentially decreasing the size and extent of the talik.

Figures 11 and 12 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 to within the cover materials or the very top of the tailings throughout 2008.
- The geothermal performance of the cover continues to improve with time. The tailings remain frozen throughout the year and are remaining cooler for longer periods of time (i.e. BGC03-11). Additionally, the time period in which the overlying cover materials are thawed continues to decrease with time (i.e. BGC03-20).
- The maximum active layer thaw depth interpreted from the thermistors on Figure 11 ranged from 1.2 to 1.6 m bgs. It should be noted that the interpretation of active layer thickness using thermistor data is based on a linear extrapolation between temperatures of the nodes located across the tailings/ cover interface. The geothermal profile across the tailings cover interface is non-linear, due to the ice saturation within the base of the shale. As such, the interpretations of active layer thaw depths based on thermistor data

are considered to be conservative. It should also be noted that thermistor nodes actually located in tailings were generally observed to exhibit sub-zero ground temperatures year round.

It should be noted that frost gauges FG1, FG2 and FG3 were not monitored in 2008 due to low levels of methylene blue within each of the frost gauges. Maintenance of these frost gauges is planned for this winter and they should be operable again in 2009. It should also 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 units, 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 Dike Spillway are also provided on Figure 12. As can be seen, the concentration of zinc in the water coming off the Surface Cell continued to be low throughout 2008, compared to the historical data record. This suggests that the improved geothermal performance of the Surface Cell cover system observed in 2007 and 2008 has had beneficial effects on the quality of the surface water runoff.

The results of the water quality testing completed on the samples collected from the monitoring wells installed in the Surface Cell talik are provided in Table 5.

Table 5 - Summary of Water Quality Monitoring Results from Surface Cell Talik Monitoring Wells

Monitoring Well	Sample Date	Field Parameters		Total Metals Concentrations (mg/L)		
		pH	Conductivity (mS/cm)	Cadmium	Lead	Zinc
BGC05-11 (edge of talik)	October 13, 2005	10.94	3.23	<0.001	0.004	0.01
	August 27, 2006	11.29	3.69		0.058	0.08
	September 5, 2007*	10.5	3.18	0.0013	0.064	0.09
	August 16, 2008			0.018	0.44	0.3
BGC05-12 (centre of talik)	October 13, 2005	10.28	4.92	0.004	0.628	0.54
	August 27, 2006	10.33	3.69		0.208	0.29
	September 5, 2007*	9.7	3.00	0.0037	0.127	0.17
	August 16, 2008			<0.001	0.02	<0.1

* Note: pH and conductivity values were derived from separate samples collected on August 10, 2007.

The results from the water quality testing indicate the following:

- The metals concentrations closer to the freezing front (BGC05-11) increased significantly in 2008.
- The metals concentrations in the centre of the talik appear to be decreasing over time.

- The metals concentrations closer to the freezing front at the edge of the talik are increasing over time.

The increasing concentration of metals observed closer to the freezing front is likely related to rejection of metals as the pore water freezes, a process known as cryo-concentration. This process was expected to occur as the talik freeze-back occurs. The elevated metal concentrations have likely resulted in an increased freezing point depression, as previously discussed.

6.3.2 West Twin Dike

Construction Details

The West Twin Dike is a frozen core, upstream constructed, earth fill dike that separates the Surface Cell and the Reservoir (Figure 4). The dike is constructed of frozen, compacted shale and founded on frozen, settled tailings. The dike is approximately 14 m high and the downstream face slopes at an angle of approximately 15°. The downstream face of the dike 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 II (Figure II-8). 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 dike shows no indications of erosion or settlement;
- No seepage was noted on the face of the dike or at the toe of the dike.

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

Monitoring Data

The West Twin Dike is instrumented with five thermocouple cables installed within the dike and four thermistors and one vibrating wire piezometer installed from the crest of the dike. The location of each of these instruments is provided on Figures 5 and 13. Select plots providing the results of the monitoring, for interpretation purposes, are provided on Figures 14 through 15.

Figure 14 provides data from thermistors BGC03-33 and BGC03-34, which provide a continuous geothermal monitoring profile from 5 m below the crest of the dike to approximately 24 m bgs, approximately 6 m below the base of the dike. The data indicates the following:

- The entire profile is cooling over time.
- The small zone of tailings between 22 and 24 m bgs previously considered to be thawed now appears to have cooled below -0.5°C, likely indicating the pore water has now become frozen.

