ERDC

2007 Geotechnical Closure Studies, Keno Hill, YT

Prepared for:

Elsa Reclamation and
Development Company Ltd.
1920-200 Granville Street
Vancouver, BC
V6C 1S4

Prepared by:

SRK Consulting
Engineers and Scientists

Project Reference Number
SRK 1CE012.000

March 2008

2007 Geotechnical Closure Studies, Keno Hill, YT

Elsa Reclamation and Development Company Ltd.

1920 – 200 Granville Street
Vancouver, B.C., V6C 1S4
Canada

SRK Consulting (Canada) Inc.
Suite 2200, 1066 West Hastings Street
Vancouver, B.C. V6E 3X2

Tel: 604.681.4196 Fax: 604.687.5532
E-mail: vancouver@srk.com Web site: www.srk.com

SRK Project Number 1CE012.000

March 2008

Authors
Lowell Wade, M.Sc., E.I.T. (B.C.)
Consultant

Dylan MacGregor, G.I.T. (B.C.)
Senior Consultant

Reviewed by
Cam Scott, P.Eng. (B.C.)
Principal Consultant

Table of Contents

List of Tables

List of Figures

List of Appendices

1 Introduction

1.1 Background

Elsa Reclamation and Development Company Ltd. (ERDC) is in the process of preparing a closure plan for the various components of the former United Keno Hill Mine (UKHM) property in the Yukon. ERDC contracted SRK Consulting (Canada) Inc. (SRK) to carry out physical hydrogeology, geochemistry, and geotechnical field investigations to better understand in-situ conditions at the Valley Tailings Facility (VTF) and how those conditions, particularly in respect to permafrost, might have changed since construction over two decades ago. In addition, SRK was required to evaluate the physical and geotechnical conditions at select waste rock piles with a view to identifying the need for and the relevant issues associated with potential resloping of these piles. A field program was carried out from October 14th to 28th, 2007 to satisfy the following objectives:

- Develop an understanding of the foundation conditions under VTF Dams #1, #2, and #3 for use in determining the long-term dam stability. Monitor physical hydrogeology, geochemistry and temperature at a number of common locations along the dams.
- Develop an understanding of the current conditions at select waste rock piles so that closure measures can be developed on a pile-by-pile basis. Assess the geotechnical suitability and realistic reclamation outcomes for the re-sloped footprint of select piles.

This report presents the results of the field investigation and related assessments.

1.2 Overview of Field Program

From October 14th to 25th, a fifteen hole drill program was conducted at the VTF using a track-mounted percussion drill.

Six boreholes were completed along the crests of Dam #1, Dam #2 and Dam #3. Soil stratigraphy, depth to bedrock, geotechnical conditions and permafrost extent and characteristics were logged and samples were collected for laboratory testing. Monitoring wells and 5-bead thermistor cables were installed in the completed boreholes (Figure 1) to provide data on the respective groundwater flow and temperature regimes.

An additional six boreholes were completed within the tailings impoundments behind Dam #1 and Dam #3. Three boreholes extended to bedrock to determine the extent of tailings, overburden, permafrost, as well to determine bedrock depth and lithology, and samples were collected for soil characterization. Adjacent to each of these boreholes, a shallow borehole was completed to near the base of the tailings. Monitoring wells were installed in each of the completed boreholes, i.e. both deep and shallow holes, to allow monitoring of water levels and groundwater chemistry within and below the tailings.

Three boreholes were completed west of Dam #3, and a monitoring well was installed in each borehole to allow monitoring of water chemistry and level. To the northwest of Dam #3, one borehole was completed adjacent to the Pumphouse Pond access road to provide a background monitoring station. Two boreholes were completed downstream of the elbow of Dam #3 adjacent to the floodplain of Flat Creek to allow monitoring of groundwater downgradient of the VTF.

Thirteen waste rock sites were inspected on October 25th and 26th. These sites were selected for additional reconnaissance based on dump size, and stability and terrain features. The sites visited were: Bermingham, Black Cap, Dixie, Sime pits, Galkeno 300, Hector Calumet, Lucky Queen, No Cash 500, Onek, Ruby, and Townsite. Access to the sites was by truck or snowmobile.

Throughout the field program the winds were generally slight with daytime temperatures reaching highs of 0°C (average) and lows down to -13°C (average). Conditions ranged from sunny clear skies to overcast with periods of snow.

