6.2.8 Summary of Geothermal Modelling of Tailings Cover

The design of the cover system for tailings should be composed of a minimum of 0.25 m of Twin Lakes sand and gravel overlying 1.0 m of quarried shale fill. Based on the results of the modeling, this proposed thickness appears adequate to resist both the 1 in 100 year warm event and the High Sensitivity estimate of global warming over the next 100 years. This conclusion is based on the assumption that the thermal properties used within the geothermal model can be constructed (and maintained) within the actual cover system.

6.3 Area 14 – Waste Rock Cover

In the summer of 1988, a sulphide waste dump created at the Area 14 ore body was flattened and covered with a layer of shale material, as reported in Nanisivik Mines (1991). Area 14 is a satellite ore body situated on a west-facing slope, approximately 1 km to the east of East Twin Lake. The Area 14 cover is roughly trapezoidal in shape and approximately 55 m in width in the east-west direction and approximately 40 m in the north-south direction Boreholes were drilled through the shale cover into the underlying material in September 1990 and thermocouple strings were installed. These thermocouples have been monitored since that time and hence, they provide a data set for the long-term assessment of the thermal performance of the waste dump.

Two boreholes and thermocouple strings were installed through the cover in 1990. Borehole #90-2 (also referred to as Thermocouple #8 or T/C#8) is located just some 6 m east of the west crest edge. Borehole #90-1 (also referred to as T/C#7) is situated more centrally within the Area 14 dump, approximately 28 m east of Borehole #90-2. The two simplified borehole logs on Figure 22 and 23 indicate that the shale cover thickness is 2 to 2.1 m.

Thermocouple data has been collected over varying durations and frequencies for both cables since they were installed in 1990. Figures 22 and 23 plot the measured temperatures versus date and measured temperature versus depth for some of the selected dates (i.e. trumpet curves).

It should be noted that data collection was not continuous (e.g. every month). As can be seen from Figures 22 and 23, the frequency of thermocouple readings has been variable since 1990. In fact, no readings appear to be available for the majority of 1991, 1992, 1998 and later than 2000 (up until July 2002 when one additional set of data was recorded). This variation in reading frequency tends to skew the overall trend of the results and potentially the extreme values as well, since it is undetermined if the warmest and the coldest values were recorded during any one specific year.

Initially, from Figure 22, it can be concluded that the shale cover layer on native soils between 1.4 and 5.3 m depth is subzero for the entire period of record. Alternatively, it can be seen that the shallowest node at 1.7 m on shale cover over waste rock (Figure 23) has warmed to 0°C over the period of record.

The two thermocouples cables, even though installed through presumably the same amount and type of shale cover, and subject to the same climatic conditions, show different subsurface thermal regimes. This difference is attributed to the differences in the subgrade materials beneath the cover layer, as noted below:

- T/C #7 (Borehole #90-1) was installed through a cover layer underlain by "native ground" of silty fine sand with gravel and cobbles that was frozen and well-bounded with noted ice lenses. The description appears to indicate that the native material is fine-grained and potentially ice-saturated.
- T/C #8 (Borehole #90-2) was installed through a cover layer into mine waste rock fragments, frozen but with void spaces between rock fragments. Ice inclusions were limited to particle coatings. A 0.3 m thick layer of ice was located below the mine waste layer. The description appears to indicate that the mine waste material was unsaturated.

The cover layer over saturated (and hence, low permeability) in situ soils never warmed greater than –2°C at 1.4 m depth, indicating that the active layer depth was less than the node depth. Extrapolation of the temperature data would indicate an active layer depth of approximately one metre or less, which would be roughly equivalent to the values measured in the Test Cell covers over tailings. Over the five years of early records, supplemented by the data from July 2002, the maximum temperature (approximately –2°C) at 1.4 m depth appears relatively constant.