- The rate of cooling at depth (deeper than 21 m) appears to have increased in 2008. The increased rate of cooling observed in this interval in 2008 also suggests that the pore water has now become frozen.

Figure 15 provides data from additional thermistors installed from the crest of the dike, as well as one vibrating wire piezometer installed within the thawed zone at depth. The data indicates the following:

- The profile immediately upstream of the dike is frozen to at least 20 m bgs.
- The geothermal profile immediately upstream of the West Twin Dike continues to cool with time.
- The pore pressures within the small thawed zone at approximately 24.5 m bgs (approximately 6.5 m below the base of the dike) are approximately 5.5 m artesian and continue to increase over time (an increase of approximately 0.9 m between September 2007 and September 2008).

Figure 16 provides data from the thermocouples installed within the dike. The data indicates that the dike and the immediate dike foundation remained in a frozen state throughout 2008. It should be noted that the thermocouple data is quite erratic and is only considered accurate to within 1°C (compared to +/- 0.2 °C accuracy of the thermistors). Hence, only general conclusions or trends based on the data obtained from the thermocouples are stated herein.

6.3.3 Test Cell Tailings Cover

Construction Details

A thermal cover was constructed over the Test 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) 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 (Figure 1). The armour material was sourced from the Twin Lakes Delta deposit (Figure 1). The Test Cell tailings cover is drained by a main swale which conveys surface water directly into the Reservoir.

Inspection Conditions

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

- No erosion of the cover was observed.
- No ponding on the cover was observed.
- The rip rap at the Test Cell outlet had yet to be extended below the normal water line.

The following maintenance items were recommended:

- The rip rap at the Test Cell outlet should be extended below the water level to approximately 369.4 m elevation.

Based on information from site, it is understood that some of this work was undertaken after the inspection in 2008. This work will be reviewed as part of the 2009 inspection.

Monitoring Data

The Test Cell is instrumented with two thermistors, four vibrating wire piezometers, two frost gauges and two monitoring wells. The location of each of these instruments is provided on Figure 13. Select plots providing the results of the monitoring are provided on Figures 17 and 18.

Figure 17 provides geothermal and piezometric monitoring data collected from the Test Cell in 2008. The data indicates the following:

- The subsurface profile to 15 m depth in the Test Cell at the base of the West Twin Dike (BGC05-04) is colder than -3^{o}C and is assumed to be frozen. The geothermal profile below 10 m in this area continues to cool with time, even at a depth of 15 m where cooling of more than 1^{o}C has been observed since 2007. Some warming of the top 10 m of the geothermal profile was observed in this area in July 2008, likely in relation to the warm air temperatures observed in May and June of 2008, compared to the same time period in 2007.
- As suggested by thermistor BGC05-29, the subsurface profile inside the former location of the Test Cell dike is frozen to below 15 m bgs and continues to cool with time.
- The pore water pressures throughout the talik generally range from 1 to 3 m bgs. Generally only a nominal increase in pore pressure (< 0.5 m) was observed in 2008, compared to 2007.
- Elevated pore pressures were observed at instrument BGC05-24, likely due to freeze-back of the tailings surrounding the piezometer tip at this location.
- The temperature of the unfrozen pore water is generally between -0.2 and -0.4^{o}C and continues to slowly cool with time. However, the pore water temperature recorded by instrument BGC05-24 is much cooler (-1.7^{o}C), related to the advanced stage of freeze-back at this location.
- When the piezometric monitoring data collected from piezometer BGC05-20 is compared to the water level in the Reservoir, a good correlation is observed. This indicates that the hydraulic connection between the Test Cell talik and the Reservoir remains.

Figure 18 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 2008.
- The geothermal performance of the cover in 2008 is similar to, or slightly better than, what was observed in 2006 and 2007.

It should be noted that no data was collected from the frost gauges in the Test Cell in 2008 due to problems with the frost gauges. Maintenance is planned for the frost gauges and data should be available from these instruments in 2009.

The results of the water quality testing completed on the samples collected from the monitoring wells installed in the Test Cell talik are provided in Table 6.