2 Methods

2.1 Drilling

All boreholes were drilled using a Becker Hammer Drill mounted on a Komatsu MST-2600 rubber track platform. All boreholes were vertical and were completed using double-walled drill steel with compressed air return in a manner that is very similar to a reverse circulation drill. In particular, air is pumped down the double-walled drill steel. The air and any drill cuttings return to a cyclone at surface via the interior of the drill steel. The internal and external diameter of the rods is 76.2 mm and 139.7 mm, respectively. Samples were collected in a 20 L pail placed under the cyclone at defined intervals and stratigraphic changes. Drilling was carried out by Glacier Dredge Drilling from Whitehorse, using a single 2-person crew, working 10-hour shifts.

For unconsolidated and loosely consolidated silts and clays, the drill rods were allowed to fall under their own weight while clearing the bit with compressed air. The soft ground conditions did not provide sufficient resistance to develop compression in the hammer cylinder to cycle the hammer for the next blow. The cold temperatures required the use of an ether injector to cycle the hammer. Very poor sample recovery was obtained in unconsolidated and loosely consolidated soils. Once consolidated sediments were encountered the hammer was started with moderate air pressure. Excellent sample recovery was achieved. Boreholes were advanced to refusal in either bedrock or permafrost.

SRK engineer Mr. Lowell Wade, E.I.T. supervised the drill, logged the recovered material, and collected representative soil samples for geotechnical testing. Mr. Dave Desmarais of Access Consulting Group assisted with the drill program. Samples were shipped to EBA Engineering’s soil testing laboratory in Whitehorse. All remaining soil was discarded next to the respective borehole.

The borehole locations were initially marked according to co-ordinates provided by SRK, but final locations were adjusted to suit field conditions. The surveyed coordinates, depth and orientation of the completed boreholes are provided in Table 1.

Table 1: Geotechnical Borehole Locations

Hole ID	Northing[1]	Easting[1]	Collar Elevation (m)	Depth (m)	Inclination[2]
GT7	7088574.811	474924.265	699.842	17.46	-90°
GT8	7088476.806	474773.028	697.086	17.27	-90°
GT9	7088546.493	474680.145	696.353	13.17	-90°
GT10	7088123.152	474410.377	693.739	10.29	-90°
GT12	7088339.117	474316.461	694.278	15.48	-90°

1. UTM Projection NAD 83 Zone 8.
2. Relative to the horizontal plane.

2.2 Laboratory Testing

A total of 92 bulk (i.e. disturbed) soil samples were collected and shipped to the EBA testing laboratory in Whitehorse. Table 2 summarizes the samples selected for laboratory testing.

Table 2: Sample List and Laboratory Testing Program

Location	Sample [ID:Depth (Type)][1]	Natural Moisture Content	Particle Size Distribution by Sieve Analysis
Dam #1	GT7: 11.5 – 12.0 m (SM)	✓	✓
Dam #2	GT8: 13.5 – 14.0 m (GM)	✓	✓
Dam #3	GT10: 1.5 – 2.0 m (GM)	✓	
	GT10: 7.5 – 8.0m (SM)	✓	✓
Valley Tailings	H4 DEEP: 0.0 – 0.5 m (SM - tailings)	✓	
	H4 DEEP: 1.0 – 1.5 m (SM - tailings)	✓	
	H4 DEEP: 2.0 – 2.5 m (SM - tailings)	✓	
	H4 DEEP: 6.2 – 6.7 m (GM)	✓	
	H5 DEEP: 6.5 – 7.0 m (PT)	✓	
	H5 DEEP: 8.5 – 9.0 m (SM)	✓	
	H5 DEEP: 10.5 – 11.0 m (GM)	✓	
	H6 DEEP: 2.5 – 3.0 m (GM)	✓	

1. Soil type is designated soil symbol according to the Unified Soil Classification System (USCS).
2. GM = Gravel, silt, (Till).
3. SM = Sand, silty.
4. PT = Peat.
5. CL = Clay, low plastic.
6. BR = Bedrock. All bedrock samples were turned over to ERDC at site.

2.3 Waste Rock Pile Inspection

A visual inspection of the largest waste rock dumps and selected other waste rock piles and downgradient terrain was carried out following the VTF drilling program in October 2007. Sites were selected for investigation to cover a range of location, waste rock pile size, steepness of original ground, and terrain features adjacent to (and particularly downgradient of) the waste rock piles. Access to the sites was by truck or snowmobile; traverses of the waste rock piles and downgradient terrain were carried out on foot.

Previous inspections (in 2005 and 2006) were carried out without the benefit of aerial photographs of the property captured in 2006 or the detailed topographic mapping compiled from these photographs. The 2007 investigations were guided by both the aerial photographs and the 1m contour interval maps of each dump inspected.

2.4 Resloping Assessment

Options for resloping several waste rock piles were examined using AutoCAD. Three candidate final slopes angles were evaluated- 2H:1V, 2.5H:1V, and 3H:1V. Sections were cut through the steepest areas of the waste rock piles using the topographic surface developed in 2006, and lines having the candidate slope angles were visually positioned on the sections such that cut and fill areas were approximately balanced.

