including some mineralized rock. This material was routinely relocated into the underground mine from 2001 to 2003 such that only a small "remnant" remains on surface.

Run off from the DMS Rejects storage area is intermittent (i.e., there are no permanent streams in the immediate rock pile area). Runoff from this area enters Twin Lakes Creek, which is monitored for water quality prior to entry into Strathcona Sound.

This material is considered to represent a moderate (relative to the other Nanisivik rock piles and open pits) ARD risk that requires mitigation because of the likely content of mineralized rock.

3.4 Description of Open Pits

3.4.1 West Open Pit

The West Open pit is in the West Adit area at the Main (01S) portal. The pit was actively mined from 1980 to 1995 to extract ore that was a small, near-surface surface extension of the underground ore body. Waste rock was either taken directly into the underground mine for use as backfill, placed into the 02 rock dump or, possibly, used as bulk fill in the West Adit Access Road (per Section 4.5.1).

The dimensions of the West Open pit are approximately 75 m by 200 m and the highest pit wall (the east wall) was approximately 25 m. The pit was developed largely as a shallow hole with a ramp access from the west side.

Water that accumulated in the West Open Pit prior to mine closure was pumped on an as-required basis to the Industrial Complex where it became part of the tailings stream delivered to the WTDA. This procedure was implemented because of the occasional high suspended sediment content of the pit water. Since mine closure, a relatively small volume of water has been allowed to accumulate in the pit pending implementation of an approved reclamation measure.

Post reclamation run off from the West Open Pit area will be intermittent (i.e., there are no permanent streams in the immediate rock pile area). Runoff from this area enters Twin Lakes Creek, which is monitored for water quality prior to entry into Strathcona Sound.

The ARD test data summarized in section 3.2 demonstrate that the West Open Pit samples have an overall average strongly positive NNP and NP:AP >3, which is generally interpreted as non-acid generating and not requiring the implementation of ARD mitigation measures. Further, the data set does not contain any samples that have negative or marginal ARD test results. However, it is known that there was mineralized rock in the wall of the pit at some sections and that the pit requires reclamation for land use purposes irregardless of the ARD risk.

3.4.2 East Open Pit

The East Open Pit is in the East Adit area immediately outside of the 39N portal. The pit was actively mined from 1987 to 2001 to extract ore that was a near-surface extension of the underground ore body. Waste rock was either taken directly into the underground mine for use as backfill or placed into the East Adit rock dumps (also referred to as 39N and 39S). A large portion of the waste rock that was placed into the rock dumps had, by 2003, been relocated into the underground mine as part of the progressive reclamation program described above.

The dimensions of the East Open Pit were approximately 100 m by 200 m and the highest pit wall (adjacent to the underground workings) was approximately 20 m. The pit was developed largely as a side hill cut daylighting to the north towards the mine access road.

The 39N adit connected the East Open Pit to the underground mine. In 2002, the brow of the 39N adit was blasted down to extract ore in this area. This blasting blocked the adit with rock and stabilized the "brow" of the adit.

Much of the pit area was backfilled with waste rock from the East Adit rock pile as part of the progressive reclamation activities that were carried out in 2002 and 2003.

Run off from the East Open Pit is intermittent (i.e., there are no permanent streams in the immediate area). Runoff from this area flows to the East Adit treatment facility where, during mine operations, the water combined from several source areas was treated with lime on an as-required basis for metals removal prior to release to Chris Creek. The treatment facility is proposed to be operated on an as-required, contingency basis through the mire reclamation period also. Water quality at the inflow and outflow from the treatment facility will be monitored.

The ARD test data summarized in section 3.2 demonstrates that the East Open Pit (sampled prior to the 2002 and 2003 backfilling activities) is considered to be an ARD risk.

3.4.3 East Adit Trench

The East Adit trench is a relatively small surface excavation located to the east of the East Open Pit. The trench was mined from 2000 to 2001. The dimensions of the East Adit trench are approximately 10 m X 50 m and up to 15 m deep. Approximately 10 m of underground excavation was also completed into the south wall of the east Adit trench. This small underground development did not connect to the main underground workings. Waste rock was placed in the East Adit rock piles.

Run off from the East Adit Trench is intermittent (i.e., there are no permanent streams in the immediate area). Runoff from this area flows to the East Adit treatment facility where, during mine operations, the water combined from several source areas was treated with lime on an as-required basis for metals removal prior to release to Chris Creek. The treatment facility is proposed to be operated on an as-required, contingency basis through the mire reclamation period also. Water quality at the inflow and outflow from the treatment facility will be monitored.

No samples from the East Adit trench were assessed as part of the ARD assessments. However, it is known that there was mineralized rock in the East Adit Trench and it is considered to represent a moderately high ARD risk (relative to other Nanisivik rock piles and open pits) based on an assumed similarity to the East Open Pit sample set. Therefore, mitigation is required. Additionally, reclamation for land use purposes would be required regardless of the ARD risk.

3.4.4 Oceanview Open Pit

The Oceanview Open Pit is in the Oceanview area northeast of the East Adit. This pit was actively mined from approximately 2000 to 2002 to extract surficial and near-surface ore. The Oceanview pit was excavated as a side hill cut daylighting on the north side with dimensions of approximately 75 m X 100 m and up to 10 m deep. Approximately 500 m of underground excavation was also completed in the Oceanview area with an entry point located immediately to the west of the Oceanview pit. This small underground development, mined from approximately 1990 to 1996, did not connect to other underground workings. Waste rock was placed in a local rock pile located to the west of the Oceanview pit.