In the cover layer over unsaturated mine waste, the active layer depth is deeper than the other cable over in situ soils; 1.7 m in T/C#8 versus approximately 1 m in T/C#7. Since it is assumed that the shale cover properties and climatic conditions for the two locations are similar, the only other major difference relates to the saturated nature (and the related permeability) of the underlying substrate. Since the underlying foundation of waste rock is not saturated, water that percolates into the shale cover during active layer thawing can potentially drain from the cover layer into the unsaturated zone under the cover. This is in contrast to the shale cover over the tailings (and also in the shale dike fill on the West Twin Dike) where the increasing saturation of the shale cover layer is easily inferred from site test cell data, given the year after year reduction in the depth of active layer thaw.

As was done for the tailings cover system, it is necessary to determine an extra amount of cover required to ensure freezing of the waste under the expected air temperatures increases due to climate warming until 2100. Based on thermal modeling carried out for the shale cover over frozen, saturated tailings, it was determined that the cover thickness needed to be increased from approximately 0.9 to 1.25 m or an increase of 0.35 m. This amount of thickness increase was for high-moisture content shale and as noted, lower content shale cover would produce approximately 0.15 m of additional thaw. Hence, the following rationale is provided for the shale cover thickness placed over unsaturated materials such as waste rock and landfill wastes:

1.	Thaw depth measured in field trials (over parts of 9 years)	1.70 m.
2.	Increase for global warming estimates for high-moisture content shale	0.35 m.
3.	Additional conservative thickness for lower- moisture content shale	0.15 m.
	Estimated total thickness	2.20 m.

Therefore, based on actual field trial from site, and using high values for climate warming and conservative allowances for moisture contents, a total thickness of 2.2 m of shale cover is recommended for covering unsaturated substrates such as waste rock piles and landfill wastes. As noted in Section 6.2, the thermal properties of the Twin Lakes sand and gravel are similar to that for the shale cover. Hence, up to 0.25 m of shale can be replaced with sand and gravel.

6.4 Summary of Cover Design Verification

The principal conclusions drawn from the review of test cover work include the following:

- Test covers constructed from shale have shown that maintaining subzero conditions above the underlying tailings is possible.
- Best results have been observed from covers located away from heat sinks and covers that incorporate light coloured surface capping materials.
- Moisture conditioning the shale cover material as it is placed decreases the time required to reach stable active layer depths.
- Geothermal modelling has indicated that the depth of the active layer in shale cover over tailings will:
    - reach a depth of around 1.0 m when subjected to air temperatures estimated for a 1:100 warm year, and
    - reach a maximum depth of 1.22 m below ground surface under the High Sensitivity global warming scenario.
- The active layer in shale cover over unsaturated substrate will reach greater depths as compared to the tailings cover. As such, a cover thickness of 2.2 m is recommended for the cover of unsaturated material.

The saturation of the shale during construction would be beneficial in limiting the depth of active layer thaw in the short term. However, moisture conditioning may not be practical considering the large areas that will need to be covered and the time of year the cover will be constructed. Natural infiltration of surface water into the cover materials will be beneficial for increasing the saturation level and the grading plan will consider flat grades to facilitate infiltration.

7.0 SURFACE CELL AND TEST CELL COVER DESIGN

7.1 Objectives and Grading Plan

The closure concept for the tailings in the Surface Cell and the Test Cell is to provide a cover that will mitigate the potential long-term environmental impacts from exposed tailings. The design objectives for the cover are the following;

1. Physically isolate the tailings and prevent water and wind erosion.
2. Place the cover so that permafrost aggradation occurs and the tailings remain subzero through the entire year.
3. Allow for water infiltration to occur into the cover so that water (and the associated ice-saturation) within void space significantly reduces oxygen exchange into the underlying tailings.

The subzero nature of the tailings and the cover will reduce the potential for acid generation by reducing the reaction rate due to temperature effects and limitation of oxygen uptake by the tailings. In addition, the frozen nature of the tailings and portions of the cover reduces the potential for migration of oxidation and/or metals leaching products from the area.

