Golder Associates Ltd.

500 – 4260 Still Creek Drive
Burnaby, British Columbia, Canada V5C 6C6
Telephone 604 296-4200
Fax 604-298-5253

FINAL REPORT
DETAILED DESIGN OF CENTRAL DIKE
MEADOWBANK GOLD PROJECT
VOLUME 3

Submitted to:

Meadowbank Mining Corporation
Suite 950, One Bentall Center
505 Burrard Street
Vancouver, BC
V7X 1M4

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APPENDIX VII

FEASIBILITY LEVEL DESIGN REPORT

The feasibility-level design for the Central Dike at the Meadowbank Gold Project was presented in the report:

Golder, 2004. Meadowbank Gold Project Tailings Dike Basic Engineering Design, Report. Golder Associates Ltd.

The feasibility-level design included:

- Final elevation of main tailings dam of El. 139.6 masl;
- Options for full and partial cutoff;
- Optional grout curtain; and
- Frozen tailings concept.

Economic analyses and an increase in the ore reserve led to several conceptual changes in the dike design concept that were presented in a variety of documents. However, no technical analyses were completed or used to support the final design.

The final design presented in this report differs from the feasibility level design. Major differences include:

- Section changed from core of compacted till, dual granular filter layers, and rockfill shells to: rock fill embankment with upstream bituminous liner with two zone upstream filter;
- Final crest elevation changed from El. 139.6 masl to El. 148 masl. to accommodate change in ore reserve from 19.8 Mt to 22.0 Mt;
- Change from 2 Horizontal: 1 Vertical sideslopes to 1.5 Horizontal: 1 Vertical sideslopes;
- Dike alignment is updated for 2006 bathymetry; and
- Cutoff and grout curtain are included in the design.

The Stormwater Dike and Saddle Dams cross sections have also been revised.

- Section change similar to the Central Dike with the exception of upstream sideslopes regraded to 3 Horizontal: 1 Vertical, and two options are presented for the impermeable element including compacted till or bituminous liner.

- New design includes cutoff trench to bedrock.

- Final crest elevations have been increased to accommodate changes in ore reserves.

- Material properties updated to reflect latest laboratory test results.

Golder Associates Ltd.

500 – 4260 Still Creek Drive
Burnaby, British Columbia, Canada V5C 6C6
Telephone (604) 296-4200
Fax (604) 298-5253

REPORT ON

MEADOWBANK GOLD PROJECT
TAILINGS DIKE
BASIC ENGINEERING DESIGN

Submitted to:

Cumberland Resources Ltd.
Suite 950, One Bentall Centre
505 Burrard Street
Vancouver, BC
V7X 1M4

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3	Copies -	Cumberland Resources Ltd.
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EXECUTIVE SUMMARY

This report presents a basic engineering design for the proposed tailings containment dike at the Meadowbank Gold Project in Nunavut. This report was prepared for use by Cumberland Resources Ltd. (CRL) as part of their overall feasibility study. The proposed tailings dike will be required to contain approximately 20 million tonnes of tailings within the northwest arm of Second Portage Lake. The tailings will be produced by milling of the ore obtained from mining of the Portage, Goose Island, and Vault Pits. The mine will be operated over a period of ten years.

Due to uncertainty about whether the in situ foundation material will perform adequately as a seepage control barrier, two dike design cross-sections have been considered in the seepage analyses, a 'Full Cutoff' (conservative) design, and a 'Partial Cutoff' design. The Full Cutoff design assumes that the foundation material will be permeable and that a cutoff trench and grout curtain will be required. The Partial Cutoff design assumes that the foundation material is of sufficiently low permeability to control seepage. Therefore, neither the till cutoff nor the grout curtain would be required, and only a nominal key-in trench for the till core would be constructed.

If mining of the North Portage area adjacent to the dike is not started until Year 4, then the Partial Cutoff design could be implemented, relying on deposited tailings to act as an upstream seepage blanket, if necessary. This scenario was also considered in the seepage analyses.

The tailings dike will be constructed 'in the dry', after drawing down the water in the northwest arm of Second Portage Lake by approximately 28 m. The dike will be constructed in two stages: Stage 1 will be constructed in Year -1 of the mine life to a crest elevation of 120 m A.S.L., while Stage 2 construction will occur in Year 3, raising the dam to the final crest elevation of 139.6 m A.S.L.

Based on current materials balance calculations, sufficient quantities of suitable rockfill and till borrow materials will be available from pre-mining and starter pit mining activities for the Stage 1 construction. Construction materials for the Stage 2 raise will be available from ongoing mining activities in Year 3.

Slope stability analyses indicate that the dike will be stable under static and pseudostatic load conditions, in the short-term and long-term cases, for frozen, partially frozen, or unfrozen conditions.

During operation of the mine, the dike will need to control seepage from the tailings impoundment area toward the west wall of the Portage Pit both through, and beneath the dike structure. Current mine planning indicates that the north portion of Portage Pit, closest to the proposed tailings dike, will be mined beginning in Year 4.

The seepage modelling indicates that the maximum seepage expected to reach the west wall of the Portage Pit, due to the effects of the tailings pond, will be:

- For Full Cutoff design = approximately 30 litres/second;
- For Partial Cutoff design = approximately 30 litres/second;
- For Partial Cutoff design with upstream tailings seepage blanket = approximately 70 litres/second (assuming the foundation till is permeable, as for Full Cutoff design).

The possibility of using the deposited tailings as an upstream seepage blanket could offer significant advantages over the Full Cutoff design. This design approach should be considered further in future stages of design, if the current plan for mining the north portion of the Portage Pit in Year 4 is maintained.

The design concept for the tailings storage facility involves the control of the acid generating potential and metal leaching potential of the tailings through the promotion of partial freezing of the tailings as they are deposited during operations, and complete freezing of the tailings during post-closure. At the end of the mine life, the northwest arm of Second Portage Lake will be filled to above the existing lake surface with tailings. During closure portions of the pit de-watering dikes will be breached. This will result in the lake coming in contact with the tailings dike, and potentially acting as a heat source on the dike face. Consequently, a key aspect to the success of the frozen tailings concept will be the ability to maintain the core of the dike in a frozen state, similar in concept to a natural shoreline.

Both steady-state and transient thermal modeling for the post-closure indicate that the dike will remain frozen with the lake against its outside face. The transient thermal analyses included an allowance for climate change over the 100 years following closure of the tailings impoundment.

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1.0 INTRODUCTION

Cumberland Resources Ltd. (CRL) is currently evaluating the feasibility of developing the Meadowbank Gold Project. The project is located approximately 70 km north of Baker Lake in Nunavut, as shown on Figure 1.1.

The Meadowbank Gold Project consists of several gold-bearing deposits within close proximity to one another. A general site plan of the proposed Meadowbank Mine is shown in Figure 1.2. The four main deposits are the:

- Vault Deposit;
- Third Portage Deposit (including Bay Zone and Connector Zone);
- North Portage Deposit; and
- Goose Island Deposit.

The Third Portage Deposit is located on a peninsula, and extends northward under Second Portage Lake, and southward under Third Portage Lake. The North Portage Deposit is located on the northern shore of Second Portage Lake. The Third Portage Deposit, Bay Zone, Connector Zone, and North Portage Deposit will be mined from a single pit that will extend approximately 2 km in a north-south direction, and between about 200 m and 400 m in an east-west direction.

The Goose Island Deposit lies approximately 1000 m to the south of the Third Portage Deposit, and beneath Third Portage Lake.

The deposits are situated adjacent to and beneath lakes. Consequently, a series of dewatering dikes will be required to isolate the mining activities from the lakes (see the East, Bay Zone, and Goose Island Dikes as shown on Figure 1.2).

The tailings resulting from the mining and milling of the ore will be deposited into the northwest arm of Second Portage Lake. The tailings will be discharged as a slurry (Golder 2004a).

The purpose of this report is to present tailings dike design alternatives, and to evaluate the technical feasibility of constructing the tailings dike at the proposed location crossing Second Portage Lake. In addition, this report provides quantity estimates adequate to be used by CRL in a feasibility-level cost estimate.

2.0 TAILINGS DIKE SELECTION STUDY

A site selection study was conducted previously to identify a preferred storage location and deposition method for tailings at the Meadowbank site (Golder 2004a).

The key criteria used to select the preferred tailings storage area were the following:

- The location should be within a catchment draining toward the open pits;
- The facility must have capacity to store the expected volume of tailings produced over the mine life;
- The facility must have potential to store increased volumes of tailings if ore reserves are expanded;
- The location must not preclude future mine expansion; and
- The facility must allow for collection and control of supernatant.

Seven potential tailings storage options were considered in the site selection study. The option of sub-aerial slurry disposal in the North Arm of Second Portage Lake was selected as the preferred option due to the following main factors:

- Reduced potential for ARD/ML generation;
- Ease of operation in the harsh arctic climate; and
- Relatively low capital cost of.

The proposed tailings facility layout is shown on Figure 2.1.

3.0 GENERAL SITE CONDITIONS

Much of the following description of general site conditions is summarized from site studies carried out by Golder (Golder 2002b, Golder 2002c, Golder 2003a), or from the Project Description Report (CRL 2003).

3.1 Topography and Lake Bathymetry

The general site area consists of low, rolling hills with numerous small lakes. The topography in the immediate vicinity of the main deposits (Third Portage, Connector Zone, North Portage, and Goose Island Deposits) is generally flat, with topographic relief on the order of 10 m to 12 m, but as high as 60 m locally. Elevations vary from about 133 m Above Sea Level (A.S.L.) along the Third and Second Portage Lake shorelines, and up to maximum elevations of approximately 200 m A.S.L. to the northwest of the deposits.

Elevations in the vicinity of the Vault Deposit range from about 139 m A.S.L. at the Vault Lake shoreline to about 160 m A.S.L. just west of the deposit.

Bathymetric surveys of the lakes adjacent to and overlying the main deposits have been carried out, and are presented in previous reports (Golder 2002a, Golder 2003b). The results of the surveys indicate maximum lake depths of approximately 38 m in Second Portage Lake.

3.2 Surficial Geology

The project area is covered by laterally extensive deposits of glacial till. In general terms, the till can be described as a silty sand/gravel till, having a fines (silt plus clay) content between about 30% and 40%, based on laboratory grain size analyses (Golder 2002b, Golder 2002c, Golder 2003a). The till also contains up to boulder-sized particles.

The material that has been recovered from beneath Second Portage and Third Portage Lakes during geotechnical drilling along the alignments of the proposed tailings an dewatering dikes generally can be described as cobbles and gravel with traces of sand, silt, and clay. Locally, samples of sand have been obtained. Samples of clayey sand material have been recovered using split spoon sampling methods.

3.3 Permafrost

The project is located within the zone of continuous permafrost. The land surface in the project area is underlain by continuous permafrost, while lakes that are deeper than about 2 m will be underlain by a talik, or zone of permanently unfrozen ground. Based on thermal studies carried out to date (Golder 2003c, Golder 2004b), the project is underlain by permafrost up to 550 m deep, depending on proximity to lakes and other factors. The depth of the active layer in the project area ranges from about 1.3 m in areas of shallow overburden and away from the influence of lakes, to 4.0 m nearest to lakes. A summary of estimated geothermal properties for two thermistors in the area of the proposed tailings dike are given in Table 3-1. Detailed information is provided in Golder's Permafrost Report (Golder 2003c).

Based on recent ground conductivity surveys (Golder 2003d) and compilation of regional data, the ground ice content is expected to be low. Locally on land, ice lenses and ice wedges are present, as indicated by ground conductivity, and by permafrost features such as frost mounds. These areas of local ground ice are generally associated with low lying areas of poor drainage. Over most of its length, the tailings dike will be constructed below existing lake level, where no ground ice will be present. Ground ice could be present at the abutments of the dike, outside the current shoreline.

Table 3-1: Summary of Estimated Geothermal Properties for Tailings Dike Thermistors

Borehole	Location	Vertical Depth of Installation (below ground surface)	Approx. Depth of Zero Annual Amplitude	Estimated Zero Amplitude Temp.	Estimated Geothermal Gradient	Estimated Mean Annual Surface Temp.	Estimated Vertical Depth of Active Layer	Estimated Vertical Depth of Permafrost
		(m)	(m)	(°C)	(°C/m)	(°C)	(m)	(m)
03GT-TD5A	Tailings Dike South Abutment	42.5	Insufficient Data	Insufficient Data	0.051	N/A	2.8	N/A
03GT-TD-1	Tailings Dike 2nd Portage Abutment	44.2	Insufficient Data	Insufficient Data	0.051	N/A	1.3	N/A

Notes:

1. Where thermistors are installed adjacent to lake bodies, and are installed in the direction of, or terminate beneath, the lake surface, geothermal properties are indicative of borehole specific thermal conditions, and not necessarily of the regional thermal regime.
2. N/A indicates the estimation of a certain geothermal property is Not Applicable due to the proximity of installation to lake body.

A talik exists below Second Portage Lake, and is expected to extend through the permafrost.

3.4 Climate

Table 3-2 summarizes precipitation data from the Meadowbank site.

Table 3-2: Annual Precipitation Data 1998 – 2002

Year	Recorded Precipitation (mm)
1998	177.1
1999	190.2
2000	100.5
2001	84.1
2002	146.7

Source: Meadowbank Gold Property – Project Description, 2003 – CRL 2003.

The annual precipitation at the site generally falls as rain between June and September, while snow falls generally between October and May. Snowfall may, however, occur at any time of year. Table 3-3 summarizes mean monthly climate data collected from the site since 1997.

Table 3-3: Summary of Monthly Climate Data

Month	Air Temperature					Mean Soil Temperature at 0.2 m to 0.3 m depth (°C)
	Extreme Day		Average Monthly			
	Max (°C)	Min (°C)	Max (°C)	Min (°C)	Mean (°C)	
January	-4.9	-43.0	-28.2	-34.9	-31.6	-24.7
February	-9.1	-46.8	-27.9	-35.2	-31.7	-28.2
March	-3.1	-43.6	-21.7	-29.7	-25.5	-24.4
April	2.1	-35.4	-12.7	-22.1	-17.2	-17.6
May	8.0	-22.3	-2.3	-9.3	-5.6	-7.4
June	22.7	-12.9	7.8	0.0	3.8	1.9
July	29.8	1.3	17.2	7.6	12.4	11.0
August	27.4	-0.4	13.6	6.7	9.9	9.6
September	20.5	-8.2	5.8	1.1	3.3	3.7
October	5.3	-24.1	-4.8	-10.6	-7.6	-2.9
November	-1.3	-34.4	-14.5	-21.5	-18.0	-12.1
December	-5.4	-39.8	-22.3	-28.9	-25.6	-19.2

Source: AMEC 2003 and Golder 2003c.

Wind speeds of greater than 100 km/h have been reported at the site. Estimates of wave heights on Third Portage Lake during one such event were reportedly on the order of 2 ft to 3 ft (0.6 m to 0.9 m), based on personal communication with CRL site personnel during 2002.

Based on data obtained during recent geotechnical drilling investigations carried out between late April and early June of 2003 (Golder 2003a), ice thickness on the lakes is expected to vary from about 1.5 m to about 2.5 m.

3.5 Seismicity

The Meadowbank project is located in an area of low seismicity, as shown in Figure 3.1 and Table 3-4. Low seismicity is considered to correspond to areas where the PGA for the 1 in 475 year seismic event (10% probability of exceedance in 50 years) is less than 0.04g (CDA 1999).

Table 3-4: Peak Horizontal Ground Accelerations for Meadowbank Site

Return Period of Seismic Event (years)	Peak Horizontal Ground Acceleration (g)
100	0.018
200	0.025
475	0.034
975	0.044

Source: Seismic Risk Calculation for Meadowbank Project Site,
Geological Survey of Canada, Natural Resources Canada, Sidney, B.C., July, 2003 – See Appendix V.

4.0 DESIGN BASIS AND CRITERIA

Table 4-1 includes the key design basis and criteria for the current tailings dike design.

Table 4-1: Summary of Tailings Dike Design Criteria

Design Criteria	Value	Source/Comments
Mine Design life	11 years	CRL
Mill Production (solids)	5500 tonnes per day	AMEC
Total Mass of Tailings solids to be contained	19.8 million tonnes	Golder Mine Waste Management Report (Golder 2004a)
Average Specific Gravity of Ore	2.9	Golder Mine Waste Management Report (Golder 2004a)
Average Settled Void Ratio of Tailings	1.0	Experience with similar tailings
Average Settled Moisture Content of Tailings	35%	Experience with similar tailings
Average Settled Dry Density of Tailings	1.45 tonnes/m^3	Calculated based on specific gravity and settled void ratio
Minimum setback from pit crest to inside toe of dike	60 m	See Note 1.
Maximum size of haul trucks on dike	Caterpillar 777D	Dam Crest to serve as part of Vault haul road
• Width	6.05 m	Caterpillar handbook
• Tire diameter	2.5 m	Caterpillar handbook (27.00R49 tire)
Maximum wave height	0.6 to 0.9 m	Meadowbank Site (pers. com. 2002)
Maximum Ice thickness	1.5 to 2.5 m	Based on geotechnical drilling
Minimum dike crest width	30 m	To comply with NWT Mine Health and Safety Regulations – See Note 2.
1 in 975 design seismic event	PHGA = .044g PHGV = .039 m/s	Pacific Geoscience Centre Seismic Hazard Evaluation
Canadian Dam Association hazard classification	High	Canadian Dam Association Dam Safety Guidelines
Minimum factor of safety for static load conditions	1.5	Canadian Dam Association Dam Safety Guidelines
Minimum factor of safety for pseudostatic load conditions	1.2	Canadian Dam Association Dam Safety Guidelines
Minimum factor of safety for end-of-construction condition – see Note 3.	1.3	Canadian Dam Association Dam Safety Guidelines
Minimum freeboard	2.0 m during operations, 1.0 m at closure	Canadian Dam Association Dam Safety Guidelines
Second Portage Lake surface elevation	133.1m ASL	
Third Portage Lake surface elevation	134.1m ASL	
Required minimum reclaim water pond volume	600,000 m^3	CRL – this volume is required by mill to maintain proper chemistry for process
Final Tailings Surface Elevation	136.6 m ASL	Golder Mine Waste Management Draft Report (Golder 2004a)

Notes for Table 4-1:

1. A minimum setback of 60 m (80 m nominal setback) between the open pit side toe of the dike and the edge of the Portage open pit ultimate crest has been assumed. This distance has been assigned to allow a reasonable working distance to the crest of the Portage pit. The 60-m minimum distance is less than the 80 m assigned for the dewatering dikes, due to the low likelihood that the Portage Pit would be expanded toward the tailings dike (i.e., toward the west). The final setback distance will be based on other factors, including:
    - Pit slope stability;
    - Peak particle velocities and acceleration of embankment materials due to blasting;
    - Porewater pressure increase and potential deformation related to blasting.

2. The tailings dike crest will act as a portion of the haul road from the Vault Pit to the mill site. The dike crest width should comply with NWT Mine Health and Safety Act and Regulations, or equivalent regulations for Nunavut, for minimum width of haul roads (NWT and Nunavut 1995). For single lane traffic the minimum width is twice the width of the widest haulage vehicle used on the road; for double lane traffic the minimum width is three times the width of the widest haulage vehicle. A shoulder barrier of at least three-quarters the height of the largest tire on any vehicle using the road is required.

3. The end-of-construction condition for the tailings dike ends when tailings deposition begins.

An additional criterion is that the dike section should maximize the use of materials obtained during pre-stripping and mining. These materials are till and run-of-mine rockfill.

4.1 Requirement for Thermal Barrier after Closure

The conceptual closure plan for the tailings impoundment includes flooding the Portage Pit area by breaching the Goose Island Dike. This will result in water eventually ponding on the east side of the tailings dike, to an elevation of approximately 134.1 m A.S.L. (the current lake level for Third Portage Lake).

The potential for acid generation and metal leaching from the tailings via seepage to the deep groundwater regime can be reduced by limiting the contact of water with the tailings mass. This can be achieved by developing a horizontally-continuous layer of frozen tailings across the facility in the long term. Therefore, after closure, the tailings dike must also act as a thermal barrier toward the tailings area.

Frozen conditions are not required to maintain the physical stability of the tailings dike. The tailings dike has been designed to be physically stable under unfrozen, partially frozen, and frozen conditions.

5.0 DESIGN ALTERNATIVES

5.1 Tailings Dike Site Conditions

The proposed tailings facility layout is shown on Figure 2.1, and the proposed tailings dike embankment is shown in plan on Figure 5.1. The site conditions along the proposed dike centreline are shown in Figure 5.2. This section was developed using the information obtained from geotechnical investigations conducted in 2002 and 2003 (Golder 2002b, 2002c, 2003a). Logs for boreholes in the area of the proposed tailings dike are included in Appendix I.

These boreholes indicate the following:

- The maximum depth of foundation soil is approximately 18 m;
- The foundation soil consists of glacial till and possibly glacial outwash deposits. The till contains significant amounts of gravel, and cobbles. Based on samples collected from surface around the Meadowbank project site, the material could also contain significant silt or clay. Since water was circulated during drilling, very few fines were recovered.
- At the bedrock contact, there is a zone of highly fractured bedrock. This zone extends along most of the proposed alignment of the tailings dike.
- The zone of fractured bedrock is at least 10 m thick. None of the boreholes reached a less-fractured zone. However, based on results from drilling at nearby locations, the fractured zone may be less than 20 m thick.

In addition to the fractured surficial bedrock, the Second Portage Lake fault will underlie the tailings dike, and will cross the proposed dike alignment approximately perpendicularly. The fault is expected to be a relatively discrete structural feature, based on geotechnical drilling investigations (Golder 2002b, Golder 2003a). The hydraulic conductivity of the fault was measured as 5.1×10^{-6} m/s (see Appendix I).

5.2 Design Alternatives

Due to the inability to recover the fine fraction of the foundation material during sampling, it is uncertain whether the in situ till material along the alignment of the proposed tailings dike is of sufficiently low permeability and of sufficient extent to act as part of a seepage control blanket. This information might not be available until such time as the area has been dewatered. As such, two possible design cross-sections have been developed, as shown in Figure 5.3.

The first design alternative, the ‘Full Cutoff’ design, includes a full cutoff through the foundation till materials to bedrock. In addition to the compacted till cutoff component, this design would include a pressure grouted curtain in the fractured bedrock.

The second design alternative, the ‘Partial Cutoff’ design assumes that the foundation till material has sufficiently low permeability, and is of sufficient lateral extent, that a full foundation cutoff is unnecessary. In this case, only a shallow key-in has been included in the section.

Current mine planning indicates that the north portion of Portage Pit, closest to the proposed tailings dike, will be mined beginning in Year 4. In this case, it is possible that the deposited tailings could act as a low-permeability upstream seepage blanket. This scenario was also considered in the seepage analyses.

5.3 Proposed Tailings Dike Sections

The proposed typical tailings dike cross-sections are shown on Figure 5.3.

The proposed dike cross-sections consist of:

- A rockfill shell, constructed from run-of-mine waste rock. The upstream and downstream faces have been designed at a 2H:1V slope;
- Upstream and downstream filter zones;
- A low-permeability till core;
- The dike will have a minimum crest width of 30 m.

Additionally, for the Full Cutoff design, the cross-section includes:

- A low-permeability compacted till cutoff through the foundation soil.
- A pressure-grouted grout curtain through the fractured bedrock zone. At this time it has been assumed that the fractured bedrock is up to 20 m deep, based on available geotechnical drilling information along the dike alignment.

Design details for the proposed cross-sections are presented in the following sections.

5.4 Tailings Facility Design Capacity and Required Crest Elevation

The elevation of the crest of the dike has been selected to provide storage capacity for the presently-known ore reserves, plus 3 m to provide freeze-thaw and traffic protection for the core.

The required capacity for storage of tailings is calculated using the total mass of tailings (19.8 million tonnes), and the predicted settled dry density (1.45 tonnes / m^3). This gives a total required volume of 13.7 million m^3.

Figure 5.4 shows the storage capacity – elevation curve for the proposed tailings facility. From Figure 5.4, the maximum elevation for the required volume of tailings is shown to be 136.6 m A.S.L. Allowing 3 m for freeze-thaw and traffic protection, the required crest elevation for the dike is 139.6 m A.S.L. The additional three metres of height is in excess of the estimated height required for freeboard, and wave run-up.

5.5 Proposed Construction Methodology

The tailings dike will be constructed under ‘dry’ conditions, after a portion of Second Portage Lake has been dewatered to elevation 105 m. The area will be dewatered once the East and Bay Zone dikes have been completed (see Figures 1.2 and 2.1).

The tailings dike will be constructed to elevation 120 m in Year -1 of the mine life. Subsequently, by Year 3, the dike will be constructed to its final crest elevation of 139.6 m.

The sequencing of the tailings dike construction, and the overall tailings facility, is summarized in Table 5-1.

Table 5-1: Summary of Tailings Storage Facility Development

Year	Description of Activities
-1	• Dewater Second Portage Arm to at least elevation 105 m. • Construct first stage of tailings dike up to elevation 120 m.
1	• Commence discharging slurry.
3	• Construct second stage of tailings dike to elevation 139.6 m. • Construct perimeter dikes at west end. • Operate water pond within main portion of tailings facility.
5	• Construct Stormwater Dike to elevation 136.6 m.
6 to 10	• Operate water pond in western portion of 2nd Portage Arm. • Place slurry to elevation 136.6 m (3.5 m above current lake level). • Maintain water management pond at west end of lake.
Closure	• Place ultramafic capping layer to maintain tailings frozen below active layer.

5.6 Stormwater Dike and Saddle Dams

As part of the operation of the tailings impoundment, it will be necessary to maintain a separate stormwater pond within the tailings impoundment. In order to keep the stormwater separate from the tailings and supernatant, it will be necessary to construct a stormwater dike within the tailings impoundment. In the last two to three years of operation, the stormwater pond will be inundated with tailings.

The Stormwater Dike and the Saddle Dams 1 to 4 are shown in plan on Figure 2.1. Figure 5.5 shows conceptual cross-sections for the stormwater dike, and for the saddle dams.

At the perimeter of the tailings impoundment, saddle dams will be required. For Saddle Dams 2 and 3, the existing ground elevation at the proposed saddle dams is higher than 136.6 m A.S.L. (the maximum elevation of tailings). Therefore, the function of these saddle dams is only to act as freeboard, and not to retain tailings or water. As such, the embankments for Saddle Dams 2 and 3 will comprise only rockfill.

For Saddle Dams 1 and 4, the existing ground elevation at the proposed saddle dams is approximately 135.0 m A.S.L. (lower than the maximum elevation of tailings). Therefore, these saddle dams could retain tailings or water, up to a maximum of approximately 1.6 m. As such, the embankments for Saddle Dams 1 and 4 will comprise a till core with rockfill shells.

6.0 GEOTECHNICAL ANALYSES

6.1 Slope Stability

Slope stability analyses were carried out for the two alternative design sections for the tailings dike. The section chosen for slope stability analyses is included on Figure 5.3. This section corresponds to the maximum section of the dike.

The slope stability analyses were done for unfrozen conditions. If the dike and/or the foundation materials freeze, the strength of the materials would increase, and the slope stability of the dike would increase.

Stability analyses have been carried out for four stages of development, as follows:

1. End of Stage 1 construction: The first stage of the tailings dike would be constructed up to elevation 120 m. For the Full Cutoff design, it was assumed that the foundation soil is a permeable material. Strength of this material was assigned effective stress parameters.

   For the Partial Cutoff design, it was assumed that the foundation soil would be undrained, and the strength governed by the undrained shear strength of the material. However, since no data is available about the shear strength of the foundation soil, a range of undrained strengths from 10 to 100 kPa was modelled for the foundation till to determine the minimum undrained shear strength required to achieve Factor-of-Safety design criteria. A potential upstream failure, through the foundation till layer, was modelled.

2. High Water Condition: During the initial stages of mine life, water will be ponded against the upstream face of the tailings dike, at a maximum elevation of 120 m A.S.L. A potential downstream slope failure was modelled for this condition.

3. In Year 10 of the mine life, deposition of tailings will be complete, to elevation 136.6 m. A potential downstream slope failure was modelled for this condition.

4. After closure, the Goose Island dewatering dike will be breached, and water will be allowed to flood the Portage Pit area, up to elevation 134.1 (the elevation of Third Portage Lake surface). A possible downstream failure was modelled for this condition.

Limit equilibrium analyses were carried out using the commercially available software SLIDE™.

The range of possible failure surfaces was limited to those that pass through the till core. This was done since it is only when the till core is affected that the overall performance of the tailings dike is compromised.

Long-term conditions were analyzed using effective stress strength parameters for drained conditions.

Static and pseudostatic conditions were modelled. Pseudostatic analyses for earthquake load conditions were carried out for the long-term condition using effective stress strength parameters.

Both circular and block-type failures were considered. In all cases, circular failures were found to be more critical.

Material properties used in the analyses are summarized in Table 6-1.

Table 6-1: Summary of Material Properties used in Slope Stability Analyses

Material	**Saturated Unit Weight (kN/m^3)**	**Effective Stress Parameters**		**Undrained Strength Parameter, c_u (kPa)**	**Pore Pressure Ratio r_u**	**Basis for Property Selection**
		Cohesion, c' (kPa)	**Angle of Internal Friction (°)**			
Till Core and Cutoff	15.7	0	28	--	0.3	Direct shear testing[1]
Rockfill	18.6	0	40	--	--	Previous experience with similar material
Foundation Till	17	0	28 to 32	10 to 100	--	Previous experience with material with similar grain size distribution

Notes: 1. Golder 2002b.
2. For till core material, c'=0 assumed for effective stress case.

For the Meadowbank site, the predicted PGA is 0.044 g for a seismic event with a return period of 975 years (see Table 3-4.). The pseudo-static analyses have been done using a horizontal acceleration of 0.022 g. This value corresponds to one-half of the firm ground acceleration for the 1000-year return period event (USACE 1984). The 1000-year return period is considered appropriate, given that:

- The dike will be retaining water and tailings while men and equipment are working in the Portage pit, and
- The design life of the dike is less than 20 years.

Results of the stability analyses are included in Appendix II.

6.1.1 Results of Analyses for End of Stage 1 Construction Conditions

Slope stability analyses were carried out to evaluate the short-term, end of Stage 1 construction situation, for both design sections. For the Full Cutoff design, the foundation till material was assumed to be permeable and, consequently, stability was assessed using effective stress parameters. For the Partial Cutoff design, the foundation till was assumed to be undrained, and stability was assessed using a range of undrained shear strengths of 10 to 100 kPa.

In both cases, the dike was modelled using a crest elevation of 120 m. This corresponds to the first stage of construction, to be completed in Year -1 of the mine life.

For the Partial Cutoff design case, the section was analyzed to determine the values of the undrained shear strength (c_u) which would yield Factors of Safety (FOS) of 1.0 and 1.3. The results of the stability analyses are contained in Appendix II.

A FOS of 1.3 is the minimum value required for the end of construction condition. A FOS of 1.0 is the value at which failure would begin to occur.

Table 6-2: Summary of End of Stage 1 Construction Stability Analyses

Condition	Strength Parameters	Minimum Calculated FOS	Required Undrained Shear Strength of Foundation Till to Achieve a Factor of Safety of 1.3 (kPa)
Drained	c’, φ	2.7	---
Undrained	c_u	See Note 1	60 to 70

Notes: 1. A factor of safety of 1.3 has been assumed in order to calculate the minimum undrained shear strength of the foundation till to meet design requirements.

As shown in Table 6-2, the analyses indicate that the Stage 1 dike will be stable for drained end-of-construction conditions, with an associated FOS of 2.7.

The analyses also indicate that, for undrained end of construction conditions, the minimum undrained shear strength of the foundation materials required to achieve a FOS of 1.3 is about 60 to 70 kPa. The foundation soils that have been recovered during the geotechnical investigations carried out in other areas of the Meadowbank site indicate silty till material containing significant proportions of gravel and cobbles. Undrained shear strengths of this material are expected to be at least equal to or greater than 70 kPa, based on experience with similar materials at other sites. In the Partial Cutoff design case, undrained shear strength testing will be required during the detailed engineering design stage for the dike.

If, during construction, it is determined that the undrained shear strength of the foundation till is lower than 70 kPa, then the stability of the embankment can be increased by flattening the overall slopes of the rockfill zones, to achieve the required FOS.

A potential progressive failure scenario was also modelled for the end-of construction scenario (see Appendix II). The progressive failure was modelled by steepening a portion of the upstream face of the dike, simulating a prior failure of a portion of the upstream slope near the toe. These analyses indicate that the dike will be stable for steepened upstream slope angles, and the dike will not be prone to progressive slope failure.

6.1.2 Results of Analyses for Long-Term, Steady State Seepage Conditions

Slope stability analyses were done to evaluate the stability of the dike under long-term, steady-state seepage conditions, at three critical points in the operational life of the dike, and after closure as follows:

- In the early stages of mine life, free water ponded against the dike, with the water surface at approximately 120 m A.S.L. This situation was modelled under static and pseudostatic conditions;
- At the end of Year 10, deposition of tailings will be complete, and the tailings will be at their maximum elevation. This situation was modelled under static and pseudostatic conditions;
- During closure of the facility, water will be allowed to flood the Portage Pit side of the tailings dike. This situation was modelled under static and pseudostatic conditions.

Stability of the embankment was assessed using effective stress parameters (see Table 6-1). During operations, the minimum required FOS under static loading conditions is 1.5 and under pseudo-static loading is 1.2.

The full results of the long-term analyses are included in Appendix II, and are summarized in Table 6-3.

Table 6-3: Summary of Long-Term Slope Stability Analyses

Failure Mode	**Minimum Calculated Factors-of-Safety**		**Minimum Yield Acceleration (g)**
	Static (Minimum Required = 1.5)	**Pseudostatic (Minimum Required = 1.2)**	
High Water (Water at Elevation 120 m)	2.0	1.8	0.21
End of Deposition (Tailings at Elevation 136.6)	2.3	2.2	0.41
Closure	4.9	4.3	0.43

Note: Yield acceleration = the peak horizontal ground acceleration (PGA) that produces a FOS of 1.0.

The calculated Factors of Safety are greater than the minimum values required for static and pseudostatic conditions.

The minimum yield acceleration indicated in Table 6-3 is 0.21 g. Since the predicted PGA of 0.044 g is below the minimum calculated yield acceleration, the deformation of the dike will be small during the design earthquake event.

Based on the analyses, the dikes will be stable in the long-term, for static and pseudostatic loading conditions.

6.2 Seepage

Seepage analyses were carried out for the maximum section, for both the Full Cutoff and Partial Cutoff designs (see Figure 5.3) using the commercially available software SEEP/W™. The material parameters used in the analyses are presented in Table 6-4.

Unfrozen soil conditions were generally assumed in the model. One analysis scenario modelled the seepage assuming the till core of the dike was frozen. The conditions modelled represent the anticipated high water condition in the early stages of mine life. This represents the maximum seepage expected during the life of the dike. During subsequent years, tailings will be deposited near the upstream face of the dike, and seepage should decrease. By Year 5, it is anticipated that the tailings pond will be approximately 800 m from the upstream face of the dike.

The hydraulic conductivity assumed for the fractured bedrock is based on the falling head tests completed in boreholes 03GT-TD-02, -04, and -06 (drilled approximately along the centreline of the proposed dike), and corresponds to the maximum value of 4.0 x 10^{-5} m/s recorded in the three tests (see Appendix I). The value of hydraulic conductivity used is a higher permeability than that measured in the Second Portage fault zone, by approximately one order of magnitude. The lower permeability in the fault zone is thought to be a result of the infilling of fractures within the fault zone. A contingency has been designed to include for drilling and grouting of discrete features within the fractured bedrock.

Fluxes were computed at the proposed Portage Pit west wall for each of the two designs. Table 6-5 shows the predicted fluxes.

The final deposited surface elevation of the tailings is anticipated to be 136.6 m A.S.L. Under these circumstances, a small hydraulic gradient toward the re-flooded Portage pit area would exist. In the event that the total mine production is less than anticipated, or the settled density of the tailings is greater than expected, then the final elevation of the deposited tailings could be lower than elevation 134.1 m A.S.L. In this case, a hydraulic gradient toward the tailings would exist. This situation has been modelled as part of this study (see Appendix III).

Table 6-4: Summary of Material Properties Used in Seepage Analyses

Material	Hydraulic Conductivity (X 10^{-6} m/s)	Comments/Basis for Properties
Till Core and Cutoff (Cutoff is for Full Cutoff Design only)	0.1	• Falling head tests from Dec 2002 geotechnical testing; and • Experience with materials with similar genesis and grain size distribution • If till core and / or cutoff material is thawed after initial freezing, it is possible that the hydraulic conductivity of this material could increase, unless the upstream portion of the till is maintained in a frozen state – see Section 7.2.
Rockfill	10,000	
Foundation Till – Full Cutoff Design	100	• Assumes material is free-draining
Foundation Till – Partial Cutoff Design	0.1	• Assumes material is relatively low permeability
Grout Curtain – Full Cutoff Design only	0.05	• Previous experience
Fractured Bedrock	40	• BH 03GT-TD-4 falling head packer test – see Appendix I.
Deeper Bedrock	0.001	• Report on Hydrogeology Baseline Studies; (Golder 2003e).
Tailings	0.1	• Conservative estimate for fine-grained tailings, based on experience with similar materials, and published values (Vick 1990)

According to the current mining plan, the north portion of the Portage pit nearest to the proposed tailings dike will not be mined until at least Year 4 of the mine life. This situation could allow for an optimization of the dike design by relying on the low permeability of the deposited tailings to act as a seepage barrier to flow toward the Portage open pit. This situation has also been analyzed for the situation where:

- The foundation till is of higher permeability;
- The dike cross-section includes a till core but no cutoff structures;
- Tailings have been deposited against the upstream face of the dike, and at a nominal slope into the impoundment;
- The tailings pond is at a distance of 200 m from the face of the dike (based on Year 3 predictions).

The resulting flux and flow are indicated in Table 6-5.

Table 6-5: Seepage Fluxes and Flows at the Portage Pit West Wall

Design	Flux (m^3/s/m)	Flow into Portage Pit (L/s)
Full Cutoff Design	3.3×10^{-5}	26
Partial Cutoff Design	3.5×10^{-5}	28
Partial Cutoff Design with Year 3 tailings beach (pond at 200 m from upstream dike face)	9.0×10^{-5}	71
Partial Cutoff Design with Frozen Core and Cutoff	3.3×10^{-5}	26
Full Cutoff Design with tailings beach at 100 m from upstream dike face	1.5×10^{-5}	12

The total flow was determined by applying the calculated flux over a dike length of 800 m. The calculated flux corresponds to the maximum section, and therefore produces a conservatively high estimate when applied over the length of the proposed dike.

Seepage flow-nets are included in Appendix III.

It is anticipated that the majority of the seepage flows will report to the pit dewatering system. This water would be returned to the reclaim water pond.

The seepage analyses show that the proposed designs are effective at controlling seepage through the tailings dike during mine operation.

7.0 POST-CLOSURE THERMAL ANALYSES

The potential for acid generation and metal leaching from the tailings via seepage to the deep groundwater regime will be reduced by the development of a horizontally-continuous layer of frozen tailings across the tailings mass. This will limit the infiltration of air and water to the tailings.

A cover of ultramafic rock will be placed over the tailings, such that the active layer does not develop within the tailings mass, thereby limiting cryoturbation within the frozen tailings.

After closure, the tailings dike will need to act as a thermal barrier to limit the heat transfer from lake water toward the tailings. The current analyses of the overall tailings facility predict that the tailings and the existing talik below the North Arm of Second Portage Lake will freeze in the long term (Golder 2004b).

A thermal model of the tailings dike was developed using the software TEMP/W^{TM}. The objective of this thermal analysis was to determine whether the 0ºC isotherm would lie within the tailings dike, or would penetrate into the tailings. Both steady-state and transient models were run.

7.1 Steady State Analysis

A steady state analysis of the post-closure dike configuration was performed using the following boundary conditions:

- Ground surface temperature = -11ºC;
- Water temperature = +4ºC;
- Geothermal flux at base of model = 0.051 W/m^2

The ground surface temperature was applied over the surface of the tailings, and on the exposed portion of the tailings dike. The water table in the east side of the dike was assumed to extend horizontally through the rockfill, to the till core.

Material properties used in the thermal analyses are shown in Table 7-1.