Table 6 - Summary of Water Quality Monitoring Results from Test Cell Talik Monitoring Wells

Monitoring Well	Sample Date	Field Parameters		Total Metals Concentrations (mg/L)		
		pH	Conductivity (mS/cm)	Cadmium	Lead	Zinc
BGC05-21	August 27, 2006	9.43	4.92		0.501	0.950
	September 5, 2007*	9.5	6.74	0.0272	0.34	1.31
	July 25, 2008			0.0221	0.106	0.38
BGC05-23	August 27, 2006		>5.00		0.150	1.010
	September 5, 2007*	7.9	20.00	0.06	0.30	2.00

* Note: pH and conductivity values were derived from separate samples collected on August 10, 2007.

No sample was collected from monitoring well BGC05-23 in 2008 due to the heat trace not functioning properly. Attempts will be made to repair the heat trace and collect a sample in 2009.

The data indicates the following:

- There was a large decrease in metals concentrations observed in monitoring well BGC05-21, which is located near the centre of the talik.
- The metals concentrations observed in the Test Cell talik in 2008 are similar to the concentrations observed in Surface Cell talik. This may indicate the well has now become fully developed and the metals concentrations are reflective of the pore water quality in the Test Cell talik.
- Despite the hydraulic connectivity between the Test Cell talik and the Reservoir, the higher zinc concentrations exhibited by the pore water in the Test Cell talik does not appear to be negatively impacting the water quality in the Reservoir.

Data from the monitoring wells in the Test Cell should be reviewed with a note of caution. Since the wells are not artesian, they may not be as well developed as the wells in the Surface Cell.

As such, the water quality parameters derived from the lab results may not be entirely representative of the pore water quality within the talik. Additionally, since only limited data is available, any temporal trends suggested by the data should also be viewed with caution.

6.3.4 Test Cell Dike

Construction Details

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

Inspection Conditions

Select photos from the inspection are provided in Appendix II (Figure II-10). The main observation made during the inspection was that the surface of the north/south arm of the Test Cell dike was observed to be soft and undulating with some minor settlement. It was recommended that additional compaction be applied to the surface of the north/south arm of the dike to prevent erosion of these materials.

Monitoring Data

The Test Cell Dike is instrumented with three thermistors. The location of each of these instruments is provided on Figure 13. Select plots providing the results of the monitoring are provided on Figure 19. The monitoring data indicates the following:

- The dike and foundation immediately beneath the dike remained in a frozen state throughout 2008.
- The foundation of the dike is frozen below 20 m bgs.
- The subsurface profile beneath the dike continues to cool, even at depths of 20 m.
- The freezing front is migrating downwards, as shown by the data from BGC03-22 which illustrated the migration of the -0.5^{o}C isotherm from approximately 17 m bgs in 2003 to approximately 20.5 m bgs in 2008.

6.3.5 Toe of Test Cell Dike Tailings Cover

Construction Details

A thermal cover was constructed over the tailings at the toe of the Test Cell Dike 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 Dike, especially immediately adjacent to the remnant Test Cell dike. The shale was sourced from the Mt. Fuji and Area 14 borrow areas (Figure 1). The armour material was sourced from the Twin Lakes Delta deposit (Figure 1). The rip rap was sourced from the dolostone outcrop at the south end of the West Twin Dike.

Inspection Conditions

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

- No erosion of the cover was observed.
- No erosion of the rip rap or disturbance due to ice plucking was observed.

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

Monitoring Data

The cover at the toe of the Test Cell Dike is instrumented with two thermistors, one vibrating wire piezometer and two frost gauges. The location of each of these instruments is provided on Figure 13. Select plots providing the results of the monitoring are provided on Figure 20. The graphs indicate the following:

- The subsurface profile at the toe of the Test Cell dike (BGC05-27) between 4 and 17 m bgs is colder than -0.5^{o}C and is assumed to be frozen. Based on the monitoring data, the geothermal profile above 17 m appears to be cooling with time. The upper portion 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 demonstrates the hydraulic connectivity between the tailings at depth and the Reservoir remains intact.
- The geothermal performance of the cover at the toe of the Test Cell dike was inferred to be improved over the performance in 2008, based on the thermistor data. As illustrated on Figure 20, the temperature of the tailings near the cover/tailings interface was consistently frozen and cooler (by about -0.2^{o}C) in 2008 compared to 2007.

6.3.6 Toe of West Twin Dike Tailings Cover

Construction Details

A thermal cover was constructed over the tailings at the toe of the West Twin Dike 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 (Figure 1). The armour material was sourced from the Twin Lakes Delta deposit (Figure 1). The rip rap was sourced from the dolostone outcrop at the south end of the West Twin Dike.