Therefore, the Surface Cell and the Test Cell covers will be constructed of a layer of 0.25 m (minimum thickness) of Twin Lakes sand and gravel (for erosion protection) overlying a 1.0 m (minimum thickness) layer of quarried shale (for insulation and containment of infiltration water). The Twin Lakes sand and gravel will be quarried from the deltaic deposit located between East Twin Lake and West Twin Lake. The shale will be quarried from several sites around the mine site. The majority of the shale is expected to be derived from the Mount Fuji, East Twin Lake and West Twin Lake quarries.

Topographic high points on the tailings surface will be graded prior to construction of the cover to limit the thickness of cover required in the topographic low spots. In addition, where fill thicknesses are greatly in excess of 1.25 m, select native materials such as till or shale quarry strippings may be used. The proposed tailings grading plan for the Surface Cell is illustrated on Figure 24. The cover will be constructed according to the cover grading plan illustrated on Figure 25. The longitudinal grade of the main drainage swales within Surface Cell cover will be constructed to a minimum of 0.5%. The drainage swales will direct surface water to the spillway inlet location near the south edge of the Surface Cell.

The proposed tailings grading plan for the Test Cell is illustrated on Figure 26. The cover will be constructed according to the cover grading plan illustrated on Figure 27. The main drainage swales within Test Cell cover will be constructed to a minimum grade of 0.5%. The drainage swales within the Test Cell cover will direct surface water to the edge of the Test Cell and the water will report to the Reservoir.

7.2 Construction Quantities

The proposed Surface Cell cover grading plan will result in the placement of approximately:

- Regrading of 65,000 m^3 of tailings;
- 400,000 m^3 of shale;
- 95,000 m^3 of Twin Lakes sand and gravel

The proposed Test Cell cover grading plan will result in the placement of approximately:

- Regrading of 7500 m^3 of tailings;
- 151,500 m^3 of shale;
- 27,500 m^3 of Twin Lakes sand and gravel

These quantities are neat and in place with no allowance for bulking.

Quantities for other areas requiring cover are detailed in the Quarry Development and Reclamation Plan Report (Part G, Item 6).

7.3 Survey Limitations

The current survey of the Surface Cell was conducted in September 2003 by Sub-Arctic Surveys Ltd. (SAS) of Yellowknife, N.W.T. The survey was conducted in UTM NAD 83 grid coordinates using an approximate datum to calculate elevations. The survey was converted to mine grid using common points available in both grid systems and a best fit approach. The grading plan presented in Section 7.1 and the construction quantities discussed in Section 7.2 were derived from this survey information. As such, prior to construction, the elevation datum and the mine grid coordinates should be verified and adjusted, if found to be in error. The grading plan and construction quantities for the Surface Cell reclamation cover should be adjusted, based on the updated survey information.

The most current survey of the Test Cell was conducted by mine site staff in 2000. The grading plan presented in Section 7.1 and the construction quantities discussed in Section 7.2 were derived from this survey information. As such, prior to construction, the topography and bathymetry of the Test Cell should be verified. The grading plan and construction quantities should be adjusted based on the updated survey information.

7.4 Material Specifications

In order to achieve the expected performance of the two materials in the cover layer, a number of materials specifications are outlined herein. The cover system has design objectives to meet, as noted in Section 4.0, but certainly, the placement of cover materials do not have such critical structural properties as fill placed within a water-retaining dam, for example.

The shale layer is required for insulation above the tailings and to allow for infiltration (and capture) of surface water into the void spaces. The shale material should not settle excessively so that surface grades are deformed after placement. Additionally, if a 1 m thickness of shale is placed at very low densities, then some resultant settlement would occur, perhaps reducing the effectiveness of the insulating cover. As a result, some control on the density of the shale cover is required.

The quality control aspects of the placement and compaction of coarse-grained soils is problematic for a number of practical reasons. Firstly, it is not possible to undertake Standard Proctor density testing (typical for cohesive soils) on coarse-grained soils, such as gravel and cobbles, since the top-size particle for the test is limited to 20 mm (equivalent to medium-grained gravel). Secondly, a number of in situ tests to check the density of placed fill are either meaningless (e.g. nuclear densometer probe placed next to a cobble) or problematic to carry out (e.g. a sand cone in coarse fill with limited fines content). As a result, it is fairly typical in the quality control of coarse-grained soils to specify a "best efforts" compaction approach (or a "performance specification") rather than a quantitative value relative to the Standard Proctor. The performance specification is set in the field, usually with a test fill, using the required fill material and the construction equipment (dozer and haul trucks) proposed for the operation. Once the test fill is built, a performance specification relating the number of equipment passes, lift thickness, moisture conditions and required density is then set.