The Oceanview pit was backfilled with waste rock from the local rock pile as part of the progressive reclamation activities that were carried out in 2002 and 2003. All of the waste rock except a small "remnant" quantity had been relocated into the pit, as of August 2003.

Run off from the Oceanview Open Pit is intermittent (i.e., there are no permanent streams in the immediate pit area). Runoff from this area was pumped out of the pit and underground workings during mine operations but will flow freely over the area after reclamation. Run off water is monitored at the pit.

Although, no samples from the Oceanview Open pit were assessed as part of the ARD assessments, the samples of Oceanview waste rock (i.e., from the rock pile) led to the conclusion provided above that the Oceanview rock pile is considered to represent an ARD risk that does require mitigation. This conclusion is considered to apply equally to the Oceanview Open Pit.

The Oceanview area was selected for mining because of the natural abundance of mineralized soil and rock on surface in this area. The occurrence of natural mineralization on surface extended well beyond the boundaries of the open pit. The area disturbed for development of the open pit and underground entryway will be reclaimed to match the natural contours and to provide a safe surface environment.

3.5 Geothermal Conditions

An investigation of the presence of permafrost at the West and East Open Pits was part of a field program conducted in 2003. BGC Engineering Inc. supervised the drilling of a borehole at each of the pits in August (coincident with the annual maximum thaw penetration). The boreholes were instrumented with thermocouples at various depths. A memo documenting this borehole installation and the initial thermal monitoring results, as prepared by BGC Engineering Inc., is provided in Appendix A.

4. Reclamation Plan

4.1 Specific Reclamation Objectives

The specific objectives for reclamation of rock piles and open pits are to:

1. Minimize the risk of ARD or metal leaching; and
2. Provide a safe surface environment that matches the natural conditions.

The potential for ARD and metal leaching from waste rock and open pits has been assessed, as described in Section 3, and the reclamation measures described below effectively minimize this risk. The ARD assessment described above led to the following relative risk classification of the rock piles and open pits:

1. Highest Risk: K-Baseline and 09-South rock piles;
2. Moderately High Risk: West Adit/02 South rock pile, East Open Pit and (assumed) East Adit Trench;
3. Moderate Risk: East Adit and Area 14 rock piles, (assumed) DMS rejects storage area;
4. Low Risk: West Open Pit; and
5. Lowest Risk: West Adit Access Road, Oceanview rock pile and (assumed) Oceanview Open Pit.

The definition of a safe surface environment for the reclamation of rock piles and open pits is the creation of slopes that correspond to the local natural conditions, the placement of surface materials that also correspond to the local natural conditions and the elimination of surface holes that may be a safety hazard to people or wildlife.

4.2 Approach to Reclamation Activities

The reclamation activities that are proposed for the rock piles and open pits have been grouped according to the areas requiring reclamation as follows:

1. West Adit Area: West Adit/02 South rock pile, 09 South rock pile, DMS Rejects storage area, West Adit Access Road and West Open Pit;
2. East Adit Area: East Adit rock piles, East Open pit and East Adit Trench;
3. Oceanview: Oceanview rock pile and Oceanview Open Pit; and
4. Area 14: Area 14 rock pile

The overall approach to achieving these reclamation objectives is to consider and apply the most appropriate of the following reclamation measures:

1. Relocate waste rock to eliminate or reduce the requirements for surface reclamation at the pile location;
2. Fill open pits to achieve a smooth surface contour that prevents surface ponding and provides a safe surface environment;
3. Provide a thermal cover such that the covered materials freeze into permafrost;
4. Assess the net negative effects of intrusive reclamation work against the potential long term environmental risk;
5. Conduct additional ARD investigations to increase confidence in current observations and assumptions; and
6. Institute a monitoring and contingency program.

4.3 Thermal Barrier Cover

4.3.1 Overview of Cover Design

Placement of a thermal cover over residual rock piles and filled open pits is proposed in several locations as the means of minimizing the risk of ARD and metal leaching by freezing the mineralized materials into permafrost. The design proposed in this report is consistent with the design proposed for the landfill facility, as described the Landfill Closure Plan (GLL, 2004a).

The most relevant report for design of the thermal barrier cover over waste rock and open pits is the report "Engineering Design of Reclamation Covers" (BGC, 2004a) (the "Covers Report"). This report also makes reference to several other reports listed below:

- Closure and Reclamation Plan for Nanisivik Mine Plan (GLL, 2002a);
- Geotechnical Assessment of Cover Materials for West Twin Disposal Area Nanisivik Mine, Baffin Island, NWT (Golder Associates, 1999); and
- Reclamation Cover Design for Nanisivik Mine West Twin Disposal Area Surface Cell (GLL, 2002b).