Inspection Conditions

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

- No erosion of the cover was observed.
- The thermokarst features observed in 2007 had been backfilled and no additional surface deformation was observed.
- Additional rip rap was stockpiled along the shoreline waiting to be placed, as recommended in the 2007 inspection report.
- No erosion of the rip rap along the shoreline was observed.

The following maintenance items were recommended:

- The rip rap stockpiled along the shoreline should be placed appropriately.

Based on information from site, it is understood that this work was undertaken after the inspection in 2008. The work will be reviewed as part of the 2009 inspection.

Monitoring Data

The tailings cover at the toe of the West Twin Dike is instrumented with two thermistors. The location of each of these instruments is provided on Figure 13. Select plots providing the results of the monitoring are provided on Figure 21. The graphs indicate the following:

- The subsurface profile between the bottom of the active layer and the bedrock surface is colder than -4^{o}C and is assumed to be frozen.
- The temperatures at depth measured by Thermistor BGC05-26 are warmer than those observed at the same depth by Thermistor BGC03-19. This is likely due to the fact that BGC05-26 was placed in the area where the decant water from the Surface Cell used to be discharged. This was an area of consistent water cover (1 to 2 m deep) which likely resulted in a warmer geothermal profile at depth.
- The subsurface thermal regime is continuing to cool.
- The geothermal performance of the cover was inferred to be improved in 2008 compared to 2007 based on the thermistor data. As illustrated on Figure 21, the temperature near the base of the cover materials was observed to be cooled throughout much of the summer of 2008, compared to 2007.

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 2008. This channel is considered the final discharge point for water from the WTDA before entering the environment in Twin Lakes Creek. Samples were collected weekly and subsequently forwarded to a laboratory for a variety of tests. Water samples were tested for pH, conductivity, Total

Suspended Solids (TSS), total metal concentrations, and ammonia (NH_3). The total zinc concentrations observed at the West Twin Outlet Channel throughout 2008 are illustrated on Figure 22. As can be seen, the total metal concentrations observed throughout 2008 met discharge criteria, as they have since the covers were completed in 2005. Additionally, the total zinc concentrations observed in August were lower in 2008 than they were in 2007, indicating improved performance. The data suggests that the thermal covers, and the water cover in the Reservoir, are effective in limiting metal loading to the water in the Reservoir.

6.3.7 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 II (Figure II-13). 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.
- The armour surface was observed to be very loose.
- No areas of significant settlement were observed in the cover.

The following maintenance items were recommended:

- Complete the spreading of the armour on the lower portion of the west face.
- Apply additional compaction to the armour surface.

Based on information from site, it is understood that this work was undertaken after the inspection in 2008. This work will be reviewed as part of the 2009 inspection.

Monitoring Data

The Landfill cover is instrumented with one thermistor and one frost gauge. The location of each of these instruments is provided on Figure 23. Select plots providing the results of the monitoring are provided on Figure 24. The graphs indicate the following:

- The landfill debris underlying the cover remained frozen throughout the year.
- The geothermal profile within the underlying landfill debris is generally stable.
- The active layer thaw did not penetrate into the underlying waste material.
- The thermal performance of the landfill cover was improved in 2008 compared to 2007. This is inferred from both the frost gauge and thermistor data provided on Figure 23. The frost gauge data indicates the active layer thickness in 2008 reached a maximum depth of approximately 1.75 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 0.5°C cooler in 2008 compared to the maximum temperature recorded in 2007.

6.3.8 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 II (Figure II-14). The main observations are summarized by the following:

- No erosion of the armour surface was noted.
- No areas of settlement were observed during the 2008 inspection.
- No seepage water was observed at the toe of the cover.
- The roadway across the toe of the cover area had yet to be armoured.

The following maintenance items were recommended:

- Complete the grading and armouring of the access road at the toe of the pit when regular road use is no longer required.

Based on information from site, it is understood that some of this work was undertaken after the inspection in 2008 and will be reviewed as part of the 2009 inspection.

Monitoring Data

One borehole was drilled through the West Open Pit cover in 2008 to permit the installation of a thermistor string. The purpose of the thermistor is to monitor the freeze-back of the underlying waste materials as well as the active layer thaw within the cover materials. The thermistor string has been forwarded to the site monitoring staff and is to be installed prior to the 2009 monitoring season.