Table 7-1: Summary of Material Properties Used in Post-Closure Thermal Analyses

Material	Thermal Conductivity (J/sec-m-°C)		Volumetric Heat Capacity (J/m^3-°C) ($x10^6$)		Volumetric Water Content	Basis for Properties
	Frozen	Unfrozen	Frozen	Unfrozen		
Till Core and Cutoff (Cutoff is for Full Cutoff Design only)	3.3	2.4	1.9	2.5	0.28	See Note 1
Rockfill	3.3	2.8	2.4	2.6	0.12	See Note 1
Foundation Till	3.3	2.8	2.4	2.6	0.12	See Notes 2 and 3
Fractured Bedrock	3.3	2.8	2.4	2.6	0.12	See Note 1
Deep Bedrock	3.5	3.4	2.39	2.4	0.02	See Note 1
Tailings	2.2	1.6	2.2	2.95	0.50	See Note 1

Notes:
1. Golder 2004b
2. Farouki 1986.
3. Johansen 1975.

Figure 7.1 shows the results of the steady-state thermal analyses. The 0ºC isotherm is located within the tailings dike, indicating that the dike would be an effective thermal barrier between the lake and the tailings.

7.2 Transient Analyses

The tailings dike area was also analyzed for the transient thermal case, for:

- The case where no variation from the current climate patterns is anticipated; and,
- The case where there will be a 5.5°C increase in average air temperature over the one-hundred years following closure of the mine.

The purpose of the transient model was to assess the potential for seasonal variations in temperature to affect the till core of the dike, particularly the top portion of the core. Given that the hydraulic conductivity of the till could increase if thawed after being frozen, it was also important to assess the potential for thawing due to climate change.

The material thermal properties used in the transient analyses were the same as those used in the steady-state analysis, as given in Table 7-1.

Other parameters used in the analyses are shown in Table 7-2.

Table 7-2: Summary of Modelling Parameters for Post-Closure Transient Thermal Modelling

Parameter	Conditions Used in Model
Initial Conditions	Post-Closure steady-state conditions assumed.
Boundary Condition Functions	• For tailings surface and exposed portion of tailings dike, a function assuming no snow cover was used – see temperature functions in Figure 7.2, as taken from Golder thermal modelling report (Golder 2004b). • For climate change, a linear warming trend of 5.5°C over 100 years was used – see Figure 7.3. • A constant temperature of +4°C was used for water.
Time steps	Ten-day time steps used.
Total duration of modelling	Ten years for transient modelling not including climate change. Duration chosen to be sufficient to allow stabilization of 0°C isotherm below active layer. For climate change, 100 years was used.

Figure 7.4 summarizes the results of the transient thermal modelling without including for climate change, and shows the isotherms for January and August. Figure 7.5 shows the results for the transient thermal modelling including the effects of climate change.

The figures indicate that the active layer does not penetrate into the till core, and the till core will remain frozen.

8.0 DIKE CONSTRUCTION MATERIAL VOLUME ESTIMATES

8.1 Tailings Dike

Based on the alignment shown in Figure 5.1 and on the typical sections for each of the design alternatives shown on Figure 5.3, volumes of construction fill materials were estimated using previous bathymetry studies, and the 3D terrain modeling software Land Development Desktop™ (LDD). The volumes were checked by end-area method using contour areas taken from AutoCad™.

Table 8-1 summarizes the estimated fill volumes for each of the tailings dike construction materials. These quantities are accurate to within 20%, and are considered suitable for feasibility-level purposes. The quantities are not intended to be used for bidding purposes.

Table 8-1: Quantity Estimates for Tailings Dike Construction Materials

Construction Material	**Volume (m^3)**	
	Full Cutoff Design	**Partial Cutoff Design**
Stage 1 Construction to crest elevation 120 m – Year -1		
Rockfill	490,000	490,000
Till Core	200,000	200,000
Till Cutoff (Full Cutoff) / Till Core Key-In (Partial Cutoff Design)	162,500	20,000
Filter	30,000	20,000
Road Surfacing	15,000	15,000
Stage 2 Construction to crest elevation 139.6 m – Year 3		
Rockfill	330,000	330,000
Till Core	60,000	60,000
Filter	20,000	20,000
Road Surfacing	7,000	7,000
Excavation of Lake-Bottom Sediments (Assume 1 m thickness)	75,000	75,000

8.2 Tailings Dike Grout Curtain

Table 8-2 includes estimated quantities for drilling and grouting for the injection-grouted grout curtain. Table 8-2 also includes estimated quantities for the concrete cap. These quantities apply to the Full Cutoff design.

Table 8-2: Quantity Estimates for Grout Curtain and Concrete Cap – Full Cutoff Design Only

Item	Quantity
No. of Grout Curtain Holes	800
Total drilling length – grout curtain	16,000 m
Volume of grout – grout curtain	1,650,000 litres
No. of consolidation grouting holes	1,200
Total drilling length – consolidation grouting	6,000 m
Volume of grout – grout curtain	250,000 litres

The quantities in Table 8-2 are based on the designs shown in Figures 5.1, 5.3 and 5.5, and on the following assumptions.

- Foundation rock is characterized as highly fractured. Average conductivity from field tests is around 3 to 4 x 10^{-5} m/s in the upper 5 m to 10 m of bedrock;
- Assume a nominal depth of treatment to 20 m in bedrock across the foundation. Note that the geotechnical drilling did not penetrate through the fractured bedrock layer;
- Estimates assume a single row grout curtain;
- Slope length along centreline of core trench: 1,200 m;
- Average hole spacing in completed curtain: 1.5 m
- One upstream and one downstream row of consolidation grout holes;
- Average hole spacing in consolidation rows: 2 m;
- Depth of consolidation grout holes: 5 m; and
- Assume 75 l/m grout admission, with 15% waste.

8.3 Stormwater Dike and Saddle Dams

Estimated fill quantities for the stormwater dike and saddle dams are shown in Table 8-3, based on the alignments shown on Figure 2.1, and the conceptual cross-sections shown on Figure 5.5.

Table 8-3: Quantity Estimates for Stormwater Dike and Saddle Dam Construction Materials

Construction Material	Volume (m^3)
Stormwater Dike – crest elevation 136.6 m	
Rockfill	9,100
Till Core	2,900
Filter	400
Saddle Dams – crest elevation 139.6	
Saddle Dam #1 – Rockfill – Till Core – Filter	9,300 3,000 500
Saddle Dam #2 – Rockfill	1,000
Saddle Dam #3 – Rockfill	1,700
Saddle Dam #4 – Rockfill – Till Core – Filter	5,500 1,700 300

8.4 Available Till and Rockfill Quantities

Both till and rockfill for construction of the Stage 1 tailings dike will come from pre-stripping at the proposed North Portage and Third Portage pit areas, and from mining at a proposed starter pit at the Third Portage Deposit. The initial source of rockfill will be a Third Portage starter pit. The starter pit would be entirely enclosed by land at the Third Portage Deposit.

The volumes of available till and rockfill are based on the latest mine plan. (see Appendix IV).

Materials to construct the tailings dike could consist of:

- Intermediate volcanic (IV) rock – in the upstream rockfill;
- Iron formation (IF) rock – in the downstream rockfill; and
- Till overburden from stripping of open pits.

The final determination of the appropriate use of one rock type or the other as fill for either the upstream or downstream rockfills will depend on considerations such as potential for acid generation, and metal leaching. Additional geochemical testing, water balance studies, and lake basin hydraulic modeling will help to address questions relating to the appropriate usage of the particular rock types. These studies are underway.

Preliminary material balance estimates (see Appendix IV) indicate that:

- Sufficient quantities of rockfill borrow materials for the Stage 1 tailings dike will be available through a combination of mining of the Third Portage starter pit, and stripping of the North Portage Deposit.
- Sufficient quantities of till borrow material for the Stage 1 tailings dike will be available from stripping of the Third Portage and North Portage deposits.
- The required volumes of till and rockfill material for construction of the Stage 2 tailings dike in Year 3 will be sufficient. These materials will come from on-going mining activities at the Portage pit.

9.0 CONSTRUCTION METHODOLOGY

The proposed construction sequence consists of the following main components:

1. Lower the water level in the North Arm of Second Portage Lake to elevation 105 m.

2. Remove and dispose of lake-bottom sediments which are unsuitable as foundation material. Lake-bottom sediments will be removed using conventional earth-moving equipment, under 'dry' conditions. The sediments will be disposed of within the proposed tailings impoundment. The foundation area of the proposed dike slopes to the west, therefore any sediment-laden runoff will be naturally contained within the tailings impoundment.

3. Assess the suitability of the foundation material as a low-permeability seepage barrier.

   In order to determine whether the in situ foundation material is suitable as a low-permeability seepage barrier, it will be necessary to perform site and laboratory investigations on this material, prior to proceeding with the construction of the dike section. The primary objective of the investigation will be to confirm the permeability of the foundation material, and its areal extent, to determine whether it would perform adequately as a seepage barrier.

   The investigations could consist of the following:
   - Logging and sampling of approximately 50 test pits within the dike footprint and in the area directly upstream of the dike;
   - Logging and sampling of approximately five to ten boreholes within the dike footprint and in the area directly upstream of the dike. Downhole falling head or constant head tests will also be performed, one in each borehole;
   - Laboratory testing of fine-grained materials from the test pits and boreholes, including index testing, and flexible-wall permeameter testing of the fine fraction of the samples. A minimum of approximately five sets of tests would be required.

   For the Full Cutoff Design only (if it is determined that neither the foundation material is adequate as a seepage barrier, nor that blanketing the upstream side of the dike with tailings will reduce the seepage to the Portage Pit sufficiently):

   3(a) Excavate till cutoff to bedrock contact. Excavated material could be suitable as fill in the rockfill zone of the dike;
   3(b) Construct concrete mat. Drill and grout the fractured bedrock zone;
   3(c) Backfill cutoff zone with compacted, low-permeability till material;

4. For both designs, construct Stage 1 rockfill, filter, and till core embankment to elevation 120 m in Year -1.

5. For both designs, Construct Stage 2 rockfill, filter, and till core embankment to elevation 139.6 m in Year 3.

10.0 CONSTRUCTION MATERIAL GUIDELINES

10.1 Rockfill Shell

The function of the rockfill is to support the till core, and to act as a freeze-thaw protection layer for the core. This material should be a durable, coarse, free-draining material with high shear strength.

The design criteria for the rockfill include the following:

1. The material should be free-draining. Material with a fines content (passing the No. 200 sieve) of less than approximately 8% to 10% is acceptable.

2. Particles should be large and durable enough to resist wave and ice erosion.

3. The grain size distribution of the filter adjacent to the till core must meet filter requirements with the till, and with the rockfill shell. This might require adjusting the blast pattern to produce a finer material than would normally be blasted during pre-strip operations. Additionally, it might be necessary to screen the blast-run rockfill to obtain a fine rockfill filter material.

Based on the above, it is recommended that the rockfill and filter gradation limits be set, on a preliminary basis, as shown on Figure 10.1.

10.2 Till Core and Cutoff

The purpose of the core material is to act as a seepage and thermal barrier, as discussed in previous sections. A material guideline grain size distribution for the till core material is shown on Figure 10.1. Grain size determinations of till materials recovered from the Meadowbank project area indicate that the till available from the pre-stripped materials at the Third and North Portage Deposits is within these limits.

The material used in the till core and cutoff (Full Cutoff design only) should have a maximum hydraulic conductivity of 1×10^{-7} m/s.

The materials specified in this section are similar to the materials specified for use in the dewatering dikes (Golder 2003f).

11.0 CONCLUSIONS AND RECOMMENDATIONS

The following are conclusions and recommendations based on the results of the Meadowbank tailings dike design study.

1. The foundation of the proposed tailings dike includes a highly-fractured zone of shallow bedrock. In order to control seepage through this zone, a low-permeability cutoff will be required. If the existing dike foundation material is of sufficiently low permeability, and of sufficient areal extent, it could act as an upstream seepage control blanket. If the dike foundation material is permeable, a cutoff and injection-grouted grout curtain may be required, depending on the sequencing of the open pit development and tailings deposition against the tailings dike. The cutoff would be constructed through the dike foundation material, and the grout curtain would be constructed through the fractured bedrock and into less-fractured rock.

   Due to the uncertainty about whether the dike foundation soil is of sufficiently low permeability and areal extent to act as a seepage control blanket, it is recommended that two design options be carried to the detailed design stage, to allow flexibility in sequencing of the development of the Portage Pit, until such information is available. These designs are:

   - Full Cutoff design: This design is for the case where the dike foundation material is permeable. The dike section will consist of a rockfill shell, till core embankment, a till cutoff to bedrock contact, and an injection-grouted grout curtain through the fractured bedrock zone.
   - Partial Cutoff design: This design is for the case where the foundation material is adequate as a seepage control barrier. This dike section would be essentially the same as for the Full Cutoff, but would not include a till cutoff or grout curtain.

2. The possibility of using the deposited tailings as an upstream seepage blanket could offer significant advantages over the Full Cutoff design. If the current plan for mining the northern portion of the Portage Pit in Year 4 is maintained, it is recommended that the Partial Cutoff Design with an upstream tailings blanket be used for cost estimation purposes, and a contingency be made for grouting discrete permeable features within the foundation.

3. The tailings dike will be constructed in two stages. Stage 1 construction, to an elevation of 120.0 m A.S.L., will take place in Year -1, after the North Arm of Second Portage Lake has been lowered to elevation 105 m. Stage 2 construction will take place in Year 3, up to the final crest elevation of 139.6 m.

4. The slope stability analyses indicate that the tailings dike will be stable under short-term, undrained, static load conditions, and under long-term, static and earthquake load conditions.

5. The seepage modelling indicates that the maximum seepage expected to reach the west wall of the Portage Pit, during the time that the tailings pond is in contact with the dike face, will be:

- For Full Cutoff design = approximately 30 litres/second;
- For Partial Cutoff design = approximately 30 litres/second;
- For Partial Cutoff design with upstream tailings seepage blanket = approximately 70 litres/second.

This seepage will be captured by the pit dewatering system, and will ultimately be pumped back to the tailings pond.

Over time, seepage is expected to decrease due to the development of a tailings beach against the dike face, and the corresponding movement of the tailings pond westward, away from the dike face.

6. Thermal modelling indicates that the dike will be an effective thermal barrier between the re-flooded lake area and the tailings. Transient thermal modelling included an estimate of climate change during the 100 years following closure.

7. Based on preliminary material balance calculations, the quantities of till and rockfill available from mining activities will be sufficient to construct the dike.

   The required volumes of till and rockfill material for construction of the Stage 1 tailings dike in Year -1 will need to be generated during mining of a proposed starter pit at the Third Portage Deposit, and during on-land pre-stripping activities at the North Portage Deposit. This will require careful sequencing.

   The required volumes of till and rockfill material for the Stage 2 construction of the tailings dike in Year 3 will come from on-going mining activities at the Portage pit.

8. Further investigations of the foundation materials along the proposed dike alignment are recommended prior to construction. These investigations would provide additional data for geotechnical design of the tailings dike, and would reduce uncertainty about the suitability of the existing foundation material as a seepage control barrier.

12.0 CLOSING REMARKS

We trust the information contained in the above report meets your requirements at this time. Please feel free to contact us if you need more detailed information on any of the information presented in the report.

GOLDER ASSOCIATES LTD.

Don Hickson, P.Eng.
Geotechnical Engineer

Cameron Clayton, P.Geo.
Mining Group

Terry Eldridge, P.Eng.
Principal

DAH/CJC/TLE/dah/vee
03-1413-427/4200

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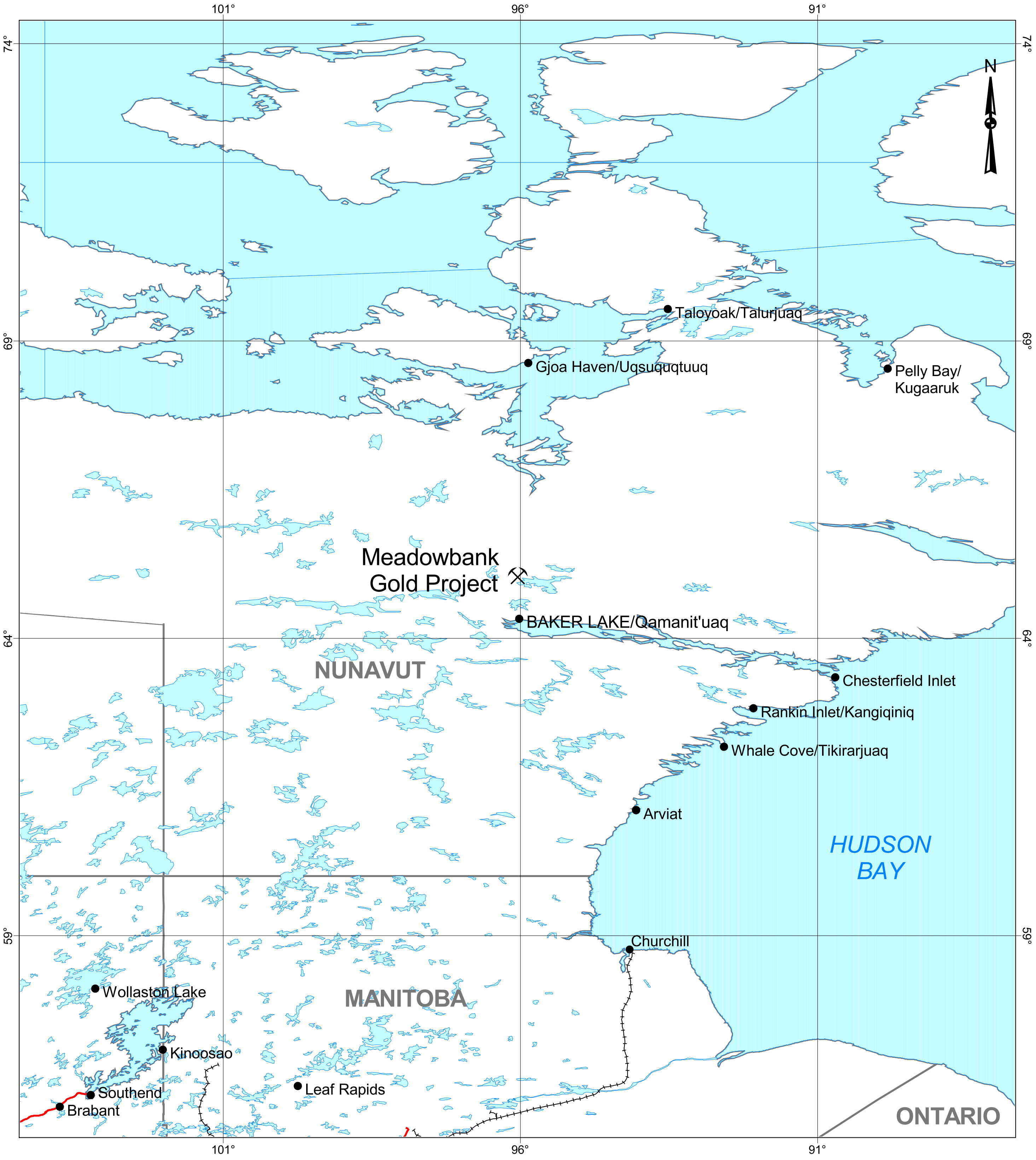
REFERENCES

Golder 2002a	Lake Bathymetry Survey, Meadowbank Project, Golder Associates Ltd., November 2002.
Golder 2002b	Factual Report on Geotechnical Drilling, Hydrogeological, and Geophysical Investigations, Meadowbank Project, Nunavut; Golder Associates Ltd., 2002.
Golder 2002c	Factual Report on Summer 2002 Geotechnical Drilling, Hydrogeological and Permafrost Investigations, Meadowbank Gold Project, Nunavut; Golder Associates Ltd., 2002.
Golder 2003a	Summary Report on Spring 2003 Field Geotechnical Studies, Meadowbank Project, Nunavut; Golder Associates Ltd., September, 2003.
Golder 2003b	2003 Bathymetry Survey, Meadowbank Project, Nunavut, Golder Associates Ltd., September, 2003.
Golder 2003c	Report on Permafrost Thermal Regime Baseline Studies Meadowbank Project Nunavut, Golder Associates Ltd., December 2003.
Golder 2003d	Report on Ground Ice EM31 Investigation, Meadowbank Project, Nunavut, Golder Associates Ltd., September, 2003.
Golder 2003e	Report on Hydrogeology Baseline Studies – Meadowbank Gold Project, Golder Associates Ltd., December, 2003.
Golder 2003f	Report on Design of Dikes with Soil-Bentonite Cutoff Wall - Meadowbank Gold Project, Golder Associates Ltd., October, 2003.
Golder 2004a	Report on Mine Waste Management, Meadowbank Gold Project, Nunavut, Golder Associates Ltd., 2004 (in progress).
Golder 2004b	Report on Preliminary Thermal Modelling of Tailings Disposal in the Second Portage Lake – Meadowbank Gold Project, Golder Associates Ltd., 2004 (in progress).
CRL 2003	Meadowbank Gold Property, Project Description Report, Cumberland Resources Ltd. March, 2003.

AMEC 2003	Meadowbank Gold Project Baseline Hydrology Report, AMEC Earth and Environmental Ltd., December 2003.
CDA 1999	Dam Safety Guidelines, Canadian Dam Association, January 1999.
NWT and Nunavut 1995	Northwest Territories and Nunavut Consolidation of Mine Safety and Health Regulations R-125-95, 1995.
USACE 1984	Rationalizing the Seismic Coefficient Method, M. Hynes-Griffin and A. Franklin, USACE, WES, Miscellaneous Paper GI-84-13, 1984
Farouki 1986	Thermal Properties of Soils, Farouki, O.T. 1986, Trans Tech Publications, Clausthal-Zellerfeld, Germany.
Johansen 1975	Thermal conductivity of Soils. Ph.D. diss., Johansen, Ø. 1975, Norwegian Technical Univ., Trondheim; also, U.S. Army Cold Reg. Res. Eng. Lab. Transl. 637, July 1977.
Vick 1990	Planning, Design, and Analysis of Tailings Dams. Vick, Steven G., BiTech Publishers Ltd., Vancouver, B.C., Canada, 1990.



200 0 200 Kilometers

Scale - 1:10,000,000

LEGEND

- ⚒ Meadowbank Project
- ● Town/Village
- ☐ Provincial Border
- 🟦 Water
- Primary Highway
- Railroad

REFERENCE

Base digital data obtained from ESRI Inc.,
DATUM: WGS84 PROJECTION: Geographic

PROJECT

CUMBERLAND
RESOURCES LTD.

TITLE

LOCATION PLAN
MEADOWBANK PROJECT

PROJECT No. 03-1413-427			SCALE AS SHOWN	REV. 0
DESIGN	DAH	19 Dec. 2003	**FIGURE 1.1**	
GIS	CDB	19 Dec. 2003		
CHECK	CJC	19 Dec. 2003		
REVIEW				

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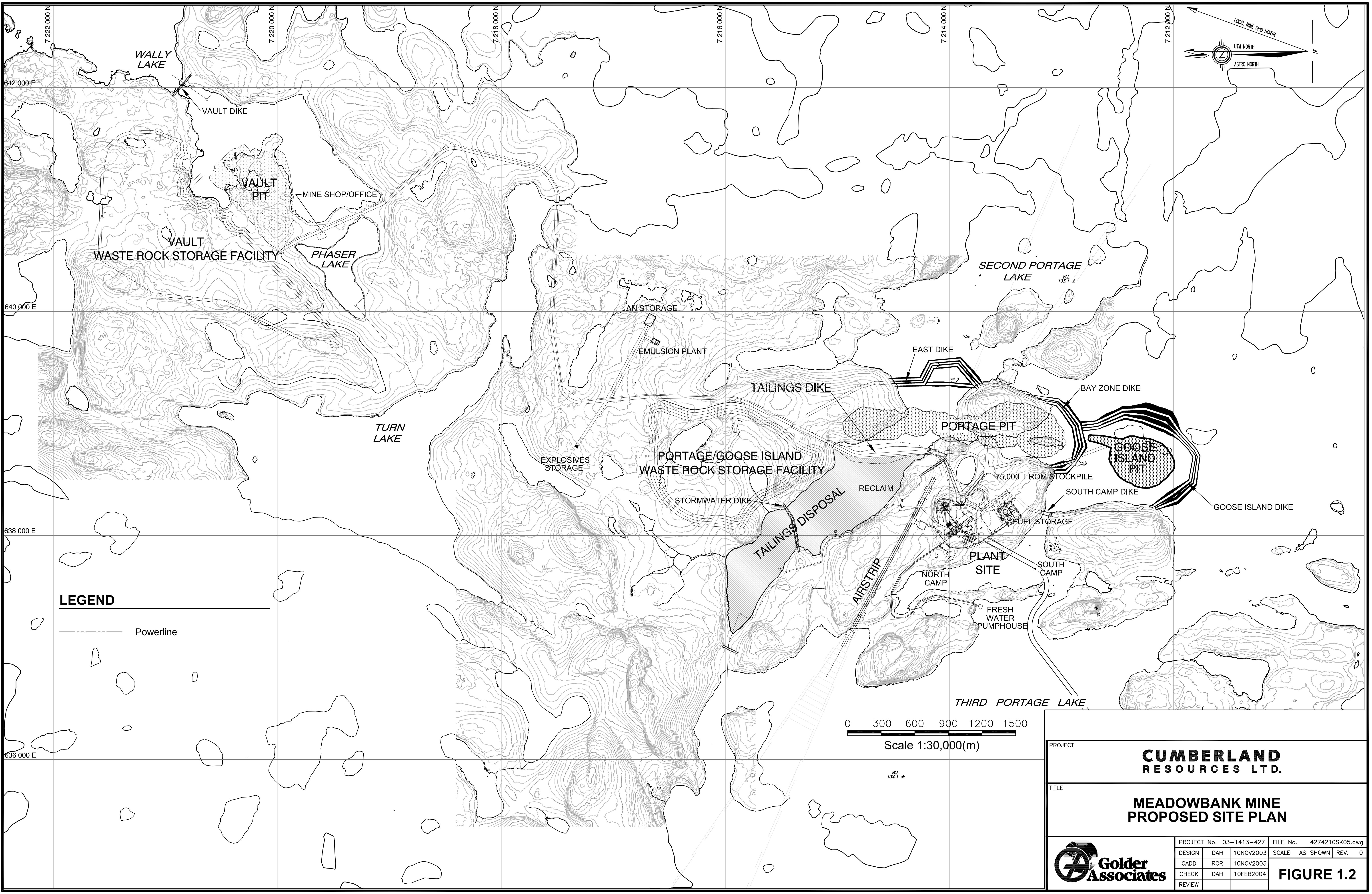


PROJECT

CUMBERLAND
RESOURCES LTD.

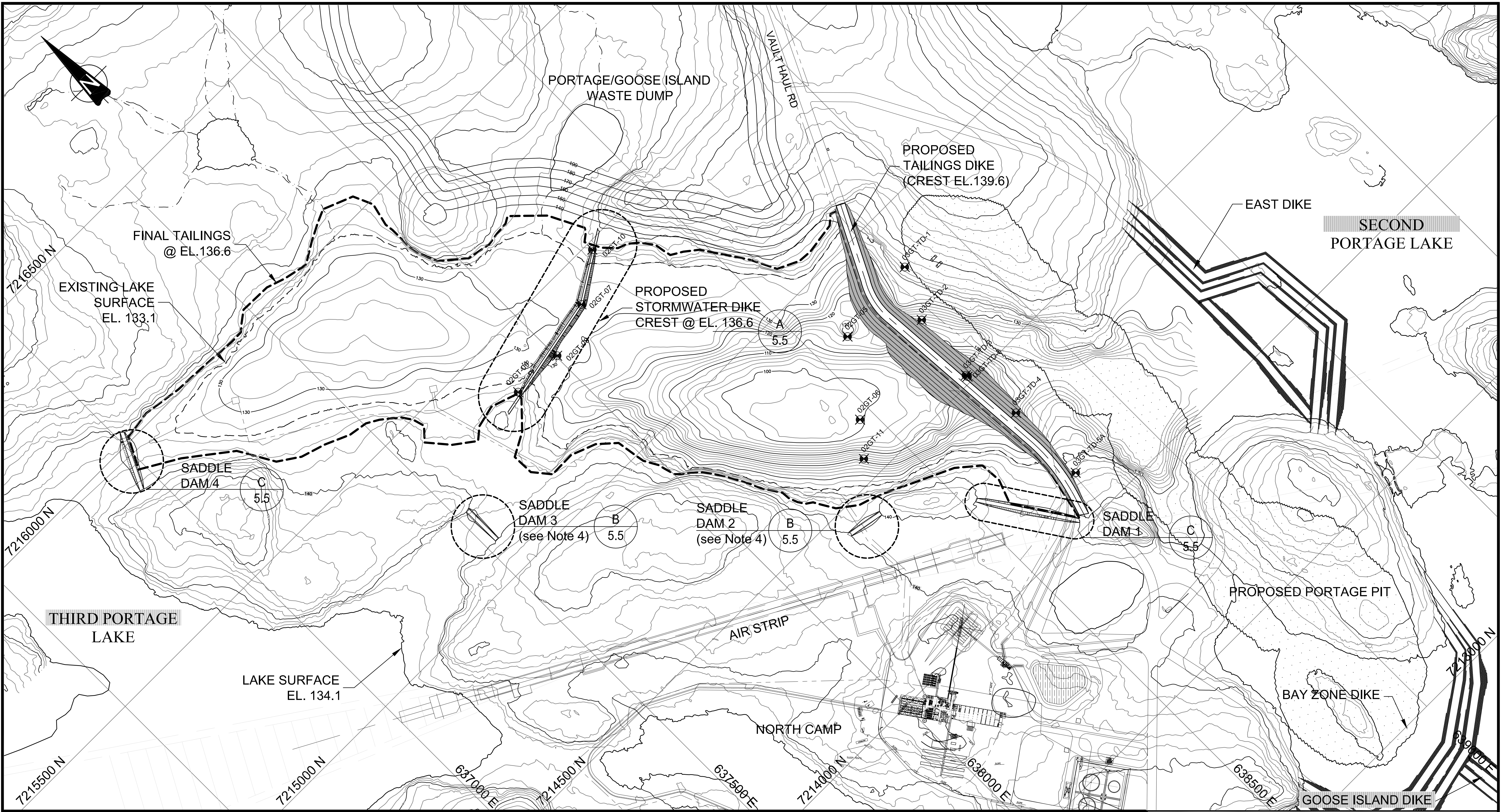
TITLE

MEADOWBANK MINE PROPOSED SITE PLAN

Golder Associates

PROJECT No.	03-1413-427		FILE No.	4274210SK05.dwg
DESIGN	DAH	10NOV2003	SCALE AS SHOWN	REV. 0
CADD	RCR	10NOV2003		
CHECK	DAH	10FEB2004	**FIGURE 1.2**	
REVIEW				

REVISION DATE: 04/02/12 2:54pm By: rroque CADD FILE: N:\Bur-Graphics\Projects\2003\1413\03-1413-427\4210\Drafting\cad\4274210SK05.dwg



NOTES

1) Contour information on land supplied by Cumberland Resources Ltd.
2) Contours below lake surface are based on bathymetric surveys by Golder Associates Ltd., 2002 and 2003.
3) Lake contours are based on surveyed lake surface elevations:
   - 2nd Portage Lake = 133.1 m
   - 3rd Portage Lake = 134.1 m
4) Saddle Dams 2 & 3 will be constructed of Rockfill only.
5) All elevations are in metres above mean sea level.

LEGEND

⊕ 02GT-05	Golder borehole, 2002
⊕ 03GT-TD-2	Golder borehole, 2003
— · —	Creek/Stream
— — —	Powerline

0 100 200 300 400 500
Scale 1:10,000 m

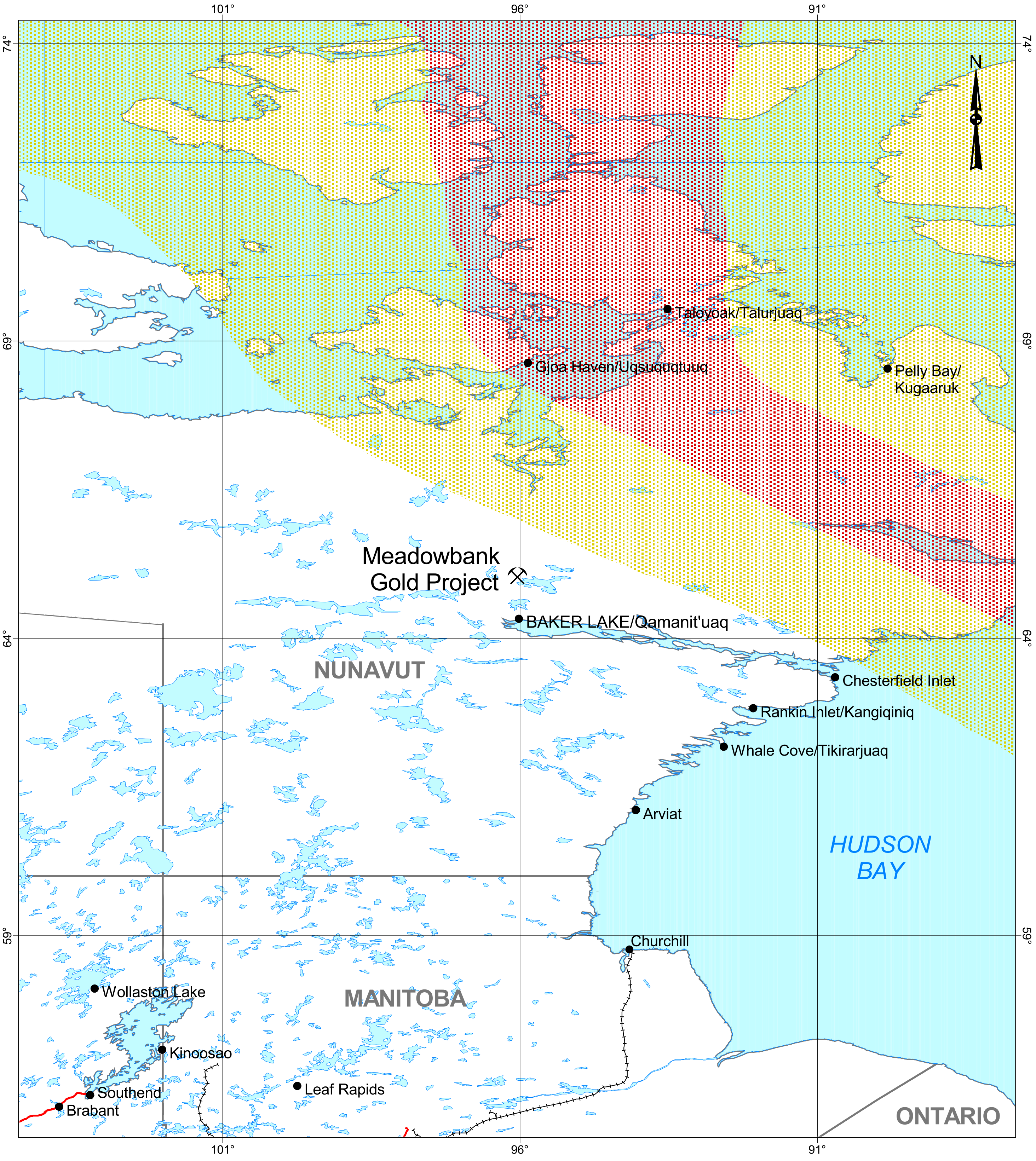
PROJECT
CUMBERLAND RESOURCES LTD.

TITLE
PROPOSED TAILINGS FACILITY LAYOUT

Golder Associates

PROJECT No.	03-1413-427		FILE No.	Figure 5.1
DESIGN	DAH	10NOV2003	SCALE AS SHOWN	REV. 0
CADD	RCR	10NOV2003	**FIGURE 2.1**	
CHECK	DAH	10FEB2003		
REVIEW				

CADD FILE: N:\Bur-Graphics\Projects\2003\1413\03-1413-427\4210\Drafting\cad\Figure 5.1.dwg
By: rroque
REVISION DATE: 04/02/13 3:04pm



200 0 200 Kilometers

Scale - 1:10,000,000

LEGEND

⚒ Meadowbank Project

● Town/Village

Peak Horizontal Ground Acceleration (g), for 10% probability of exceedance in 50 Year Event

☐ 0 - 0.039

🟨 0.04 - 0.079

🟥 0.08 - 0.109

☐ Provincial Border

🟦 Water

Primary Highway

Railroad

REFERENCE

Base digital data obtained from ESRI Inc.,
DATUM: WGS84 PROJECTION: Geographic

PROJECT

CUMBERLAND
RESOURCES LTD.

TITLE

SEISMIC ZONING MAP

Golder Associates

PROJECT No. 03-1413-427			SCALE AS SHOWN	REV. 0
DESIGN	DAH	19 Dec. 2003	**FIGURE 3.1**	
GIS	CDB	19 Dec. 2003		
CHECK	DAH	10 Feb. 2004		
REVIEW				

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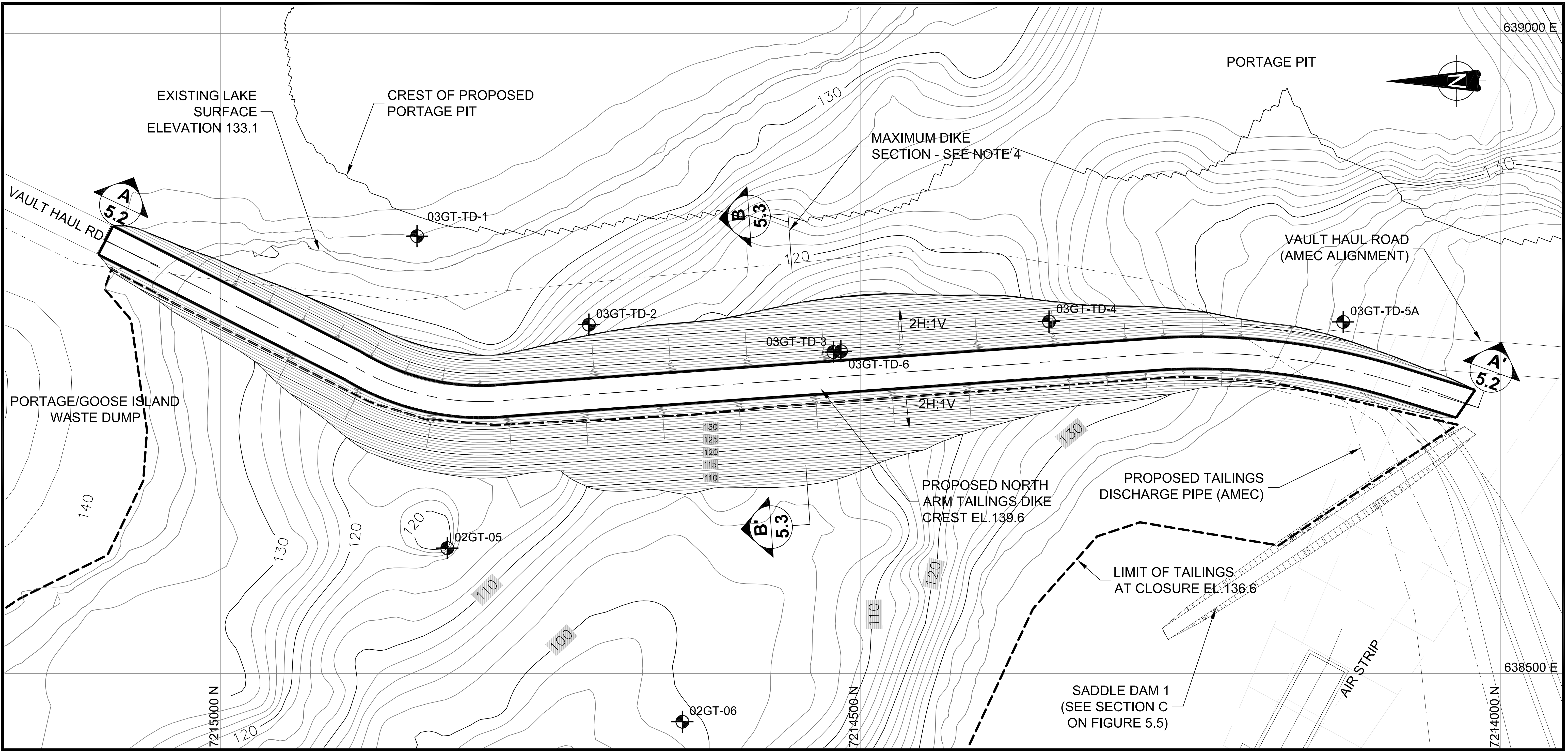
CADD FILE: N:\Bur-Graphics\Projects\2003\1413\03-1413-427\4210\Drafting\cad\Figure 5.2.dwg
REVISION DATE: 04/02/13 3:07pm By: rroque



NOTES

1) Contour information on land supplied by Cumberland Resources Ltd.