As noted, the shale cover needs to be dense enough to control settlement to some extent. Alternatively, the material should be loose enough to allow for surface water to infiltrate. Thirdly, a low amount of fines is desirable to prevent potential frost heaving issues. Therefore, for the shale cover fill, the following protocol is provided in order to set the compaction performance specification before construction proceeds:

- A test pit will be excavated into the top of Test Cell Test Cover #1 (cover is observed to have achieved desired thermal properties). The material removed from the test pit will be weighed, the volume of the test pit will be determined and in the in situ density of that cover material will be calculated.
- A test fill will be constructed, (before final construction proceeds) on a hard substrate, using the required shale fill in layers of uncompacted thickness not exceeding 500 mm. A number of passes with the dozer and haul trucks will be recorded and the in situ density will be determined by excavating a small test pit.

Based on this information, and the other density value obtained from the test pit in Test Cell Test Cover #1, a "performance specification" (number of passes and layer thickness) will be formulated to provide a reasonable and practical level of compaction for the fill. The performance specification will then be checked by monitoring surface operations and that the placement surface is firm, tight and free of ruts from vehicles. Occasional in situ density tests will be undertaken in small test pits to provide quality assurance of the work.

As a result of the foregoing discussion, the following specifications are provided for the shale cover material:

1. Material – dark grey to black shale (and occasional dark grey stringers of dolomitic mudstone) derived from the Lower Member of the Victor Bay Formation. Shale fill shall not contain roots, topsoil, organic matter, debris or any other material deemed unsuitable by the geotechnical engineer.
2. Gradation – broadly graded, run-of quarry sizing within the gradation envelope noted on Figure 28 with a maximum particle diameter of 250 mm and with less than 15% passing 0.075 mm diameter (No. 200 sieve).
3. Compaction level – performance specification will be set later, prior to construction.
4. Moisture content – the moisture content required for construction placement will be that value required to achieve the required performance specification. In some cases, saturation of the shale layer will be allowed, as long as the performance specification is achieved.
5. Lift thickness – a maximum lift thickness of 500 mm of uncompacted material will be tested in the test fill to determine its use for the project. When placing shale over top of thawed (active layer) tailings, a minimum layer thickness of 500 mm is specified. If heavy equipment is used, and tailings are disturbed up into the shale layer, then a thicker layer may be required to avoid disturbing the tailings surface.

The armouring layer of sand, gravel and cobbles is required to prevent wind and water erosion of the underlying shale material. The material may also be useful to reflect solar radiation and hence, lighter colour material is more appropriate. Therefore, the following specifications are provided for the material:

1. Material – light coloured sand, gravel and cobbles derived from the unconsolidated West Twin "sand and gravel" deposit located between West and East Twin Lakes. Fill shall not contain roots, topsoil, organic matter, debris or any other material deemed unsuitable by the geotechnical engineer.
2. Gradation – broadly graded, run-of quarry sizing within the gradation envelope noted on Figure 29 with a maximum particle diameter of 125 mm and with less than 5% finer than 0.075 mm diameter (No. 200 sieve).
3. Compaction level – nominal compactive effort will be required to ensure that the material is firmly placed on the surface of the shale. Final surface shall be firm and tight as observed by visual methods, with no signs of rutting due to construction traffic. No quantitative compaction level is required.
4. Moisture content – no requirements on the placement moisture content, other than to achieve noted compaction levels.
5. Lift thickness – the entire layer thickness of 250 mm may be placed in one lift.