Nine of ten dumps containing at least 100,000 tonnes of waste rock were evaluated, representing approximately 85% of the total waste rock (4.6 million tons of an estimated total property inventory of 5.4 million tons). These were: Bermingham; No Cash 500; Hector 400 adit; Hector #1 Vein pit; Calumet 1-15 pit; Sime pits; Galkeno 300; Onek; and Black Cap. Four smaller waste rock piles (Dixie, Ruby, Townsite, and Lucky Queen 500) that were inspected in 2007 by virtue of being located on the inspection route between the largest dumps were also evaluated.

A resloped toe of the waste rock pile was estimated by measuring (in section) the distance that each candidate resloping angle extended the dump toe, and shifting the position of the existing toe downgradient by the resulting value. Several assumptions were made during this exercise:

- To determine a comparative footprint area, a fixed upper limit of the waste rock pile was selected to be consistent with all re-sloping options.
- For several waste rock piles, the original topography is steeper than 3H:1V. Moving the section line back so that the 3H:1V slope would intersect the original topography would result in excavation of original ground. This prevented the estimation of the total foot print area of several 3H:1V resloped sections of the waste rock piles.

The dump footprint areas that would result from resloping to each of the three slope angles evaluated were estimated as follows:

- In section, the distance from the existing toe to the intersection of the resloping line with original ground was measured.
- In plan view, an alignment of the resloped toe was estimated by extending the entire toe downslope by the distance measured in section for each resloping angle.
- New dump footprint areas were calculated using the resulting polygons. The upslope limit of waste rock was fixed for all estimates of footprint area.

2.5 Geotechnical Evaluation of Underground Workings

A desktop study to evaluate the stability of selected crown pillars as recommended in the Baseline Environmental Report (SRK, 2006). This desktop study was to be based on a review of operational records, including backfill records and engineering and geology long- and cross-sections, of the shallow stopes at the major mines.

These records were to be accessed through the digital library of scanned copies of the contents of the engineering and geology vaults. This resource consists of tens of thousands of files which were scanned in the order physically encountered in the respective vault. As such, the files are not organized by subject area at this time, and the digital file name provides the only indication of file content. Although considerable effort was invested searching through the available files, no additional information was identified to further inform an assessment of crown pillar stability. There may be value in revisiting this exercise if the digital files are organized by subject at some future point.

3 Results

3.1 Valley Tailings Facility Investigations

3.1.1 Drilling Results

In general recovery of overburden and dam fill materials was excellent (above 90%). Poor recovery (less than 10%) was experienced in very loose, wet soils where the Becker Hammer fell freely under its own weight. In loose soils, it was difficult to develop sufficient compression to initiate firing of the diesel hammer. Recovery from the cyclone was constant, so that stratigraphic layers were typically preserved. However, precision in depth determination was estimated to be approximately ± 0.5 m. Where free water was encountered, the fine grained material was suspended in the water and the larger and heavier material settled to the bottom of the sample pail. Soil description under these conditions was interpretive.

The installation of the monitoring wells and thermistor cables proved to be challenging until an efficient installation method was developed. The drill crew had never used the drill for instrument installation, so a routine had to be developed. It was found that installing the instrumentation to ground level and allowing the drill to move off the borehole then installing the stick-up and well casing was successful as this sequence reduced the risk of instrumentation damage. Using bentonite chips as back fill during the installation of the monitoring wells and thermistor strings presented problems below the water table. It was found that the bentonite chips would hydrate quickly and would get “hung up” in the annulus between the instrumentation and the inside of the bit. To overcome this problem, well graded gravel was harvested from local sources and used as backfill. However, if the sand used in the sand pack around the slotted screen of the monitoring well was added too quickly, it would bridge between the drill rods and the PVC standpipe. It was imperative that the bottom of the drill steel be above the backfill level or the backfill material would bind the drill rods to the instrumentation and lift the instrumentation as the drill rods were pulled from the borehole.

Under dry conditions, the monitoring well was lowered into the borehole and the filter sand was placed during drill rod removal. Once the sand pack was installed, the drill rods were pulled and the drill moved off the bore hole to allow bentonite to be slowly added for the remainder of the installation.

For the most part, stick-up and well casing installation followed monitor well and thermistor string installation. At the conclusion of the field program, a couple of boreholes still required well stick-up and steel well casing installation. Due to the cold conditions, the lack of water close by and time constraints this had not been accomplished. These installations are planned for completion at a later date by Dave Desmarais of Access Consulting.