2) Contours below lake surface are based on bathymetric surveys by Golder Associates Ltd., 2002 and 2003.

3) Lake contours are based on surveyed lake surface elevations:
2nd Portage Lake = 133.1 m
3rd Portage Lake = 134.1 m

4) Basic Engineering Design includes 2 Alternatives for Typical Dike Section. See Figure 5.3.

5) All dimensions in metres.

6) All elevations in metres above sea level

LEGEND

⊕ 02GT-05	Golder borehole, 2002
⊕ 03GT-TD-2	Golder borehole, 2003
— · — · —	Powerline

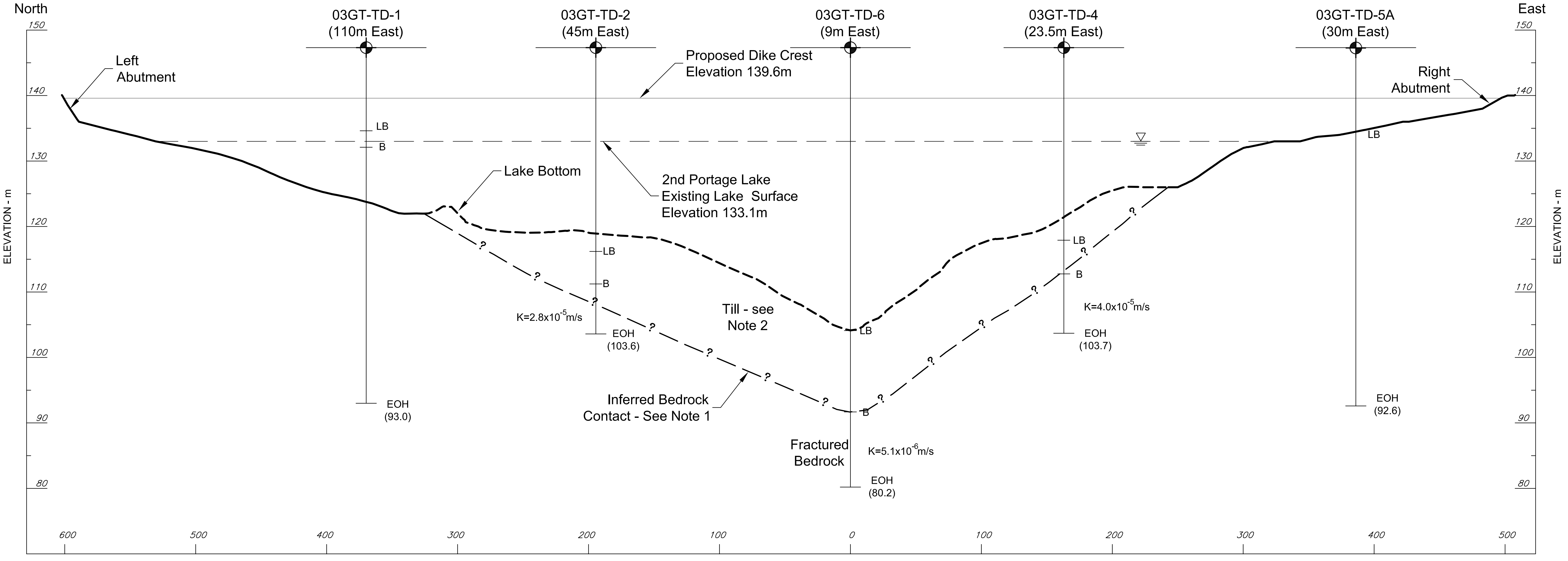
0 30 60 90 120 150
Scale 1:3,000 (m)

PROJECT
CUMBERLAND RESOURCES LTD.

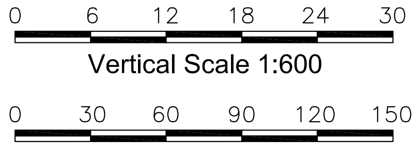
TITLE
PROPOSED TAILINGS DIKE PLAN

Golder Associates

PROJECT No.	03-1413-427		FILE No.	Figure 5.2
DESIGN	DAH	10NOV2003	SCALE AS SHOWN	REV. 0
CADD	RCR	10NOV2003		
CHECK		16FEB2003	**FIGURE 5.1**	
REVIEW		16FEB2003		



A 5.1 SECTION ALONG DIKE CENTRELINE



Vertical Scale 1:600

Horizontal Scale 1:3000(m)

NOTES

1) Geological contacts are inferred. Actual contact locations are valid only at borehole locations. Variation from the inferred geological is expected between boreholes.

2) Foundation material recovered during drilling indicated a dense gravel till with cobbles and boulders. Few fines were recovered during drilling and sampling.

3) All elevations in metres above mean sea level.

LEGEND

— —?— —	Inferred Geological Contact
03GT-TD-1	Reverse Circulation Borehole Logged by Golder - 2003
LB	Lake Bottom Location in Borehole Log
B	Bedrock Contact in Borehole Log
EOH (80.2)	End of Borehole at Elevation 80.2masl as Recorded in Borehole Log

PROJECT

CUMBERLAND
RESOURCES LTD.

TITLE

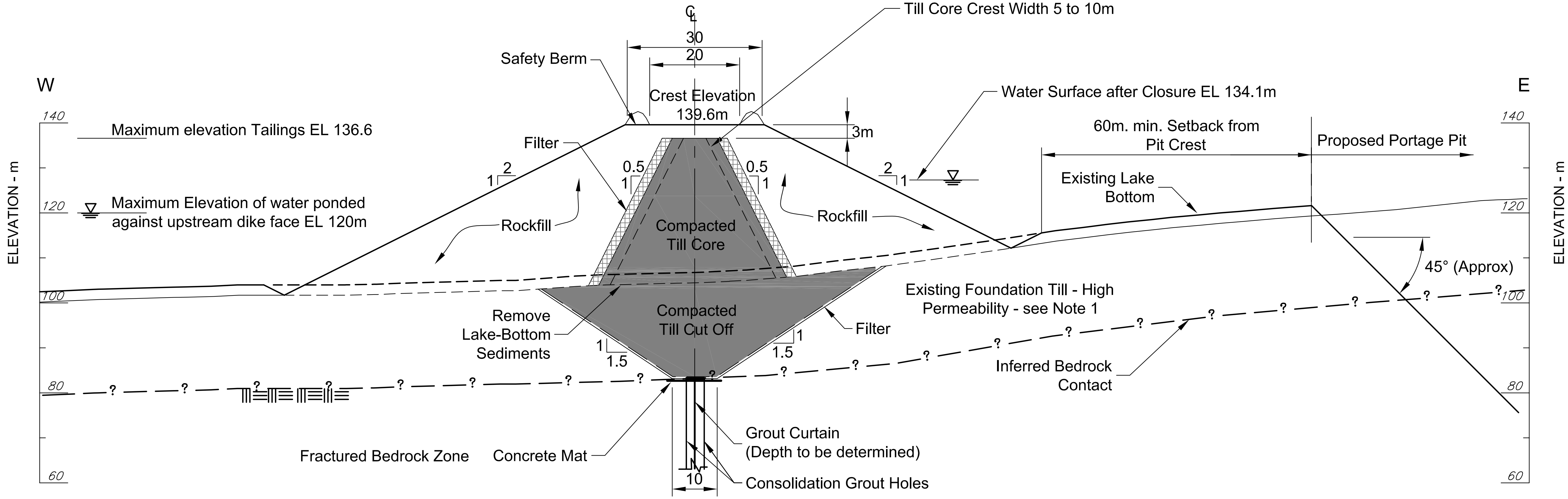
PROPOSED TAILINGS DIKE
SITE CONDITIONS

Golder Associates

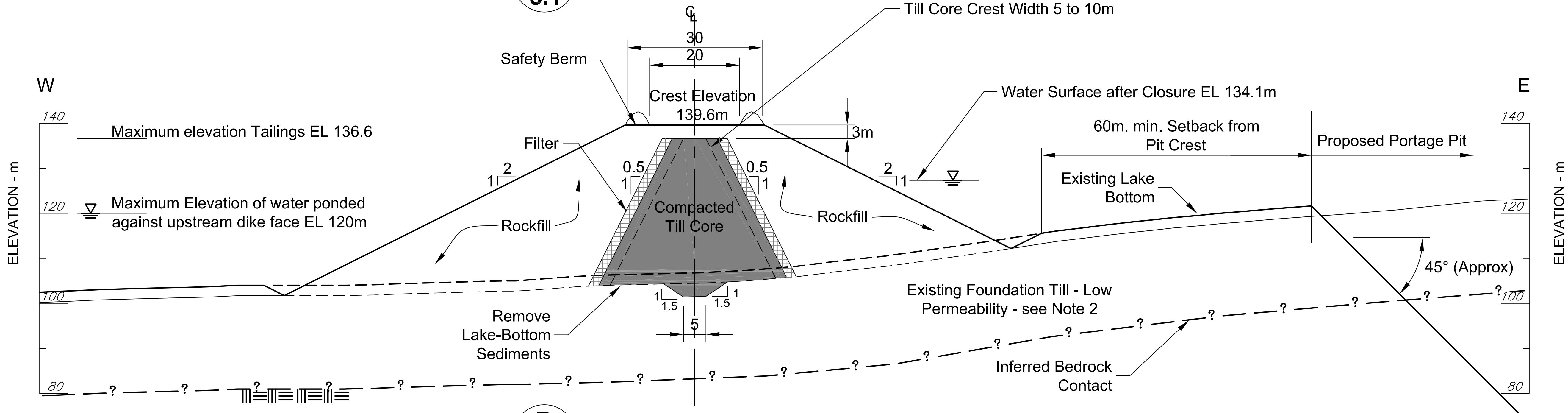
PROJECT No.	03-1413-427		FILE No.	Figure 5.3
DESIGN	DAH	10NOV2003	SCALE AS SHOWN	REV. 0
CADD	RCR	10NOV2003		
CHECK		10FEB2004	**FIGURE 5.2**	
REVIEW		16FEB2004		

CADD FILE: N:\Bur-Graphics\Projects\2003\1413\03-1413-427\4210\Drafting\cad\Figure 5.3.dwg

REVISION DATE: 04/01/15 11:03am By: rroque



B 5.1 **SECTION - FULL CUTOFF**



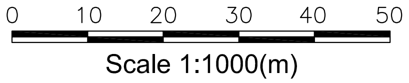
B 5.1 **SECTION - PARTIAL CUTOFF**

NOTES

1) Full Cutoff Design assumes that existing till material is highly permeable and requires foundation cut off structures.

2) Partial Cutoff Design assumes the existing till material is of sufficient areal extent and of sufficiently low permeability that foundation cut off structures are not required.

3) All dimensions in metres. All elevations in metres above mean sea level.



Scale 1:1000(m)

PROJECT
CUMBERLAND RESOURCES LTD.

TITLE
PROPOSED TAILINGS DIKE
DESIGN ALTERNATIVES
TYPICAL CROSS SECTIONS

Golder Associates

PROJECT No. 03-1413-427			FILE No. 031413427SK01	
DESIGN	DAH	10NOV2003	SCALE AS SHOWN	REV. 0
CADD	RCR	10NOV2003	**FIGURE 5.3**	
CHECK		10FEB2004		
REVIEW		16FEB2003		

CADD FILE: N:\Bur-Graphics\Projects\2003\1413\03-1413-427\4210\Drafting\cad\031413427SK01.dwg

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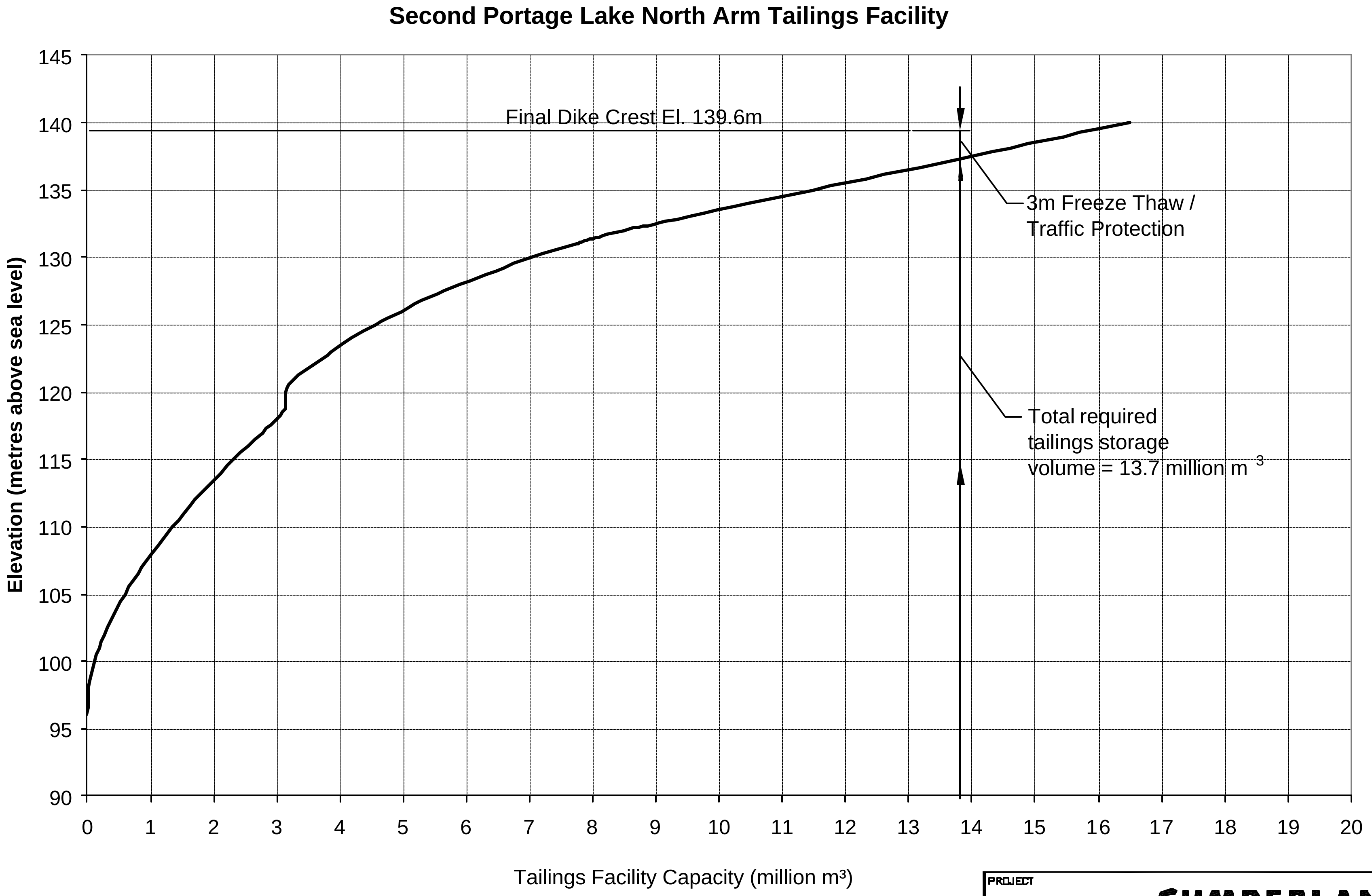


NOTES

1) Total tailings volume assumes total tailings of 19.8 million m^3, and a settled dry density of 1.45 tonnes/m^3 (corresponding to a void ratio of 1.0).

PROJECT

CUMBERLAND RESOURCES LTD.

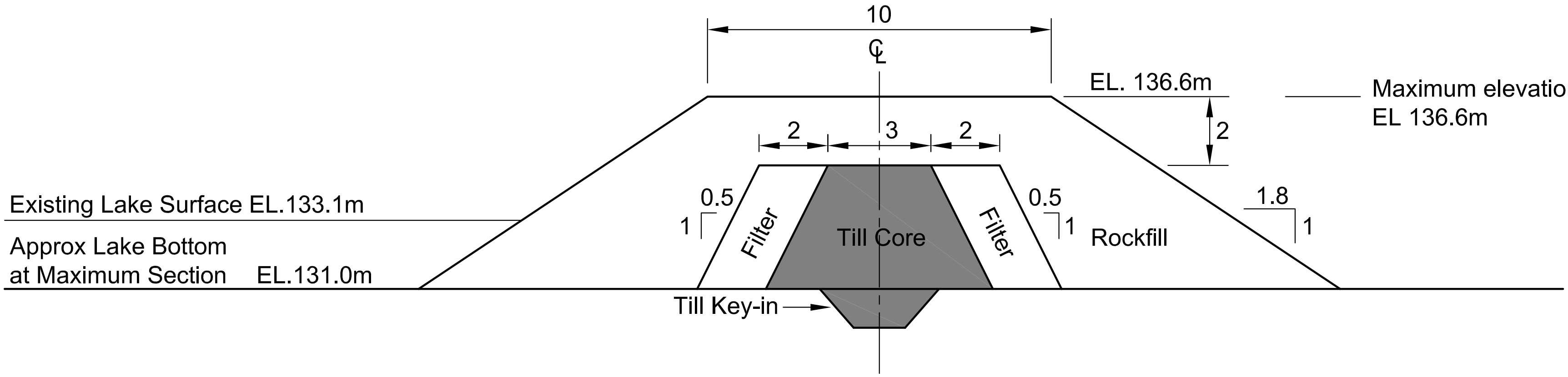
TITLE

PROPOSED TAILINGS FACILITY - TAILINGS STORAGE CAPACITY

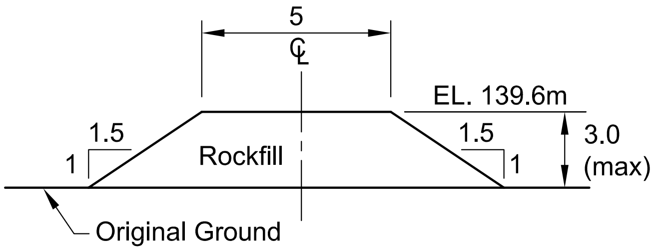
Golder Associates

PROJECT No. 03-1413-427			FILE No. 4274210SK06
DESIGN	DAH	03DEC2003	SCALE NA REV. 0
CADD	RCR	03DEC2003	**FIGURE 5.4**
CHECK		10FEB2004	
REVIEW		16FEB2004	

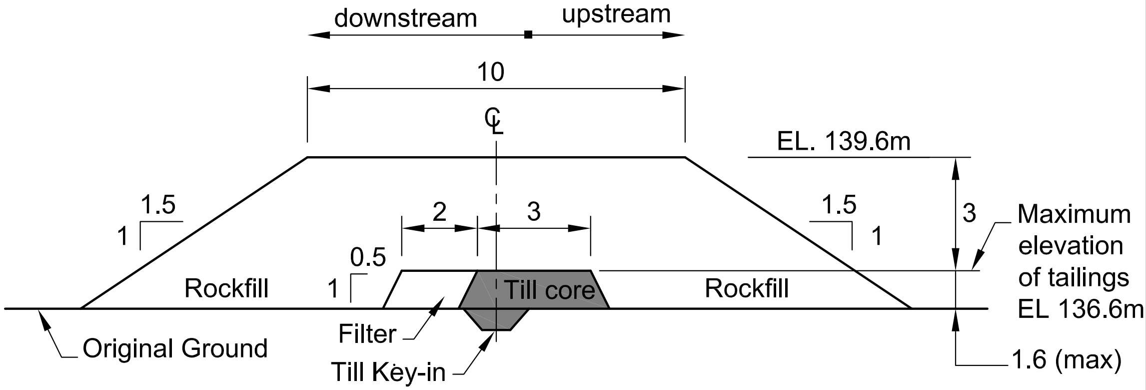
REVISION DATE: 04/02/12 1:54pm By: rroque CADD FILE: N:\Bur-Graphics\Projects\2003\1413\03-1413-427\4210\Drafting\cad\031413427SK02.dwg



A 2.1 SECTION - STORMWATER DIKE



B 2.1 SECTION - SADDLE DAMS 2 & 3

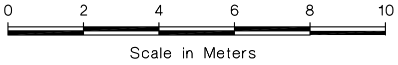


C 2.1 SECTION - SADDLE DAMS 1 & 4

NOTES

1) All dimensions in metres.

2) All elevations in metres above mean sea level.



PROJECT

CUMBERLAND
RESOURCES LTD.

TITLE

STORMWATER DIKE AND SADDLE DAMS
CONCEPTUAL CROSS SECTIONS

Golder Associates

PROJECT No. 03-1413-427			FILE No. 031413427SK02		
DESIGN	DAH	16DEC2003	SCALE AS SHOWN	REV.	0
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CHECK		10FEB2004			
REVIEW		16FEB2004			

REVISION DATE: 04/02/12 2:03pm By: rroque CADD FILE: N:\Bur-Graphics\Projects\2003\1413\03-1413-427\4210\Drafting\cad\4274210SK09.dwg

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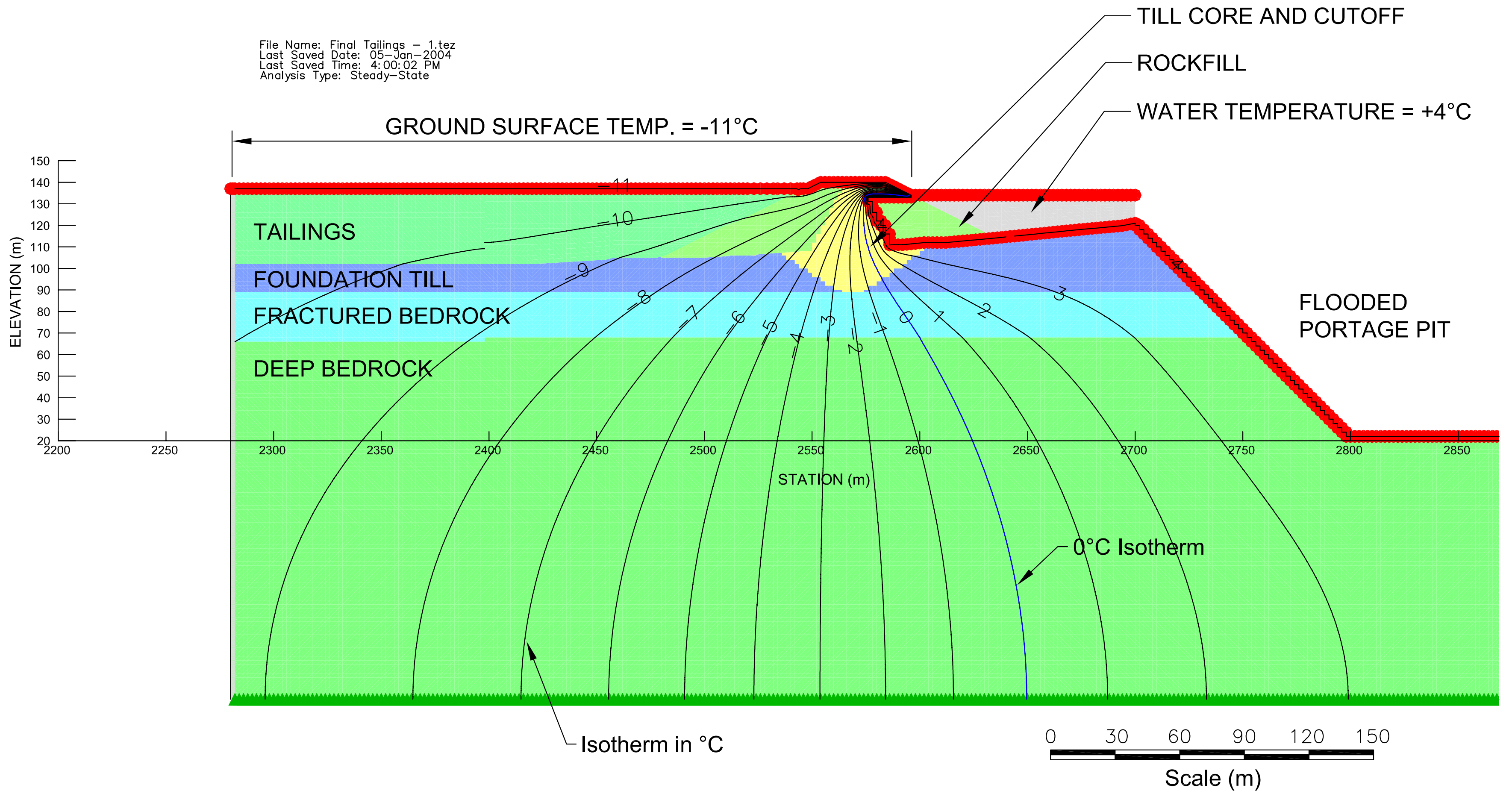
Last Saved Date: 05–Jan–2004
Last Saved Time: 4:00:02 PM
Analysis Type: Steady–State



MATERIAL PROPERTIES

Material Type	Thermal Conductivity (J/sec-m-°C)		Volumetric Heat Capacity (J/m³-°C)(x 10^6)		Volumetric Water Content
	Frozen	Unfrozen	Frozen	Unfrozen	
Till Core & Cutoff	3.3	2.4	1.9	2.5	0.28
Rockfill	3.3	2.8	2.4	2.6	0.12
Foundation Till	3.3	2.8	2.4	2.6	0.12
Fractured Bedrock	3.3	2.8	2.4	2.6	0.12
Deep Bedrock	3.5	3.4	2.4	2.4	0.02
Tailings	2.2	1.6	2.2	2.95	0.5

NOTES

1) Analyses done using TEMP/W^{TM} Software.

PROJECT

CUMBERLAND
RESOURCES LTD.

TITLE

POST-CLOSURE THERMAL MODELLING
PROPOSED TAILINGS DIKE - STEADY
STATE ANALYSIS

Golder Associates

PROJECT No.		03–1413–427	FILE No.	4274210SK09.dwg
DESIGN	DAH	23DEC2003	SCALE NA	REV. 0
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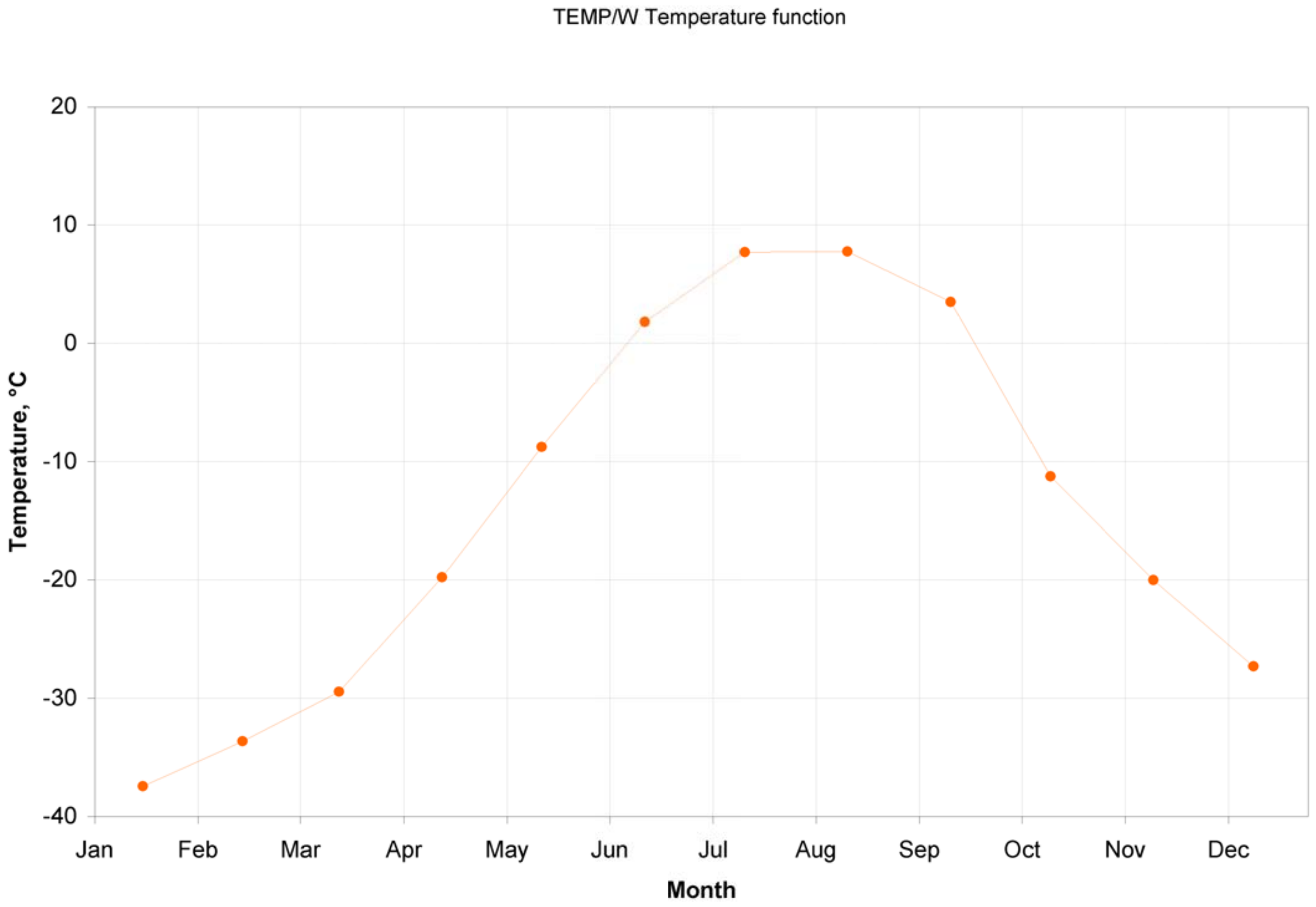
CHECK		10FEB2004		
REVIEW		16FEB2004		

REVISION DATE: 04/01/9 4:36pm By: sreddy CADD FILE: N:\Bur–Graphics\Projects\2003\1413\03–1413–427\4210\Drafting\cad\4274210SK16.dwg



NOTES

1) Analyses done using TEMP/W^{TM} Software.

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

SURFACE TEMPERATURE FUNCTION FOR TRANSIENT THERMAL ANALYSIS

Golder Associates

PROJECT No. 03–1413–427			FILE No.	4274210SK16
DESIGN	DAH	09JAN2004	SCALE NTS	REV. 0
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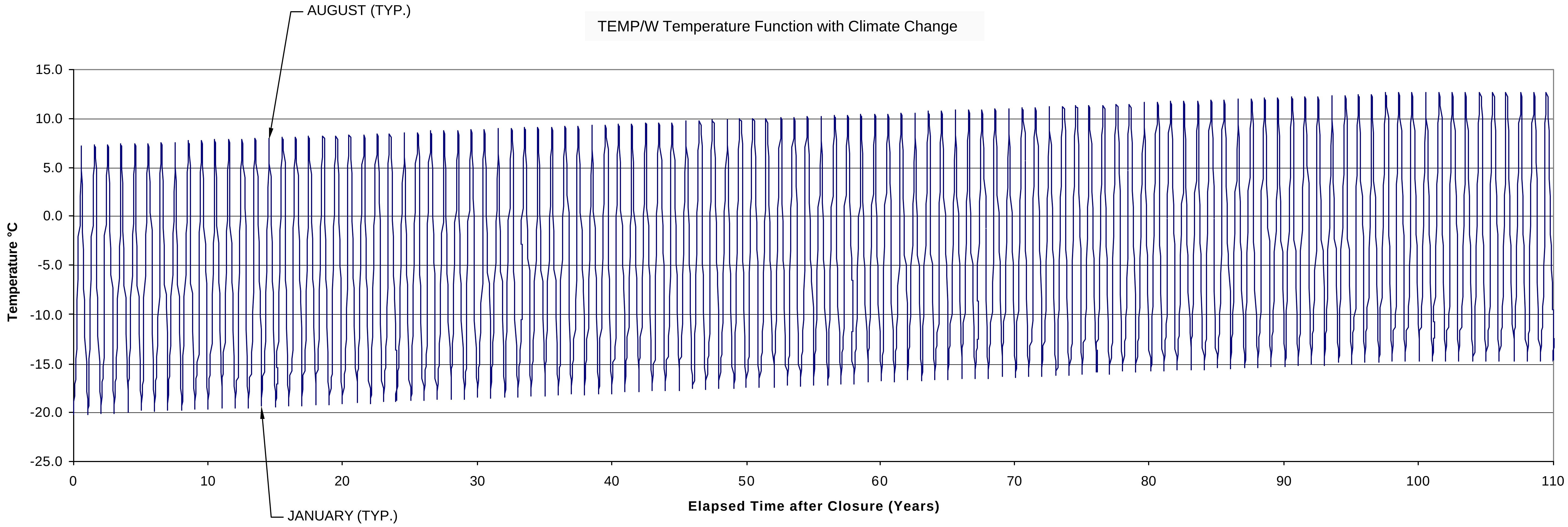
CHECK		09JAN2004		
REVIEW		16FEB2004		



NOTES

1) Analyses done using TEMP/W^{TM} Software.

2) Temperature increase of 5.5°C based on draft report on Mine Waste Management, Meadowbank Gold Project, Nunavut, Golder Associates Ltd, December 2003.

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

SURFACE TEMPERATURE FUNCTION FOR TRANSIENT THERMAL ANALYSIS INCLUDING CLIMATE CHANGE PREDICTION

Golder Associates

PROJECT No. 03-1413-427			FILE No. 4274210SK16	
DESIGN	DAH	10FEB2004	SCALE NA	REV. 0
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CHECK		10FEB2004		
REVIEW		18FEB2004		

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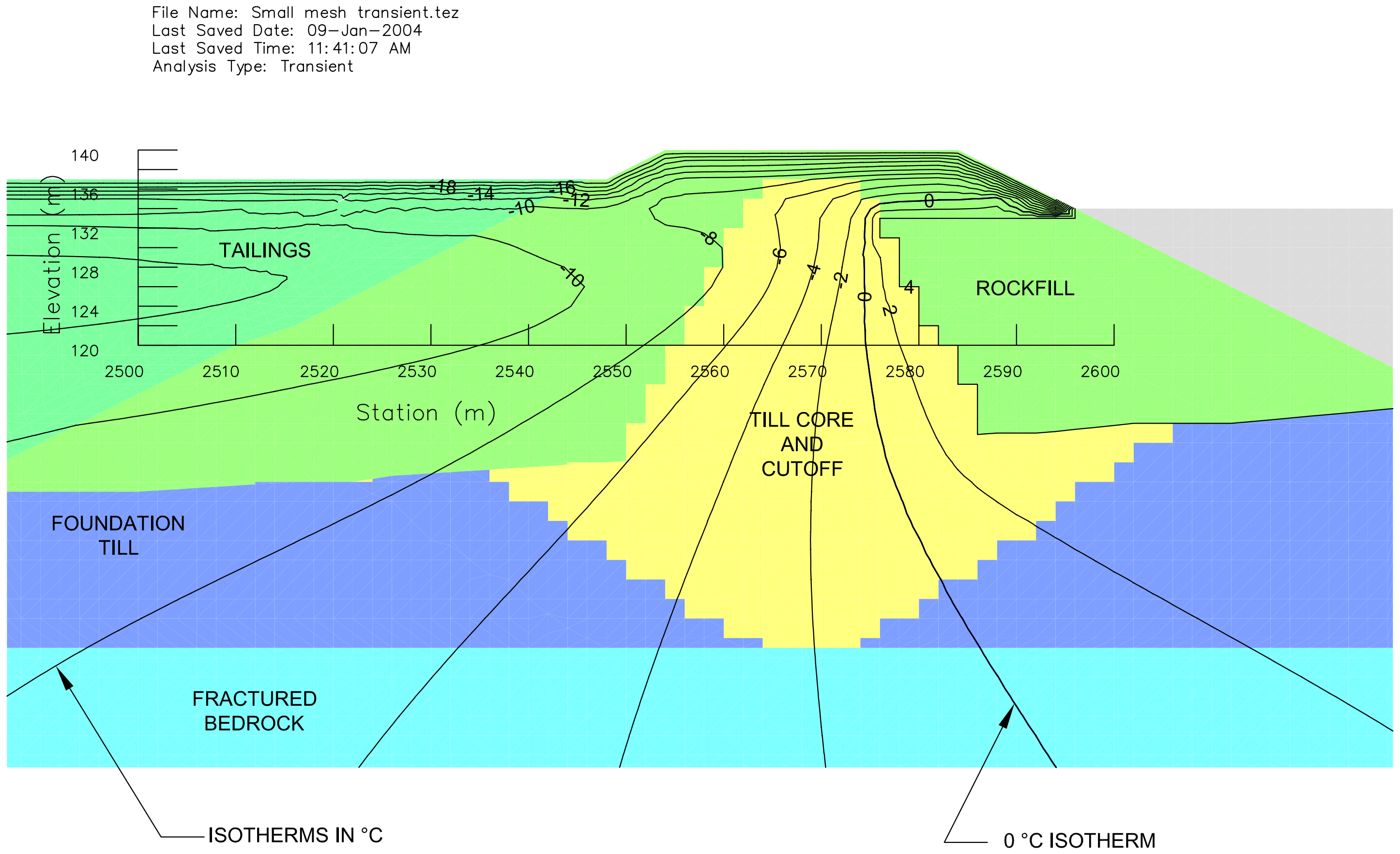
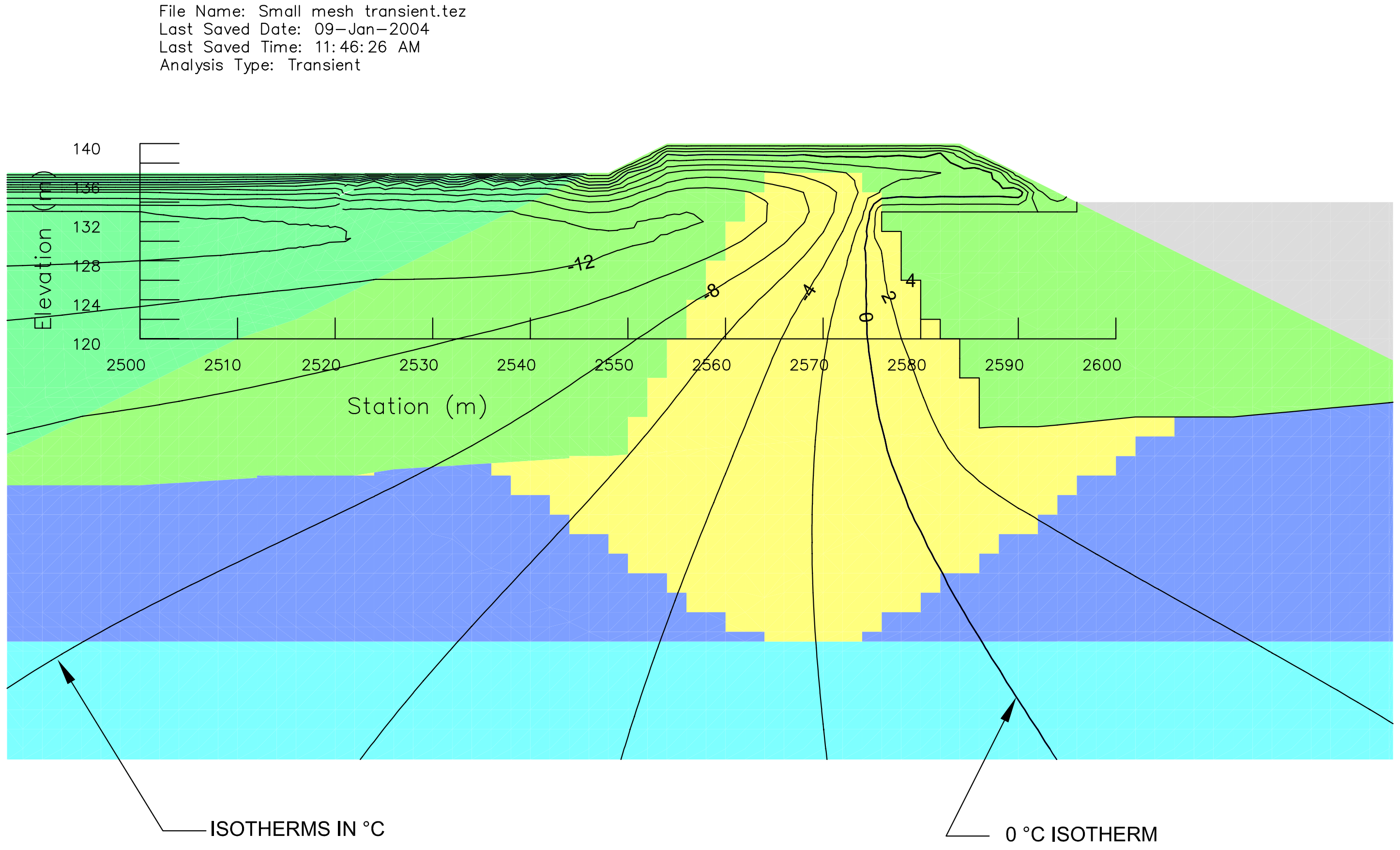


THERMAL REGIME IN JANUARY



THERMAL REGIME IN AUGUST

MATERIAL PROPERTIES

Material Type	Thermal Conductivity (J/sec-m-°C)		Volumetric Heat Capacity (J/m³-°C)(x 10⁶)		Volumetric Water Content
	Frozen	Unfrozen	Frozen	Unfrozen	
Till Core & Cutoff	3.3	2.4	1.9	2.5	0.28
Rockfill	3.3	2.8	2.4	2.6	0.12
Foundation Till	3.3	2.8	2.4	2.6	0.12
Fractured Bedrock	3.3	2.8	2.4	2.6	0.12
Deep Bedrock	3.5	3.4	2.4	2.4	0.02
Tailings	2.2	1.6	2.2	2.95	0.5

NOTES

1) Analyses done using TEMP/W^{TM} Software.
2) All dimensions are in metres. All elevations in metres above sea level.