6.3.9 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 II (Figure II-15). The main observations are summarized by the following:

- Some minor surface erosion was noted on the upper portion of the cover.
- No seepage was observed at the toe of the cover.
- Some loosening of the rock in the remnant highwall was observed.

In general, the East Open Pit cover appears to be in satisfactory condition. As such, no maintenance was recommended. The loose rock observed in the East Open Pit highwall will eventually fall onto the adjacent bench and does not pose any concern with respect to access to the underground workings.

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 Figure 25. Select plots providing the results of the monitoring are provided on Figure 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.

- 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 and continues to cool with time.
- The active layer monitoring data from Thermistor BGC05-03 indicates that the active layer was confined within the cover materials throughout 2008. The thermal performance of the cover continues to improve with time, suggesting that ice-saturation at the base of the cover is occurring over time.
- Both frost gauges installed in the East Open Pit cover have become inoperative due to the leaking of the methyl blue solution. It is recommended that these instruments be replaced in 2009.

6.3.10 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

Select photos from the inspection are provided in Appendix II (Figure II-16). The main observations are summarized by the following:

- Minor surface erosion was observed near the upslope edge of the cover where a minor amount of water was observed running onto the surface of the cover.
- 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.

6.3.11 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 (Figure 1). The armour material was sourced from the Chris Creek "A" borrow area (Figure 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 II (Figure II-17). 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 indications of flowing water along the upslope edge of the berm.
- Minor surface erosion was noted along the side slope at the south end of the cover. The erosion was noted to be slightly more progressed than was observed in 2007.
- Some seepage was noted at the toe of the cover.
- Some 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 was observed in 2007.
- The thermokarst feature observed in 2007 was backfilled, as recommended in the 2007 inspection report.

In general, the Oceanview Open Pit cover appears to be in satisfactory condition. As such, no maintenance was recommended.

It should be noted that the minor erosion noted on the slope face was not unexpected. The armour material at this location contains a fine grained fraction that was expected to wash away with time. 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, which can be observed in Photo 49 on Figure II-17, 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 Figure 27. Select plots providing the results of the monitoring are provided on Figure 28. The graphs indicate the following:

- The active layer was confined within the cover materials throughout 2008.
- The waste rock underlying the cover has frozen back and remained completely frozen throughout 2008.
- The geothermal profile beneath the cover materials has generally stabilized.
- Based on the thermistor data collected from BGC05-01, the geothermal performance of the cover improved in 2008 compared to 2007. The maximum active layer thaw depth indicated by Thermistor BGC05-01 was estimated to be approximately 1.5 m bgs, compared to approximately 1.6 m bgs observed in 2007.
- The maximum active layer thaw depth indicated by Frost Gauge FG16 was measured to be approximately 1.55 m bgs, compared to approximately 1.45 m bgs observed in 2007.

6.3.12 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 (Figure 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 waste 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 (Figure 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 II (Figure II-18). The main observations are summarized by the following:

- No erosion of the cover materials was observed.
- No areas of significant settlement were observed in 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 Figure 29. Select plots providing the results of the monitoring are provided on Figure 30. The graphs indicate the following:

- The underlying waste rock remained frozen throughout 2008.
- The active layer thaw was limited to the upper 1.4 m of the cover and did not penetrate into the underlying waste rock in 2008.
- The geothermal performance of the cover in 2008 was nominally equivalent to the performance observed in 2006.

It should also be noted that the site staff has indicated that water quality monitoring data collected in Chris Creek, down gradient of the Area 14 waste rock pile, continued to be well within the regulatory criteria throughout 2008.

6.3.13 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 Figure 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 (Figure 1). The armour material was sourced from the Twin Lakes Delta deposit (Figure 1).

Inspection Conditions

Select photos from the inspection are provided in Appendix II (Figure II-19). 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 significant settlement were observed.

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 Figure 31. Select plots providing the results of the monitoring are provided on Figure 32. The graph indicates he following:

- The active layer thaw was limited to the upper 1.8 m of the cover and did not penetrate into the underlying tailings in 2008.
- The geothermal performance of the cover in 2008 was improved compared to the performance observed in 2007.

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 western end of the mine, as illustrated on Figure 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 Figure 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 2008. The observations are summarized by the following:

- No indications of surface deformation were observed.
- No indication of seepage from the mine workings was 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 2007.
- 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. As such, no maintenance was recommended.