A complete log of the completed geotechnical boreholes and the installation details for the monitoring wells and thermistor cables are provided in Appendix A. The following sections summarize the results of the drilling program.

GT7

Borehole GT7 was drilled to refusal at a depth of 17.46 m on the upstream crest of Dam #1 (Figure 1). Sample recovery from GT7 was generally good over the borehole except in the wet till below the peat. Recovered soils did not contain permafrost and the hole was dry at the bottom at the time of drilling, with refusal in bedrock. A monitoring well and a thermistor cable were installed at this location.

GT8

Borehole GT8 was drilled to refusal at a depth of 17.27 m on the downstream crest of Dam #2 as shown on Figure 1. Sample recovery from GT8 was generally 100% over the entire length of hole, except for a one meter interval at the contact zone between the base of the dam fill and the native till. It is assumed that this very soft interval contained peat. Recovered material was unfrozen and refusal was in bedrock. A monitoring well and a thermistor cable were installed at this location.

GT9

Borehole GT9 was drilled to refusal at 13.17 m on the upstream crest of Dam #2 (Figure 1). Upon completion of the borehole, a monitoring well and a thermistor cable were installed. Sample recovery from GT9 was poor in the dam fill but generally 100% over the remaining length of hole. All recovered material was unfrozen, with refusal in bedrock. The bottom of the borehole was dry at the time of drilling.

GT10

Borehole GT10 was drilled to refusal at 10.29 m on the downstream crest of the southeast limb of Dam #3 as shown on Figure 1. A monitoring well and a thermistor string were installed in the borehole. Sample recovery from GT10 was generally 100%. The borehole met refusal in bedrock and was dry at the bottom at the time of drilling. No frozen material was encountered.

GT12

Borehole GT12 was drilled to refusal at a depth of 15.48 m on the upstream crest of the northern half of Dam #3 (Figure 1). Sample recovery from GT12 was generally excellent. Recovered overburden was unfrozen and refusal was in bedrock. A monitoring well and a thermistor cable were installed in the completed borehole.

3.1.2 Thermistor Data

Thermistor string readings were taken upon completion of installation to make sure that the cables were functioning properly. A second series of thermistor reading were collected by SRK just prior to leaving site. The October 2007 thermistor data is presented in the drill logs in Appendix A.

No permafrost was encountered in the boreholes within the VTF. This is confirmed by the temperature profiles provided by the thermistor strings which indicate that ground temperatures in October were above 0°C, with values ranging from 1°C to 8.4 °C. Maximum temperature values, ranging from 5 °C to 8.4 °C, were measured between 3.0 m and 5.5 m for all thermistor strings. Above 1m in depth, the temperatures were below 0 °C which can be attributed to the seasonal penetration associated with the onset of seasonally cold air temperatures.

3.1.3 Laboratory Testing Results

Eleven samples were subjected to basic geotechnical classification testing, with the primary results summarized in Table 3. Complete laboratory data sheets are included as Appendix B.

Table 3: Results of Foundation Indicator Testing

Sample [ID:Depth (Type)]	Water Content (%)	Gravel (%)	Sand (%)	Silt (%)
GT7: 11.5 – 12.0 m (SM)	8.7	50	44	6
GT8: 13.5 – 14.0 m (GM)	3.4	42	35	23
GT10: 1.5 – 2.0 m (GM)	7.9			
GT10: 7.5 – 8.0m (SM)	6.1	70	23	7
H4 DEEP: 0.0 – 0.5 m (SM - tailings)	7.5			
H4 DEEP: 1.0 – 1.5 m (SM - tailings)	6.7			
H4 DEEP: 2.0 – 2.5 m (SM - tailings)	23.3			
H4 DEEP: 6.2 – 6.7 m (GM)	6.1			
H5 DEEP: 6.5 – 7.0 m (PT)	67.0			
H5 DEEP: 8.5 – 9.0 m (SM)	19.8			
H5 DEEP: 10.5 – 11.0 m (GM)	3.9			
H6 DEEP: 2.5 – 3.0 m (GM)	5.6			

Water content of the samples varied from 3.4% in the compact gravel at depth to 67.0% in the peat. This peat had been compressed by the weight of the overlaying tailings. The single sample of dam fill material yielded a moisture content of 7.9%. This was close to the average moisture content of 7.7% measured within the sands and gravels under the peat. An average moisture content of 12.5% was measured within the tailings.

3.2 Waste Rock Pile Studies

3.2.1 2007 Waste Rock Pile Inspection

Snow cover and frozen ground at the time of the 2007 site visit limited the inspection to confirming dump slope angles, looking for signs of oversteepening, and inspecting terrain below dumps to inform the resloping assessment. Figure 2 shows the locations of dumps inspected in 2007.