The key points relevant to design of a thermal barrier cover over waste rock and open pits are summarized as:

- Monitoring of the mine site will be conducted during reclamation activities and for a period of five years after completion of reclamation work. Monitoring will include water quality, ground temperatures, general reclamation and geotechnical inspections;
- For waste rock and open pits, a dry cover composed of natural materials is considered appropriate;
- Five test pad covers were constructed at the West Twin Lakes Disposal Area (WTDA) in the early 1990's. The covers generally consisted of 2 m of shale; some had internal layers of sand and gravel

and others had sand and gravel caps. The maximum depth of active layer thaw ranged from 0.95 m to 1.63 m between 1993 and 1997;

- A 2.0-2.1 m thick shale cover was constructed over the sulphide rock pile at Area 14 in 1990. Two boreholes were drilled through the cover and into the waste dump and thermocouple strings were installed within the shale cover and the waste rock to a maximum depth of 6.6 m below ground surface. Based on the temperature data from the thermocouples, it was concluded that the thaw depth was consistently recorded at depths of just less than 1.4 m and at 1.7 m in the two boreholes. The borehole with 1.7 m thaw depth was considered to be more relevant to waste rock piles and open pits;
- A one-dimensional geothermal model, calibrated with the available data, predicted that an additional 0.5 m of cover material would be required under the high (i.e., worst) estimate case of global warming for a 100-year period for the proposed soil covers over unsaturated materials;
- Of the potential natural materials onsite, only two are available in sufficient quantity to be considered: Twin Lakes Sand and Gravel; and shale. Samples of each were subjected to a series of laboratory tests to determine the geotechnical durability of the material under a variety of test conditions. The shale was determined to be suitable for use as a thermal barrier but was not recommended for use as a long-term surface covering material due to potential freeze-thaw breakdown. The Twin Lakes Sand and Gravel was more durable under freeze-thaw conditions and was determined to be suitable for use as a long term surface capping material.

4.4 Final Cover Design

4.4.1 Geotechnical Design Requirements

The geotechnical issues to be addressed include:

1. cover thickness/thermal performance;
2. availability of materials;
3. infiltration;
4. durability;
5. gradation/filtration;
6. slope stability; and
7. erosion.

Cover Thickness/Thermal Performance

The cover thickness and thermal performance of the thermal barrier cover for rock piles and open pits was developed in and is described fully in the Covers Report. The design rationale and components are summarized as follows:

1. Shale is the most available and abundant cover material and has demonstrated adequate thermal properties; however, the better long term durability of the Twin Lakes sand & gravel suggests that this material is the most suitable to provide an erosion resistant cap on the final exposed surface;
2. Thermal modeling has demonstrated that both the shale and the Twin Lakes sand and gravel share similar thermal properties such that there is no appreciable difference in their thermal performance if in the order of 0.25 m of Twin Lakes sand & gravel is used as the capping (surface) layer of the cover;
3. Experience and observations of the shale cover at Area 14 are more relevant to rock piles and open pits than observations at the WTDA test cells because of the unsaturated and more permeable nature of the materials being covered in rock piles and open pits;
4. The Area 14 data indicate that 1.7 m of shale cover is sufficient to maintain freezing temperatures in the covered waste materials; and
5. The thermal modeling suggests that an additional 0.5 m of cover would be required to maintain frozen conditions in the covered waste materials under the extreme, 100-year climate warming scenario; and

Availability of Natural Materials

The availability of sufficient quantities of shale and East Twin Sand & Gravel has been investigated as documented in the report, "Quarry Development and Reclamation Plan" (BGC, 2004b) (the "Quarries Report").

The Quarries Report includes details regarding development, operation and reclamation of the borrow areas to be used.

Infiltration

The cover will consist of granular materials and will be permeable. It is anticipated that precipitation and snowmelt will infiltrate into the cover during the spring/summer and will become become frozen within the waste pile. Over time, it is expected that this process will generate an ice rich layer within the cover. Observations and test data described in the Covers Report for the WTDA Test Cells and for the Area 14 rock pile cover confirm the general expectation that an ice rich layer will form in the base of the cover materials at the depth of the active thaw layer. This is due to the infiltration of runoff water to the base of the active layer where the water freezes. Once frozen, the latent heat of ice maintains the frozen condition. In fact, the depth of thaw in the WTDA Test Cells decreased over time due to the progressive accumulation of frozen infiltration water.

In the case of covering the Nanisivik rock piles and open pits with shale, the formation of an ice rich layer at the depth of the active thaw zone is anticipated to occur more slowly than the cover over tailings. This is because the (assumed) unsaturated void spaces within the waste materials may allow infiltrating water to initially migrate into the waste pile before the sub-zero temperatures cause the water to freeze in place. Hence, aggradation of the ice rich layer may begin at some depth within the waste materials and propagate upwards. Ultimately, infiltrating water will remain within the cover material and there will be no anticipated infiltration into the waste.

Durability

The durability of the proposed cover materials is not an issue for relatively flat slope in the range of 2 to 5% grade. However, in steeper areas with slopes up to 33% (i.e., 3H:1V), there is a risk that fines from the shale cover material could possibly be washed through the capping material at the base. If the shale cover material is non-durable and breaks down, this process could result in significant erosion or a decrease in its internal friction angle, reducing slope stability.

The durability of the cover materials to weathering and physical breakdown has been assessed as documented in the Covers Report. Samples of the potential cover materials underwent laboratory tests including relative absorption, Los Angeles abrasion, slake durability, and freeze-thaw cycles. A petrographic analysis on the Twin Lakes sand and gravel was also completed.

The Twin Lakes sand and gravel was determined to be very durable (0.1% loss) under freeze-thaw conditions. Since the Twin Lakes sand and gravel is not subject to physical breakdown, it is well suited for the erosion-resistant capping layer. The samples of shale had higher losses in the freeze-thaw and Los Angeles abrasion tests and are not recommended for the capping layer. However, the shale is suitable as a thermal barrier layer underlying the surface cap.