0 5 10 15 20 25
Scale in Meters

PROJECT
CUMBERLAND RESOURCES LTD.

TITLE
POST-CLOSURE THERMAL MODELLING PROPOSED TAILINGS DIKE - TRANSIENT ANALYSES

Golder Associates

PROJECT No. 03–1413–427			FILE No. 4274210SK16	
DESIGN	DAH	23DEC2003	SCALE AS SHOWN	REV. 0
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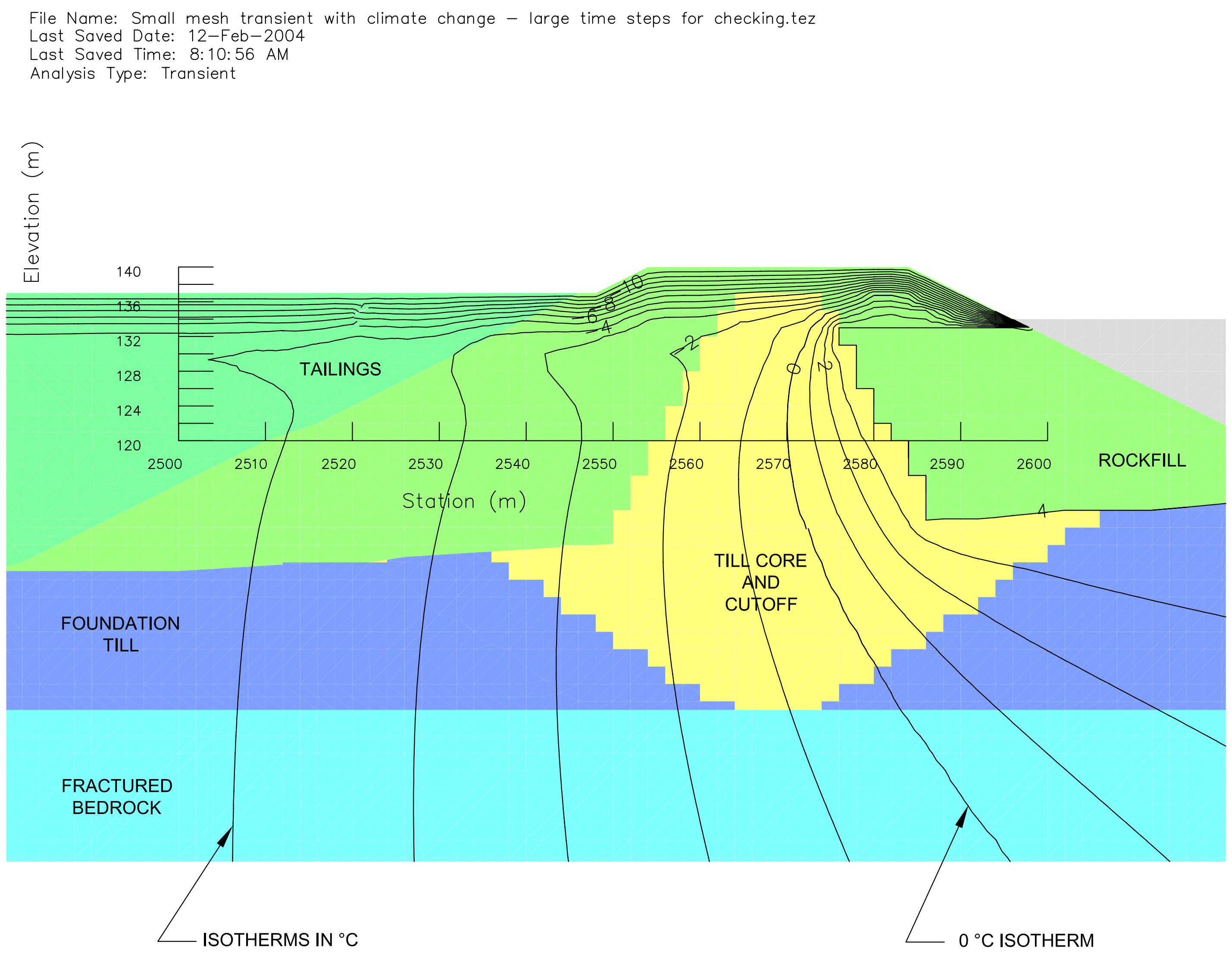
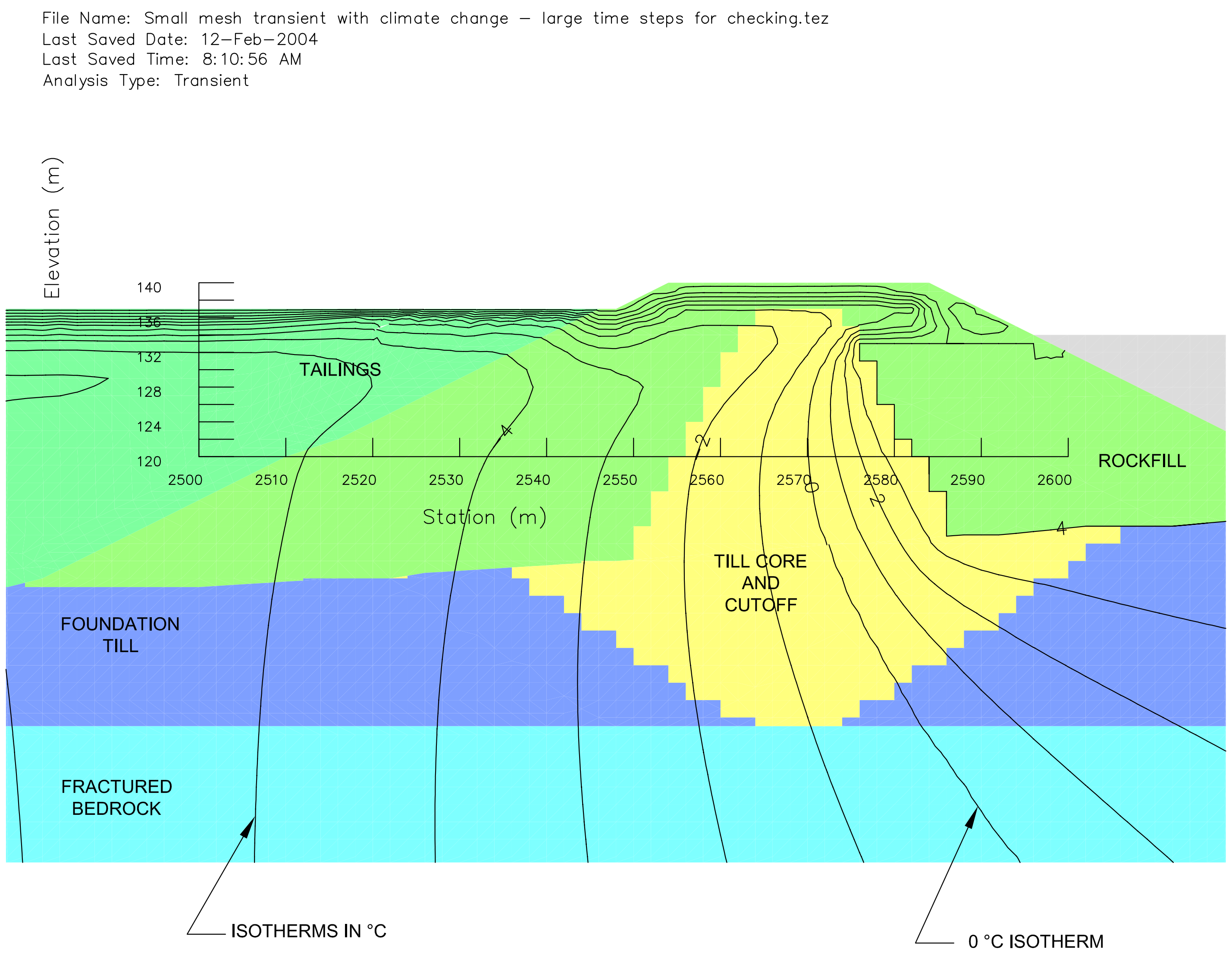
CHECK		10FEB2004		
REVIEW		16FEB2004		

REVISION DATE: 04/01/15 11:18am By: rroque CADD FILE: N:\Bur-Graphics\Projects\2003\1413\03-1413-427\4210\Drafting\cad\4274210SK16.dwg



CLIMATE CHANGE YEAR 100
JANUARY



CLIMATE CHANGE YEAR 100
AUGUST

MATERIAL PROPERTIES

Material Type	Thermal Conductivity (J/sec-m-°C)		Volumetric Heat Capacity (J/m³-°C)(x 10^6)		Volumetric Water Content
	Frozen	Unfrozen	Frozen	Unfrozen	
Till Core & Cutoff	3.3	2.4	1.9	2.5	0.28
Rockfill	3.3	2.8	2.4	2.6	0.12
Foundation Till	3.3	2.8	2.4	2.6	0.12
Fractured Bedrock	3.3	2.8	2.4	2.6	0.12
Deep Bedrock	3.5	3.4	2.4	2.4	0.02
Tailings	2.2	1.6	2.2	2.95	0.5

NOTES

1) Analyses done using TEMP/W^{TM} Software.
2) All dimensions are in metres. All elevations in metres above sea level.

0 5 10 15 20 25
Scale in Meters

PROJECT
CUMBERLAND
RESOURCES LTD.

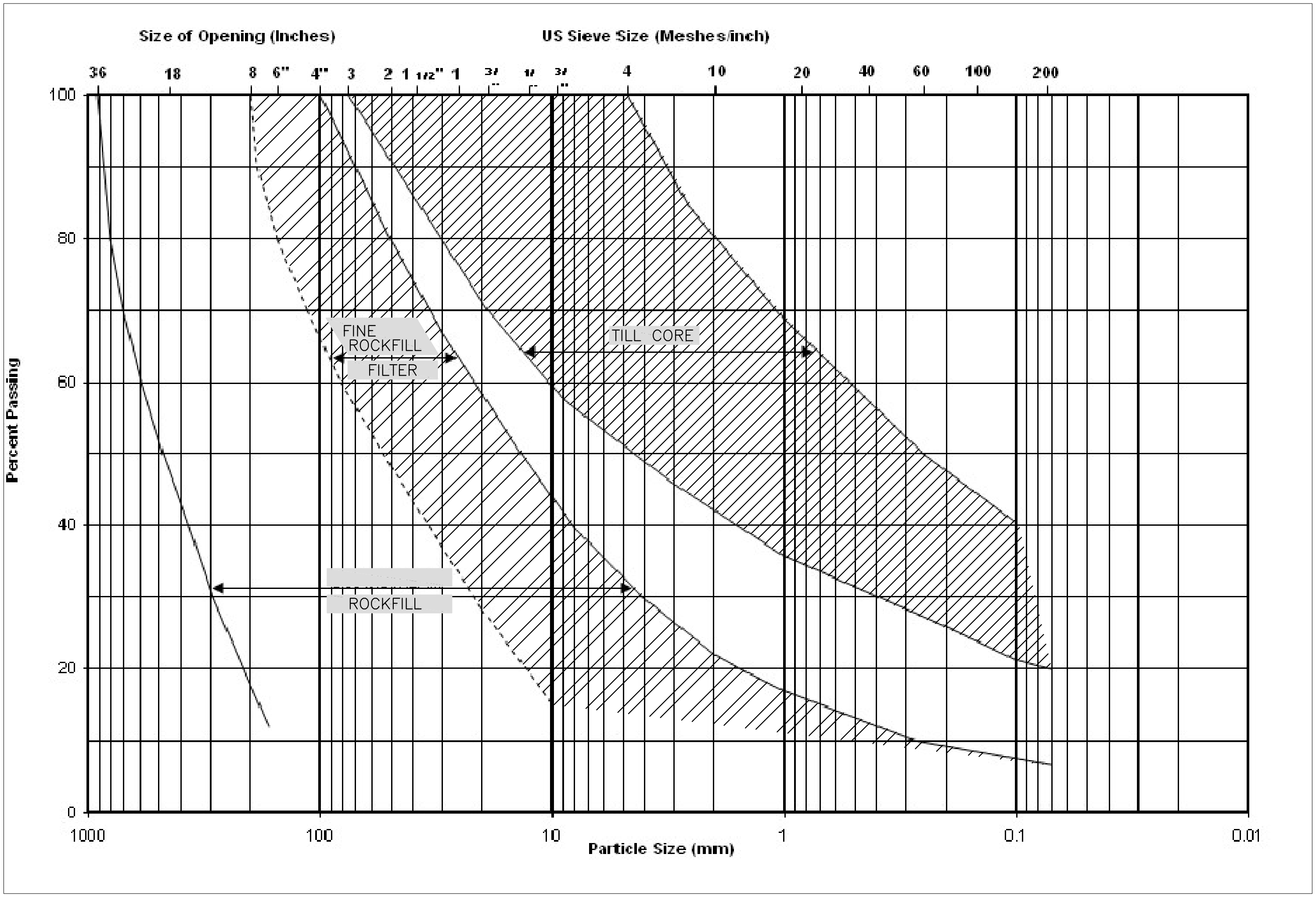
TITLE
POST-CLOSURE THERMAL MODELLING
PROPOSED TAILINGS DIKE - TRANSIENT ANALYSES
INCLUDING CLIMATE CHANGE EFFECTS

Golder Associates

PROJECT No.	03–1413–427		FILE No.	4274210SK16
DESIGN	DAH	10FEB2004	SCALE AS SHOWN	REV. 0
CADD	SRR	10FEB2004	**FIGURE 7.5**	
CHECK		10FEB2004		
REVIEW		16FEB2004		

REVISION DATE: 04/02/12 11:07am By: sreddy CADD FILE: N:\Bur–Graphics\Projects\2003\1413\03–1413–427\4210\Drafting\cad\4274210SK16.dwg

REVISION DATE: 04/02/12 2:01pm By: rroque CADD FILE: N:\Bur-Graphics\Projects\2003\1413\03-1413-427\4210\Drafting\cad\4274210SK18.dwg



NOTES

1) Till core gradation based on samples analyzed as reported in Winter 2002 and Summer 2002 factual reports by Golder.

2) Fine rockfill filter and rockfill designed to be filter-compatible using criteria developed by Sherard, et.al. (self filtering not considered), and presented by U.S. Army Corps of Engineers.

PROJECT

CUMBERLAND
RESOURCES LTD.

TITLE

MATERIAL GUIDELINES
PROPOSED GRAIN SIZE DISTRIBUTION
TILL CORE AND ROCK FILL

Golder Associates

PROJECT No. 03-1413-427			FILE No.	4274210SK18
DESIGN	DAH	10FEB2004	SCALE	NA REV. 0
CADD	RCR	10FEB2004		
CHECK		10FEB2004	FIGURE 10.1	
REVIEW		16FEB2004		

APPENDIX I

GEOTECHNICAL BOREHOLE LOGS

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-05

SHEET 1 OF 3

LOCATION: Causeway Alignment, North Hole

DRILLING DATE: 17 May, 2002
DRILL RIG: LY38
DRILLING CONTRACTOR: Boart-Longyear

DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			CORE		GRADATION %			HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-5} 10^{-4} 10^{-3} 10^{-2} WATER CONTENT PERCENT Wp W Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	RUN No.	RECOVERY % 80 60 40 20	GRAVEL	SAND	FINES			
		Ice Surface													
0	LY38 - HQ3	Ice.		0.00											
2		Water.		2.00											
10		*CONTINUED NEXT PAGE*													

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: CJC/JRT
CHECKED:

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-05

SHEET 2 OF 3

LOCATION: Causeway Alignment, North Hole

DRILLING DATE: 17 May, 2002
DRILL RIG: LY38
DRILLING CONTRACTOR: Boart-Longyear

DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	CORE RUN No.	CORE RECOVERY % 80 60 40 20	GRADATION % GRAVEL	GRADATION % SAND	GRADATION % FINES	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-5} 10^{-4} 10^{-3} 10^{-2} WATER CONTENT PERCENT Wp W Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10	LY38 - HQ3	Water. *(continued)*													
11		Inferred lake bottom sediments and coarse sand, cobbles and gravel. (OVERBURDEN)	▨	11.00											
12															
		Bedrock Encountered. Refer to ROCK LOG for continuation of rock description.													
13															
14															
15															
16															
17															
18															
19															
20															

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: CJC/JRT
CHECKED:

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-05

SHEET 3 OF 3

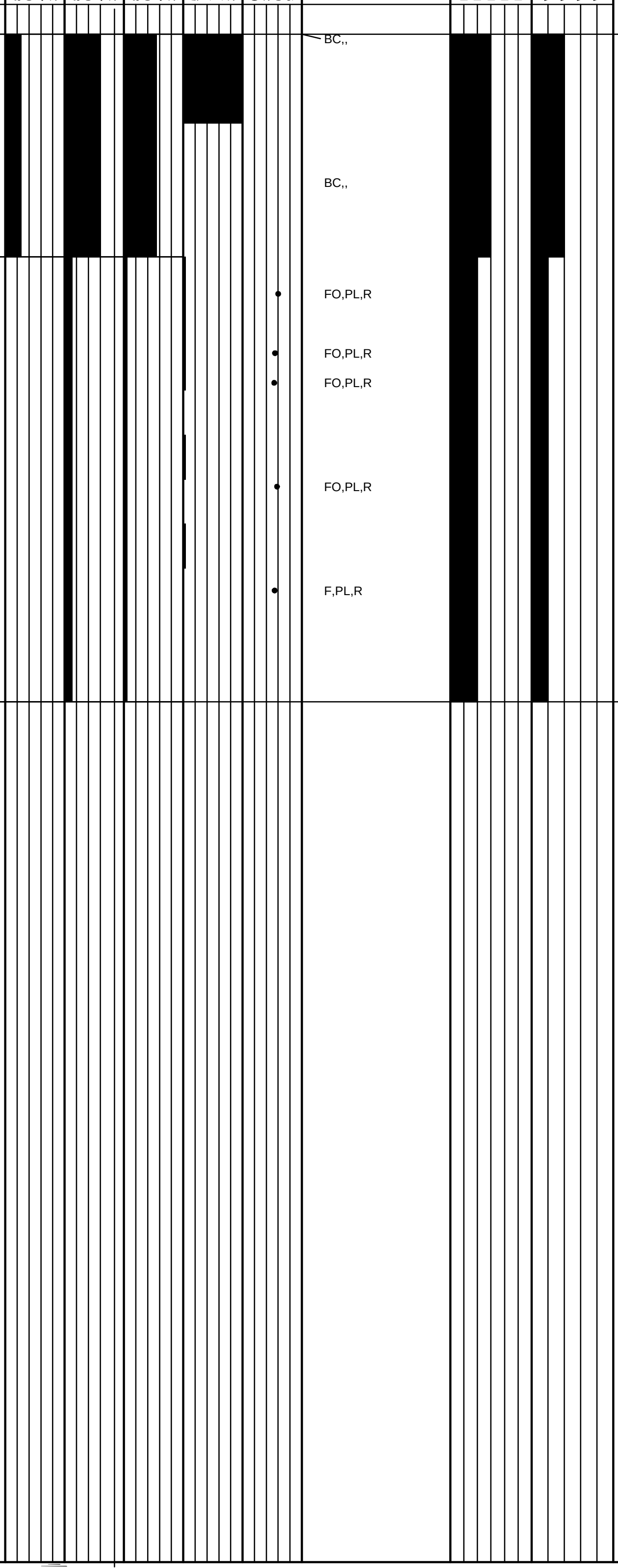
LOCATION: Causeway Alignment, North Hole

DRILLING DATE: 17 May, 2002
DRILL RIG: LY38
DRILLING CONTRACTOR: Boart-Longyear

DATUM: Local

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED CH-CHLORITIZED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	NOTES WATER LEVELS INSTRUMENTATION
		Continued from SOIL LOG.				
12.50–14.00	Boart-Longyear LY38 - HQ/HW	Slightly weathered, light grey, foliated, fine to medium grained, medium strong, INTERMEDIATE VOLCANICS, with quartz.	12.50	1	BC,, BC,,	
14.00–17.00		Fresh, light grey, foliated, fine to medium grained, strong, INTERMEDIATE VOLCANICS, with quartz.	14.00	2	FO,PL,R FO,PL,R FO,PL,R FO,PL,R F,PL,R	15.0m to 17.0m Falling Head Packer Test k=2.6X10-3 cm/s
17		End of DRILLHOLE.	17.00			



DEPTH SCALE
1 : 50

Golder Associates

LOGGED: CJC/JRT
CHECKED:

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-06

SHEET 1 OF 5

LOCATION: Causeway

INCLINATION: -90°

DRILLING DATE: 17 May, 2002

DRILL RIG:

DRILLING CONTRACTOR: Boart-Longyear

DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	CORE: RUN No.	RECOVERY % (80 60 40 20)	GRADATION %: GRAVEL	SAND	FINES	HYDRAULIC CONDUCTIVITY, k, cm/s (10⁻⁵ 10⁻⁴ 10⁻³ 10⁻²) / WATER CONTENT PERCENT Wp ⊢ W ⊣ Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ice Surface													
0	LY38 - HQ3	Ice.		0.00											
2		Water.		2.00											
10															

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: CJC/JRT

CHECKED:

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-06

SHEET 2 OF 5

LOCATION: Causeway

DRILLING DATE: 17 May, 2002
DRILL RIG:
DRILLING CONTRACTOR: Boart-Longyear

DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	SOIL PROFILE STRATA PLOT	SOIL PROFILE ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	CORE RUN No.	CORE RECOVERY % 80 60 40 20	GRADATION % GRAVEL	GRADATION % SAND	GRADATION % FINES	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-5} 10^{-4} 10^{-3} 10^{-2} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10	LY38 - HQ3	Water. *(continued)*													
11															
12															
13															
14															
15															
16															
17															
18															
19															
20															

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: CJC/JRT
CHECKED:

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-06

SHEET 3 OF 5

LOCATION: Causeway

DRILLING DATE: 17 May, 2002
DRILL RIG:
DRILLING CONTRACTOR: Boart-Longyear

DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	CORE: RUN No.	CORE: RECOVERY % 80 60 40 20	GRADATION %: GRAVEL	GRADATION %: SAND	GRADATION %: FINES	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-5} 10^{-4} 10^{-3} 10^{-2} / WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20															
21															
22															
23															
24															
25	LY38 - HQ3	Water. *(continued)*													
26															
27															
28															
29															
30															

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

LOGGED: CJC/JRT
CHECKED:

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-06

SHEET 4 OF 5

LOCATION: Causeway

DRILLING DATE: 17 May, 2002
DRILL RIG:
DRILLING CONTRACTOR: Boart-Longyear

DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	CORE: RUN No.	RECOVERY % 80 60 40 20	GRADATION %: GRAVEL	SAND	FINES	HYDRAULIC CONDUCTIVITY, k, cm/s 10^-5 10^-4 10^-3 10^-2; WATER CONTENT PERCENT Wp W Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
30	LY38 - HQ3														
31															
32															
33															
34															
35		Water. *(continued)*													
36															
37															
38															
39															
40															

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: CJC/JRT
CHECKED:

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-06

SHEET 5 OF 5

LOCATION: Causeway

DRILLING DATE: 17 May, 2002
DRILL RIG:
DRILLING CONTRACTOR: Boart-Longyear

DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			CORE		GRADATION %			HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-5} 10^{-4} 10^{-3} 10^{-2}	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	RUN No.	RECOVERY % 80 60 40 20	GRAVEL	SAND	FINES	WATER CONTENT PERCENT Wp W Wl 10 20 30 40		
40															
41	LY38 - HQ3	Water. *(continued)*													
42		End of DRILLHOLE.		42.70											
43															
44															
45		HOLE ABANDONED. Lake Bottom at Approximately 42.7m depth. - casing set to bottom, NQ rods lowered to start drilling. - entire drill string and casing lost.													
46															
47															
48															
49															
50															

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: CJC/JRT
CHECKED:

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-07

SHEET 1 OF 3

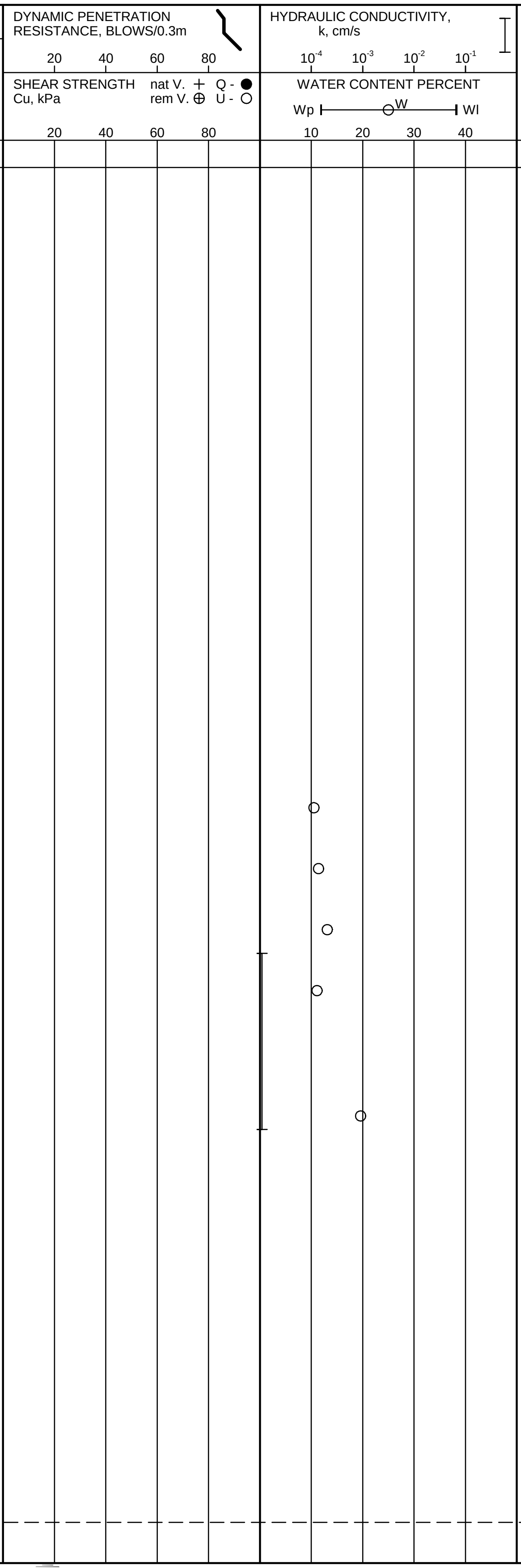
LOCATION: West Dyke

BORING DATE: 13 May, 2002

DATUM: Local

BORING METHOD: LY38 - HQ3

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
0	Ice Surface					
0–1.80	Ice.	0.00				
1.80–3.60	Water.	1.80				
3.60–4.05	Loose, yellow, silty CLAY. [LAKE BOTTOM SEDIMENTS]	3.60	1	50 DO	15	
4.05–6.50	Firm, massive, grey, silty, sandy clay. (TILL) [OVERBURDEN] - at 4.05m to 4.5m yellow to grey, silty, sandy clay with gravel.	4.05	2	50 DO	11	
			3	50 DO	11	
			4	50 DO	35	
			5	50 DO	15	
			6	50 DO	14	5.8m to 7.1m Falling Head Packer Test
6.50–9.50	Inferred loose, wet, grey, green, white, pink, rounded to subrounded COBBLES, GRAVEL and coarse SAND. (i.e. cobbles, gravel, and inferred boulders contained within a sand matrix.) [OVERBURDEN]	6.50	7	WS		
9.50–		9.50				



ADDITIONAL LAB. TESTING

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DEPTH SCALE
1 : 50

LOGGED: CJC/JRT
CHECKED:

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-07

SHEET 2 OF 3

LOCATION: West Dyke

BORING DATE: 13 May, 2002

DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-4} 10^{-3} 10^{-2} 10^{-1} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10	LY38 - HQ3	Inferred grey, green, white, pink, rounded to subrounded COBBLES, GRAVEL and coarse SAND. (i.e. cobbles, gravel, and inferred boulders contained within a sand matrix.) [OVERBURDEN] *(continued)*									
11											
12		Bedrock Encountered. Refer to ROCK LOG for continuation of rock description.									
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: CJC/JRT

CHECKED:

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-07

SHEET 3 OF 3

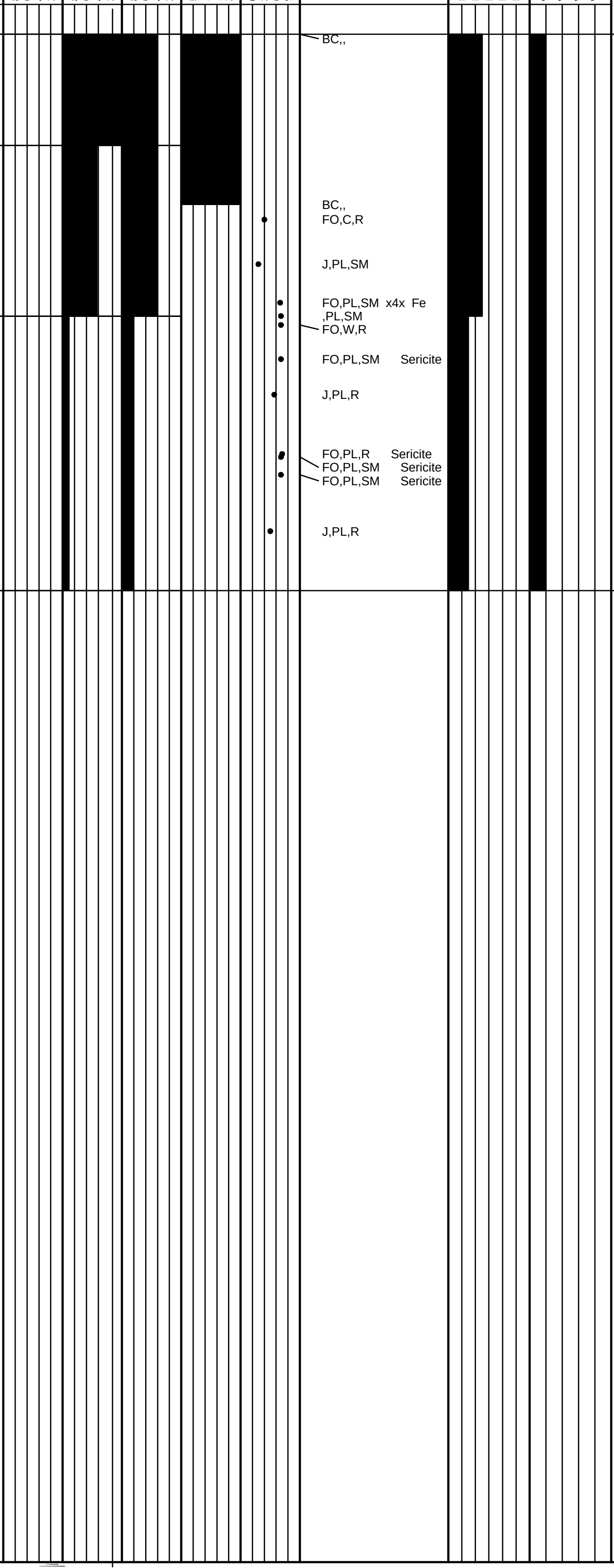
LOCATION: West Dyke

DRILLING DATE: 13 May, 2002
DRILL RIG: LY38
DRILLING CONTRACTOR: Boart-Longyear

DATUM: Local

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED CH-CHLORITIZED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTES WATER LEVELS INSTRUMENTATION
		Continued from SOIL LOG.				
12–13.65	Boart-Longyear LY38 - HQ/HW	Slightly weathered, light grey-green, foliated, fine to medium grained, medium strong to strong, SILICIFIED INTERMEDIATE VOLCANICS. - Transitional into quartzite?	▽ ▽ ▽	11.75	1 2	13.04m to 13.33m Sample Taken. 13.5m to 15.5m Packer Test k=1.2x10-4 cm/s
13.65–15.50		Fresh, white, fine grained, strong to very strong, QUARTZITE. - Fracture surfaces are silicified.		13.65	2	13.74m to 13.90m Sample Taken. 15.30m to 15.5m Sample Taken.
		End of DRILLHOLE.		15.50		



BC,,
BC,,
FO,C,R
J,PL,SM
FO,PL,SM x4x Fe
,PL,SM
FO,W,R
FO,PL,SM Sericite
J,PL,R
FO,PL,R Sericite
FO,PL,SM Sericite
FO,PL,SM Sericite
J,PL,R

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: CJC/JRT
CHECKED:

DRILLHOLE 022-14~1.GPJ GLDR_CAN.GDT 25/2/04

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-08

SHEET 1 OF 2

LOCATION: West Dyke

BORING DATE: 14 May, 2002

DATUM: Local

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-4} 10^{-3} 10^{-2} 10^{-1}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl : 10 20 30 40

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE / SHEAR STRENGTH	HYDRAULIC CONDUCTIVITY / WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ice Surface									
1 2	LY38 - HQ3	Ice.		0.00							
3 4		Water.		2.30							
5		Dense, yellow, CLAY, SILT, SAND and GRAVEL. (Inferred) - Sa #1: Su est. = 25 kPa		4.10	1 2	50 DO 50 DO	56 94				
6		Loose, gravel and cobbles. [OVERBURDEN]		5.70							
7 8		Inferred loose, grey-green, white, rounded to sub-rounded, COBBLES, coarse GRAVEL and SAND. (Inferred) [OVERBURDEN]		6.50	3 4	SH 50 DO	 29				
9 10		Bedrock Encountered. Refer to ROCK LOG for continuation of rock description.									

BOREHOLE 022-14~1.GPJ GLDR_CAN.GDT 25/2/04

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: CJC/JRT

CHECKED:

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-08

SHEET 2 OF 2

LOCATION: West Dyke

DRILLING DATE: 14 May, 2002
DRILL RIG: LY38
DRILLING CONTRACTOR: Boart-Longyear

DATUM: Local

FR-FRACTURE	F-FAULT	SM-SMOOTH	FL-FLEXURED	BC-BROKEN CORE
CL-CLEAVAGE	J-JOINT	R-ROUGH	UE-UNEVEN	MB-MECH. BREAK
SH-SHEAR	P-POLISHED	ST-STEPPED	W-WAVY	B-BEDDING
VN-VEIN	S-SLICKENSIDED	PL-PLANAR	C-CURVED	CH-CHLORITIZED

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | PENETRATION RATE (m/min) | FLUSH | COLOUR % RETURN | RECOVERY: TOTAL CORE % (80 60 40 20), SOLID CORE % (80 60 40 20) | R.Q.D. % (80 60 40 20) | FRACT. INDEX PER 0.3 (5 10 15 20) | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS (0 30 60 90), TYPE AND SURFACE DESCRIPTION | ROCK STRENGTH INDEX (R5 R4 R3 R2 R1) | WEATH-ERING INDEX (W1 W2 W3 W4) | NOTES WATER LEVELS INSTRUMENTATION

Drilling record: Boart-Longyear, LY38 - HQ/HW

Continued from SOIL LOG.

8.30 – Slightly weathered, white to light grey, massive, fine to medium grained, medium strong, QUARTZ VEIN, with sulphides.

- Vein has open vuggy fractures.

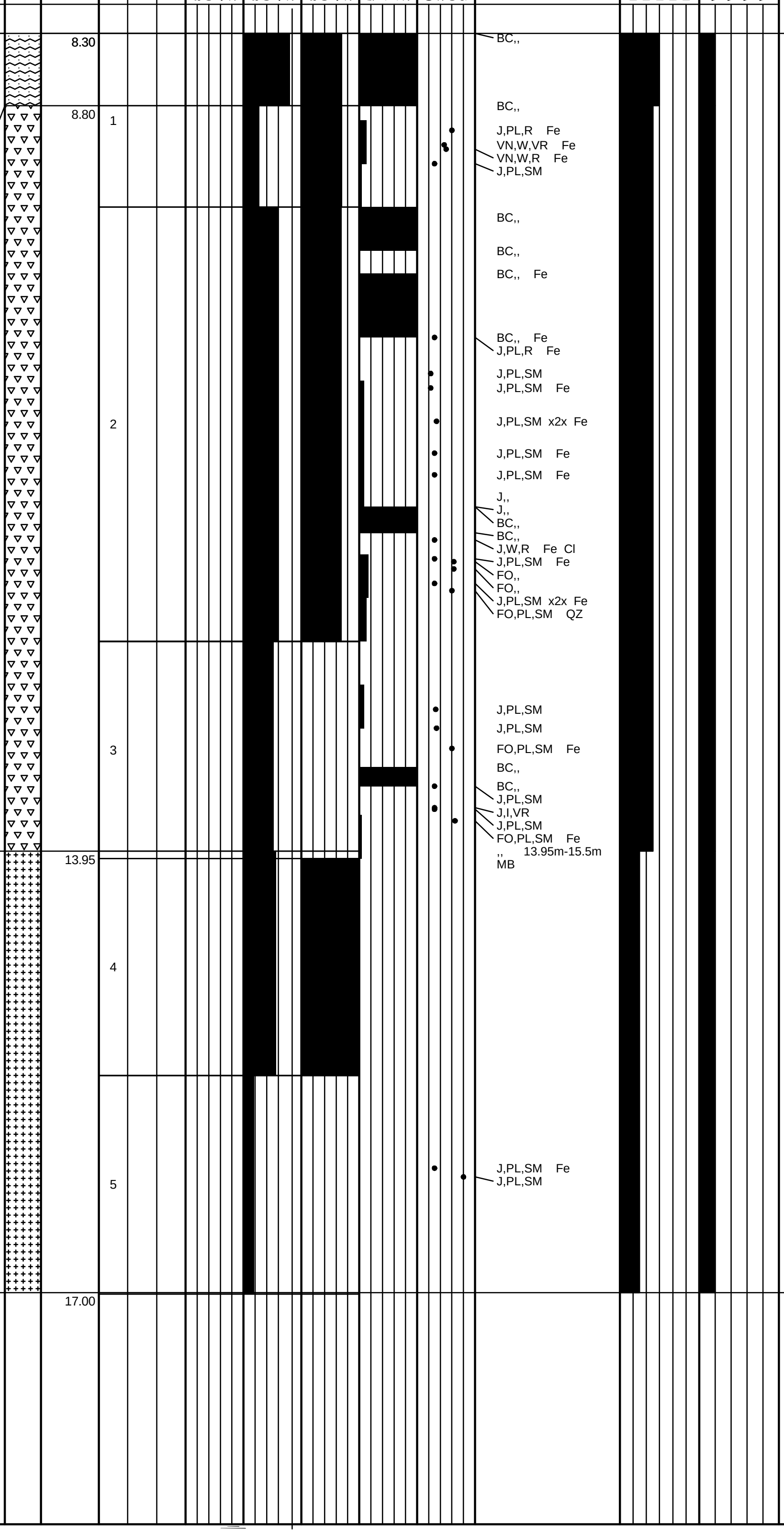
8.80 – Fresh, white to grey, massive, fine grained to medium grained, strong, silicified, INTERMEDIATE to FELSIC VOLCANICLASTICS.