The observations from the 2007 investigations generally agreed with the findings of previous rounds of inspection in 2005 and 2006. Areas of minor oversteepening were noted at some of the larger dumps, specifically Bermingham, Black Cap, Onek, #35 Vein (Sime area), and Galkeno 300. Deterioration of loadout cribbing at No Cash 500 was noted, with related instability of the finer-grained underground waste rock retained by the cribbing.

3.2.2 Resloping Assessment

The existing and candidate footprint areas for the eleven waste rock piles evaluated were estimated and measured using AutoCAD; the resulting sections and plans are shown in Figures 3a through 12b. The results are summarized in Table 4 with the complete results provided in Appendix C.

There are a few cases where resloping may not be an appropriate option. For example, resloping the No Cash 500 waste rock pile will result in waste rock being pushed into the No Cash 500 Creek. An alternate solution to this waste rock pile will be required. There may be other waste rock piles on the property that will require similar consideration, such as the eastern-most dump at Onek, the Keno 700 dump, Bellekeno 625 dump and the Silver King 100 adit dump.

Table 4: Scoping Estimates of Footprint Areas for Resloped Waste Rock Piles

Site	Avg. Ht. (m)	Area (m^2) (Existing Conditions)	Area (m^2) (Resloped 2H:1V)	% of Original Area	Area (m^2) (Resloped 2.5H:1V)	% of Original Area	Area (m^2) (Resloped 3H:1V)	% of Original Area
Bermingham	24	39,500	43,500	110%	55,600	141%	69,600	176%
Black Cap	21	25,850	31,200	121%	36,600	142%	NA	NA
Calumet/ Hector pits	29	97,600	117,300	120%	151,600	155%	NA	NA
Dixie	19	1,950	1,950	100%	2,300	118%	3,750	192%
Galkeno 300	14	5,400	7,500	139%	9,200	170%	10,900	202%
Hector Adit	29	14,500	17,000	117%	25,000	172%	NA	NA
Lucky Queen 500	13	9,700	10,200	105%	10,950	113%	12,000	124%
Onek	25	45,700	47,130	103%	NA	NA	NA	NA
Ruby	18	2,000	2,000	100%	6,300	315%	7,100	355%
Sime	20	42,950	53,200	124%	71,950	168%	NA	NA
Townsite	14	5,400	5,400	100%	6,550	121%	8,650	160%

Notes:

1. NA values in the Resloped 3H:1V column indicate that the down gradient slope is greater than 3H:1V- the regrading line does not intercept original topography.
2. The slope of the original topography down gradient of the Onek waste rock pile, Section P-P’, is greater than 2H:1V so no regrading lines intercept the original topography. The total footprint area of the resloped options does not include a contribution from Section P-P’.

4 Discussion: Valley Tailings Facility

4.1 Valley Tailings Drill Program

The following conclusions are based on the results of the VTF drill program:

- The VTF drill program indicates that Dams #1, #2 and #3 were constructed on top of tailings and peat, i.e. it had not been stripped from the dam foundation prior to dam construction.
- Peat underlies the tailings within the impoundment.
- No permafrost was encountered in any of the boreholes completed within the VTF. If permafrost is present within the VTF, it is within the bedrock at an indeterminate depth. This indicates permafrost degradation has occurred as permafrost was encountered under the dams in 1981. Table 5 provides the depth to permafrost recorded by EBA (EBA, 1982) compared to the depth to bedrock encountered by this field program.

Table 5: Permafrost Degradation Over the Past 25 Years

Dam #1				
EBA, 1981		**SRK, 2007**		
Bore Hole ID	**Depth to Permafrost (m)**	**Bore Hole ID**	**Depth to Bedrock (m)**	**Estimated Permafrost Degradation over 25 years (m)**
BH 1-1	6.8			
		GT7	17.3	11.5
BH 1-2	4.9			
Dam #2				
BH 2-1	7.2			
		GT8	17.3	8.5
BH 2-2[1]	10.5			
		GT9	13.2	6.2
BH 2-3	3.5			
Dam #3				
BH 3-1	4.4			
		GT10	10.4	5.5
BH 3-2	5.5			
		H11	15.8	11.5
BH 3-3	3.1			
		GT12	15.5	9.0
BH 3-4	10.0			

Notes:

1. No permafrost was encountered in this borehole.

4.2 Dam Performance

4.2.1 Introduction

The past performance and current condition of the three dams within the Valley Tailings Facility (VTF) are useful indicators of their future stability. To facilitate the assessment of future long-term performance of these three dams, the following information has been compiled:

- a summary of the dam construction sequence and timing;
- total settlement of each of the dams;
- classification of each of the three dams based on the most recent Canadian Dam Safety Guidelines;
- a flood frequency analysis; and
- the current seismic hazard based on the 2005 seismic hazard model for Canada.