The durability of the shale is not as critical as for the capping layer. However, the material within the sideslope cover should be durable enough so that loss of fines subject to seepage pressures does not result in loss of cover integrity. One sample (five sub-samples) of the Twin Lakes shale and the Mt. Fuji shale were tested for freeze-thaw durability. The Twin Lakes shale had an average loss of 2.3% (the range of loss was from 0.3% to 11.1%) after 25 freeze-thaw cycles and the Mt. Fuji sample had an average loss of 19.7% (range from 1.2% to 46.3%). However, Golder (1999), noted that this loss would have been 6.1% if the Mt. Fuji sample did not split along a bedding plane (large pieces that spalled off the sample had to be counted as lost material under the test protocols). Therefore, this freeze-thaw test result appears to overpredict the loss of material under freeze-thaw conditions by a large degree.

Samples collected in 2003 from the West Twin Disposal Area test cell cover are also relevant. The cover on Test Cell no. 1 was constructed in 1991 and consisted of 2 m thick layer of Mt. Fuji shale. Two samples of the shale were collected from 0.6 m and 1.3 m depth and submitted for grain size analyses. The grain size analyses indicated that both samples consisted of moderately well-graded gravel with some sand and only 3-5% fines. These results suggest that the Mt. Fuji shale, which has been subject to freeze-thaw cycles for 12 years in the field, is durable.

In summary, the laboratory freeze-thaw tests and field trial generally indicate that the shale at the site is durable with the possible exception of the one Mt. Fuji sample, which was reported to be suspect and likely not representative of the material or standard test conditions. The laboratory tests also indicate that there may be some variability between the Mt. Fuji shale and the Twin Lakes shale. Therefore, quality control measures should be taken with respect to material durability when constructing the sloped section of the cover. Both freeze-thaw tests and local field experience should be used to assess and confirm the durability of the shale material placed on relatively steeper slopes, as described in Section 4.5.6.

Gradation/Filtration

For the proposed two-layer cover system, the adjacent materials should be filter compatible with respect to grain size distribution. There are two requirements to be met:

1. The upper material (in this case, Twin Lakes sand and gravel) should not fall into the voids of the lower material; and
2. The lower material (in this case, shale) should not wash through the voids of the upper material at the steeper sideslope portions of the cover where lateral flow of infiltrating water through the cover materials may occur.

The Twin Lakes sand & gravel is a well-graded material that is coarser than the shale, which is also well-graded. Since the shale is well-graded (contains about 35% sand based on Unified Soil Classification system), the voids between the shale particles that would allow migration of fines to pass will likely be approximately equal to the D_{10} size, which is 0.4 mm. Based on the available grain size data, 96% of the Twin Lakes sand and gravel is larger than 0.4 mm, which would mean that only 4% of the particles could potentially migrate through the shale. However, because it is well-graded, the fine particles within the sand and gravel will likely be interlocked with larger particles and will not be mobile. Even if some of the fines did migrate into the shale, it is likely that the volume would be insignificant and would not result in any loss of the cover thickness. Therefore, the first requirement will be met for the proposed cover.

For the second requirement, the proposed cover materials were verified against a conservative filter criteria that was developed for drains used for seepage control (Craig 1983) as follows:

a) $(D_{15})_f / \underline{(D_{85})_s} < 4\text{-}5$

b) $(D_{15})_f / \underline{(D_{15})_s} > 4\text{-}5$

c) $(D_{50})_f / \underline{(D_{50})_s} < 25$

where D_{15} = the particle size at which 15% of the soil is finer,
D_{50} = the particle size at which 50% of the soil is finer,
D_{85} = the particle size at which 85% of the soil is finer,
f = the filter soil, East Twin sand and gravel
s = the soil to be retained, shale

Using the grain size data presented by Golder (1999), the following effective sizes are:

$(D_{15})_f = 4.0$ mm $(D_{50})_f = 20$ mm
$(D_{15})_s = 1.0$ mm $(D_{50})_s = 9.3$ mm $(D_{85})_s = 22.5$ mm

and a) $(D_{15})_f/(D_{85})_s = 0.18$, which is <4-5
b) $(D_{15})_f/(D_{15})_s = 4$, which is on the boundary of this criteria and marginally acceptable
c) $(D_{50})_f/(D_{50})_s = 2.15$, which is <25.

Criterion b) ensures that the flow capacity of the filter is greater than the flow capacity of the soil to be retained and is not considered to be as important as criteria a) or c). Therefore, the above filter criteria are met for the proposed two layer cover system.

Figure 14 of the Covers Report shows five grain size distribution curves for the Twin Lakes sand and gravel. The sample analyzed by Golder (1999) was selected as the coarsest material with the highest percentage of gravel and it is expected to have the largest void spaces and the poorest capability to retain fines. Assuming that this sample is the worst case scenario for the Twin Lakes sand and gravel with respect to filtering the underlying shale, the grain size specification for the shale to be retained by the Twin Lakes sand and gravel can be calculated. Based on a fixed gradation of the Twin Lakes sand and gravel, the shale could range from a well-graded gravel to a fine to medium sand and meet the filter criteria. A target grain size specification for the shale is as follows:

Particle Size	Sieve Number	Percent Passing
300 mm	-	100
75 mm	-	85-100
20 mm	-	50-100
4.75 mm	4	30-100
2 mm	10	22-100
0.84 mm	20	15-50
0.42 mm	40	10-27
0.25 mm	60	6-20
0.15 mm	100	4-15
0.075 mm	200	1-10

The above grain size specification is presented as a guide only and does not represent a "must meet condition". The grain size specification presented above is similar to that presented in Figure 29 of the Covers Report. The specification provided here allows for more sand and less fine to medium gravel compared to the specification on Figure 29 of the Covers report. It is expected that the Twin Lakes sand and gravel will vary in the field and the above specification can be modified to ensure that the filter criteria are met. Any modification would be part of a construction quality control program, which is discussed in Section 4.5.6.