8.0 COVER OF WASTE ROCK AND OPEN PITS

The open pits will be backfilled with waste rock prior to closure. The waste rock and pit walls will then be covered by a layer of shale to prevent oxidation of waste rock and sulphide mineralization outcropping on the pit walls. The details regarding the cover of waste rock piles and open pits are included in the Waste Rock Pile and Open Pits Report (Part G, Item 8).

9.0 COVER OF LANDFILL

The landfill will be covered with shale to limit infiltration and leachate generation. The placement of a cover will also help maintain frozen conditions within the underlying waste material by shifting the depth of the active layer upwards. Details regarding the landfill cover design are included in the Landfill Closure report (Part G, Item 17).

10.0 CONSTRUCTION CONSIDERATIONS

10.1 Construction Schedule Considerations

The remoteness of the site, the available options to transport equipment and supplies to site and the length of the construction season present limitations on the construction schedule for reclamation activities.

Transportation to site by sea generally occurs between July and September, although vessels have come in as early as May and as late as October. Any required heavy equipment or bulk supplies would have to be delivered during these months.

The construction season available for quarrying shale and riprap extends between April and October. Different extraction methods may be required at different times of the year. Blasting may be conducted during the early spring when ground conditions are frozen. Ripping of the thawed portion of the active layer may be completed in late spring and summer. Testing completed earlier by mine site staff on a sample collected from a test blast indicates that similar grain size characteristics can be achieved to that of normal ripping operation.

If saturated, tailings may be displaced into the shale material during cover placement due to the weight of the construction traffic. Therefore, some areas may need to be covered while the ground is frozen. The ponded water in the Surface Cell and Test Cell will need to be removed prior to initiation of cover placement in those areas. Currently, only the subaqueous tailings and a small "island" of tailings on the west side of the Surface Cell would be exposed at surface once the ponded water is removed. The remaining tailings in the Surface Cell are covered by a layer of shale that is estimated to average 300 mm thickness. The tailings currently covered by the thin layer of shale may be covered while the tailings are thawed during the summer due to the increased trafficability provided by the shale cover. Most of the tailings in the Test Cell and toe of the West Twin Dike are currently exposed at ground surface.

The regrading of tailings must be accomplished when the active layer thaw is minimal. It is suggested that regrading of the tailings surface occur in May/June to avoid the poor trafficability later in summer. It is anticipated that the reclamation works will proceed over the summer portions of a two year period.

10.2 Final Construction Drawings

The limitations of the survey information has been discussed in Section 7.3. Construction drawings will be issued following verification of the elevation datum and mine grid coordinates. This may be completed with additional benchmark and elevation data supplied by the mine site.

10.3 Quality Assurance/ Quality Control

A quality assurance/quality control (QA/QC) program is proposed to provide a means to ensure the reclamation covers are constructed to the design specifications and intent. At the current time, the proposed contractual details on who will be undertaking the reclamation work (either an external contractor or internal CanZinco resources), has not been determined. As a result, the exact components of the QA/QC program have not been finalized. The following sections outline the general components of the QA/QC program to be used during the construction of the surface covers.

10.3.1 General

It is assumed that a qualified technical representative responsible for the execution of QA and QC program will include a suitably-trained Field Representative working under the direction of a professional geotechnical engineer. The Field Representative will be on-site daily throughout the construction. This continuous attendance is a requirement in order to produce the as-built report required later. The QA/QC program will be the responsibility of the Field Representative. The Field Representative will ensure that the constructed works conform to contract documents (construction drawings) and the design intent of the reclamation cover described in this document. The Field Representative will have the authority to reject any substandard work and order the contractor to redo the work such that it meets the requirements and the intent of the contract and drawings. The Field Representative will provide daily inspection reports summarizing work undertaken, methodology used, manpower and equipment utilized and written confirmation regarding field decisions made and design alterations permitted.