Information was obtained from available annual inspection reports prepared by EBA and a geotechnical evaluation report prepared by BGC Engineering Inc (BGC, 1996). Additional information has been obtained through personal communication with Richard Trimble of EBA Engineering Consultants Ltd. (Whitehorse office).

4.2.2 Dam Construction Sequence and Timing

Dam #1 was constructed prior to 1962 for the purpose of impounding mill tailings. Dam #2 was constructed in 1973 for the purpose of providing retention time for water that passed from Dam #1 to the receiving environment. Dam #3 was constructed in 1979 to further increase the retention time for waste water. Although several design drawings for the various dams were available for review, no as-built reports were located for this study and it is assumed that all three dams were constructed as unzoned dams using local till borrow material augmented with waste rock.

4.2.3 Total Settlement To Date

Personal communication with Richard Trimble (EBA, Whitehorse) included a review of total settlement measured to-date and observed lateral movement of the dams. Accurate surveys have been conducted in the past but no records have been kept regarding the amount of fill placed on the dams to compensate for subsidence. When subsequent surveys were conducted no comparison could be made to determine settlement values or rates. During the annual dam inspections, from 2004 through 2007 negligible settlement was observed in any of the dams. Prior to 2004 up to 0.3 m/yr of local settlement has been observed in each of the dams. Based on the observed historic settlements, and the lack of settlement in recent years, it is likely that the majority of potential thaw consolidation in the peat and till underlying the dams has already occurred.

These observations are supported by the five 2007 boreholes (SRK, 2007) which did not encounter permafrost in the unconsolidated soils under the dams and in which the installed thermistors showed ground temperatures to be above 0°C. The 2007 observations are marked contrast to the permafrost conditions observed by EBA during the 1981 drill program (EBA, 1981) and the 1996 testpit program by BGC (BGC, 1996). The observed permafrost degradation is consistent with the time frame for thawing of dam foundation soils suggested by thermal modelling carried out by EBA in 1982. As permafrost no longer exists in the soils under the dams, excessive long term settlement is not expected to be an issue.

4.2.4 Dam Classification

A preliminary assessment of the classification of each of the three dams at the VTF was undertaken in accordance with the Canadian Dam Association (CDA) Dam Safety Guidelines published in November 2007. As a consequence of this assessment, the consequence classification associated with each of these dams is as follows;

- Dam 1 – Significant
- Dam 2 – Low
- Dam 3 – Low

Further details regarding these classifications and the assessment that has been completed in support of this report are provided in Appendix D.

4.2.5 Flood Frequency Analysis

Access Mining Consultants Ltd. (AMCL, 1996) estimated the PMF (1:10,000 year flood event), the 1:200 year flood event, and the mean annual flood event for several locations within the VTF. The estimates also included worst case scenarios where the Porcupine Diversion develops a breach allowing total flow to enter the impoundments either behind Dam #1 or #3. These values are summarized in Table B-5 of Access Mining Consultants Ltd. (AMCL, 1996) report. The largest estimated PMF, within the tailings impoundment, is 98 m^3/s. This PMF value was estimated for a spillway through Dam #3 and includes a worst case scenario of a breach in the Porcupine Diversion with the combined flows of Porcupine Gulch, Brefalt Creek, and Flat Creek entering the impoundment of Dam #3.

For dams in the Low to Significant category, the Inflow Design Flood (IDF) value is used. For a Low consequence dam (Dams #2 and #3), the CDA guidelines suggest using an IDF based on the 1:100 year flood event. For a Significant consequence dam (Dam #1), the IDF would be based on a flood between the 1:100 and 1:1000 year events. The 1:200 year flood event estimated by Access Mining Consultants Ltd. in 1996 is within the IDF range for a Significant consequence class. The largest estimated 1:200 year flood event within the tailings impoundment is 27 m^3/s. This 1:200 year flood event value has been used as an estimate for a spillway through Dam #3 and worst case scenario of a breach in the Porcupine Diversion into the impoundment behind Dam #3.

4.2.6 Seismic Hazard Analysis

In 2003, the Geological Survey of Canada developed the new seismic hazard model for Canada which forms the basis of the 2005 National Building Code of Canada (Adams & Halchuk, 2004). Seismic hazard calculations for the VTF were conducted using online tools (NRCAN, 2007). The seismic hazard calculations indicate a peak ground acceleration of 0.071g for a 100-year return period, 0.138g for a 500-year return period, 0.182g for a 1,000-year return period and 0.245g for a 2,475-year return period.