- Sporadic quartz veins throughout which are vuggy.
- Open fractures have up to 2mm aperature and are vuggy.
- Fe staining on all fracture surfaces.
- 2 to 3 joint sets; 1 Foliation.
- 2 Sets are at high angles and are relatively closely spaced (centimetre to metre scale).
- Less Iron staining below approx. 12m.

13.95 – Fresh, pinkish-grey, massive, medium grained, strong to very strong, GRANITE.

- RQD is not indicative of quality of rock. Run #4 was re-cored and rock was mechanically broken.

17.00 – End of DRILLHOLE.



Type and surface description (discontinuity data), in order of depth:

- BC,,
- BC,,
- J,PL,R Fe
- VN,W,VR Fe
- VN,W,R Fe
- J,PL,SM
- BC,,
- BC,,
- BC,, Fe
- BC,, Fe
- J,PL,R Fe
- J,PL,SM
- J,PL,SM Fe
- J,PL,SM x2x Fe
- J,PL,SM Fe
- J,PL,SM Fe
- J,,
- J,,
- BC,,
- BC,,
- J,W,R Fe Cl
- J,PL,SM Fe
- FO,,
- FO,,
- J,PL,SM x2x Fe
- FO,PL,SM QZ
- J,PL,SM
- J,PL,SM
- FO,PL,SM Fe
- BC,,
- BC,,
- J,PL,SM
- J,I,VR
- J,PL,SM
- FO,PL,SM Fe
- ,, 13.95m-15.5m MB
- J,PL,SM Fe
- J,PL,SM

NOTES WATER LEVELS INSTRUMENTATION:

9.38m to 9.50m
Sample Taken.

10.50m to 12.50m
Falling Head
Test
k=1.1x10-2 cm/s

11.5m to 17.0m
Falling Head
Test
k=7.3x10-3 cm/s

12.20m to 12.35m
Sample Taken.

13.5m to 17.00m
Falling Head
Test
k=3.7x10-4 cm/s

16.42m to 16.60m
Sample Taken.

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: CJC/JRT
CHECKED:

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-09

SHEET 1 OF 4

LOCATION: West Dyke

BORING DATE: 15 May, 2002

DATUM: Local

INCLINATION: -48.368° AZIMUTH: 79°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-4} 10^{-3} 10^{-2} 10^{-1}); WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ice Surface									
0	LY38 - HQ3	Inferred boulders. (TILL) [OVERBURDEN].		0.00							
1											
2		Bedrock Encountered. Refer to ROCK LOG for continuation of rock description.									
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: CJC/JRT

CHECKED:

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-09

SHEET 2 OF 4

LOCATION: West Dyke

DRILLING DATE: 15 May, 2002
DRILL RIG: LY38
DRILLING CONTRACTOR: Boart-Longyear

DATUM: Local

INCLINATION: -48.368° AZIMUTH: 79°

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED CH-CHLORITIZED

DRILLING RECORD: Boart-Longyear, LY38 - HQ/HW

Continued from SOIL LOG.

DEPTH SCALE METRES	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	NOTES WATER LEVELS INSTRUMENTATION
2	Fresh, light grey, foliated, fine to medium grained, medium strong to strong, QUARTZITE.	1.60	1	FO,U,R FO,U,R FO,U,R	Thermistor TC-4 installed from ground surface to 15.0m depth. Nodal Down Hole Depths 1 0.3m 2 0.8m 3 2.8m 4 4.8m 5 9.8m 6 14.8m 7 9.8m 8 -0.2m
3, 4, 5	Fresh, light grey, foliated, fine to medium grained, strong, QUARTZITE.	2.50	2	FO,U,R FO,U,R FO,U,R FO,U,R FO,U,R FO,U,R	
6, 7, 8	Fresh, light grey, foliated, fine to medium grained, strong, QUARTZITE.	5.50	3	FO,U,R FO,U,R FO,U,R FO,U,R FO,U,R FO,U,R FO,PL,SM	
9, 10, 11	Fresh, light grey, foliated, fine to medium grained, strong, QUARTZITE.	8.50	4	FO,U,R FO,U,R FO,U,R FO,U,R FO,U,R	9.5m to 14.5m Falling Head Test No responce 11.50m to 11.75m UCS #1
		11.50	5		

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

LOGGED: CJC/JRT
CHECKED:

DRILLHOLE 022-14~1.GPJ GLDR_CAN.GDT 25/2/04

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-09

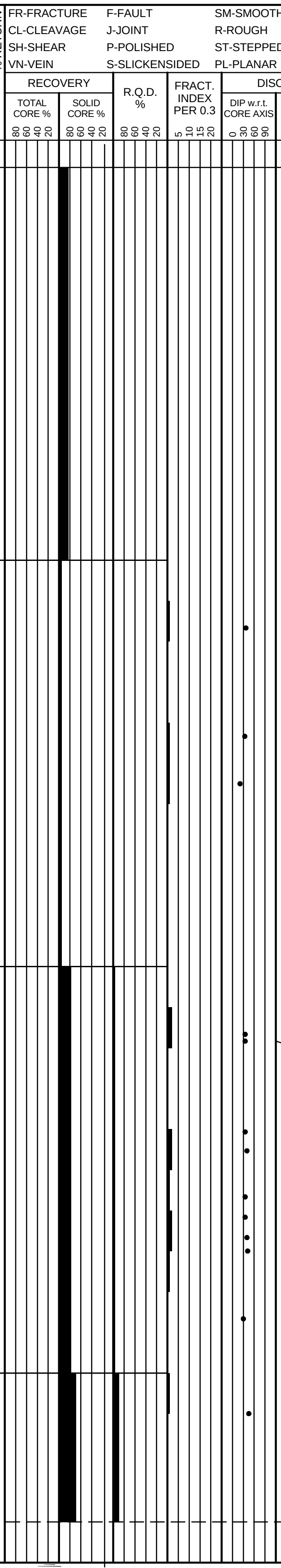
SHEET 3 OF 4

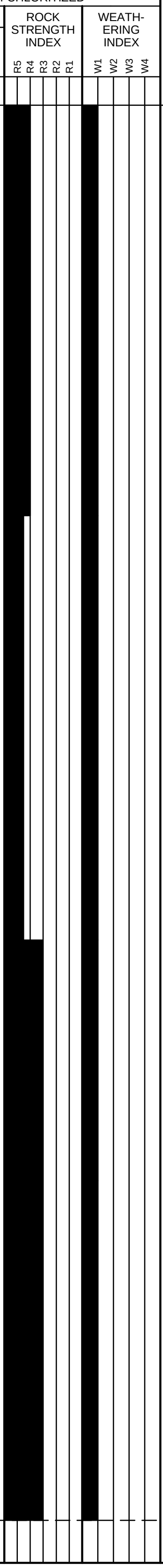
LOCATION: West Dyke
DRILLING DATE: 15 May, 2002
DATUM: Local
DRILL RIG: LY38
INCLINATION: -48.368° AZIMUTH: 79°
DRILLING CONTRACTOR: Boart-Longyear

FR-FRACTURE	F-FAULT	SM-SMOOTH	FL-FLEXURED	BC-BROKEN CORE
CL-CLEAVAGE	J-JOINT	R-ROUGH	UE-UNEVEN	MB-MECH. BREAK
SH-SHEAR	P-POLISHED	ST-STEPPED	W-WAVY	B-BEDDING
VN-VEIN	S-SLICKENSIDED	PL-PLANAR	C-CURVED	CH-CHLORITIZED

DRILLING RECORD: Boart-Longyear, LY38 - HQ/HW

DEPTH SCALE METRES	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	TYPE AND SURFACE DESCRIPTION	NOTES WATER LEVELS INSTRUMENTATION
12					
13	Fresh, light grey, foliated, fine to medium grained, strong, QUARTZITE. *(continued)*		5		
14					
		14.50			
15				FO,U,R	
				FO,U,R	
16			6	F,PL,R	16.22m to 16.50m Sample Taken.
17	Fresh, light grey, foliated, fine to medium grained, strong to very strong, QUARTZITE.				
18				FO,PL,R ,PL,R Orthogonal	
				,PL,R Orthogonal FO,PL,R	
19			7	,PL, Contact	
		19.20		FO,U,SM FO,PL,SM Fe FO,PL,VR	
20	Fresh, grey, thinly laminated (foliated), fine grained, medium strong, interbedded IRON Fm and ULTRAMAFIC VOLCANICS. - Weak magnatite banding. - 19.60m Vuggy quartz/hematite bands up to 3mm. - Fine grained disseminated sulphide throughout.			FO,PL,SM	
21			8	J,I,VR CaCO3	





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DEPTH SCALE
1 : 50

Golder Associates

LOGGED: CJC/JRT
CHECKED:

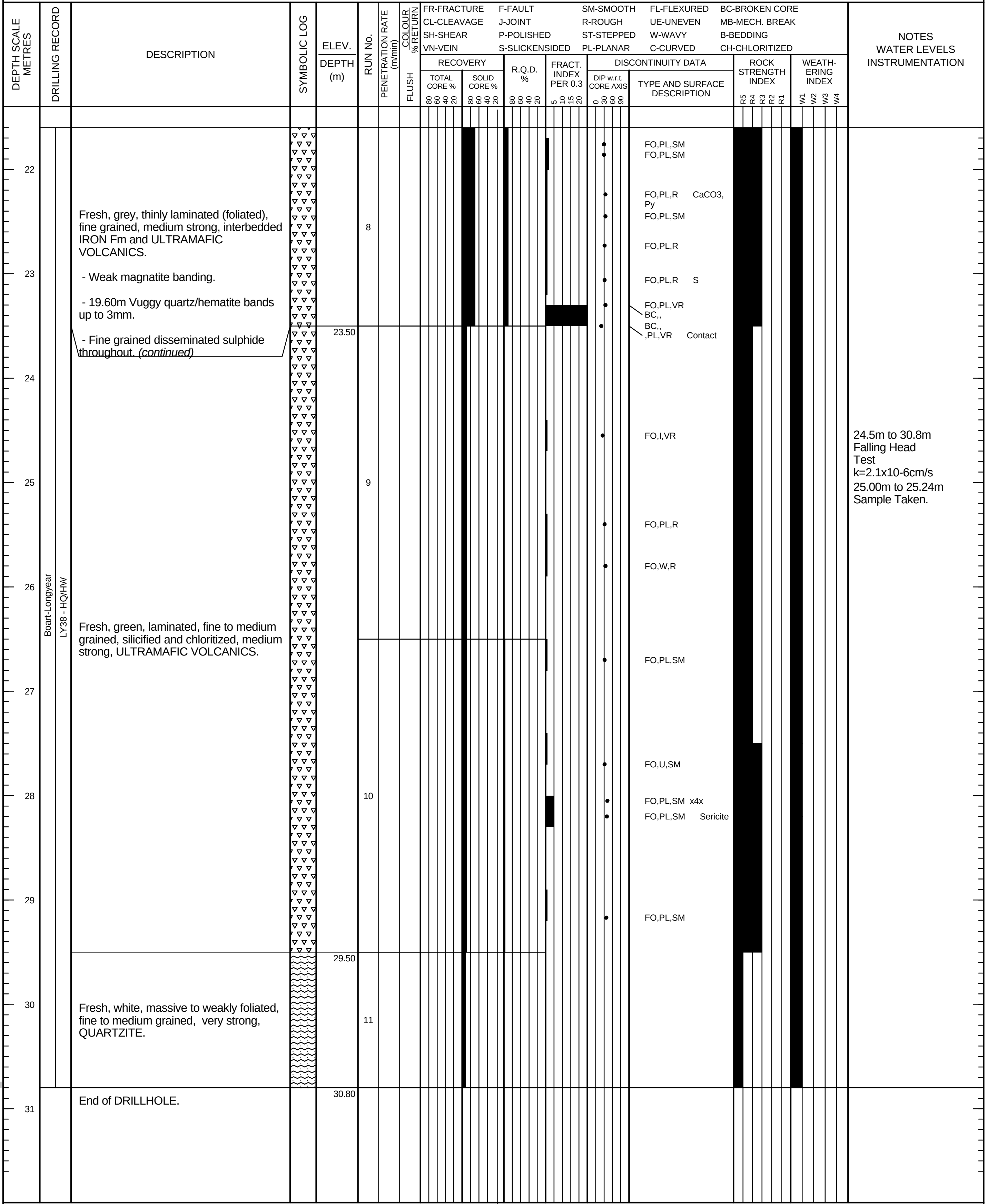
PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-09

SHEET 4 OF 4

LOCATION: West Dyke
DRILLING DATE: 15 May, 2002
DATUM: Local
DRILL RIG: LY38
INCLINATION: -48.368° AZIMUTH: 79°
DRILLING CONTRACTOR: Boart-Longyear

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED CH-CHLORITIZED



Description	Depth (m)	Run No.
Fresh, grey, thinly laminated (foliated), fine grained, medium strong, interbedded IRON Fm and ULTRAMAFIC VOLCANICS. - Weak magnatite banding. - 19.60m Vuggy quartz/hematite bands up to 3mm. - Fine grained disseminated sulphide throughout. *(continued)*	23.50	8
Fresh, green, laminated, fine to medium grained, silicified and chloritized, medium strong, ULTRAMAFIC VOLCANICS.	29.50	9 10
Fresh, white, massive to weakly foliated, fine to medium grained, very strong, QUARTZITE.	30.80	11
End of DRILLHOLE.		

FO,PL,SM
FO,PL,SM
FO,PL,R CaCO3, Py
FO,PL,SM
FO,PL,R
FO,PL,R S
FO,PL,VR
BC,,
BC,,
,PL,VR Contact
FO,I,VR
FO,PL,R
FO,W,R
FO,PL,SM
FO,U,SM
FO,PL,SM x4x
FO,PL,SM Sericite
FO,PL,SM

24.5m to 30.8m Falling Head Test k=2.1x10-6cm/s
25.00m to 25.24m Sample Taken.

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: CJC/JRT
CHECKED:

DRILLHOLE 022-14~1.GPJ GLDR_CAN.GDT 25/2/04

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-10

SHEET 1 OF 4

LOCATION: West Dyke

BORING DATE: 13 May, 2002

DATUM: Local

INCLINATION: -48.693° AZIMUTH: 238°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-4} 10^{-3} 10^{-2} 10^{-1} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	LY38 - HQ3	Silty sand and gravel, with cobbles and boulders. (TILL)	▨	0.00	1	50DC	50				
1											
		Bedrock Encountered. Refer to ROCK LOG for continuation of rock description.									
2											
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: CJC/JRT
CHECKED:

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-10

SHEET 2 OF 4

LOCATION: West Dyke

DRILLING DATE: 13 May, 2002

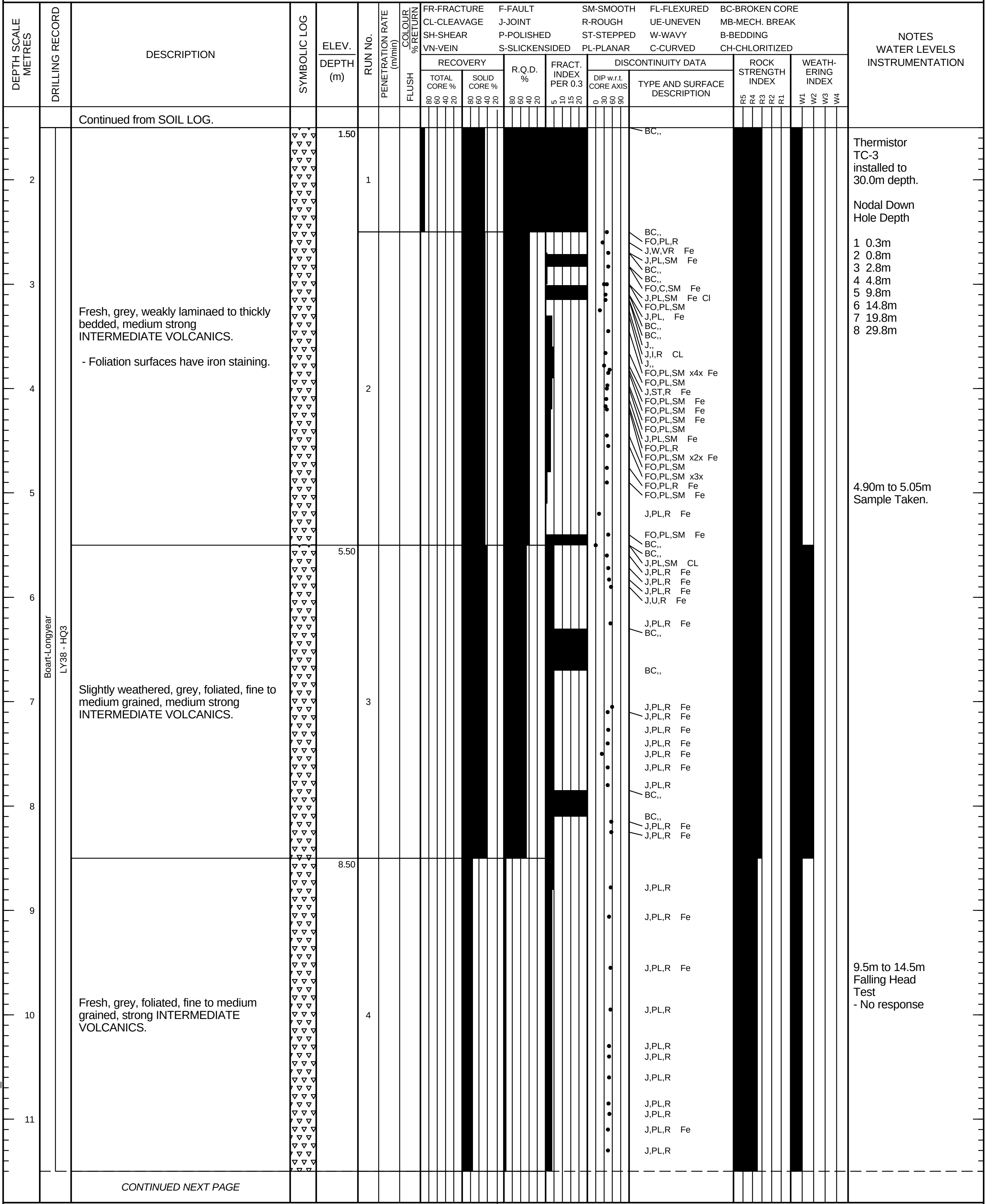
DATUM: Local

DRILL RIG: LY38

INCLINATION: -48.693° AZIMUTH: 238°

DRILLING CONTRACTOR: Boart-Longyear

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED CH-CHLORITIZED



Continued from SOIL LOG.

1.50

Fresh, grey, weakly laminaed to thickly bedded, medium strong INTERMEDIATE VOLCANICS.

- Foliation surfaces have iron staining.

5.50

Slightly weathered, grey, foliated, fine to medium grained, medium strong INTERMEDIATE VOLCANICS.

8.50

Fresh, grey, foliated, fine to medium grained, strong INTERMEDIATE VOLCANICS.

CONTINUED NEXT PAGE

BC,,
BC,,
FO,PL,R
J,W,VR Fe
J,PL,SM Fe
BC,,
BC,,
FO,C,SM Fe
J,PL,SM Fe Cl
FO,PL,SM
J,PL, Fe
BC,,
BC,,
J,,
J,I,R CL
J,,
FO,PL,SM x4x Fe
FO,PL,SM
J,ST,R Fe
FO,PL,SM Fe
FO,PL,SM Fe
FO,PL,SM Fe
FO,PL,SM
J,PL,SM Fe
FO,PL,R
FO,PL,SM x2x Fe
FO,PL,SM
FO,PL,SM x3x
FO,PL,R Fe
FO,PL,SM Fe
J,PL,R Fe
FO,PL,SM Fe
BC,,
BC,,
J,PL,SM CL
J,PL,R Fe
J,PL,R Fe
J,PL,R Fe
J,U,R Fe
J,PL,R Fe
BC,,
BC,,
J,PL,R Fe
J,PL,R Fe
J,PL,R Fe
J,PL,R Fe
J,PL,R Fe
J,PL,R Fe
J,PL,R
BC,,
BC,,
J,PL,R Fe
J,PL,R Fe
J,PL,R
J,PL,R Fe
J,PL,R Fe
J,PL,R
J,PL,R
J,PL,R
J,PL,R
J,PL,R
J,PL,R
J,PL,R Fe
J,PL,R

Thermistor
TC-3
installed to
30.0m depth.

Nodal Down
Hole Depth

1	0.3m
2	0.8m
3	2.8m
4	4.8m
5	9.8m
6	14.8m
7	19.8m
8	29.8m

4.90m to 5.05m
Sample Taken.

9.5m to 14.5m
Falling Head
Test
- No response

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: CJC/JRT

CHECKED:

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-10

SHEET 3 OF 4

LOCATION: West Dyke

DRILLING DATE: 13 May, 2002

DATUM: Local

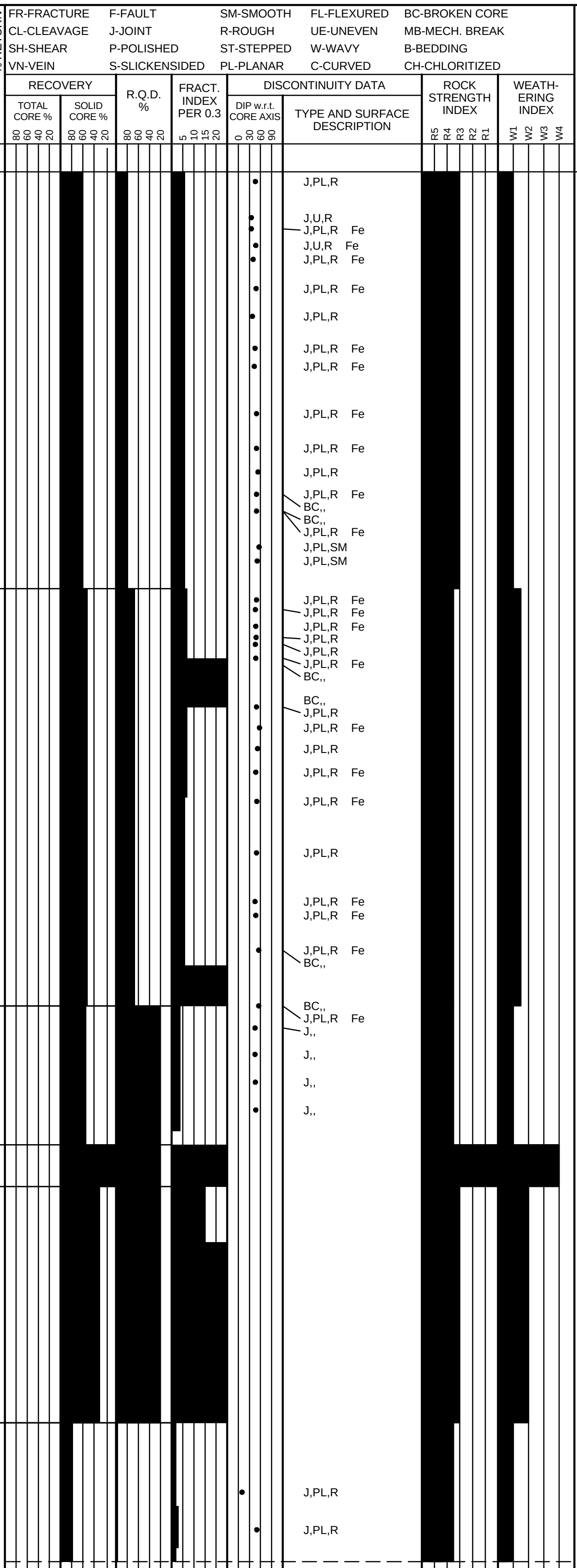
DRILL RIG: LY38

INCLINATION: -48.693° AZIMUTH: 238°

DRILLING CONTRACTOR: Boart-Longyear

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED CH-CHLORITIZED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	NOTES WATER LEVELS INSTRUMENTATION
11.5–14.5	Boart-Longyear LY38 - HQ3	Fresh, grey, foliated, fine to medium grained, medium strong INTERMEDIATE VOLCANICS.	▽ ▽ ▽	11.50	5	
14.5–17.5		Fresh, grey, foliated, fine to medium grained, medium strong INTERMEDIATE VOLCANICS.	▽ ▽ ▽	14.50	6	15.5m to 28.0m Falling Head Test k=3.1x10-5cm/s
17.5–20.5		Fresh, grey, foliated, fine to medium grained, medium strong INTERMEDIATE VOLCANICS. - 18.5m to 18.80m Fault zone contains clay rich Breccia, weathered weak, soapy texture.	▽ ▽ ▽	17.50	7	
20.5–			▽ ▽ ▽	20.50	8	



TYPE AND SURFACE DESCRIPTION

J,PL,R
J,U,R
J,PL,R Fe
J,U,R Fe
J,PL,R Fe
J,PL,R Fe
J,PL,R
J,PL,R Fe
J,PL,R Fe
J,PL,R Fe
J,PL,R Fe
J,PL,R
J,PL,R Fe
BC,,
BC,,
J,PL,R Fe
J,PL,SM
J,PL,SM
J,PL,R Fe
J,PL,R Fe
J,PL,R Fe
J,PL,R
J,PL,R
J,PL,R Fe
BC,,
BC,,
J,PL,R
J,PL,R Fe
J,PL,R
J,PL,R Fe
J,PL,R Fe
J,PL,R
J,PL,R Fe
J,PL,R Fe
J,PL,R Fe
BC,,
BC,,
J,PL,R Fe
J,,
J,,
J,,
J,,
J,PL,R
J,PL,R

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: CJC/JRT
CHECKED:

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-10

SHEET 4 OF 4

LOCATION: West Dyke

DRILLING DATE: 13 May, 2002

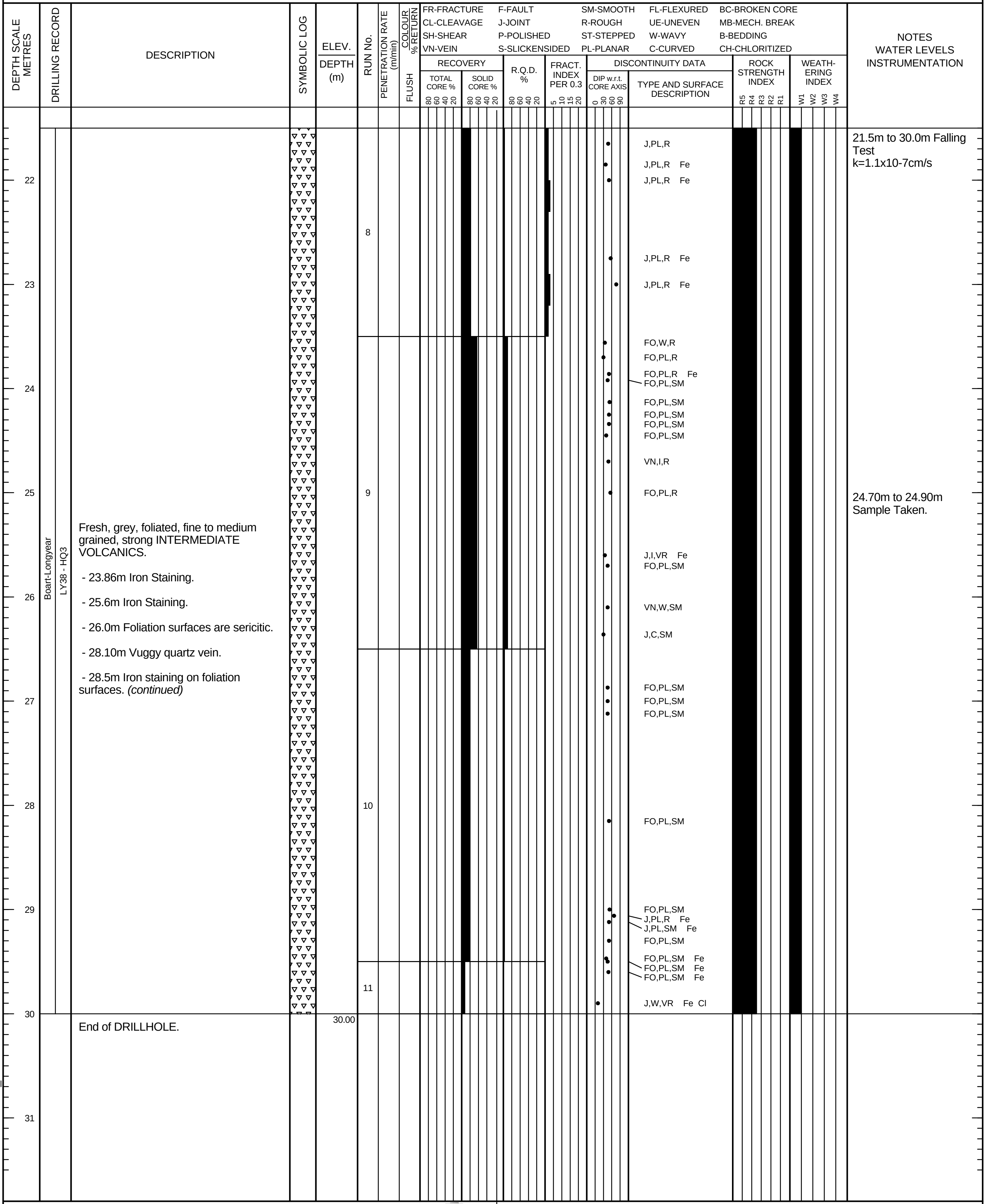
DATUM: Local

DRILL RIG: LY38

INCLINATION: -48.693° AZIMUTH: 238°

DRILLING CONTRACTOR: Boart-Longyear

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED CH-CHLORITIZED



Fresh, grey, foliated, fine to medium grained, strong INTERMEDIATE VOLCANICS.

- 23.86m Iron Staining.
- 25.6m Iron Staining.
- 26.0m Foliation surfaces are sericitic.
- 28.10m Vuggy quartz vein.
- 28.5m Iron staining on foliation surfaces. *(continued)*

End of DRILLHOLE.

J,PL,R
J,PL,R Fe
J,PL,R Fe
J,PL,R Fe
J,PL,R Fe
FO,W,R
FO,PL,R
FO,PL,R Fe
FO,PL,SM
FO,PL,SM
FO,PL,SM
FO,PL,SM
FO,PL,SM
VN,I,R
FO,PL,R
J,I,VR Fe
FO,PL,SM
VN,W,SM
J,C,SM
FO,PL,SM
FO,PL,SM
FO,PL,SM
FO,PL,SM
FO,PL,SM
J,PL,R Fe
J,PL,SM Fe
FO,PL,SM
FO,PL,SM Fe
FO,PL,SM Fe
FO,PL,SM Fe
J,W,VR Fe Cl

21.5m to 30.0m Falling Test
k=1.1x10-7cm/s

24.70m to 24.90m Sample Taken.

DRILLHOLE 022-14~1.GPJ GLDR_CAN.GDT 25/2/04

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: CJC/JRT

CHECKED:

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-11

SHEET 1 OF 3

LOCATION: Causeway

DRILLING DATE: 10 May, 2002
DRILL RIG: LY38
DRILLING CONTRACTOR: Boart-Longyear

DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			CORE		GRADATION %			HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-5} 10^{-4} 10^{-3} 10^{-2} / WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	RUN No.	RECOVERY % 80 60 40 20	GRAVEL	SAND	FINES			
0		Ice Surface		0.00											
1		Ice.													
2				2.00											
3															
4															
5	LY38 - HQ3														
6		Water.													
7															
8															
9															
10															
		CONTINUED NEXT PAGE													

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: CJC/JRT
CHECKED:

CUSTOM LOG 3 022-14~1.GPJ GLDR_CAN.GDT 25/2/04

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-11

SHEET 2 OF 3

LOCATION: Causeway

DRILLING DATE: 10 May, 2002
DRILL RIG: LY38
DRILLING CONTRACTOR: Boart-Longyear

DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			CORE		GRADATION %			HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-5} 10^{-4} 10^{-3} 10^{-2} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	RUN No.	RECOVERY % 80 60 40 20	GRAVEL	SAND	FINES			
10	LY38 - HQ3	Water. *(continued)*													
18.30		Inferred lake bottom sediments and overburden (TILL) [OVERBURDEN]		18.30											
20		Bedrock Encountered. Refer to ROCK LOG for continuation of rock description.													

Depth scale marks: 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: CJC/JRT
CHECKED:

PROJECT No.: 022-1427A Task 2000

RECORD OF DRILLHOLE: 02GT-11

SHEET 3 OF 3

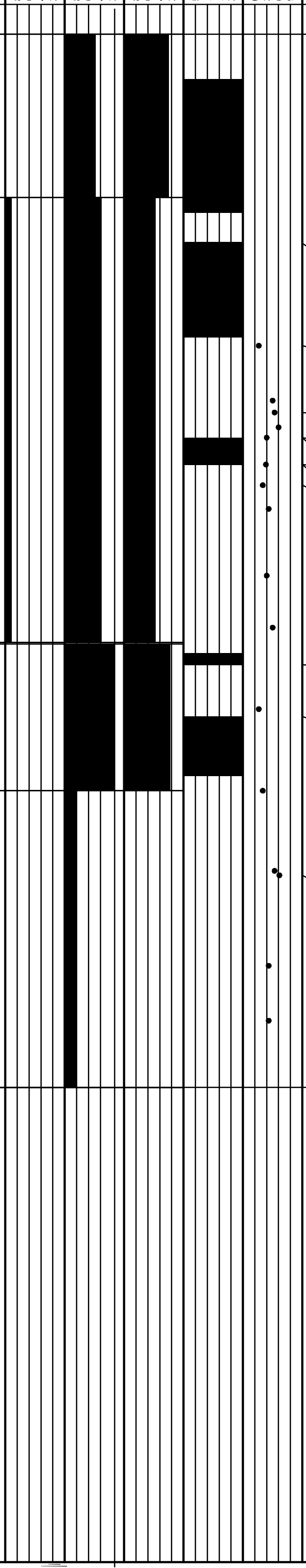
LOCATION: Causeway

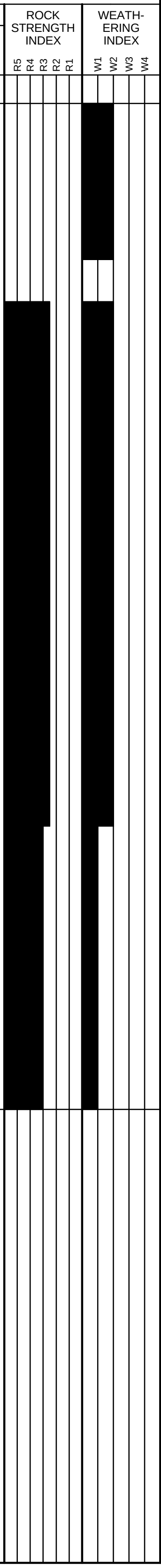
DRILLING DATE: 10 May, 2002
DRILL RIG: LY38
DRILLING CONTRACTOR: Boart-Longyear

DATUM: Local

FR-FRACTURE, CL-CLEAVAGE, SH-SHEAR, VN-VEIN, F-FAULT, J-JOINT, P-POLISHED, S-SLICKENSIDED, SM-SMOOTH, R-ROUGH, ST-STEPPED, PL-PLANAR, FL-FLEXURED, UE-UNEVEN, W-WAVY, C-CURVED, BC-BROKEN CORE, MB-MECH. BREAK, B-BEDDING, CH-CHLORITIZED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	NOTES WATER LEVELS INSTRUMENTATION
		Continued from SOIL LOG.				
20	Boart-Longyear LY38 - HQ/HW	Slightly weathered, green, very thinly laminated, vuggy, fine grained, weak to medium strong ULTRAMAFIC VOLCANICS. - Quartz veins occur every 0.2 to 0.3m these are up to several centimetres in width and very vuggy with Iron staining. - Broken core areas are characterized by vuggy vein.	19.90	1	BC,,	
21				2	BC,, BC,, ,, Lost Core 21.0-21.3m	
22					BC,, J,PL,SM FO,PL,SM Fe FO,PL,SM Fe VN,I,VR FO,W,SM BC,, BC,, J,PL,R J,PL,R J,I,VR	22.0m to 27.0m Falling Head Test k=1.6x10-3 cm/s
23					,ST,VR Orthogonal FO,C,SM Fe	23.68m to 23.80m Sample Taken.
24				3	BC,, BC,, J,W,VR BC,, BC,, J,PL,SM	
25		Fresh, green, very thinly laminated, fine grained, medium strong ULTRAMAFIC VOLCANICS. - Core is pitted and vuggy locally, much less than previous interval.	25.00	3	,PL,VR Orthogonal FO,PL,SM	25.0m to 27.0m Falling Head Test k=2.8x10-3 cm/s
26					J,W,R FO,PL,SM	25.90m to 26.12m Sample Taken.
27		End of DRILLHOLE.	27.00			
28						
29						





DEPTH SCALE
1 : 50

LOGGED: CJC/JRT
CHECKED:

APPENDIX II

STABILITY ANALYSES

Table AII-1: Summary of Limit Equilibrium Slope Stability Analyses – Meadowbank Tailings Dike

(Page 1 of 2)

Figure No. (II-)	Conditions Modelled	Calculated Minimum FOS	Calculated Yield Acceleration (g)	Required Undrained Shear Strength of Foundation Till (kPa) to Achieve	
				FOS=1.0	FOS=1.3
	End of Construction				
1	Drained Condition for foundation till; Circular Surfaces	2.8	▨	▨	▨
1	Drained Condition for foundation till; Block Surfaces	2.7	▨	▨	▨
1	Undrained Condition for foundation till; Circular Surfaces	▨	▨	~50	~65
1	Undrained Condition for foundation till; Block Surfaces	▨	▨	~45	~60
6	Construction-induced pore water pressures in till core and cutoff (r_u = 0.3); undrained condition for foundation till; circular surfaces.	▨	▨	~50	~70
6	Construction-induced pore water pressures in till core and cutoff (r_u = 0.3); undrained condition for foundation till; block surfaces	▨	▨	~40	~60
6	Construction-induced pore water pressures in till core and cutoff (r_u = 0.3); drained condition for foundation till; circular surfaces.	2.8	▨	▨	▨
6	Construction-induced pore water pressures in till core and cutoff (r_u = 0.3); drained condition for foundation till; block surfaces	2.7	▨	▨	▨
8	Progressive failure; undrained; circular surfaces	1.9	▨	▨	▨
8	Progressive failure; undrained; circular surfaces		▨	~45	~60
	High Water				
2	Circular Surfaces; Static	2.0	▨	▨	▨
2	Block Surfaces; Static	2.5	▨	▨	▨
2	Circular Surfaces; Pseudostatic	1.8	▨	▨	▨
2	Block Surfaces; Pseudostatic	2.3	▨	▨	▨

Notes:

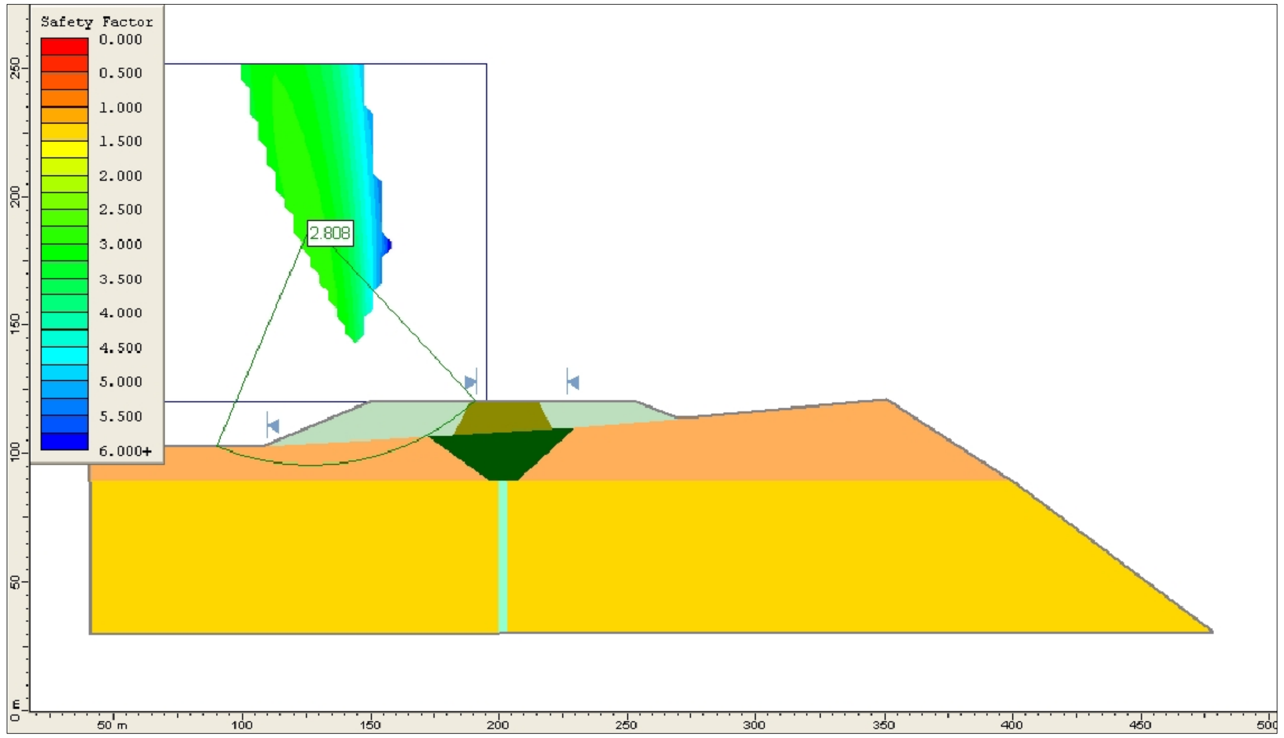
1. Yield acceleration = the peak horizontal ground acceleration (PGA) that produces a FOS of 1.0.
2. Shading indicates that value is not applicable to given modelling scenario.