Slope Stability

The waste beneath the cover will be frozen and a slide within the frozen waste is considered to be unlikely. The only potential stability issue is within the cover. The proposed final slope for the cover is a maximum of 3H:1V, which is 18 degrees or 33%. However, as previously discussed, the shale is expected to be durable based on the field trial; therefore, degradation of the material is not expected to be significant. In the short-term, the internal friction angle of the shale is expected to be a minimum of 30 degrees, taking into account its grain size distribution and angular particles. It is unlikely that the cover would become saturated with unfrozen water due to several factors including the permeability of the cover material, the available void space within the cover and the relatively low maximum expected precipitation event for this location. Hence, pore water pressure is not likely to be a factor and the factor of safety against sliding in the short-term is likely a minimum of 1.7, which is considered very stable. In the long-term, potential physical breakdown (due to freeze-thaw cycles) of the particles is expected to reduce the internal friction angle slightly. It is estimated that the reduction in the internal friction angle in the long-term could be approximately 24 degrees. The potential reduction in friction angle is expected to be partially offset by the aggradation of ice within the cover, which would provide cohesive strength to the cover. Therefore, the resulting in a factor of safety against sliding in the long-term is expected to be greater than 1.5.

Erosion

Substantial erosion of the cover could allow the active thaw layer to reach the waste, thawing the surface of the waste materials. The proposed maximum slope angles for covers over rock piles and open pits is 18 ° (3H:1V) with many areas much flatter slopes.

The selection of East Twin sand & gravel as the surface capping layer was based on the acceptable durability of this material as compared to the shale. Also, the well-graded grain size distribution of the material will also allow particles to interlock, reducing erosion potential.

The monitoring program includes inspections by qualified engineers of the physical stability of the covers. If erosion occurs, the cover would be repaired.

4.4.2 Proposed Final Cover Design

Based on the geotechnical design requirements discussed in the preceding sections, the proposed design of the cover for the landfill facility is as follows:

1. The maximum slope of a cover will be 3H:1V or 18 °;
2. A two-layer thermal cover with a total thickness of 2.20 m will be placed;

3. The upper erosion-resistant capping layer shall consist of a durable (percentage loss under freeze-thaw is in the order of or less than 1%), erosion resistant material with a minimum thickness of 0.25 m. The selected material is the Twin Lakes sand and gravel;
4. The underlying layer will be shale with a minimum thickness of 1.95 m to provide a minimum total thermal cover thickness (in combination with the surface layer) of 2.20 m. This material should not migrate through the upper layer at the base of the landfill and should meet filtration requirements. A grain size guideline (grain size distribution ranging from well-graded gravel to fine to medium sand) has been provided in Section 4.4.1. It is recommended that the shale material be durable under freeze-thaw conditions on steeper slopes, as determined in the field by qualified professionals experienced in working with shale on the site or working under the direction of an experienced engineer.

4.4.3 Construction Considerations

Construction of Lower Layer of the Thermal Cover

Once a waste surface has been prepared and approved by the on-site geotechnician (per the Quality Control program described below), the lower layer of the cover may be constructed according to the design drawings. The cover material should be placed in lifts of 0.65 m thickness.

The required compaction effort is consistent with that specified in the Covers Report (BGC 2003). The compaction process will be performance based and will consist of a number of passes from the proposed construction equipment (eg. Bulldozer and loaded haulage trucks). Other criteria for the compaction operation, subject to field verification, 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, relevelling and/or additional passes will be required; and
- Any oversized particle sizes will be removed from the fill before proceeding with compactive effort.

The total thickness of the shale layer shall be within 100 mm of the design thickness. The completed layer shall be surveyed for the as-built drawing and to verify that the total thickness of this layer is in accordance with the design.

Construction of Upper Layer of the Thermal Cover

After construction of the lower layer and verification that it meets the design requirements, the upper capping layer of the cover may be constructed according to the design drawings. The material (Twin

Lakes sand and gravel) may be placed in a single lift of 0.25 m thickness. After the material has been placed, it should be groomed smooth (to avoid leaving any peaks or troughs) to meet the final design grades. The compaction specification, consistent with the Covers Report, is to achieve a firm and tight final surface to the satisfaction of the technical field supervisor.

After placement and compaction of the top layer of the cover, it should be surveyed to verify that the design grades and thickness of the capping layer have been achieved.

4.5 Proposed Reclamation Activities

4.5.1 West Adit Area

Reclamation Activities

The reclamation activities proposed for the West Adit area, including the 02S rock pile, the 09S rock pile, the West Adit access road, and the West Open Pit (Figures 3 through 7), are as follows:

1. Relocate all remaining waste rock from the 09S rock pile (est. 7,571 m^3) plus a sufficient volume of inert demolition debris from the tear down of buildings and equipment into the deepest portions of the West Open Pit to fill it approximately to the elevation of the general area (total fill volume est. 22,500 m^3) with positive drainage;
2. Map the geology of the north pit wall to locate and delineate the sulphide exposures;
3. Conduct a geochemical assessment of the road fill from the Industrial Complex to the West Open Pit and from the West Open Pit to the 09 Portal and determine whether remedial measures are necessary for these areas based on the criteria described below;
4. Strategically place all safely retrievable waste rock from the 02S rock pile (est. 14,090 m^3) plus inert demolition debris from the tear down of buildings and equipment at the toe of the north wall of the West Open Pit such that a filled surface is achieved that conforms to the concept illustrated on Figure 4 and that provides for safe covering of all identified sulphide exposures at a maximum slope angle of 3H:1V;
5. Construct the thermal barrier cover as described herein and illustrated on Figures 3 and 4 over the filled surface from north wall of the West Open pit to the crest of the slope overlooking Twin Lakes Creek that achieves grades not steeper than 3H:1V and provides positive drainage, to the satisfaction of the on-site geotechnician, and that follows the quality control program;
6. Complete any necessary mitigative work that may be determined necessary from the geochemical assessment of the road fill materials; and
7. Integrate a light vehicle access road into the final surface that allows light vehicle access through the area but that does not compromise the thickness of the cover based on the judgement of the on-site geotechnician.
8. Execute all activities according to a quality control program; and

9. Conduct a performance monitoring program.

Backfilling of the West Open Pit

The coordinated placement of demolition debris and waste rock in the West Open Pit will require some special considerations that are described in the Waste Disposal Plan (CanZinco 2003). The specifications for the reduction in size and for cleaning of demolition debris will be the same for disposal underground as for the West Open Pit. However, placement into the West Open Pit, either into the deep hole or against the toe of the north wall, will require finer-grained fill material to be incorporated in the voids of the debris for physical stabilization during construction and covering. To this end, for the West Open Pit location, demolition debris and waste rock should be placed jointly in lifts no greater than 1 m thick and adequate fine material from the waste rock should be present to stabilize the pile. If sufficient fines are not available from the waste rock, then an alternate source of bulk fine material should be identified, likely to be shale.

The inclusion of demolition debris into the bulk fill of the West Open Pit is provides the same level of environmental protection and several other benefits as compared to backfilling with rock only. The demolition debris will provide a necessary source of fill for the West Open Pit without the need for further development of quarries. This will enable the covering and freezing into permafrost of sulphide exposures on the north wall of the pit and of the backfilled rock and demolition debris.

During the backfilling of the West Open Pit with waste rock, large boulders should be preferentially placed into the bottom of the pit or segregated for placement into the underground mine such that the backfill in the pit is physically stable and not prone to initial settlement of the cover. This should be controlled at the judgement of the on-site geotechnician.

The surface of the backfill should be waste rock that is groomed as smooth and free of voids as possible, given the nature of the fill material.

02S Rock Pile

The area occupied by the 02S rock pile includes steep slopes in natural ground that can not be safely accessed by heavy equipment. Further, Twin Lakes Creek passes directly along the base of this steep area such that the base of the slope can not be accessed for waste rock retrieval without in-stream construction works. It is possible that a safe access trail could be cut into the slope to allow heavy equipment access for waste rock retrieval, but this would require cutting and blasting into the natural ground directly above Twin Lakes Creek such that a new disturbance would be created.

The volume of waste rock that is considered to lie in this inaccessible area is anticipated to be in the order of 1,500 m^3. The ARD investigations summarized in Section 3.2.2 indicate that this material is likely to contain a mixture of carbonaceous dolostone "host" rocks and mineralized rock as evidenced by an overall weakly positive NNP and marginal NP:AP ratio.

Given that the quantity of residual rock is relatively small and of mixed rock types containing substantial acid consuming host rock, an observational approach is proposed for this residual waste rock. Water quality in Twin Lakes Creek will be monitored and assessed for identification of any observable impacts from the residual waste rock. In this way, if the residual rock is observed to be having an impact on Twin Lakes Creek, then further remediation, including possible trail building on the steep slope and possible in-creek access, could be considered.

Geology Mapping of the North Wall

The intent of the mapping of the geology on the north wall of the West Open Pit is to identify the location and extent of sulphide exposures on the wall. This will allow the on-site geotechnician to control and "field-fit" the placement of backfill waste and cover materials to ensure that the sulphide exposures are covered with the 2.2 m thick thermal cover system.

Figure 4 illustrates the concept that the backfill waste will be built up against the north wall, at a slope of up to 3H:1V, such that the final surface of the waste reaches to the upper elevation of an identified sulphide exposure. In this way, placement of the thermal barrier cover on the waste surface will provide the necessary 2.2 m thickness over the entire sulphide exposure.

The sulphide exposures are visually distinct from the local "country" rocks (shale and dolostone) and a qualified geologist or geotechnician will perform the task. It is anticipated that the exposures will be found to not be continuous across the north wall and not to extend to the top of the wall. This would mean that the thermal barrier cover would not be necessary over the entire pit wall.

Geochemical Assessment

The acid rock drainage assessment of the road from the Industrial Complex to 09 Portal suggests that this material is not an environmental risk that requires mitigation. However, the data set includes some data points in the uncertain range further investigations are recommended to increase confidence in this assessment.

The geochemical investigation would be undertaken in 2004 and would involve geological logging of test pits and drill cuttings augmented by laboratory analyses of acid rock drainage characteristics (acid base accounting using the modified Sobek method). Ultimately, the geological and laboratory classifications would be assessed against the following benchmarks:

- Ratio greater than 4: acid consuming material for which no mitigation is required;

- Ratio between 2 and 4: likely acid consuming or inert, use geological observations and judgement as a basis for determination;
- Ratio between 1 and 2: possibly acid generating, mitigation measures or further investigation required; and
- Ratio less than 1: potentially acid generating material for which mitigation is required.