The Peak Ground Acceleration (PGA) value for the Earthquake Design Ground Motion (EDGM) will depend on the consequence class of the dam. For a Low consequence dam (Dams #2 and #3), this would be a 1:500 year seismic event corresponding to 0.138g. For a Significant consequence dam (Dam #1), this would be a 1:1000 year seismic event corresponding to 0.182g.

4.2.7 Dam Stability

Stability Analyses from 1982

In 1982, EBA prepared a report summarizing a geotechnical evaluation of the VTF dams as part of UKHM’s annual submission to the Yukon Water Board. To support the evaluation, EBA conducted a geotechnical assessment of the stability of the existing Dams #1, #2 and #3 (EBA 1982; EBA 1983).

The 1982 stability analyses evaluated a model dam constructed on peat over compact till with no permafrost present in the foundation. The 1982 stability analyses modelled a typical dam section as a homogeneous embankment of sandy till or mine waste rock with a slopes of 1.5H:1V and a friction angle between 30^o to 40^o (EBA, 1982). The dam fill was modelled overlying peat or highly organic silt of varying thickness (1.4 m to 3 m) with a friction angle between 20^o to 35^o. Piezometric conditions, as well as excess pore pressures in the peat due to the absence of permafrost, were considered. The results of the analyses showed that the factor of safety for deep-seated failure in the peat below the dam fill is approximately 1.3. It was concluded that overall failure is unlikely, but yielding of the highly deformable peat was anticipated. The factor of safety against localized sloughing of the downstream slopes was calculated to be slightly above 1.0.

EBA’s analyses did not consider dynamic loading from an earthquake due to the low seismic hazard applicable at the time. In particular, the site fell within Zone 3 of the seismic zoning map for Canada which, in 1982, corresponded to a peak horizontal ground acceleration in excess of 0.06g for a 100-year return period (EBA, 1982). EBA concluded that the relatively low ground accelerations associated with this event would not invalidate the conclusions from the stability analyses completed on the basis of static loading conditions.

Construction of a Toe Berm at Dam #1 in 1996

A berm was constructed at the downstream toe of Dam #1 in 1996 based, we understand, on input from EBA. SRK is unaware of any revised stability analyses that may have been completed in relation to the design and construction of this toe berm, but the subsequent factor of safety under both static and dynamic loading conditions would have improved relative to the analytical results from 1982.

Discussion of Current Stability

Table 6 provides a summary of the factors of safety under various loading conditions for the VTF dams and what the minimum required factor of safety is likely to be. Additional comments are provided below.

Table 6: Summary of Stability Analyses

Failure Mode and Loading Condition	Factor of Safety			
	1982	1996	2008	Required for Closure
Static, deep-seated, Dam #1	1.3	>1.3 (N/A)	>1.3 (N/A)	≥1.5
Static, deep-seated, Dams #2 and #3	1.3	1.3[1]	1.3[1]	
Static, shallow (face failure), Dam #1	≥1.0	≥1.0 (N/A)	≥1.0 (N/A)	≥1.3[2]
Static, shallow (face failure), Dams #2 and #3	≥1.0	≥1.0[1]	≥1.0[1]	
Dynamic, deep-seated (based on pseudo-static analysis), Dam #1	N/A	>1.0? (N/A)	>1.0? (N/A)	≥1.0[3]
Dynamic, deep-seated (based on pseudo-static analysis), Dams #2 and #3	N/A	N/A	N/A	

N/A = not analyzed.

Note 1: The value has not been recalculated but is assumed to be the same as it was for the analyses of 1982.

Note 2: The selection of this factor of safety depends on the site specific consequences and the expectations of stakeholders. It is possible that a minimum factor of safety of 1.5 might be required for regulatory reasons.

Note 3: The selection of this factor of safety depends on the consequences. In other jurisdictions, where the consequences of failure are more severe, the required factor of safety can be as high as 1.2.

The current stability of the VTF dams under static loading conditions has been based on extrapolations from the work that was done in 1982 and the fact that a toe berm was installed at Dam #1 in 1996. No analyses were completed in 1982 or since in relation to dynamic loading, i.e. from an earthquake.

The following comments are provided in relation to dynamic loading. The simplest approach to assessing the stability of dams under dynamic loading conditions is the pseudo-static analysis, in which the earthquake load is simulated by an "equivalent" static horizontal acceleration acting on the mass of the fill, in a limit-equilibrium analysis. The pseudo-static approach has certain limitations, but the methodology is considered to be generally conservative, and is the one most often used in current practice. If the calculated factor of safety from pseudostatic analysis is greater than the minimum criterion, the dam is considered seismically stable. However, if the calculated factor of safety is less than the minimum criterion, deformation analyses are normally undertaken to evaluate the amount of earthquake-induced settlement. This will, in turn, determine whether the dam will be left with adequate freeboard following the design earthquake.