Table AII-1: Summary of Limit Equilibrium Slope Stability Analyses – Meadowbank Tailings Dike
(Page 2 of 2)

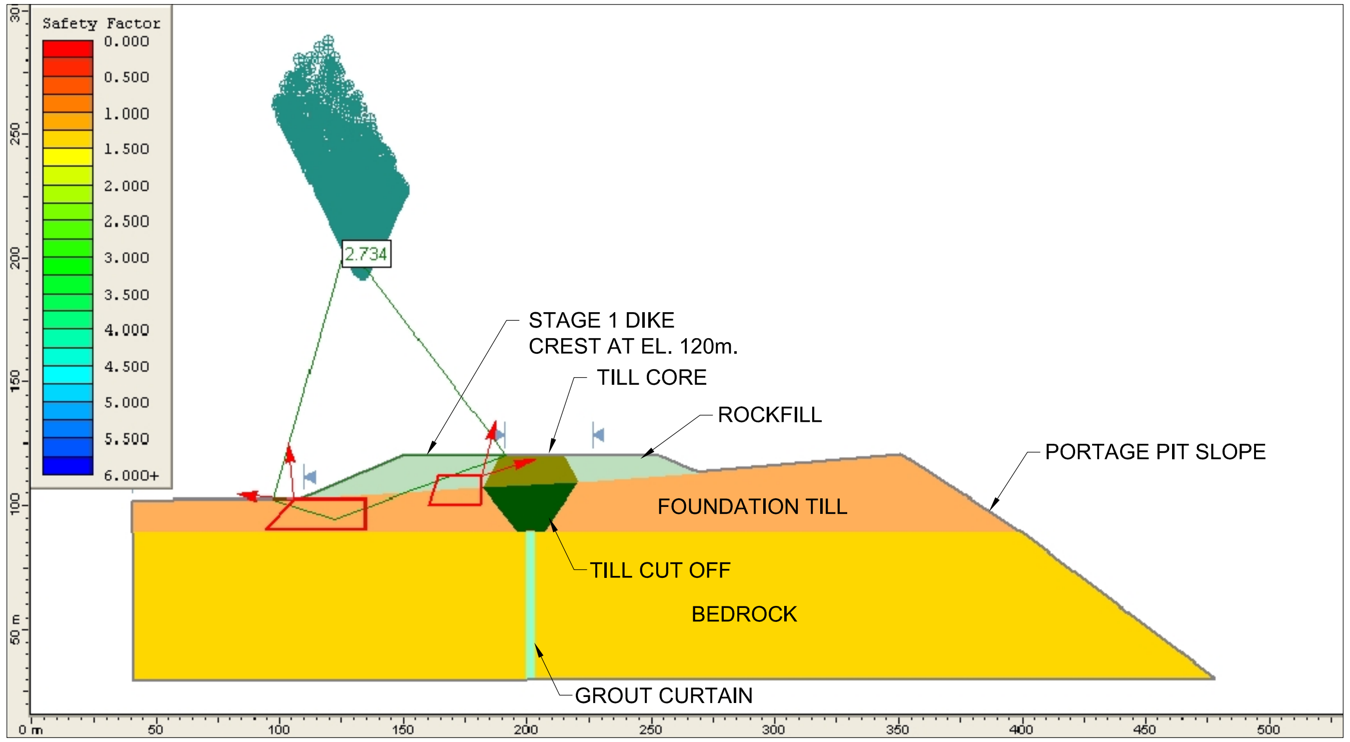
Figure No. (II-)	Conditions Modelled	Calculated Minimum FOS	Calculated Yield Acceleration (g)	Required Undrained Shear Strength of Foundation Till (kPa) to Achieve	
	End of Tailings Deposition				
3	Circular Surfaces; Static	2.3			
3	Block Surfaces; Static	2.3			
3	Circular Surfaces; Pseudostatic	2.3			
3	Block Surfaces; Pseudostatic	2.2			
5	Yield Acceleration; Circular Surfaces		~0.41		
5	Yield Acceleration; Block Surfaces		~0.47		
7	Friction Angle of Foundation Till = 30°; circular	2.4			
7	Friction Angle of Foundation Till = 30°; block	2.6			
7	Friction Angle of Foundation Till = 32°; circular	2.5			
7	Friction Angle of Foundation Till = 32°; block	2.7			
	Post-Closure				
4	Circular Surfaces; Static	6.2			
4	Block Surfaces; Static	4.9			
4	Circular Surfaces; Pseudostatic	5.4			
4	Block Surfaces; Pseudostatic	4.3			
5	Yield Acceleration; Circular Surfaces		~0.43		
5	Yield Acceleration; Block Surfaces		~0.67		

Notes:

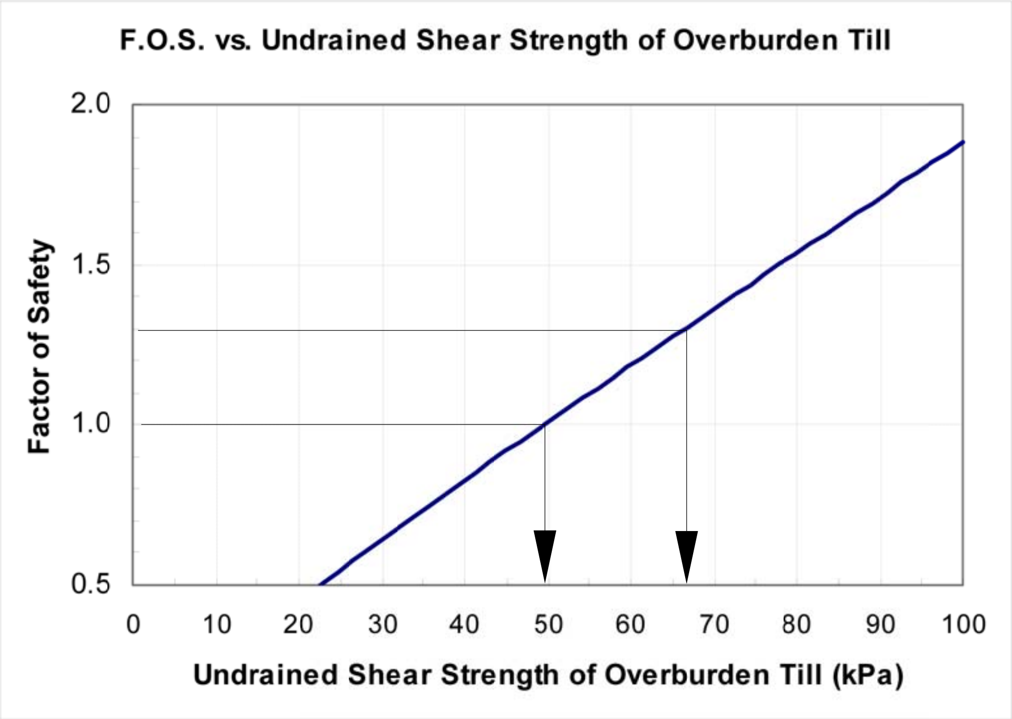
1. Yield acceleration = the peak horizontal ground acceleration (PGA) that produces a FOS of 1.0.
2. Shading indicates that value is not applicable to given modelling scenario.



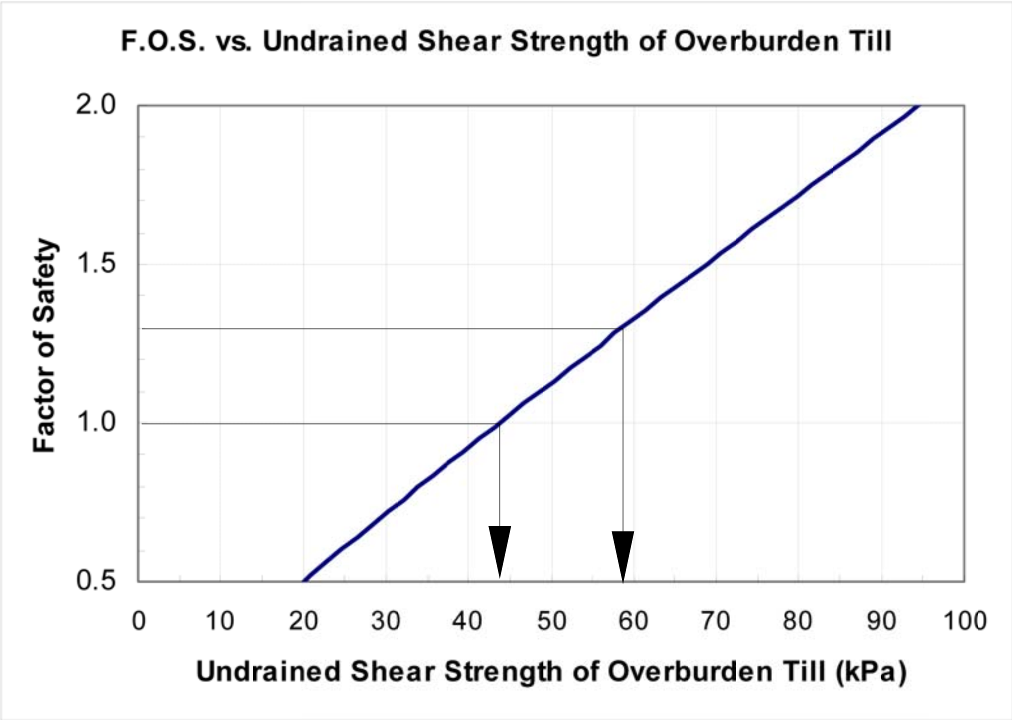
CIRCULAR FAILURE - DRAINED CONDITION IN FOUNDATION TILL



BLOCK FAILURE - DRAINED CONDITION IN FOUNDATION TILL



CIRCULAR FAILURE - UNDRAINED CONDITION IN FOUNDATION TILL - SENSITIVITY PLOT



BLOCK FAILURE - UNDRAINED CONDITION IN FOUNDATION TILL - SENSITIVITY PLOT

MATERIAL PROPERTIES

MATERIAL TYPE	Ø'
TILL CORE	28
ROCKFILL	40
TILL CUT OFF	28
FOUNDATION TILL	28 - see Note 3
BEDROCK	INFINITE STRENGTH

NOTES

1) Cohesion assumed to be equal to zero for all materials in drained conditions.
2) All values of Ø' in degrees.
3) In undrained case Ø' was not used for Foundation Till.
4) Analyses done using limit equilibrium Slope Stability Software Slide^{TM}.

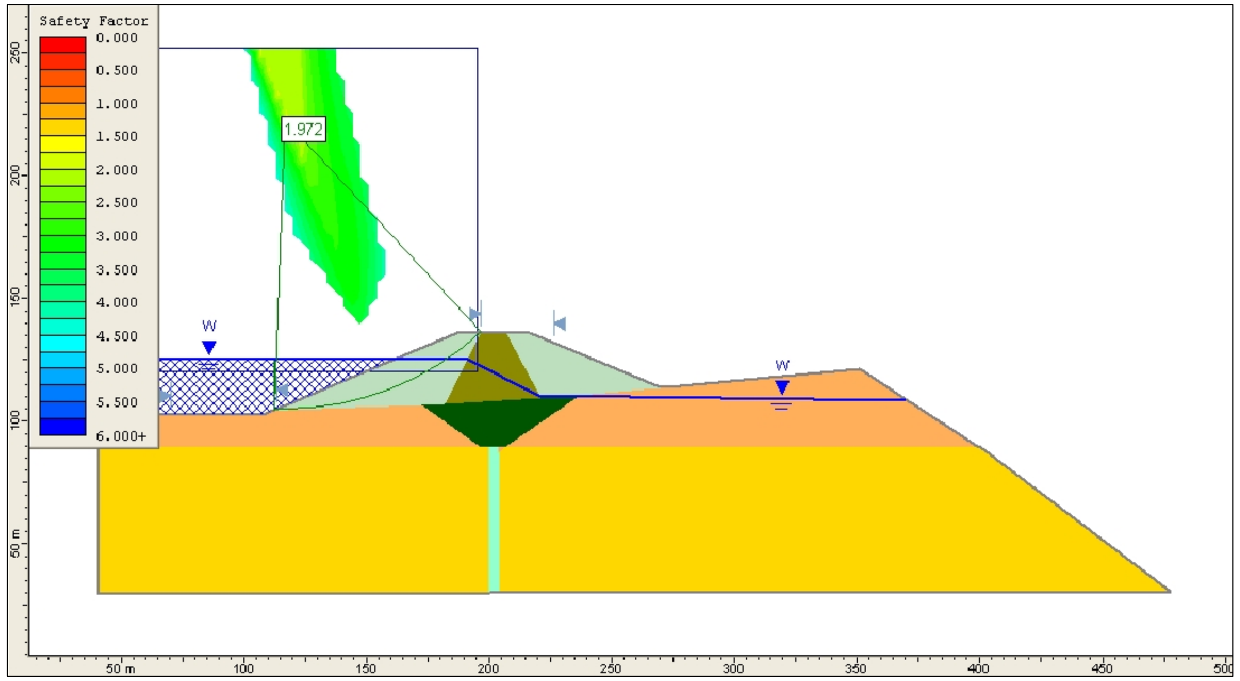
PROJECT
CUMBERLAND
RESOURCES LTD.

TITLE
TAILINGS DIKE STABILITY AT END OF STAGE 1 CONSTRUCTION

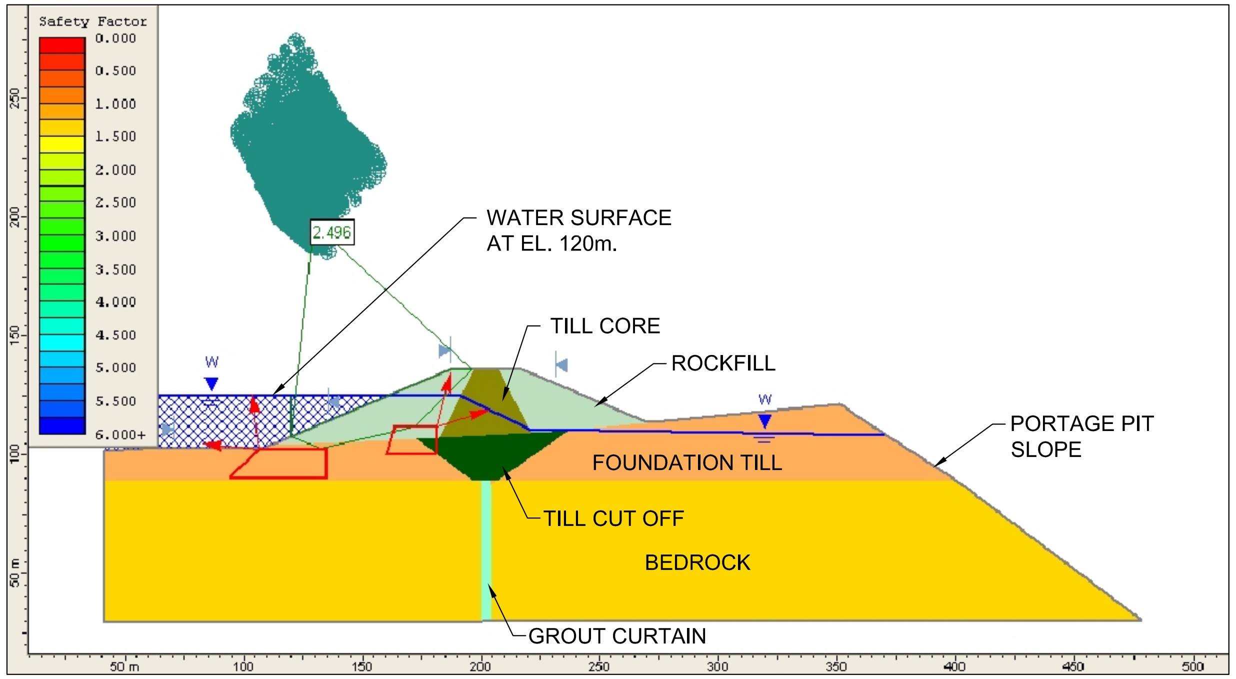
Golder Associates

PROJECT No. 03-1413-427			FILE No. 4274210SK01	
DESIGN	DAH	10NOV2003	SCALE NA	REV. 0
CADD	RCR	10NOV2003	**FIGURE II-1**	
CHECK	DAH	10NOV2003		
REVIEW				

REVISION DATE: 04/01/7 1:46pm By: rroque CADD FILE: N:\Bur-Graphics\Projects\2003\1413\03-1413-427\4210\Drafting\cad\4274210SK01.dwg



CIRCULAR FAILURE - STATIC



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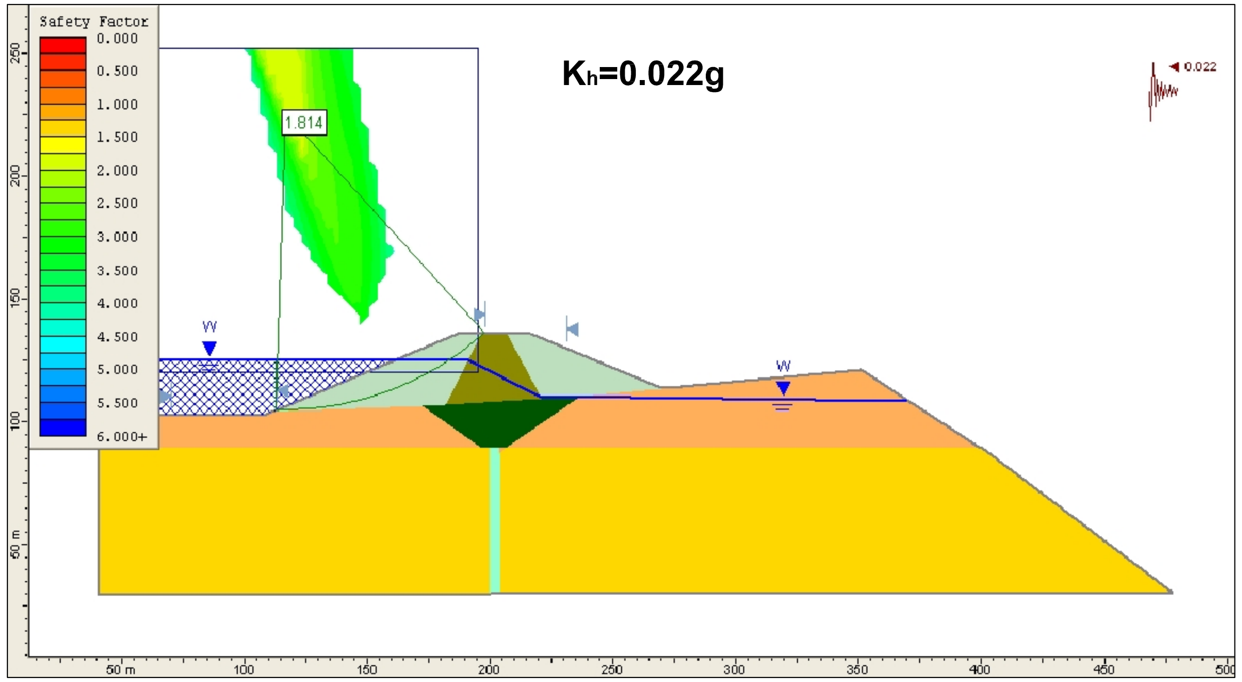
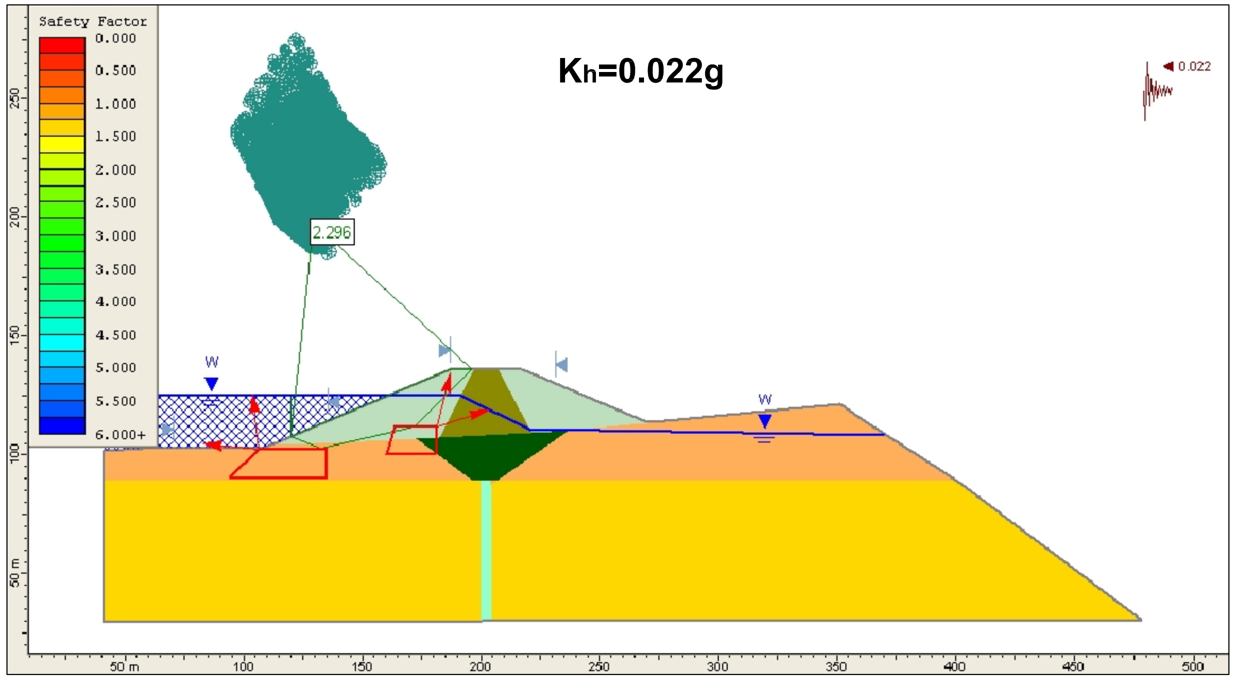


CIRCULAR FAILURE - PSEUDO STATIC



BLOCK FAILURE - PSEUDO STATIC

MATERIAL PROPERTIES

MATERIAL TYPE	Ø'
TILL CORE	28
ROCKFILL	40
TILL CUT OFF	28
FOUNDATION TILL	28
BEDROCK	INFINITE STRENGTH

NOTES

1) Cohesion assumed to be equal to zero for all materials in drained conditions.
2) All values of Ø' in degrees.
3) K_h = 0.022g corresponds to 1:975 YEAR SEISMIC EVENT
4) Analyses done using limit equilibrium Slope Stability Software Slide^{TM}.

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

TAILINGS DIKE STABILITY AT HIGH WATER CONDITION

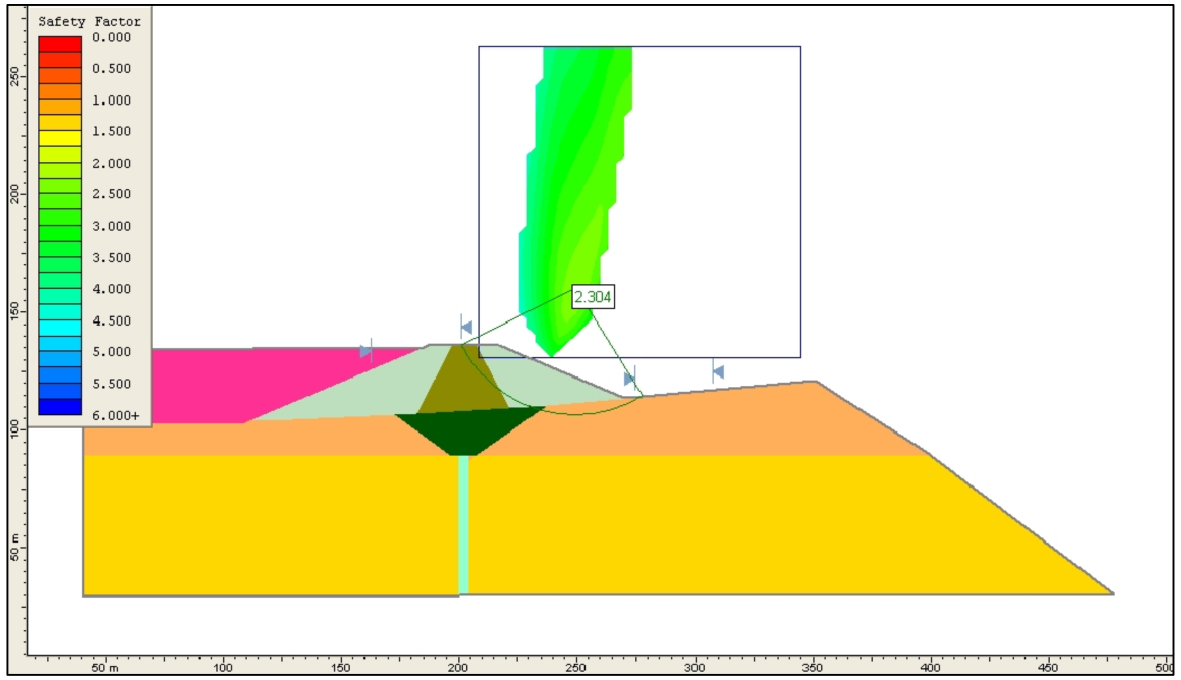
Golder Associates

PROJECT No. 03–1413–427			FILE No. 4274210SK02	
DESIGN	DAH	03NOV03	SCALE AS SHOWN	REV. 0
CADD	RCR	03DEC03	**FIGURE II-2**	
CHECK		03DEC03		
REVIEW		16FEB04		

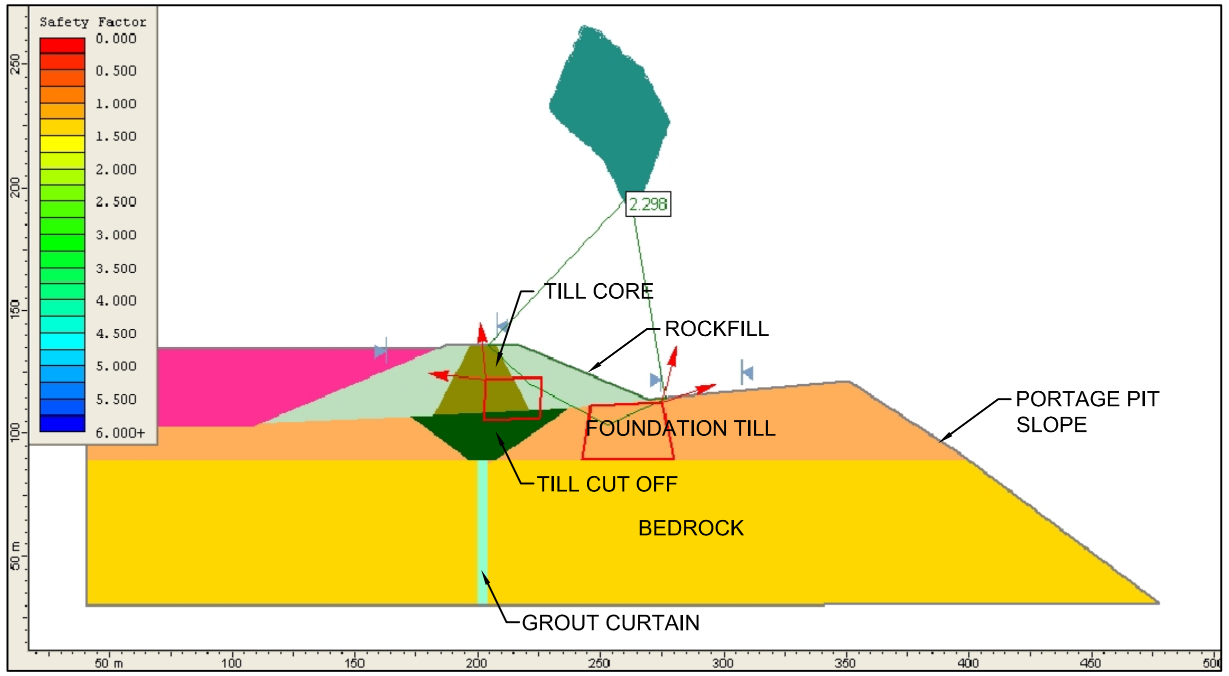
CADD FILE: N:\Bur-Graphics\Projects\2003\1413\03-1413-427\4210\Drafting\cad\4274210SK02.dwg

By: rroque

REVISION DATE: 04/01/7 4:24pm



CIRCULAR FAILURE - STATIC



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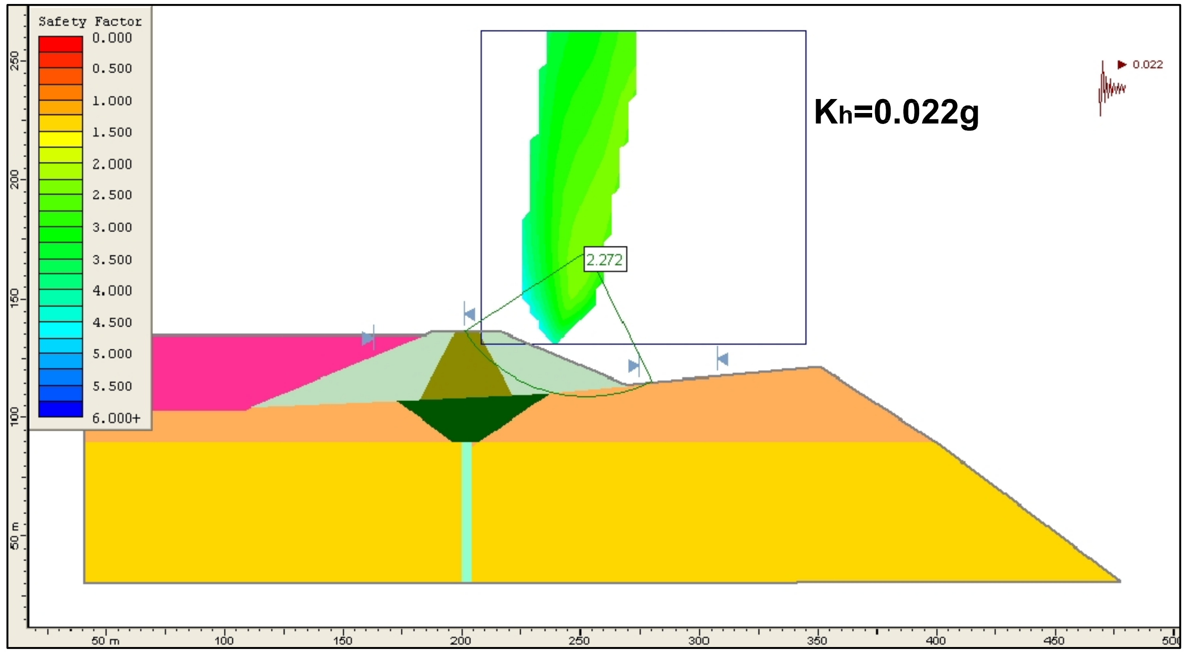
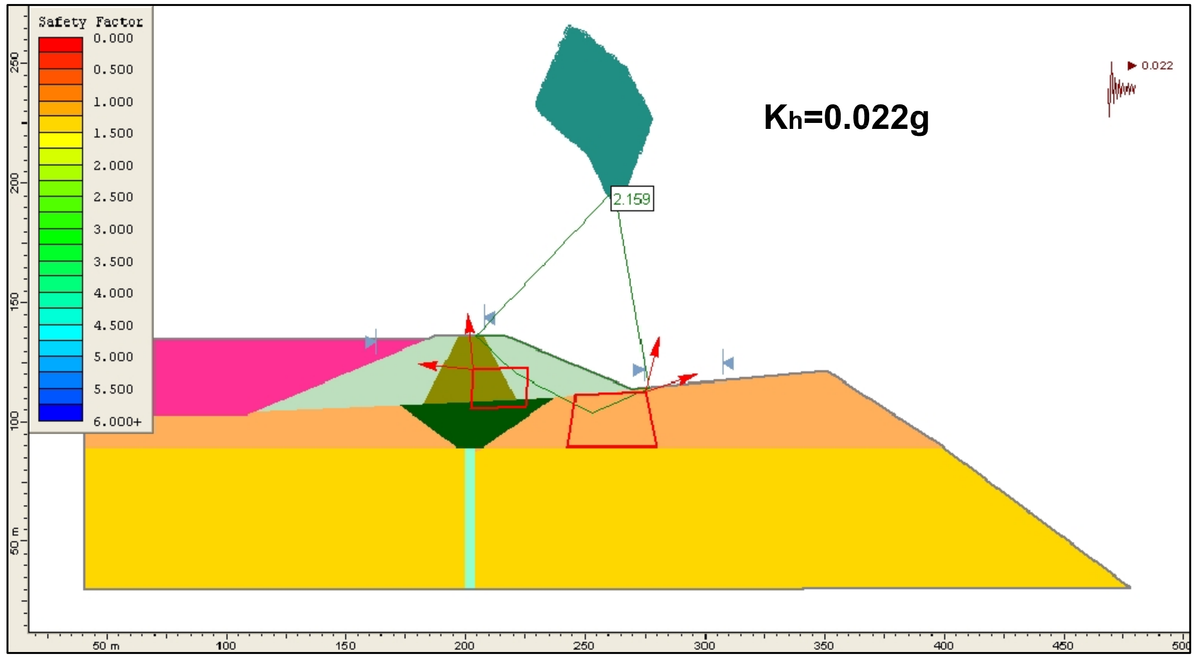


CIRCULAR FAILURE - PSEUDO STATIC



BLOCK FAILURE - PSEUDO STATIC

MATERIAL PROPERTIES

MATERIAL TYPE	Ø'
TILL CORE	28
ROCKFILL	40
TILL CUT OFF	28
FOUNDATION TILL	28
BEDROCK	INFINITE STRENGTH

NOTES

1) Cohesion assumed to be equal to zero for all materials in drained conditions.
2) All values of Ø' in degrees.
3) K_h = 0.022g corresponds to 1:975 YEAR SEISMIC EVENT
4) Analyses done using limit equilibrium Slope Stability Software Slide^{TM}.

PROJECT

CUMBERLAND RESOURCES LTD.