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 Figure 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 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

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

- No erosion of the surface of the cover was observed.
- A small (< 1 m diameter) thermokarst feature was observed near the upslope edge of the cover.
- No seepage was observed at the toe of the cover.
- A small amount of surface water was observed flowing along the east edge of the cover.

It was recommended that the thermokarst feature be backfilled.

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 Figure 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 II (Figure II-21). The main observations are summarized by the following:

- A small area of surficial settlement was observed near the southwest corner of the portal cover.
- Some minor cracking was noted along the east edge of the portal cover.
- 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.

The following maintenance items were recommended:

- Fix the area of settlement located in southwest corner of the portal cover by backfilling it with additional armour material.

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 Figure 1. The K-Baseline 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 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 II (Figure II-22). 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.

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. 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 II (Figure II-23). 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.

In general, the Area 14 portal appears to be 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 Figure 2. The 09 South Portal is a culverted entry giving access to the Main Ore Zone. The 09 South drift is approximately 5 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.

The portal plug was not constructed at the time of the July 2008 site inspection. Thus no maintenance recommendations were made at that time.

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 Figure 2. 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.

The portal plug was not constructed at the time of the July 2008 site inspection. Thus no maintenance recommendations were made at that time.

6.4.8 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 is illustrated on Figure 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

Select photos from the inspection are provided in Appendix II (Figure II-24). 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.

6.4.9 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 is illustrated on Figure 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 II (Figure II-24). 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 West Raise

Construction Details

The Oceanview West raise was located near the west end of the Oceanview underground workings, as shown on Figure 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 II (Figure II-24). 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 Area 14 Raise

Construction Details

The location of the Area 14 Raise is illustrated on Figure 1. The raise had a cross section of 5 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

Select photos from the inspection are provided in Appendix II (Figure II-24). During the inspection, it was observed that armour material had been applied to the surface area but no surficial mound had been constructed. Given the stability exhibited by the raise plug over a period of 20 years, additional surficial material is not considered necessary.

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 regrading 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 II (Figure II-25). The main observations are summarized by the following:

- Mt. Fuji
    - The benches are beginning to fill in from the ravelling of the remaining bench faces and are expected to eventually form a stable slope at the natural angle of repose.

    - The instability observed at the crest in previous inspections does not appear to be retrogressing further up slope.
    - Only minor ponding was observed in the floor. The floor is considered well drained.
    - No issues requiring maintenance were observed.
- Area 14
    - In general, the re-graded pit walls appear to be stable.
    - One area of erosion is occurring at the north end of the borrow area where natural surface water discharge occurs into the pit. 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.
    - 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.
    - The surface water drainage should be reviewed in spring 2009, during run-off, to determine if any additional grading is required.
- 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.
    - 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
    - The upper portion of the pit walls remain to be re-sloped, although this appears to be occurring naturally as the remnant bench faces continue ravelling.
    - The re-graded portion of the pit walls appear to be stable.
    - No ponding was observed in the floor of the pit.
    - It was recommended that the upper portion of the pit be re-sloped, as required, and that the bottom of the pit floor be graded once the borrow area is no longer required.

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.

Select photos from the inspection are provided in Appendix II (Figure II-26). 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 minor thermokarsting has occurred, but to a much lesser degree than what was observed in 2006. In general, the borrow area appeared to be well drained and 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.

In BGC (2008b) "Response to Review Comments in INAC Letter August 1, 2008", a comment regarding general contouring of borrow sites was made and should be reiterated here. General contouring and regrading of the site was one of the final tasks of the reclamation process and therefore occurred after the date of this inspection. As part of this process, site personnel have advised that the quarries developed during the reclamation construction process have been regraded such that they were free draining and ponding was not occurring. It should be noted here that there is a fine balance when mechanically contouring surface soils in a permafrost regime. The very act of redistributing surface soils in permafrost regimes can lead to thermokarsting and instability in areas which were previously stable. This being the case, it is sometimes better to leave minor surface disturbances than to introduce the risk of further negative impacts, especially if they are not ponding water or do not have the potential to pond water. All borrow areas will be inspected as part of the 2009 annual review and stability will be commented on in he 2009 Inspection Report.

6.6 Industrial Complex

6.6.1 Mill Foundation

Construction Details

The Industrial Complex is located approximately 1 km north of the townsite (Figure 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 II (Figure II-27). The main observations made during the inspection 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 Industrial Complex cover appears to be in satisfactory condition. As such, no maintenance was recommended.