The Site Supervisor, representing the contractor, will be required to maintain accurate records of all fill placement operations and shall provide the Field Representative with a copy of the daily record at the end of each shift. The following information will be recorded on the fill placement summary sheets:

- Location (coordinates) and elevation at the start and end of fill placement for each major individual area (e.g. Surface Cell) for each shift. Areas that have been placed, spread and compacted should be noted separately from areas that have not been compacted yet.
- Estimated quantity of material placed during the shift.
- Location (coordinates) and elevation of material sources from the borrow pits placed in each shift.
- Confirmation if any shale fill was previously placed before any new shale fill was placed (e.g. in the Surface Cell).
- Number of workers and equipment engaged during the shift.
- Unusual occurrences during fill placement such as unstable soil conditions, extreme precipitation events or variations in fill quality.

These reports will supplement the daily reports to be filled out by the Field Representative.

10.3.2 Fill Placement and QA/QC Testing

Placement of fill materials for the various layers of the cover shall be subject to the following conditions:

- No fill material shall be placed until the substrate (either tailings or shall fill) have been appropriately prepared and graded (if required) and has been approved by the Field Representative.
- Fill materials shall be placed in accordance with lines, slopes, grades and elevations as provided on final construction drawings.
- The placement, handling, spreading and compaction of the fill materials shall be performed in such a manner that the fill material is free of particle segregation, lumps, sizeable lenses, pockets and layers of material that are substantially different in gradation and texture from surrounding materials.
- Any fill material not meeting the noted requirements will be removed, remixed, blended or otherwise reworked to meet the specified requirements.
- Fill materials shall be placed and spread in continuous and approximately horizontal layers of uniform thickness.
- Hauling and placement equipment shall be routed over the fill surface such that they do not follow the same path but that the equipment track loads are spread consistently across the upper surface.

The compaction process will be performance based and will consist of a number of passes from the proposed construction equipment (e.g., dozer, loaded hauled trucks and possibly loaded water trucks, if required). Other criteria for the compaction operation, subject to verification in the test fill, will consist of the following general guidelines:

- Compaction of each layer of fill shall proceed in a systematic and continuous manner so that each portion of the layer receives an equal amount of compactive effort.
- The method of changing direction of the equipment shall result in uniform compaction.
- Overlap should occur between the various passes of the construction equipment.
- It is expected that the upper surface will be free from ruts or any uneven surface. If any are noted, re-levelling and/or additional passes will be required.
- Any oversized particle sizes will be removed from the fill before proceeding with compactive effort.

Alternatively, no compaction specification, other than a firm and tight final surface, is required for the Twin Lakes sand and gravel. Table 17 provides recommended testing frequencies for the two materials for grain size and moisture content determinations. As a result of these requirements (and others noted in the report), it will be necessary to have a geotechnical testing laboratory operating at site during the reclamation period.

Test pits will be excavated by the contractor in locations determined by the Field Representative. Spot thickness of the reclamation cover layers will be measured in these test pits. This information will be recorded by the Field Representative to ensure the minimum cover thickness requirements are being met.

10.3.3 Surveying

Surveyors will be required to undertake the following tasks with respect to the construction of the reclamation covers:

- Layout of survey control points to be used for all later work;
- Grade stakes layout for the various layers within the cover and for surface swales;
- Validation of cover thicknesses;
- Topographic surveys and the calculation of quantities placed for the various materials;
- Coordinates and elevations of all instrumentation installed; and,
- Production of final as-built drawings in both plan and section views.

10.3.4 Instrumentation

As discussed in more detail in Section 11.2, some instrumentation will be installed into and through the cover in order to provide performance monitoring. Instruments that are currently proposed include the following:

- Settlement monitoring points;
- Thermistors;
- Frost Gauges; and,
- Shallow monitoring wells.

The Field Representative, in combination with the Site Supervisor, will be required to coordinate the installation of these instruments, where and when practical.

10.3.5 As-Built Report

As required in the Water License, an as-built report will be produced for all reclamation covers placed on the Surface Cell, Test Cell, Reservoir area, rock piles, open pits and landfill. These reports will contain the following information:

- Summary of construction schedule;
- Summary of quantities and test results on materials placed;
- Summary of technical decisions made as they may deviate from original design specifications and/or intent; and
- A selection of construction photos.