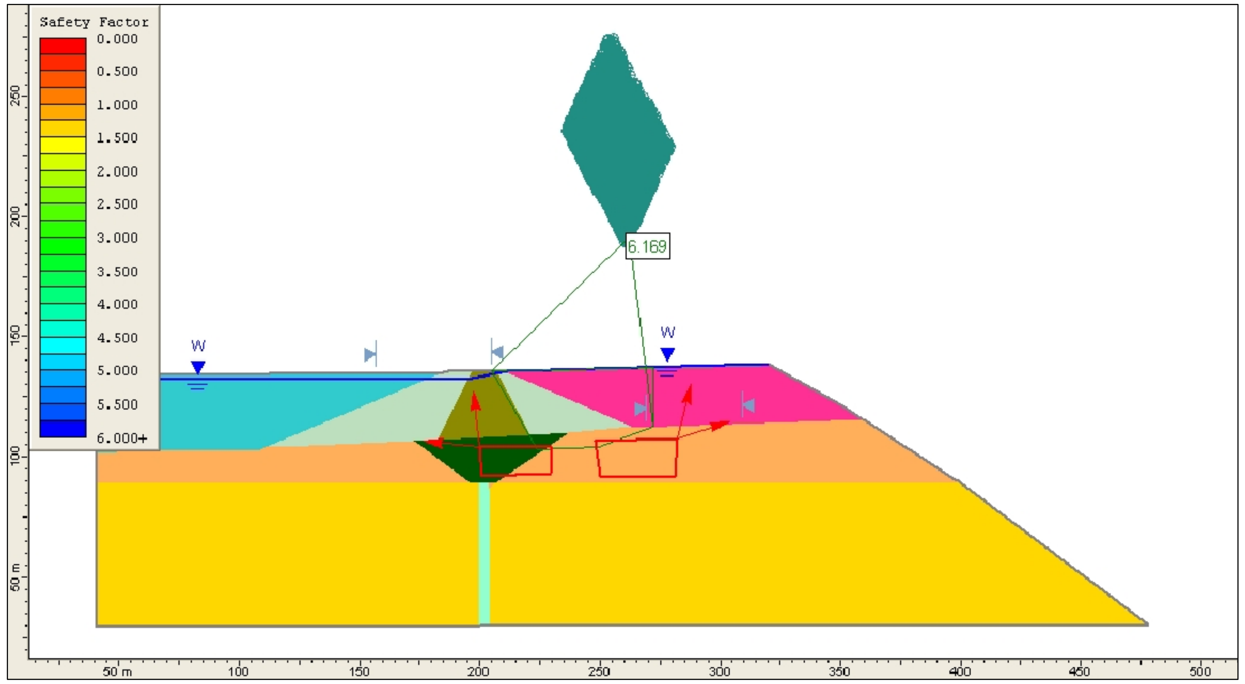
TITLE

TAILINGS DIKE STABILITY AT END OF TAILINGS DEPOSITION

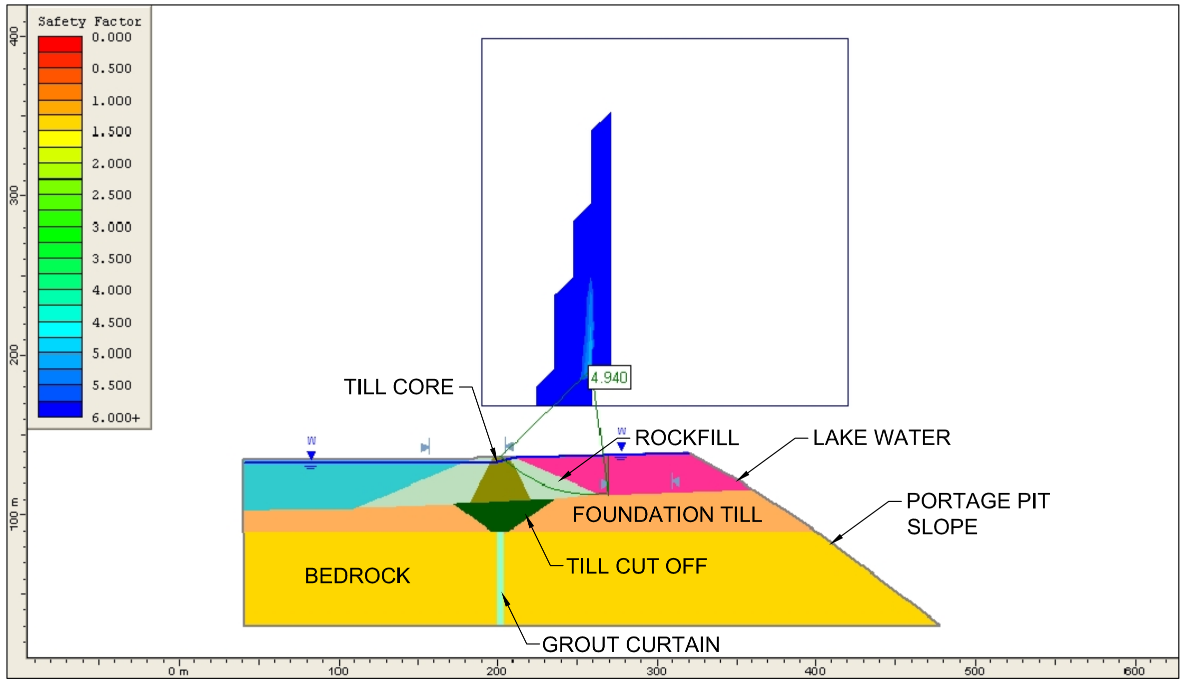
Golder Associates

PROJECT No. 03–1413–427			FILE No. 4274210SK03	
DESIGN	DAH	03NOV03	SCALE AS SHOWN	REV. 0
CADD	RCR	03DEC03	FIGURE II-3	
CHECK	DAH	03DEC03		
REVIEW				

REVISION DATE: 04/01/7 2:19pm By: rroque CADD FILE: N:\Bur–Graphics\Projects\2003\1413\03–1413–427\4210\Drafting\cad\4274210SK03.dwg



CIRCULAR FAILURE - STATIC



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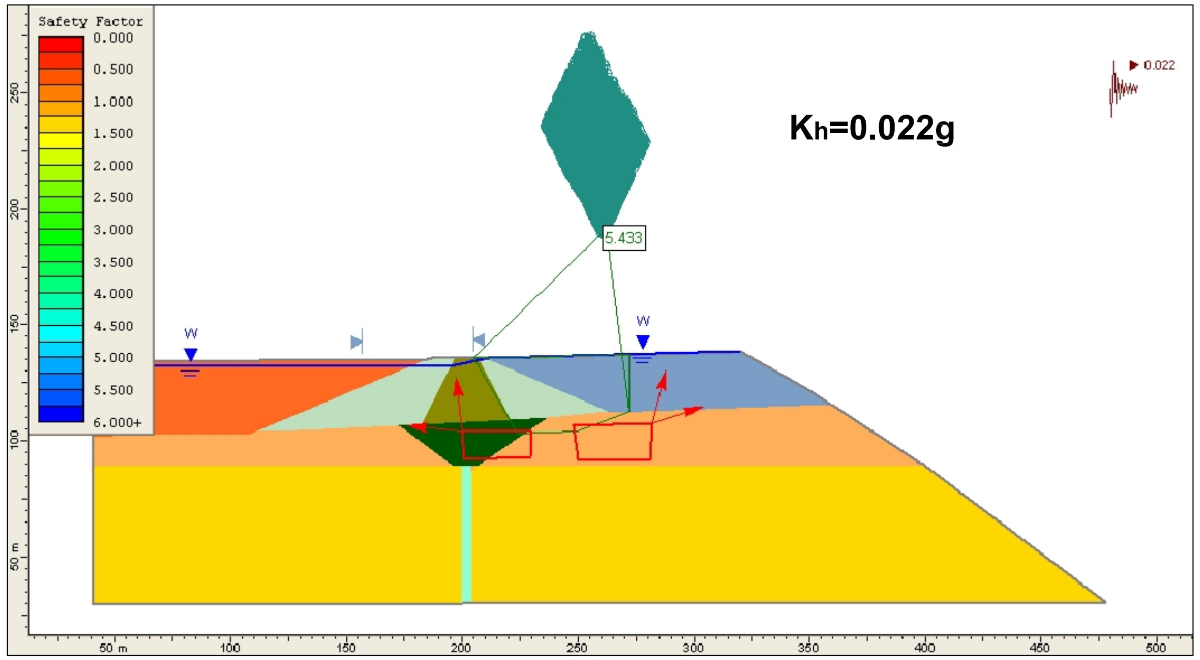
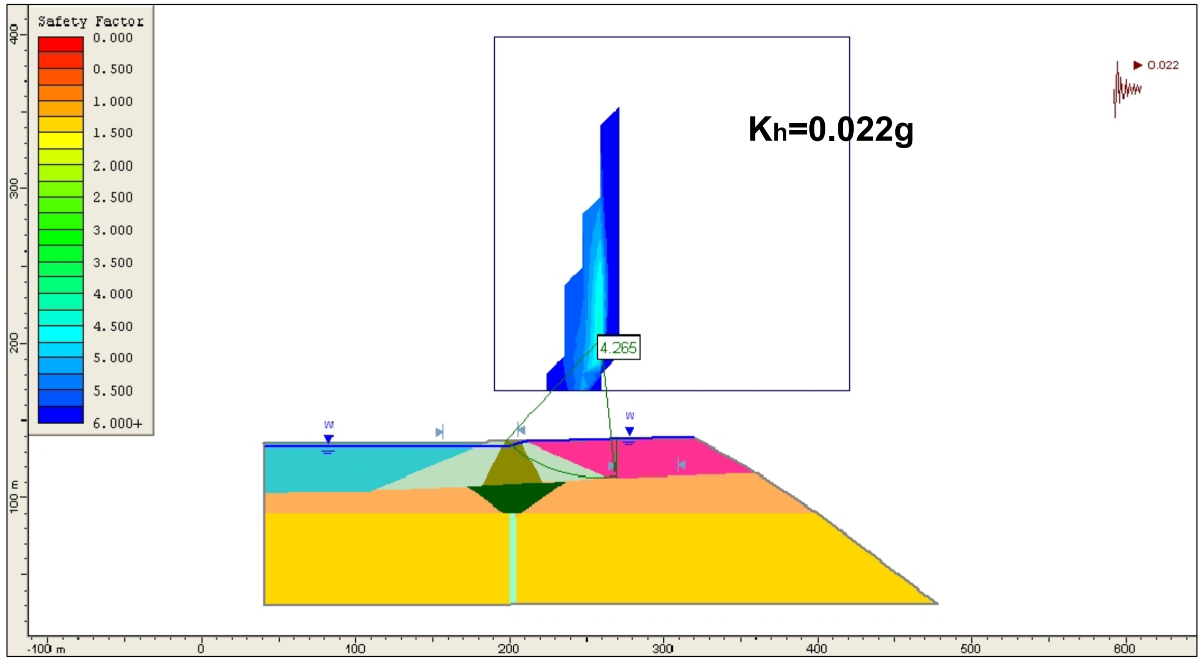


CIRCULAR FAILURE - PSEUDO STATIC



BLOCK FAILURE - PSEUDO STATIC

NOTES

1) Cohesion assumed to be equal to zero for all materials in drained conditions.
2) All values of Ø' in degrees.
3) K_h = 0.022g corresponds to 1:975 YEAR SEISMIC EVENT

MATERIAL PROPERTIES

MATERIAL TYPE	Ø'
TILL CORE	28
ROCKFILL	40
TILL CUT OFF	28
FOUNDATION TILL	28
BEDROCK	INFINITE STRENGTH

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

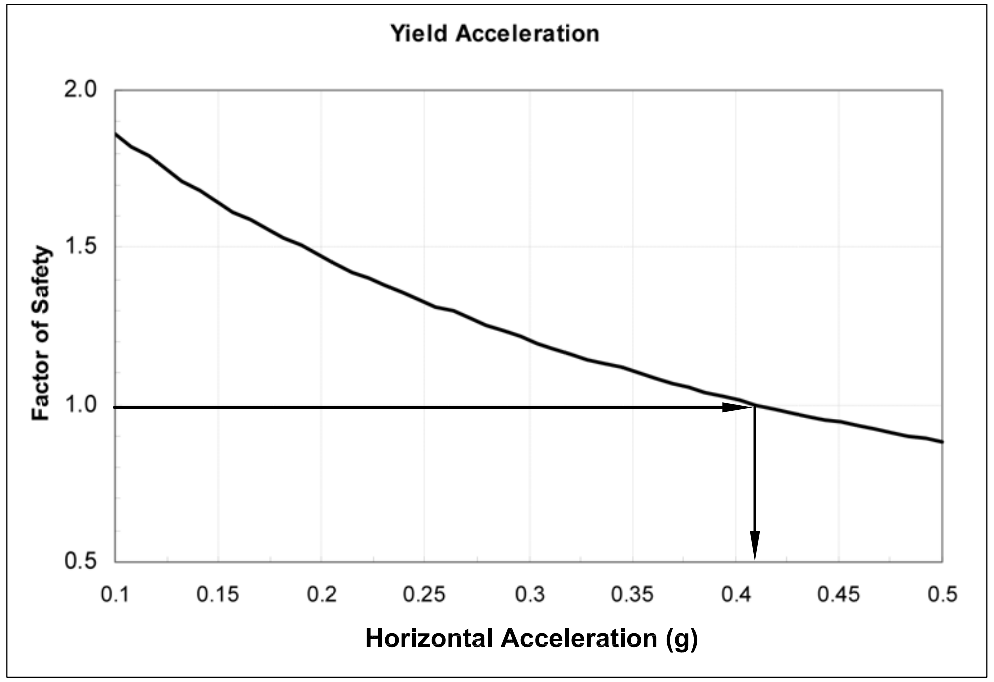
TAILINGS DIKE STABILITY AT CLOSURE

Golder Associates

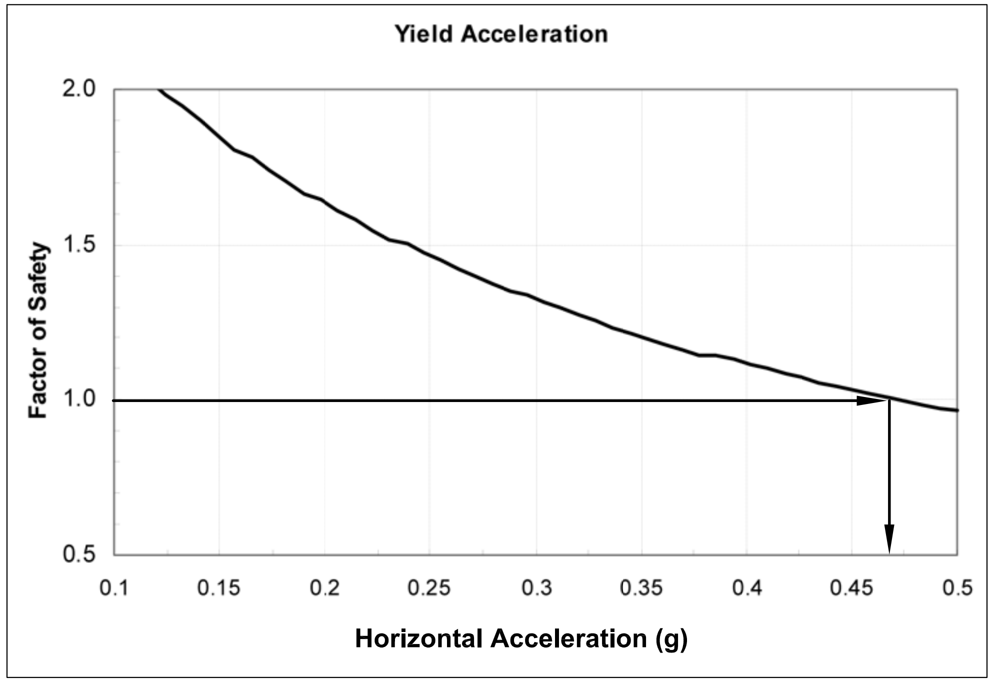
PROJECT No. 03-1413-427			FILE No. 4274210SK04	
DESIGN	DAH	03NOV03	SCALE AS SHOWN	REV. 0
CADD	RCR	03DEC03	FIGURE II-4	
CHECK		03DEC03		
REVIEW		16FEB04		

REVISION DATE: 04/01/7 4:26pm By: rroque CADD FILE: N:\Bur-Graphics\Projects\2003\1413\03-1413-427\4210\Drafting\cad\4274210SK04.dwg

END OF DEPOSITION

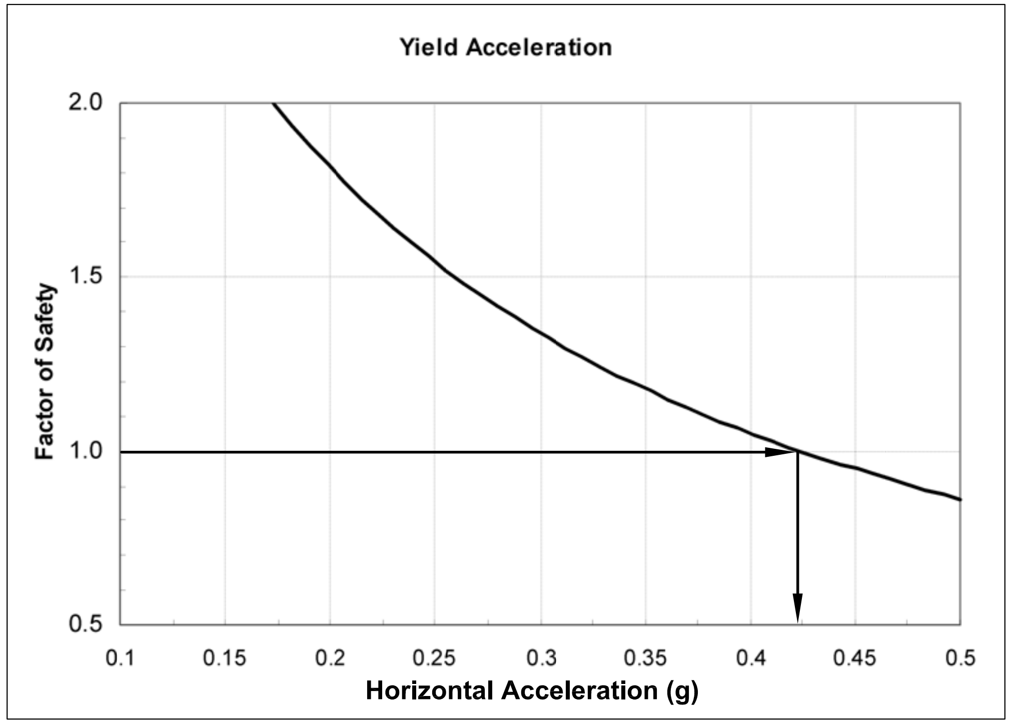


CIRCULAR FAILURES

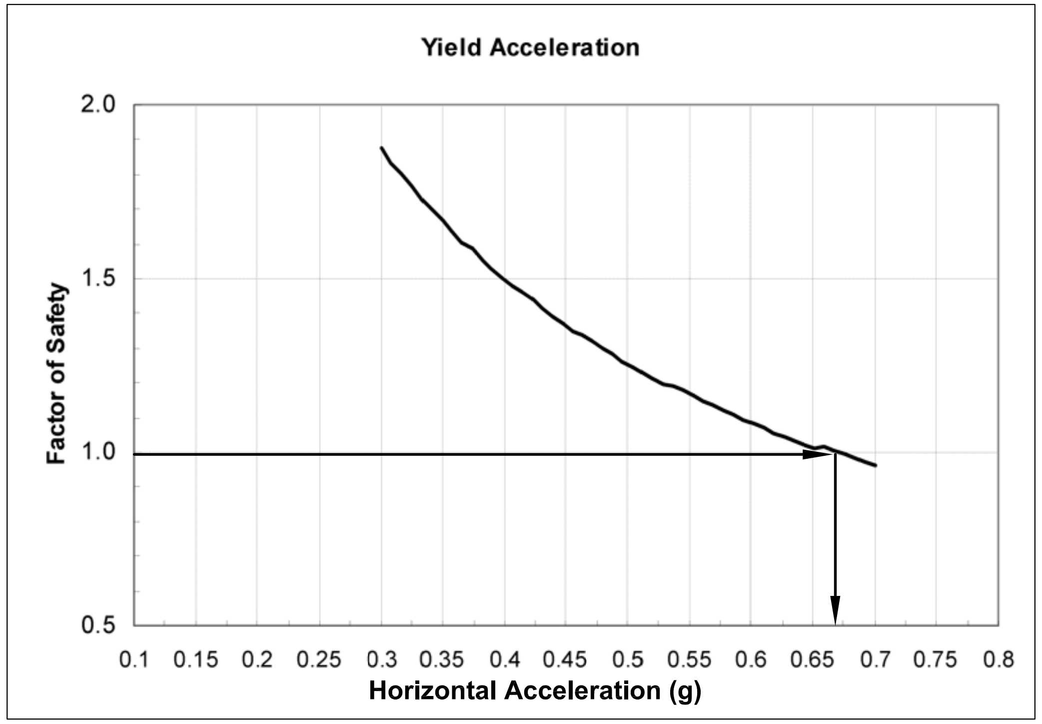


BLOCK FAILURES

CLOSURE



CIRCULAR FAILURES



BLOCK FAILURES

MATERIAL PROPERTIES	
MATERIAL TYPE	**Ø'**
TILL CORE	28
ROCKFILL	40
TILL CUT OFF	28
FOUNDATION TILL	28
BEDROCK	INFINITE STRENGTH

NOTES

1) Cohesion assumed to be equal to zero for all materials in drained conditions.
2) All values of Ø' in degrees.
3) Yield acceleration is peak horizontal ground acceleration corresponding to a factor-of-safety of 1.0.
4) Analyses done using Slide^{TM} software
5) Design PGA for Meadowbank = 0.022g.

PROJECT

CUMBERLAND
RESOURCES LTD.

TITLE

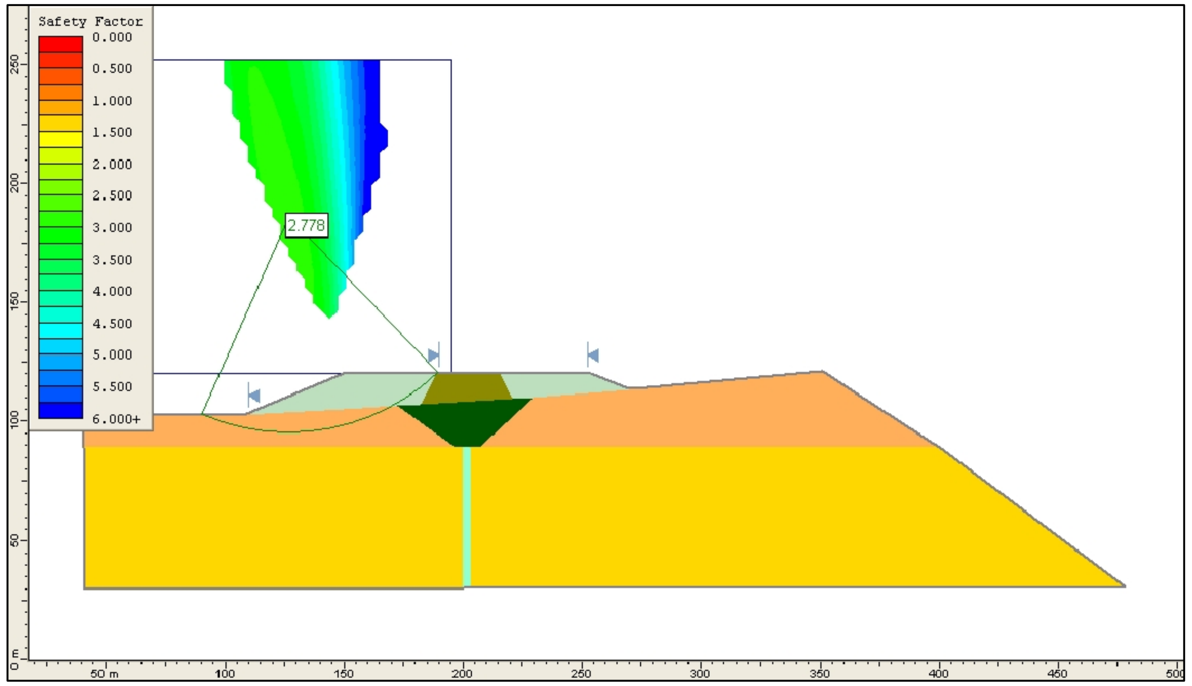
YIELD ACCELERATION AT END OF DEPOSITION AND AT CLOSURE

Golder Associates

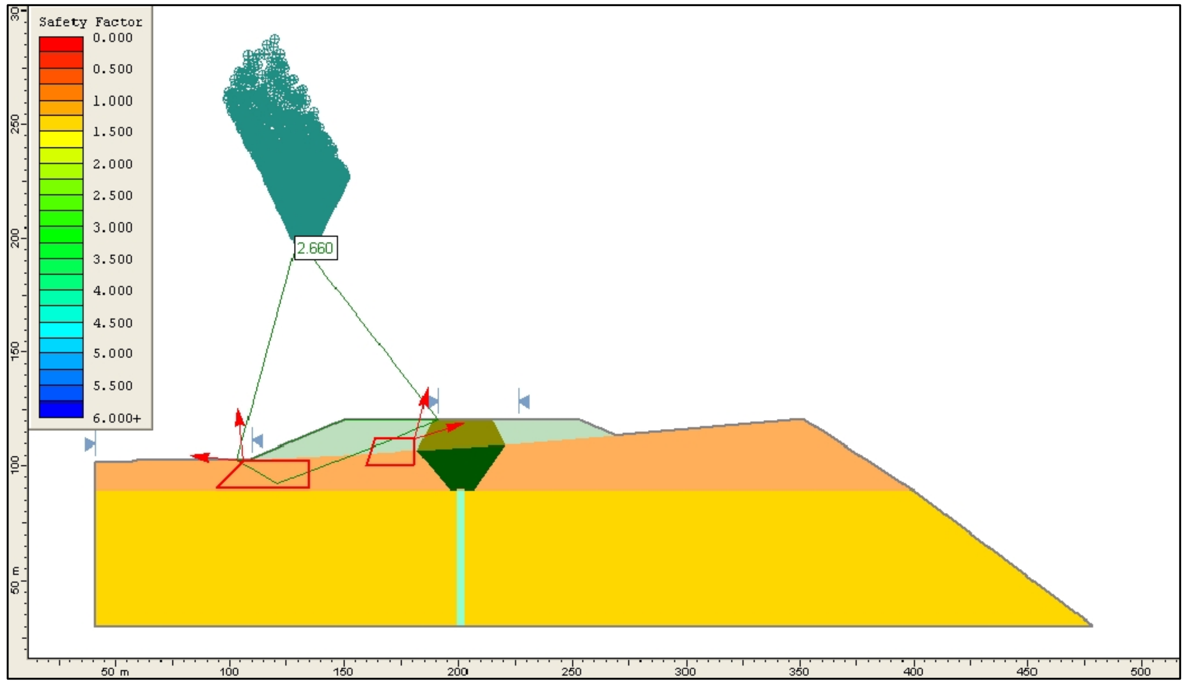
PROJECT No. 03–1413–427			FILE No. 4274210SK12	
DESIGN	DAH	07JAN04	SCALE AS SHOWN	REV. 0
CADD	RCR	07JAN04	**FIGURE II-5**	
CHECK	DAH	07JAN04		
REVIEW				

REVISION DATE: 04/01/8 2:16pm By: rroque CADD FILE: N:\Bur-Graphics\Projects\2003\1413\03-1413-427\4210\Drafting\cad\4274210SK12.dwg

DRAINED CONDITION FOR FOUNDATION TILL

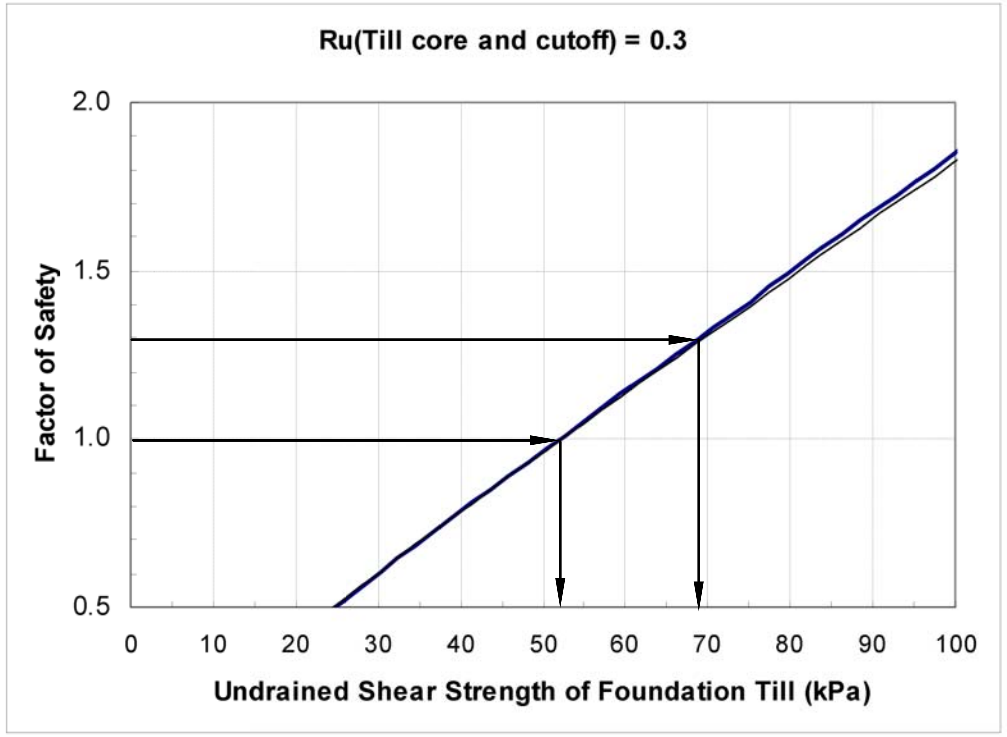


CIRCULAR FAILURE

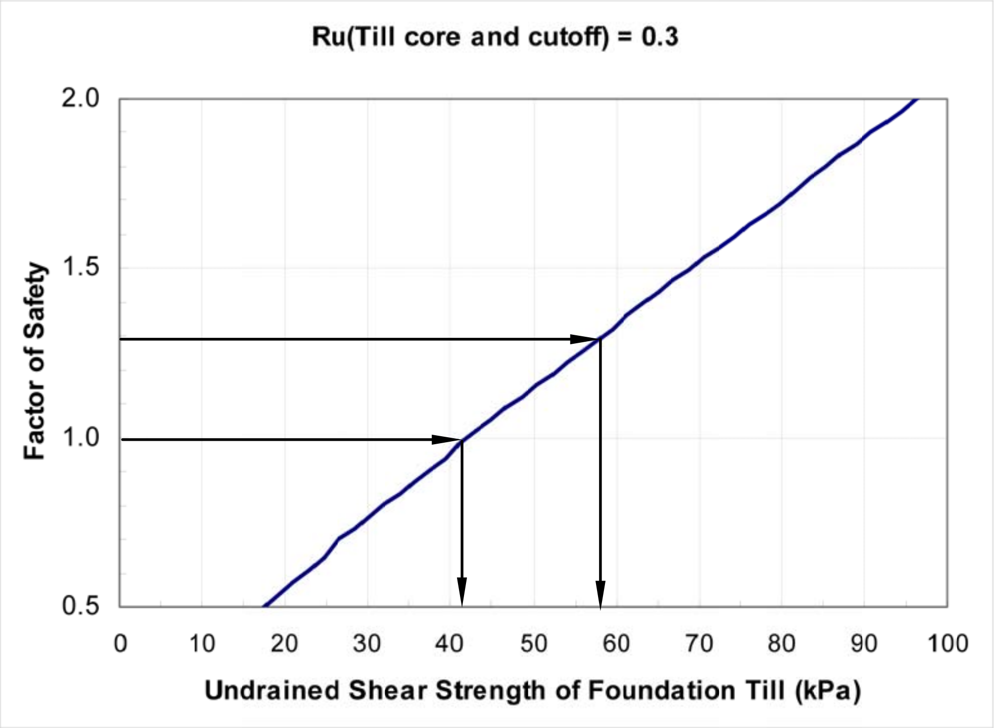


BLOCK FAILURE

UNDRAINED CONDITION FOR FOUNDATION TILL



CIRCULAR FAILURE



BLOCK FAILURE

MATERIAL PROPERTIES

MATERIAL TYPE	Ø'
TILL CORE	28
ROCKFILL	40
TILL CUT OFF	28
FOUNDATION TILL	28 - See Note 2
BEDROCK	INFINITE STRENGTH

NOTES

1) r_u for till core and cutoff assumed to be equal to 0.3.
2) For undrained case Ø=0 for foundation till.

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

CONSTRUCTION - INDUCED PORE WATER PRESSURES IN TILL CORE AND CUTOFF

Golder Associates

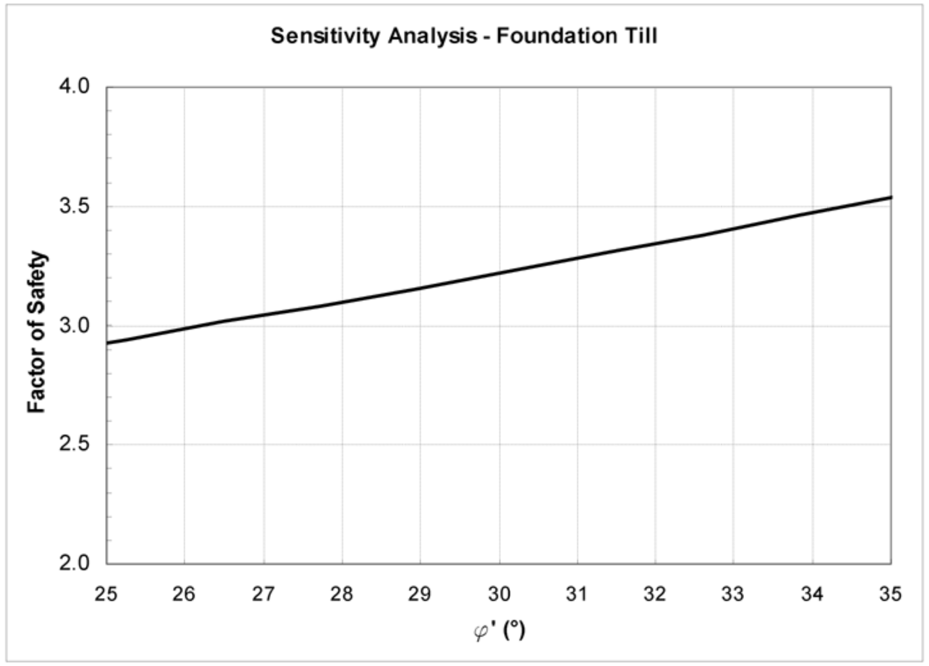
PROJECT No.	03–1413–427		FILE No.	4274210SK13
DESIGN	DAH	07JAN04	SCALE AS SHOWN	REV. 0
CADD	RCR	07JAN04	FIGURE II-6	
CHECK	DAH	07JAN04		
REVIEW				

CADD FILE: N:\Bur-Graphics\Projects\2003\1413\03-1413-427\4210\Drafting\cad\4274210SK13.dwg

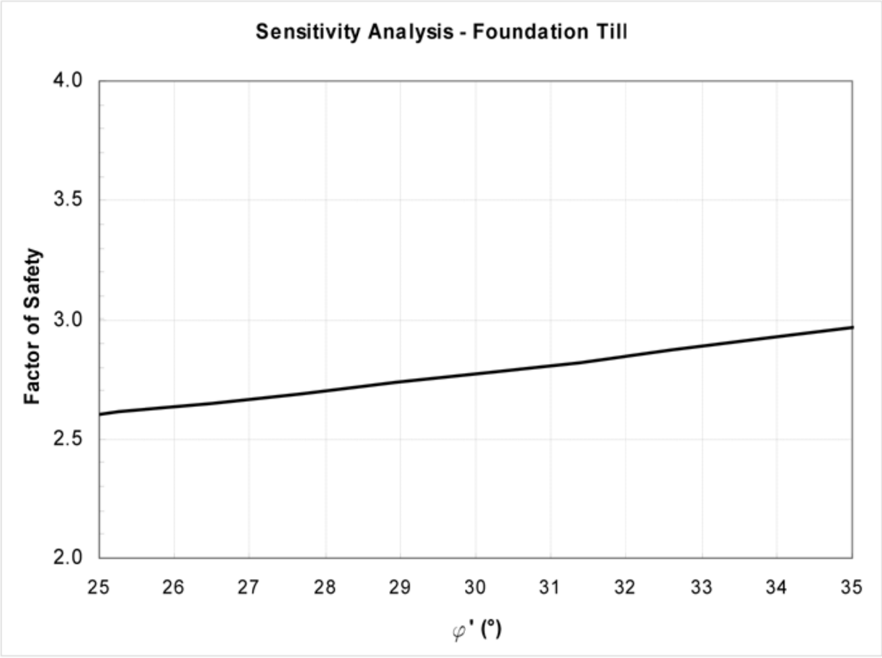
By: rroque

REVISION DATE: 04/01/8 2:22pm

HIGH WATER

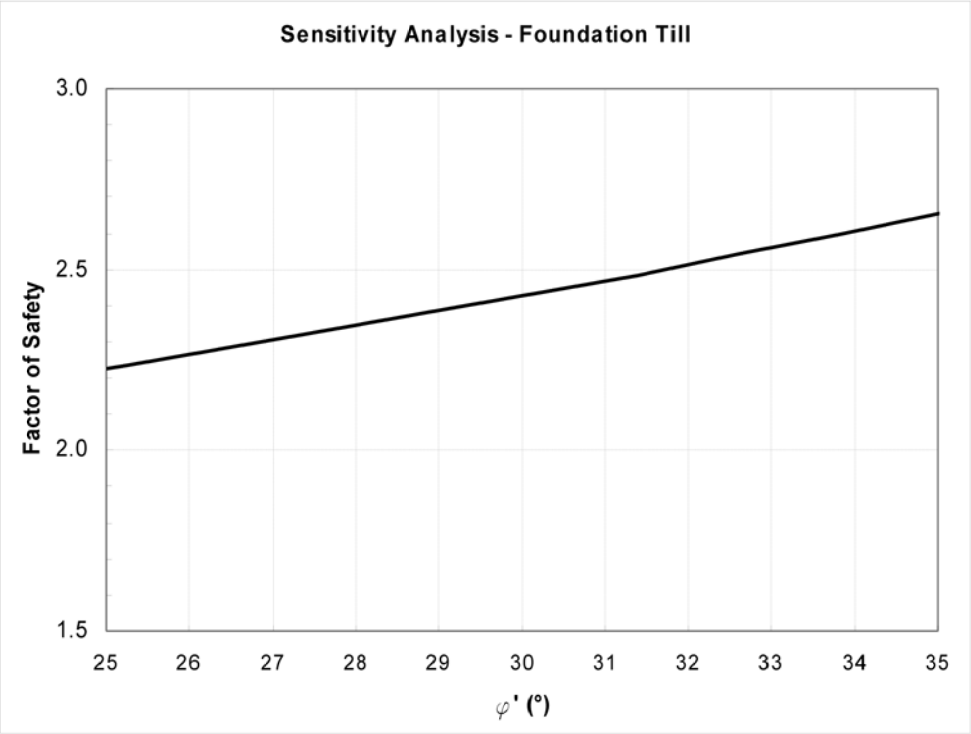


CIRCULAR

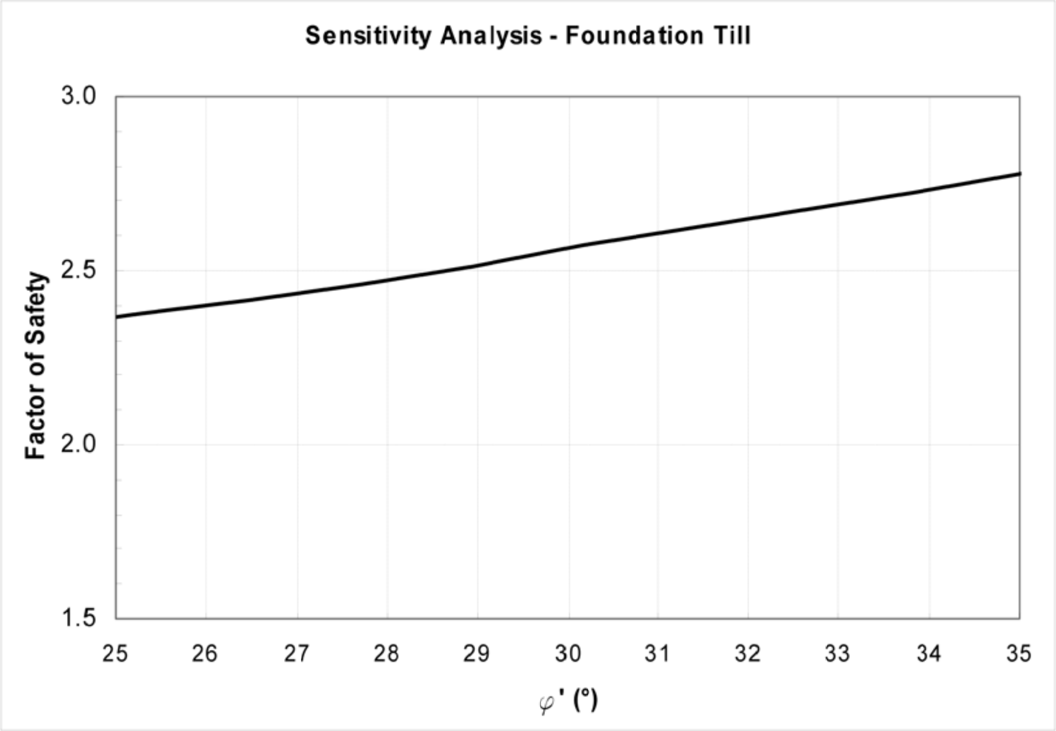


BLOCK

END OF DEPOSITION



CIRCULAR



BLOCK

MATERIAL PROPERTIES

MATERIAL TYPE	Ø'
TILL CORE	28
ROCKFILL	40
TILL CUT OFF	28
FOUNDATION TILL	28
BEDROCK	INFINITE STRENGTH

NOTES

1) r_u for till core and cutoff assumed to be equal to 0.3.
2) For undrained case Ø=0 for foundation till.

PROJECT

CUMBERLAND RESOURCES LTD.