6.6.2 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

Select photos from the inspection are provided in Appendix II (Figure II-27). The main inspection observations are summarized by the following:

- No erosion of the shale 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. It is recommended that the surface of the portal plug be armoured with appropriate material. The face of the portal plug, once armoured, should be no steeper that 3(H):1(V). Based on information from site, this work was undertaken after the July 2008 inspection. The work will be inspected as part of the 2009 site inspection.

6.7 Other Areas

6.7.1 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

Select photos from the inspection are provided in Appendix II (Figure II-28). The main observations made during the inspection are summarized by the following:

- No erosion of the cover materials was noted.
- 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.

In general, the Concentrate Storage Shed surficial cover appears to be in satisfactory condition. As such, no maintenance was recommended.

6.8 Summary of 2008 Maintenance Recommendations

The maintenance items recommended throughout Section 6 are summarized in Table 7.

Table 7 - Recommended 2008 Maintenance Items

Inspection Item	Recommended Maintenance
East Adit Treatment Area	• Dikes were breached in 2006, no dike maintenance required. • Monitor area for additional grading requirements.
Day Tank Farm spill containment berm	• Tanks, berm and liner removed, no maintenance required.
Main Tank Farm spill containment berm	• Review the following maintenance work undertaken post-inspection in 2008: • Repair the area of the containment berm affected during the adjacent hydrocarbon soils excavation. • Cover areas of exposed liner and repair any observed tears in the liner.

West Twin Dike Spillway	• Review the following maintenance work undertaken post-inspection in 2008:
	  o Re-level access road.
	  o Fix settlement area near spillway outlet.
	  o Re-grade area near deflection berms.
	  o Apply additional armour to edge of south side access ramp.

West Twin Outlet Channel	• Monitor water level upstream of the wall to assess seepage losses. • Continue to inspect the wall for additional cracking.
East Twin Creek Diversion Channel	• No maintenance required.
Surface Cell Tailings Cover	• Backfill thermokarst feature observed along south edge of cover.
West Twin Dike	• No maintenance required.

Test Cell/ Test Cell Dike Cover	• Review the following maintenance work undertaken post-inspection in 2008:
	  o Place rip rap lower on the slope at the shoreline at the Test Cell outlet.
	  o Apply additional compactive effort along north-south arm of Test Cell Dike.

Toe of West Twin Dike/ Toe of Test Cell Dike	• Review the following maintenance work undertaken post-inspection in 2008: o Spread rip rap currently stockpiled at shoreline at Toe of West Twin Dike.

Landfill Cover	• Review the following maintenance work undertaken post-inspection in 2008:
	  o Complete spreading of armour on west face.
	  o Compact the armour surface.

West Open Pit Waste Rock Cover	• Review the following maintenance work undertaken post-inspection in 2008:

Inspection Item	Recommended Maintenance
	• Apply armour to access road area at the front of the pit.
East Open Pit/ East Trench Waste Rock Cover	• Replace frost gauges at East Open Pit.
Oceanview Pit Waste Rock Cover	• No maintenance required.
Area 14 Waste Rock Cover	• No maintenance required.
Upper Dump Pond	• No maintenance required.
00/01 Portals and crown pillar	• No maintenance required.
17 N Portal	• Review the following maintenance work undertaken post-inspection in 2008: • Backfill thermokarst feature.
Oceanview Portal	• Repair settlement in SW corner.
K-Baseline Portal	• No maintenance required.
Area 14 Portal	• No maintenance required.
09 South Portal	• No maintenance required.
Lower Adit	• No maintenance required.
Shale Hill Raise	• No maintenance required.
Oceanview East and West Raises	• No maintenance required.
Area 14 Raise	• No maintenance required.
Mt. Fuji Shale Borrow Area	• No maintenance required.
Townsite Shale Borrow Area	• Review the following maintenance work undertaken post-inspection in 2008: o Re-slope crest of pit (portion which remains near vertical). o Regrade floor of pit when material removal complete.
West Twin Shale Borrow Area	• No maintenance required.
East Twin Shale Borrow Area	• No maintenance required.
Area 14 Shale Borrow Area	• Monitor during freshet to assess additional grading requirements.
Shale Hill Shale Borrow Area	• No maintenance required.
Twin Lakes Armour Borrow Area	• No maintenance required.
Kuhulu Lake Road Borrow Area	• No maintenance required.
Chris Creek Armour Borrow Area	• No maintenance required.
Area 14 Armour Borrow Area	• No maintenance required.
Industrial Complex	• No maintenance required.
Former Portal to Mill Foundation	• Review the following maintenance work undertaken post-inspection in 2008: • Armour surface of portal plug.
Concentrate Storage Shed	• No maintenance required.
Instrumentation/ Monitoring	• Frost gauge maintenance/replacement should be complete prior to the start of the 2009 monitoring season in April. • Install thermistor at the West Open Pit. • Install thermistor at the Industrial Complex.