The specific tasks of the investigation would be as follows:

1. Conduct a test pit and drill program supervised by a qualified professional;
   (a) Time the program to coincide with the anticipated maximum thaw depth;
   (b) Excavate test pits to bedrock or hard ground at intervals of 50 m along the road aproximately 75% to the outer crest and in areas of visually distinct interest;
   (c) Drill into bedrock using an air rotary, or similar, drill at intervals of 50 m along the road, offset from the test pits, approximately 75% to the outer crest;
   (d) Document a visual geological log of test pit and drill cuttings;
   (e) Collect soil samples from test pits representative of 0.3 m vertical intervals or representative of visually distinct stratigraphy; and
   (f) Collect samples of drill cuttings representative of each 1 m vertical interval drilled.
2. Conduct an analytical program;
   (a) Analyse samples in the field for paste pH and paste conductivity using a consistent and documented mixing ratio;
   (b) Based on the field analyses of paste pH and conductivity and the field observations and logs, select a subset of the total samples collected that is representative of the roadfill as a whole both in terms of areal coverage and geological characteristics; a sample set of approximately 40 samples is anticipated at this time; and
   (c) Analyse the selected samples for acid base accounting parameters according to the modified Sobek method.
3. Interpret the available information in concert with a qualified professional in the context of assessing the information against the criteria described above; and
4. Provide a recommendation, based on all of the available information, regarding which sections of the road, if any, require mitigative measures.

In this way, a more confident determination of the necessity for mitigative work will have been developed and any areas requiring mitigation could be reclaimed to the West Open Pit area during the second year of reclamation.

Cover Area

The area to be covered, dependent in the geology mapping of the north wall, is estimated to be 1.0 ha as illustrated on Figures 3 through 5. This area is based on the assumption of covering nearly all of the north wall.

The volumes of cover materials required, based on the information and designs presented herein, are estimated to be 20,000 m^3 of shale and 2,500 m^3 of Twin Lakes Sand and Gravel.

The estimated area to be covered and volume of cover materials needed is based on an assumption of covering nearly all of the north wall.

Light Vehicle Access Road

Light vehicle access through the reclaimed area will be required to enable environmental monitoring work and public access to areas on the north side of the ridge. A driving surface should be specifically constructed such that the cover thickness is not compromised. Further, consideration should be given to the strategic placement of non-mineralized boulders to ensure that light vehicle traffic travels on the intended driving surface.

The site safety and environmental protocols for subsequent monitoring and maintenance work should explicitly prohibit light vehicle (pick up trucks and ATV's) travel off of the intended driving surface. The routine site inspections and annual professional inspections should explicitly include observation and inspection for vehicle damage to the cover materials in these areas.

4.5.2 East Adit Area

Reclamation Activities

The reclamation activities proposed for the East Adit area, including the 39N/S rock pile, the East Open Pit and the East Trench (Figures 8 through 13), are as follows:

1. Relocate waste rock from the 39N/S rock pile into the East Open Pit and East Trench such that the pit and trench are filled according to Figures 8 through 13 (also incorporating waste rock relocated from the K-Baseline area into the filling plan);
2. Subsequent to filling of the East Open Pit and East Trench, continue to relocate waste rock into the underground mine, according to the requirements of the Solid Waste Disposal Plan, such that 39N/S rock pile is completely removed;
3. Construct the thermal barrier covers as described herein over the East Open Pit and the East Trench according to Figures 8 through 13 that achieves grades not steeper than 3H:1V and provides positive

drainage, to the satisfaction of the on-site geotechnician, and that follows the quality control program; and

4. Integrate a light vehicle access road into the final surface that allows light vehicle access through the area but that does not compromise the thickness of the cover based on the judgement of the on-site geotechnician.

Backfilling of the East Open Pit and East Trench

During the backfilling of the East Open Pit and East Trench with waste rock, large boulders should be preferentially placed into the bottom of the East Trench or segregated for placement into the underground mine such that the backfill in the trench is physically stable and not prone to initial settlement of the cover. Because the East Open Pit area is nearly completely filled, no boulders or gross oversize should be placed here. This should be controlled at the judgement of the on-site geotechnician.

The surface of the backfilled waste rock should be as groomed as smooth and free of voids as possible, given the nature of the fill material. Placement and compaction of waste rock into the pit should follow the same quality control measures, including lift thicknesses and compactive effort as described for placement of the shale.

Cover Area

The areas to be covered are estimated to be approximately 3.1 ha for the East Open Pit and 0.1 ha for the East Trench, as illustrated on Figures 8 through 13. The estimated volumes of cover materials required, based on the information and designs presented herein, are estimated to be 62,500 m^3 of shale and 8,950 m^3 of Twin Lakes Sand and Gravel.

39N/S Rock Pile

The volume estimated as currently remaining in the 39N/S rock pile is close to the volume of fill required to complete filling of the East Open Pit and to fill the East Trench.

However, it is possible that a small quantity of residual waste rock may remain after the pit and trench have been filled to the design contours. In this event, the residual waste rock will relocated into the underground mine, following the procedures described in the Waste Disposal Plan (CanZinco 2003).

Light Vehicle Access Road

Light vehicle access through the reclaimed area will be required to enable environmental monitoring work and public access to areas on the north side of the ridge. A driving surface should be specifically constructed such that the cover thickness is not compromised. Further, consideration should be given to the strategic placement of non-mineralized boulders to ensure that light vehicle traffic travels on the intended driving surface.

The site safety and environmental protocols for subsequent monitoring and maintenance work should explicitly prohibit light vehicle (pick up trucks and ATV's) travel off of the intended driving surface. The routine site inspections and annual professional inspections should explicitly include observation and inspection for vehicle damage to the cover materials in these areas.