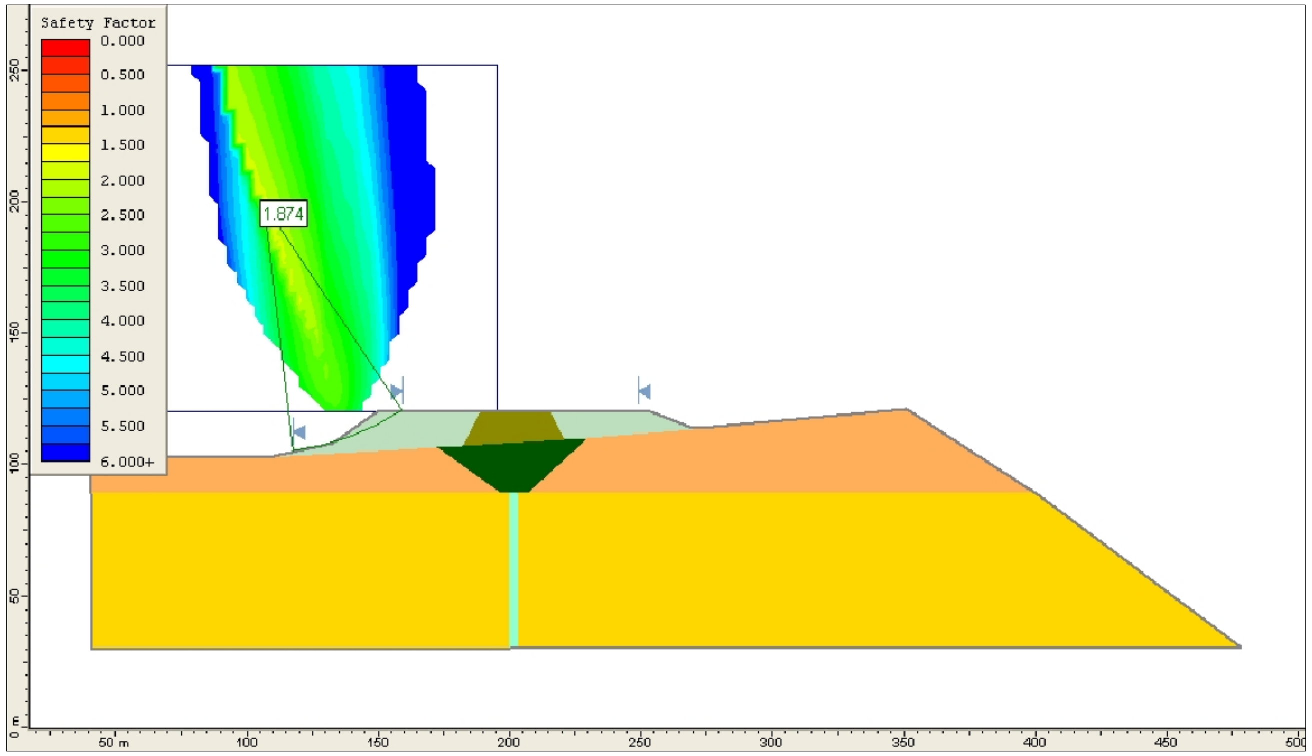
TITLE

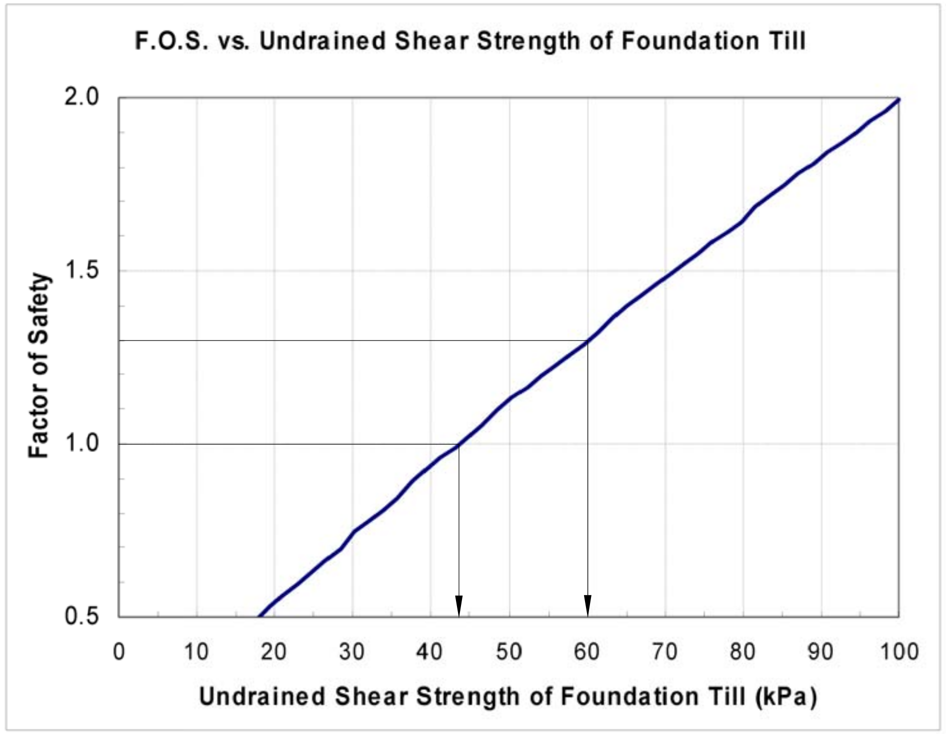
SENSITIVITY ANALYSIS - FRICTION ANGLE OF FOUNDATION TILL

Golder Associates

PROJECT No.	03-1413-427		FILE No.	4274210SK14
DESIGN	DAH	07JAN04	SCALE AS SHOWN	REV. 0
CADD	RCR	07JAN04	**FIGURE II-7**	
CHECK		07JAN04		
REVIEW		14FEB04		

REVISION DATE: 04/01/8 3:22pm By: rroque CADD FILE: N:\Bur-Graphics\Projects\2003\1413\03-1413-427\4210\Drafting\cad\4274210SK14.dwg





MATERIAL PROPERTIES	
MATERIAL TYPE	**Ø'**
TILL CORE	28
ROCKFILL	40
TILL CUT OFF	28
FOUNDATION TILL	28
BEDROCK	INFINITE STRENGTH

NOTES

1) r_u for till core and cutoff assumed to be equal to 0.3.

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

PROGRESSIVE SLOPE FAILURE AT END OF STAGE 1 CONSTRUCTION

Golder Associates

PROJECT No. 03–1413–427			FILE No. 4274210SK15	
DESIGN	DAH	07JAN04	SCALE AS SHOWN	REV. 0
CADD	RCR	07JAN04	**FIGURE II-8**	
CHECK	DAH	07JAN04		
REVIEW				

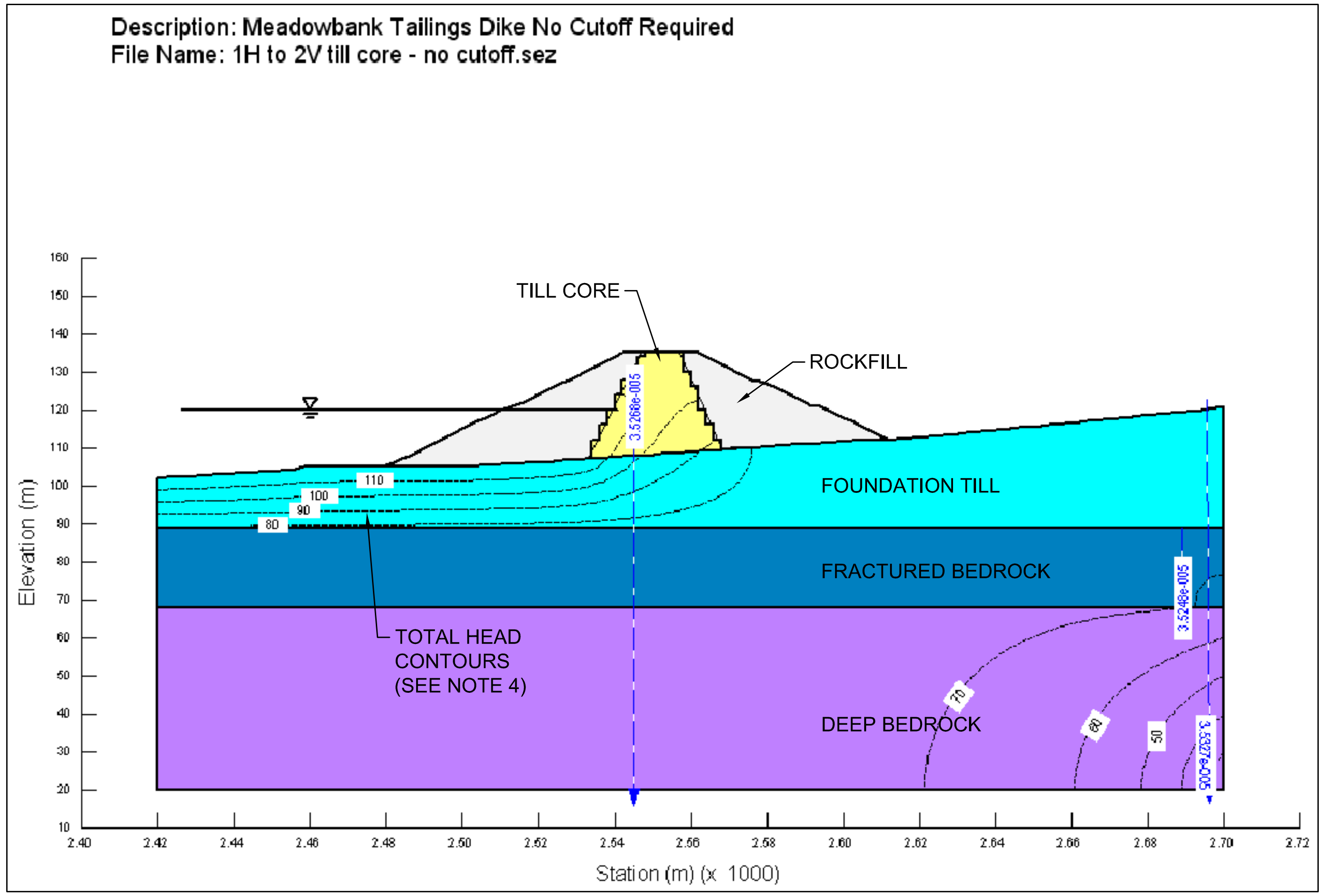
REVISION DATE: 04/01/8 3:35pm By: rroque CADD FILE: N:\Bur–Graphics\Projects\2003\1413\03–1413–427\4210\Drafting\cad\4274210SK15.dwg

APPENDIX III

SEEPAGE ANALYSES

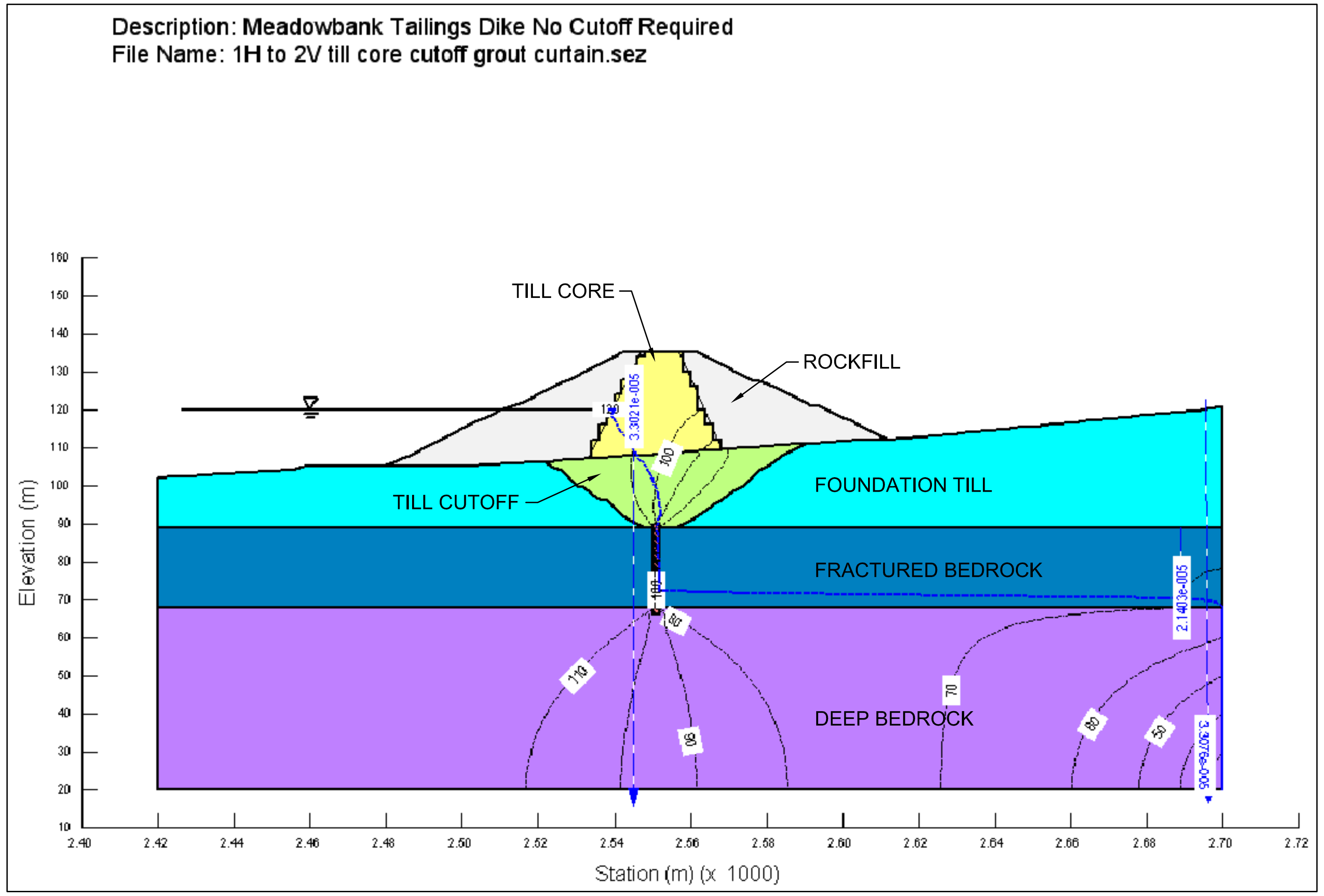
REVISION DATE: 04/01/7 1:08pm By: rroque CADD FILE: N:\Bur-Graphics\Projects\2003\1413\03-1413-427\4210\Drafting\cad\4274210SK07.dwg

ALTERNATIVE DESIGN CASE - HIGH WATER


Description: Meadowbank Tailings Dike No Cutoff Required
File Name: 1H to 2V till core - no cutoff.sez

FLUX TO PORTAGE PIT = 3.5x$10^{-5}$$m^3$/s/m

BASE CASE DESIGN - HIGH WATER


Description: Meadowbank Tailings Dike No Cutoff Required
File Name: 1H to 2V till core cutoff grout curtain.sez

FLUX TO PORTAGE PIT = 3.3x$10^{-5}$$m^3$/s/m

LEGEND

MATERIAL PROPERTIES

MATERIAL TYPE	SATURATED (k x 10^{-6} m/s)	
	BASECASE	ALTERNATIVE
TILL CORE	0.1	
ROCKFILL	NOT INCLUDED IN ANALYSES - SEE NOTE 1	
TILL CUT OFF	0.1	
FOUNDATION TILL	100	0.1
FRACTURED BEDROCK	40	
DEEP BEDROCK	0.001	
GROUT CURTAIN	0.05	

NOTES

1) Rockfill permeability will be very high relative to other materials, therfore not relevant to seepage analysis.
2) Analyses are for unfrozen conditions.
3) Analyses done using Seep/W™ software.
4) Total head displayed in metres above sea level.

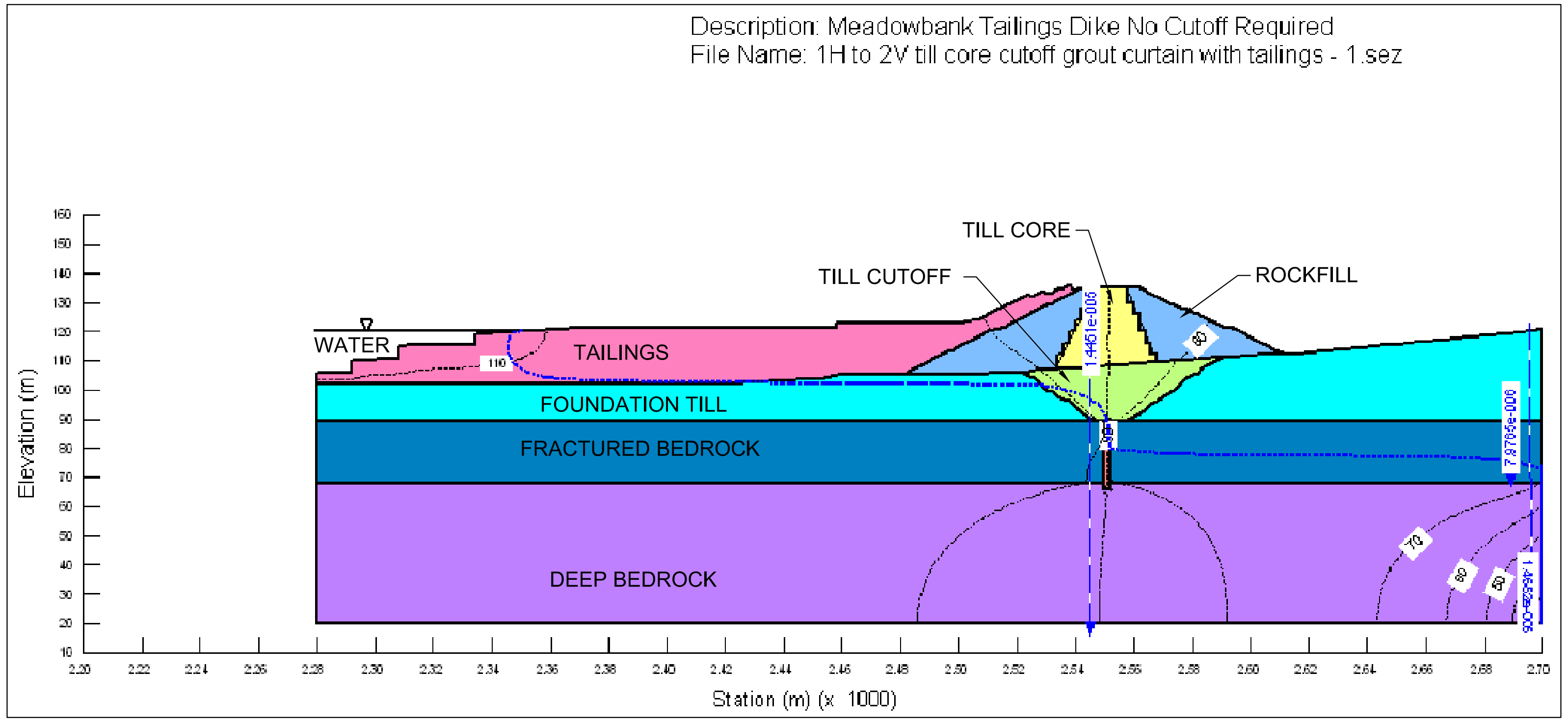
PROJECT
CUMBERLAND RESOURCES LTD.

TITLE
TAILINGS DIKE
SEEPAGE ANALYSES - 1 OF 3

Golder Associates

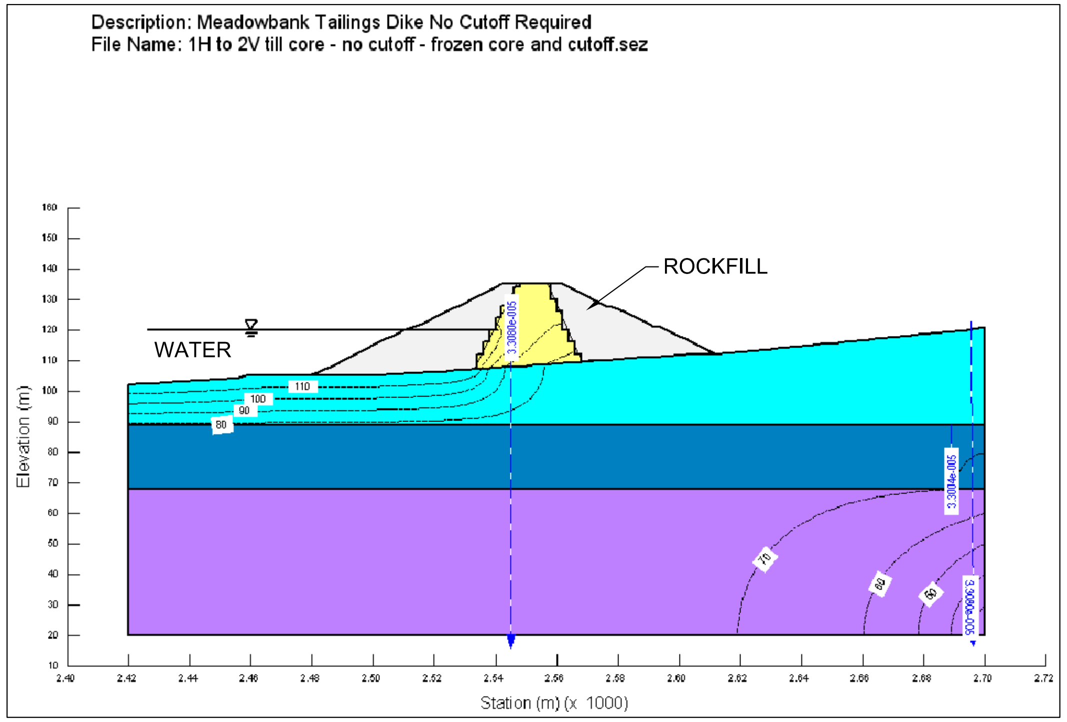
PROJECT No.	03-1413-427		FILE No. 4274210SK07	
DESIGN	DAH	03DEC03	SCALE AS SHOWN	REV. 0
CADD	RCR	03DEC03	FIGURE III-1	
CHECK	DAH	11FEB04		
REVIEW				

BASE CASE - TAILINGS BEACH 100m UPSTREAM OF DIKE



FLUX TO PORTAGE PIT = 1.5x10^{-5}m^3/s/m

ALTERNATIVE DESIGN CASE - FROZEN CORE AND CUTOFF



FLUX TO PORTAGE PIT = 3.3x10^{-5}m^3/s/m

LEGEND

MATERIAL PROPERTIES		
MATERIAL TYPE	**SATURATED** (k x 10^{-6} m/s)	
	BASECASE	**ALTERNATIVE**
TILL CORE	0.1/0.0001 (see Note 1)	
ROCKFILL	10,000	
TILL CUT OFF	0.1/0.0001 (see Note 1)	
FOUNDATION TILL	100	0.1
FRACTURED BEDROCK	40	
DEEP BEDROCK	0.001	
GROUT CURTAIN	0.05	
TAILINGS	0.1	

NOTES

1) Lower permeability for till core and cutoff is for frozen conditions.
2) Analyses done using Seep/W^{TM} software.
3) Total head displayed in metres above sea level.

PROJECT

CUMBERLAND
RESOURCES LTD.

TITLE

TAILINGS DIKE
SEEPAGE ANALYSES - 2 OF 3

Golder Associates

PROJECT No. 03–1413–427		
DESIGN	DAH	08JAN04
CADD	RCR	08JAN04
CHECK		13FEB04
REVIEW		16FEB04

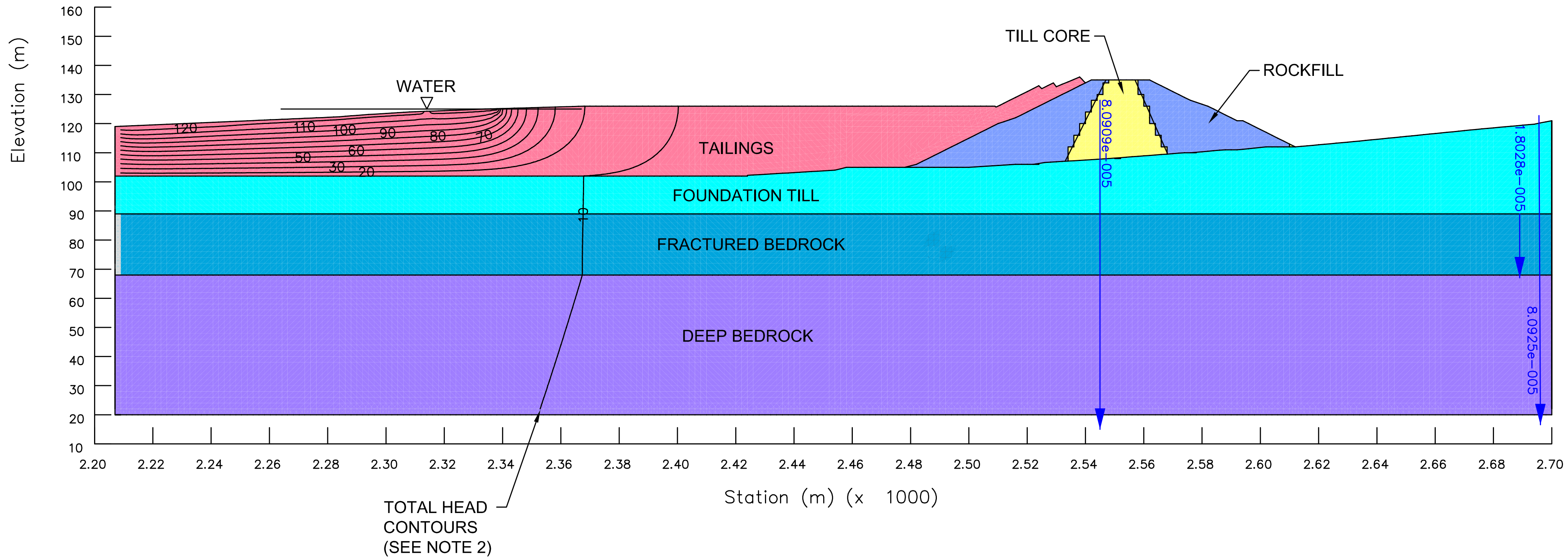
FILE No. 4274210SK11
SCALE AS SHOWN
REV. 0

FIGURE III-2

REVISION DATE: 04/01/7 12:06pm By: rroque CADD FILE: N:\Bur–Graphics\Projects\2003\1413\03–1413–427\4210\Drafting\cad\4274210SK11.dwg

TAILINGS SEEPAGE BLANKET

Description: Meadowbank Tailings Dike No Cutoff Required
File Name: Year 3 Pond at 125, tails at 123.dxf



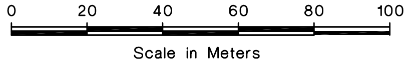
FLUX TO PORTAGE PIT = $9.0 \times 10^{-5} m^3/s/m$

LEGEND

MATERIAL PROPERTIES	
MATERIAL TYPE	**SATURATED** (k x 10^{-6} m/s)
TILL CORE	0.1
ROCKFILL	10,000
FOUNDATION TILL	100
FRACTURED BEDROCK	40
DEEP BEDROCK	0.001
TAILINGS	0.1

NOTES

1) Analyses done using Seep/W ™ software.
2) Total head displayed in metres above sea level.
3) Analyses are for unfrozen conditions.



PROJECT

CUMBERLAND
RESOURCES LTD.

TITLE

TAILINGS DIKE
SEEPAGE ANALYSES - 3 OF 3

Golder Associates

PROJECT No.	03-1413-427	
DESIGN	DAH	11FEB04
CADD	SRR	11FEB04
CHECK	DAH	11FEB04
REVIEW		

FILE No. 4274210SK19
SCALE AS SHOWN REV. 0

FIGURE III-3

CADD FILE: N:\Bur-Graphics\Projects\2003\1413\03-1413-427\4210\Drafting\cad\4274210SK19.dwg

REVISION DATE: 04/02/12 10:21am By: sreddy

APPENDIX IV

MATERIALS BALANCE

Figure 2-1
Meadowbank Mined Tonnages and Volumes

Year			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
TONNES		Assumptions	-2	-1	1	2	3	4	5	6	7	8	9	10	11	
Mined Ore Open Pit				553,539.88	1,453,960.46	2,007,500.34	2,007,500.34	2,007,500.34	2,007,500.34	2,007,500.34	2,007,500.34	2,007,500.34	2,007,500.34	1,589,509.95	110,868.84	19,767,881.86
Grade				7.07	5.13	4.22	3.93	4.07	4.43	3.84	4.02	3.49	4.04	6.36	6.36	4.38
Recovery	t		-	0.95	0.95	0.95	0.95	0.94	0.94	0.94	0.94	0.93	0.92	0.92	0.92	
Tailings Produced	**t**		-	553,536.16	1,453,953.38	2,007,492.29	2,007,492.85	2,007,492.68	2,007,492.00	2,007,493.14	2,007,492.79	2,007,493.82	2,007,492.89	1,589,500.67	110,868.19	19,767,800.86
Portage Pit																
Overburden	t		-	915,145	1,181,899	344,052	1,415,052	858,362	0	1,028,930	151,364	0	0	0	0	5,894,804
UM	t		-	161,424	870,165	2,047,706	2,606,760	4,030,192	2,756,831	2,869,373	4,230,059	2,320,748	2,422,948	680,212	53,835	25,050,256
IF	t		-	1,350,376	3,505,432	3,766,198	4,674,081	3,716,710	3,329,997	2,872,252	2,808,018	1,860,802	1,610,966	905,506	312,928	30,713,265
IV	t		-	1,749,376	3,096,487	3,468,825	3,693,520	3,131,945	2,601,659	2,692,840	1,744,856	608,850	426,829	127,400	45,150	23,387,736
QZ	t		-	1,013	138,407	161,194	541,603	125,157	186,388	16,364	0	0	0	0	0	1,170,126
Total	t		0	4,177,333	8,792,390	9,787,975	12,931,016	11,862,366	8,874,875	9,479,759	8,934,298	4,790,400	4,460,743	1,713,119	411,913	86,216,187
Goose Island Pit																
Overburden	t		-	0	0	0	0	0	0	1,028,930	151,364	0	0	0	0	1,180,294
UM	t		-	0	0	0	0	0	0	494,268	2,632,476	3,196,324	2,391,415	812,413	0	9,526,897
IF	t		-	0	0	0	0	0	0	354,271	466,229	453,435	626,081	663,942	0	2,563,958
IV	t		-	0	0	0	0	0	0	572,477	943,310	1,068,105	815,196	232,219	0	3,631,307
QZ	t		-	0	0	0	0	0	0	133,913	484,366	143,185	0	0	0	761,463
Total	t		0	0	0	0	0	0	0	2,583,859	4,677,745	4,861,049	3,832,692	1,708,575	0	17,663,920
Vault Pit																
Overburden	t		-	0	0	0	0	0	0	0	0	0	0	0	0	0
UM	t		-	0	0	0	0	0	0	0	0	0	0	0	0	0
IF	t		-	0	0											0
IV	t		-	0	5,870,425	6,719,315	3,547,203	4,815,741	7,336,539	6,864,792	4,495,692	6,765,350	4,826,036	2,298,941		53,540,034
QZ	t		-	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	t		-	0	5,870,425	6,719,315	3,547,203	4,815,741	7,336,539	6,864,792	4,495,692	6,765,350	4,826,036	2,298,941	0	53,540,034
ALL PITS																
Overburden	t		-	915,145	1,181,899	344,052	1,415,052	858,362	0	2,057,860	302,728	0	0	0	0	7,075,099
UM	t		-	161,424	870,165	2,047,706	2,606,760	4,030,192	2,756,831	3,363,641	6,862,535	5,517,072	4,814,364	1,492,626	53,835	34,577,153
IF	t		-	1,350,376	3,505,432	3,766,198	4,674,081	3,716,710	3,329,997	3,226,523	3,274,247	2,314,237	2,237,047	1,569,448	312,928	33,277,223
IV	t		-	1,749,376	8,966,911	10,188,140	7,240,723	7,947,686	9,938,197	10,130,110	7,183,858	8,442,305	6,068,060	2,658,560	45,150	80,559,077
QZ	t		-	1,013	138,407	161,194	541,603	125,157	186,388	150,277	484,366	143,185	0	0	0	1,931,590
Total Pit	t		-	4,177,333	14,662,815	16,507,291	16,478,219	16,678,107	16,211,414	18,928,411	18,107,735	16,416,799	13,119,471	5,720,635	411,913	157,008,229
VOLUMES																
Portage and Goose Pits																
Construction Rock Required																
Overburden	**m3**		-	-	-	-	-	-	-	-	-	-	-	-	-	
UM+QZ	**m3**		-	89,380	-	-	-	-	29,483	-	-	-	-	-	-	118,864
IF	**m3**		-	-	-	-	-	-	-	-	-	-	-	-	-	-
IV	**m3**		-	301,632	-	-	-	-	-	-	-	-	-	-	-	301,632
Dike Rock Required																
Overburden	**m3**		-	323,101	62,728	62,728	62,728	62,728	331,728	62,728	62,728	62,728	62,728	-	-	1,156,652
UM+QZ	**m3**		-	-	19,138	-	-	-	11,082	-	-	-	-	-	-	30,220
IF	**m3**		-	375,132	-	-	-	-	426,000	-	-	-	-	-	-	801,132
IV	**m3**		-	400,223	62,728	62,728	62,728	62,728	488,728	62,728	62,728	62,728	62,728	-	-	1,390,774
Capping Volume Required																
UM+QZ	**m3**		-	-	236,364	676,364	676,364	676,364	676,364	676,364	676,364	676,364	676,364	676,364	2,576,364	8,900,000
Portage Waste Rock Dump		1.90 t/m3														
Overburden	**m3**		-	158,554	559,324	118,352	682,036	389,042	- 331,728	1,020,356	96,603	- 62,728	- 62,728	-	-	2,567,084
Overburden Cumulative	**m3**		-	158,554	717,878	836,230	1,518,267	1,907,308	1,575,581	2,595,937	2,692,540	2,629,812	2,567,084	2,567,084	2,567,084	2,567,084
UM+QZ			-	- 3,887	275,326	486,216	980,670	1,510,662	832,134	1,173,067	3,190,426	2,302,719	1,857,512	109,229	- 2,548,029	10,166,044
UM+QZ Cumulative	**m3**		-	- 3,887	271,438	757,654	1,738,323	3,248,986	4,081,120	5,254,187	8,444,613	10,747,332	12,604,844	12,714,073	10,166,044	10,166,044
IF	**m3**		-	335,592	1,844,964	1,982,209	2,460,043	1,956,163	1,326,630	1,698,170	1,723,288	1,218,019	1,177,393	826,025	164,699	16,713,196
IV	**m3**		-	218,869	1,567,002	1,762,969	1,881,230	1,585,664	880,566	1,655,860	1,352,096	819,880	590,969	189,273	23,763	12,528,143
Net Waste Rock	**m3**			709,128	4,246,616	4,349,747	6,003,978	5,441,531	2,707,602	5,547,454	6,362,414	4,277,891	3,563,147	1,124,528	- 2,359,568	41,974,467
Cumulative Waste Rock	**m3**		-	709,128	4,955,744	9,305,490	15,309,469	20,751,000	23,458,602	29,006,056	35,368,470	39,646,360	43,209,507	44,334,034	41,974,467	41,974,467
Vault Pit																
Construction and Dike Rock Required																
Overburden	**m3**		-	14,557	-	-	-	-	-	-	-	-	-	-	-	14,557
IV	**m3**		-	41,152	-	-	-	-	-	-	-	-	-	-	-	41,152
Vault Pit Dump																
Overburden	**m3**	1.90 t/m3	-	- 14,557	-	-	-	-	-	-	-	-	-	-	-	- 14,557
IV	**m3**		-	- 41,152	3,089,697	3,536,482	1,866,949	2,534,600	3,861,336	3,613,048	2,366,153	3,560,710	2,540,019	1,209,969	-	28,137,813
Net Waste Rock	**m3**		-	- 55,709	3,089,697	3,536,482	1,866,949	2,534,600	3,861,336	3,613,048	2,366,153	3,560,710	2,540,019	1,209,969	-	28,123,256
Cumulative Waste Rock	**m3**		-	- 55,709	3,033,988	6,570,470	8,437,419	10,972,020	14,833,356	18,446,405	20,812,558	24,373,268	26,913,287	28,123,256	28,123,256	28,123,256
Tailings Produced	**m3**	1.45 t/m3	0	381,749	1,002,726	1,384,477	1,384,478	1,384,478	1,384,477	1,384,478	1,384,478	1,384,478	1,384,478	1,096,207	76,461	13,632,966
Cumulative Tailings	**m3**		0	381,749	1,384,476	2,768,953	4,153,431	5,537,909	6,922,386	8,306,864	9,691,342	11,075,820	12,460,298	13,556,505	13,632,966	13,632,966

APPENDIX V

SEISMIC RISK CALCULATION FOR MEADOWBANK SITE

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   NATURAL RESOURCES CANADA              RESSOURCES NATURELLES CANADA
   GEOLOGICAL SURVEY OF CANADA           COMMISSION GEOLOGIQUE DU CANADA

   SEISMIC RISK CALCULATION *            CALCUL DE RISQUE SEISMIQUE *

   REQUESTED BY/ DEMANDE PAR            Don Hickson, Golder Assoc., Vancouver

   SITE                                          Tenek Lake, Nunavut

   LOCATED AT/ SITUE AU            65.00 NORTH/NORD     96.05 WEST/OUEST

   PROBABILITY OF EXCEEDENCE    |
   PER ANNUM/ PROBABILITE DE    |
       DEPASSEMENT PAR ANNEE    | 0.010     0.005     0.0021    0.001
                                |
   PROBABILITY OF EXCEEDENCE    |
   IN 50 YEARS/ PROBABILITE     |
     DE DEPASSEMENT EN 50 ANS   |   40 %      22 %      10 %      5 %
  ------------------------------|-----------------------------------------
   PEAK HORIZONTAL GROUND       |
         ACCELERATION (G)       |
                                | 0.018     0.025     0.034     0.044
   ACCELERATION HORIZONTALE     |
        MAXIMALE DU SOL (G)     |
                                |
   PEAK HORIZONTAL GROUND       |
         VELOCITY (M/SEC)       |
                                | 0.011     0.017     0.029     0.039
   VITESSE HORIZONTALE          |
   MAXIMALE DU SOL (M/SEC)      |

   * REFERENCES
1. NEW PROBABILISTIC STRONG SEISMIC GROUND MOTION MAPS
   OF CANADA: A COMPILATION OF EARTHQUAKE SOURCE ZONES, METHODS AND RESULTS.
   P.W. BASHAM, D.H. WEICHERT, F.M. ANGLIN, AND M.J. BERRY
   EARTH PHYSICS BRANCH OPEN FILE NUMBER 82-33, OTTAWA, CANADA 1982.

2. ENGINEERING APPLICATIONS OF NEW PROBABILISTIC
   SEISMIC GROUND-MOTION MAPS OF CANADA.
   A.C. HEIDEBRECHT, P.W. BASHAM, J.H. RAINER, AND M.J. BERRY
   CANADIAN JOURNAL OF CIVIL ENGINEERING, VOL. 10, NO. 4, P. 670-680, 1983.

3. NEW PROBABILISTIC STRONG GROUND MOTION MAPS OF CANADA.
   P.W. BASHAM, D.H. WEICHERT, F.M. ANGLIN, AND M.J. BERRY,  BULLETIN OF
   THE SEISMOLOGICAL SOCIETY OF AMERICA, VOL. 75, NO. 2, P. 563-595, 1985.

4A.SUPPLEMENT TO THE NATIONAL BUILDING CODE OF CANADA 1990, NRCC NO. 30629.
   CHAPTER 1: CLIMATIC INFORMATION FOR BUILDING DESIGN IN CANADA.
   CHAPTER 4: COMMENTARY J: EFFECTS OF EARTHQUAKES.

4B.SUPPLEMENT DU CODE NATIONAL DU BATIMENT DU CANADA 1990, CNRC NO 30629F.
   CHAPITRE 1: DONNEES CLIMATIQUES POUR LE CALCUL DES BATIMENTS AU CANADA.
   CHAPITRE 4: COMMENTAIRE J: EFFETS DES SEISMES.
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Tenek Lake, Nunavut

         ZONING FOR ABOVE SITE/ ZONAGE DU SITE CI-DESSUS

         1990 NBCC/CNBC:  ZA = 0;  ZV = 0;  V = 0.00 M/S

     ACCELERATION ZONE/ ZONE D'ACCELERATION    ZA=0
     ZONAL ACCELERATION/ ACCELERATION ZONALE  0.00 G

     VELOCITY ZONE/ ZONE DE VITESSE            ZV=0
     ZONAL VELOCITY/ VITESSE ZONALE           0.00 M/S

                     1990 NBCC/CNBC **
      SEISMIC ZONING MAPS/ CARTES DU ZONAGE SEISMIQUE

              PROBABILITY LEVEL: 10% IN 50 YEARS
          NIVEAU DE PROBABILITE: 10% EN 50 ANNEES

            ----------------------------------
             G OR M/S   ZONE     ZONAL VALUE/
                                VALEUR ZONALE
            ----------------------------------
              0.00
                         0          0.00
              0.04
                         1          0.05
              0.08
                         2          0.10
              0.11
                         3          0.15
              0.16
                         4          0.20
              0.23
                         5          0.30
              0.32
                         6*         0.40
            ----------------------------------
      * ZONE 6:  NOMINAL VALUE/ VALEUR NOMINALE  0.40;
         SITE-SPECIFIC STUDIES SUGGESTED FOR IMPORTANT PROJECTS/
         ETUDES COMPLEMENTAIRES SUGGEREES POUR DES PROJETS D'IMPORTANCE.

     ** FOR NBCC APPLICATIONS, CALCULATED ZONE VALUES AT A SITE SHOULD BE
         REPLACED BY EFFECTIVE ZONE VALUES [ZA(EFF) OR ZV(EFF)] AS SHOWN BELOW/
        POUR APPLICATIONS SELON LE CNBC, ON DOIT REMPLACER LES VALEURS ZONALES
         CALCULEES POUR UN SITE PAR LES VALEURS EFFECTIVES [ZA(EFF) OU ZV(EFF)]
         COMME MONTRE CI-DESSOUS:

          1.  IF/SI (ZA - ZV) > 1,       ===>  ZA(EFF) = ZV + 1.
     OR/OU
          2.  IF/SI (ZA - ZV) < 1,       ===>  ZA(EFF) = ZV - 1.
     OR/OU
          3.  IF/SI  ZV=0 AND/ET ZA > 0, ===>  ZV(EFF) = 1.

           (SEE REFERENCE 2 CITED ABOVE, PAGE 677)
           (VOIR PAGE 677 DE LA REFERENCE 2 CI-DESSUS)         Jul  9 2003 12:44
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