It is recommended that these maintenance items be completed as soon as practically possible. A record of how and when the maintenance was completed should be kept for inclusion within the subsequent years annual geotechnical report.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Embankments

The work undertaken to repair the affected area of the Main Tank Farm Spill Containment Berm should be reviewed in 2009. At that time, an assessment of further reclamation work can be completed. The East Twin Creek Diversion berm is performing as anticipated and is considered fully remediated. The East Adit Treatment Facility Dikes were breached in 2006. The flow through the Treatment Pond was observed to be relatively unimpeded. However, some ponding was observed in the Retention Pond. Additional grading could be completed to improve drainage through this area and prevent ponding, but given that no negative environmental impacts are known to result from the ponding, additional grading is not considered necessary at this time. The Day Tank Farm was removed in 2007. As such, no maintenance was required in this area.

Hydraulic Structures

The West Twin Dike Spillway is functioning as intended and only minor deformation in the base and side slopes of the spillway has occurred. Maintenance was expected to be required for the spillway during the initial years following construction given the ground conditions encountered during construction. Most of the recommended maintenance items were addressed after the 2008 inspection and these repairs will be reviewed in 2009 to assess the need for additional maintenance.

A small head pond develops in the Surface Cell cover at the spillway inlet. The presence of the head pond is not considered to negatively affect the overall cover performance hence the elimination of the head pond is not considered necessary.

The rehabilitation of the West Twin Outlet Channel undertaken in 2007 appeared to improve the ability of the wall to control the water level in the Reservoir during 2008. The breaching of the East Twin Lake Access Road and removal of the culverts and stop log control structure also create a flow through hydraulic system in the Reservoir/Polishing Pond which should further stabilize the water level in the Reservoir. The channel should continue to be visually monitored in 2009 to assess if seepage losses continue and are significant.

Thermal Covers

The thermal covers appear to be physically stable with only minor erosion observed in isolated areas. The thermal performance of the covers has stabilized and, in many cases, show continued improvement. For the most part, the active layer thaw was contained within the thermal cover at most locations. This is despite the above average air temperatures experienced by site over the early summer months in 2008. 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 occur 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.

Talik Freeze-back

Talik freeze-back is occurring as anticipated in the Surface Cell. Cooling of the subsurface profile is continuing, with the upper 10 to 20 m of the subsurface profile being frozen back. The ground temperatures in the middle of the talik appear to have stabilized after previously experiencing a slight warming trend. The pore pressures in the talik continue to increase, but have been shown to be lowest near the dike and highest in the centre of the talik. The water quality in the Surface Cell talik appears to be changing with time in response to freeze-back of the tailings, as anticipated.

Talik freeze-back in the Test Cell appears to be occurring, but at a slower rate than the Surface Cell talik. The subsurface profile beneath the old Test Cell dike appears to be frozen back down to a depth of approximately 20 m. 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 2004) 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 appear to be physically stable. Minor maintenance recommendations were made at the Oceanview and 17N portals.

Shale and Armour Borrow Areas

In general, the shale and armour borrow areas appear to be physically stable and not causing any significant ponding to occur. They should continue to be monitored to determine if additional maintenance items are required.

Industrial Complex

The cover constructed over the Industrial Complex foundation should be inspected in 2009 and the thermistor string should be installed to monitor the freeze-back of the underlying waste materials as well as the thermal performance of the cover.

8.0 CLOSURE

This report provides a performance assessment of numerous structures at the Nanisivik Mine, based on a one-time visual observation and a review of monitoring instrumentation for some of the dikes and thermal covers.

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.

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FIGURES

APPENDIX I
INSPECTION MEMO

APPENDIX II
INSPECTION PHOTOS