The objective of the as-built report is to confirm that the covers have been constructed in accordance with the design intent. Any deviations, and the associated rationale, will also be included. This report will be stamped by a professional geotechnical engineer, registered to practice in Nunavut.

11.0 PERFORMANCE MONITORING

In accordance with the "Guidelines for Abandonment and Restoration of Mines in the NWT", a performance monitoring program has been developed to provide a means of measuring the effectiveness of the reclamation covers. The monitoring requirements during reclamation and closure periods are fully detailed in the Monitoring Requirements Report (Water License requirement Part G Item 9).

In general, the monitoring program provides for performance monitoring during the 2 year Reclamation Period and for a subsequent 5 year Closure Period. During the Reclamation Period, worker presence at the mine site is anticipated for construction monitoring and the maintenance purposes. This presence will enable the proposed monitoring programs to be carried out by the on-site personnel under the direction of an Environmental Coordinator and geotechnical engineer. During the Closure Period, performance monitoring will be conducted to determine the success of reclamation measures. Continuous worker presence at the mine site is not planned during the post-closure period and environmental monitoring programs will be carried out during regular site visits and possibly utilizing local field assistants and staff hired from nearby Arctic Bay.

Table 18 outlines the proposed monitoring methods and components for the covers.

11.1 Reclamation Period Monitoring

The majority of the monitoring completed during the reclamation period associated with the reclamation covers will involve quality assurance/quality control of construction of the reclamation covers for tailings, waste rock dumps, open pits and the landfill as discussed in Section 10.2. This will include monitoring cover placement to ensure design specifications are met and identify any problems encountered during placement. Detailed construction information will include the following information:

- cover thickness;
- grades and elevations;
- compaction level compared to the performance specification;
- grain size analyses; and,
- moisture content.

Monitoring of installed instruments will be conducted at the required frequency noted in Table 19, subject to their date of installation.

11.2 Closure Period Monitoring

Monitoring during the closure period will focus on collecting necessary information to evaluate the performance and effectiveness of reclamation covers. This will include the collection of ground temperature and water quality information, as well as observing the physical condition of the covers.

The monitoring schedule for the Closure Period is detailed in Table 20. The monitoring schedule is planned to be reduced through the Closure Period in anticipation of the data verifying the effectiveness of the reclamation measures. All thermistors will be read quarterly for the five year period. Frost gauges will be read every two weeks for years 1 to 3. Water quality samples will be collected once per summer for all five years. Geotechnical inspections will occur in the spring and fall for year 1 reducing to once per year for years to 5. During the geotechnical inspection, visual observations of cover deformation will be recorded and in situ samples of the armour sand and gravel, shale and underlying tailings will be collected to assess the performance of the cover. The results of the performance monitoring program will be documented and submitted to the Nunavut Water Board as a component of the annual environmental report.

Also, included in the monitoring program is the climatic data recorded at the Nanisivik AES Station. Yearly records of temperature and precipitation values will be assessed as context for evaluating the cover performance.

12.0 CONTINGENCY PLANS

Several contingency plans have been developed in order to address performance issues that may be identified during the performance monitoring program. The potential issues include erosion of the armouring layer or underlying shale, deformation of the cover as a result of settlement or frost heave, excessive depth of active layer thaw and poor quality of surface water runoff. The consequences of each issue and suggested mitigation approach are identified in Table 21. The mitigation measures range between performing localized maintenance of the covers to treatment of Reservoir water prior to release to the environment. Common to all suggested mitigation measures is identification of the root cause and appropriate reaction to limit the environmental consequences of each concern.

13.0 CLOSING

This report has been developed to satisfy requirement Part G, Item 4 in the current water license for Nanisivik Mine. We trust that this report meets the requirements of Nanisivik Mine and the water license. The report will be finalized upon receipt of your comments.

We would like to thank you for the opportunity to work on this challenging and unique assignment and look forward to providing continued geotechnical service to Nanisivik Mine throughout the closure of the mine.

Respectively submitted,

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PERMIT NUMBER: P 285
The Association of Professional Engineers, Geologists and Geophysicists of the Northwest Territories

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