4.5.3 Oceanview

Reclamation Activities

The reclamation activities proposed for the Oceanview area, including the Oceanview open pit, portal, and rock pile areas, are as follows:

1. Relocate the remnant waste rock from the rock pile into the Oceanview open pit;
2. Relocate mineral contaminated soil from the previous ore stockpile area at the portal site into one discreet area that provides positive drainage, to the satisfaction of the on-site geotechnician;
3. Construct the thermal barrier cover, as described herein, over the pit according to Figure 14 that achieves grades not steeper than 3H:1V and provides positive drainage, to the satisfaction of the on-site geotechnician, and that follows the quality control program;
4. Construct the thermal barrier cover, as described herein, over the consolidated materials at the portal site that achieves grades not steeper than 3H:1V and provides positive drainage, to the satisfaction of the on-site geotechnician, and that follows the quality control program; and
5. Conduct any required additional remediation of the underground access portal to prevent ponding of runoff water, to the satisfaction of the on-sit geotechnician, and following the requirements of the Mines Act.

Backfilling of the Oceanview Open Pit

During the backfilling of the Oceanview Open Pit, large boulders should be segregated for placement into the underground mine such that the backfill in the pit is physically stable and not prone to initial settlement of the cover. Because the pit is nearly completely filled, no boulders or gross oversize should be placed here. This should be controlled at the judgement of the on-site geotechnician.

The surface of the backfilled waste rock should be as groomed as smooth and free of voids as possible, given the nature of the fill material. Placement and compaction of waste rock into the pit should follow the same quality control measures, including lift thicknesses and compactive effort as described for placement of the shale.

Former Ore Stockpile Pad

The Phase 3 ESA Report identifies approximately 5,000 m^3 of mineral contaminated soil in the local access road and previous ore stockpile area. This material will be consolidated into one local pile of not greater than 3H:1V grade that provides positive drainage away from the pile and, ultimately, provided with the same thermal barrier cover as the open pit.

Cover Area

The area to be covered (both the pit and the previous ore stockpile pad) is estimated to be 1.75 ha. The volumes of cover materials required, based on the information and designs presented herein, are estimated to be 35,400 m^3 of shale and 5,000 m^3 of Twin Lakes Sand and Gravel.

Underground Access Portal

Any additional remediation of the underground access portal should be remediated while equipment and personnel are working in the area. The objective will be to provide a safe surface environment, to provide positive surface drainage away from the area and to follow the requirements of the Mines Act.

4.5.4 Area 14

Reclamation Activities

The reclamation activities proposed for the Area 14 area, including the existing shale covered waste rock and uncovered waste rock, (Figure 15) are as follows:

1. Consolidate surficial uncovered waste rock (est. 2,000 m^3) as illustrated on Figure 15; and
2. Construct the thermal barrier cover, as described herein, over the uncovered waste rock, complete the current shale cover with the durable cap of Twin Lakes Sand and Gravel and reduce sideslopes of the existing shale cover to not steeper than 3H:1V by placing additional shale; the cover should achieve grades not steeper than 3H:1V and provide positive drainage, to the satisfaction of the on-site geotechnician, and follow the quality control program.

Consolidating Uncovered Waste Rock

Residual waste rock is currently dispersed in the Area 14 area such that the area to be covered in the absence of consolidation would be unnecessarily large and would not blend smoothly with the existing cover. The relatively small effort required to consolidate the dispersed material is considered to provide a net positive benefit as regards cost and achievable surface contours.

The material is to be consolidated into a pile that blends smoothly with the existing covered pile and that provides positive drainage from the area.

Cover Area

The new area to be covered is estimated to be 0.1 ha, as illustrated on Figure 15. The volumes of cover materials required including completion of the existing shale cover, based on the information and designs presented herein, are estimated to be 3,500 m^3 of shale and 1,400 m^3 of Twin Lakes Sand and Gravel.

4.5.5 K-Baseline

Reclamation Activities

The reclamation activities proposed for the K-Baseline area, including the portal, and previous rock pile/ore storage areas, (Figure 16) are as follows:

1. Relocate residual waste rock (est. 4,000 m^3) to the East Open Pit following the fill plan described for that location and such that the waste rock is incorporated into the thermal cover area;
2. Reclaim the area of waste rock retrieval to a safe surface; and
3. Conduct any required additional remediation of the underground access portal to prevent ponding of runoff water, to the satisfaction of the on-sit geotechnician, and following the requirements of the Mines Act.

Underground Access Portal

Any additional remediation of the underground access portal should be remediated while equipment and personnel are working in the area. The objective will be to provide a safe surface environment, to provide positive surface drainage away from the area and to follow the requirements of the Mines Act.

4.5.6 Quality Control Program

A quality control program will be implemented, as described here, to ensure that cover materials meet the design specifications and are constructed in accordance with the this Plan. This program will include survey control, materials testing, construction monitoring and documentation.

Survey Control

Survey control is necessary to ensure that the cover slopes do not exceed the specified maximum grade and to allow preparation of as-built drawings. Topographic surveys should be conducted at three stages of construction: after backfilling of the open pits; after placement/compaction of the shale layer; and after placement/compaction of the capping layer. The survey should be completed using a 20 m grid on flatter slopes and a 15 m grid on steeper such that accurate 0.5 m vertical contour intervals can be resolved from the data. Where the slope length is less than 30 m, a minimum of three points should be collected (top, mid-point of slope and base of slope).