If, however, there is a layer in the dam or its foundation which is liquefiable, the pseudostatic analysis should not be used. The parameter most commonly used to evaluate liquefaction potential is relative density. In relation to the VTF dams, there is a layer of gravel/sand/silt immediately below the peat that apparently has a variable density which increases generally with depth. The data is relation to the relative density of this stratum indicates this unit is unlikely to be liquefiable, but the data is inconclusive (SRK is unaware of any N-values in this unit that have been derived from Standard Penetration Tests (SPT's), though eight data sets related to the rate of casing penetration during the recent Becker drilling program provided a range of 25 to 160 blows per foot and a mean of about 62 blows per foot).

Conclusion and Recommendations

The conclusions and recommendations provided below are based on the results of the 2007 field investigation, the 2007 seismic hazard calculation, the 2007 dam classification (Appendix D), a review of historical records, the 1996 flood frequency analysis (AMCL, 1996) and a review of the stability analyses completed by EBA in 1982:

- The VTF dams are currently stable under static loading conditions, but it is unclear whether their respective safety factors meet appropriate values for closure.
- The parameters used in the stability analyses completed for static loading conditions in 1982 are believed to be reasonable and can be used in future analyses to assess their current and post-closure stability.
- These same parameters, coupled with the recent seismic hazard information, can be used for pseudo-static analyses to evaluate the stability of the dams under seismic loading assuming that the foundation layers will not liquefy.
- At some point prior to final closure design, the assumption that the foundation stratum immediately below the peat at each of the permanently installed dams will not liquefy in response to the design earthquake should be checked with a geotechnical drilling program that will obtain suitable relative density data using SPTs or other suitable methods.

5 Discussion: Stability of Waste Rock Piles

5.1 Historical Stability of Waste Rock Piles

The largest waste rock piles (at the Bermingham, Calumet, Sime, Black Cap, and Onek mines), were constructed during open pit mining from 1977 to 1989, which corresponds to dump ages between 20 and 30 years. Construction of the largest waste rock pile from underground mining (the Hector 400 dump) largely occurred in the 1950s and 1960s, which corresponds to a dump age of about 50 years. The other waste rock piles on the former UKHM property were developed at similar times, with the youngest dumps being at least 20 years old. Given these ages, the geotechnical performance of the waste rock piles since construction provides an excellent indication of the geotechnical stability of the present dump configurations.

Inspections of all waste rock piles on the property by SRK in 2005, 2006, and 2007 did not reveal any evidence of foundation instability at the toes of the waste rock piles. Most of the larger dumps are located on the moderately steep slopes at the higher elevations on Galena Hill and Keno Hill, where permafrost distribution is widespread. Soils on these slopes tend to be thin, with angular frost-shattered bedrock present at or near the surface. Exceptions among the largest waste rock piles include Onek and Silver King, where dumps are situated on similar moderate slopes with thin soils, but at lower elevations. These thin soils with substantial angular cobbles and boulders are not expected to be susceptible to creep. Any thawing of permafrost due to waste rock loading will have already occurred, and the foundation soils are thought to be thaw stable in the event that future permafrost degradation does occur.

Dump slopes were typically observed to be at angle of repose. Minor evidence of past movement was noted, consisting of convex slopes and tension cracking near crests, as well as minor slumping on isolated faces. In most cases, there were no indications of recent slope movement.

The exception is the Hector # 1 Vein pit dump, which was noted to be composed of a higher proportion of fine grained waste than other pit dumps, to have recent tension cracks near the crest, and to have an eroding and steepening face. Further, ponded water was noted on the dump surface in 2005, and channelled surface runoff has cut an erosion gully through the crest, with erosion ongoing. This waste rock pile has a high likelihood of future geotechnical instability; however, the consequences of failure of this dump are very low.

5.2 Water Management Considerations

Water management considerations are required for selection of a closure measure for several waste rock piles. The Silver King adit dump, the No Cash 500 dump, and the Bellekeno 625 dump all have streams running along the toe. Although active erosion was not observed, there is a risk of future undercutting and instability at these locations. Ponded water on the surface of the Hector # 1 Vein pit and Black Cap waste rock piles was noted, as were erosion gullies on the face of both the Hector # 1 Vein dump and the Galkeno 300 dump.

Discharge from the Keno 700 adit was noted to be actively eroding the waste rock where drainage water flowed over the dump crest, and there appeared to have been a number of erosional events related to ice plug failure that have mobilized waste rock downgradient into Hope Gulch. Similarly/ flow from the No Cash 500 adit was observed in 2005 to discharge both directly from a culvert onto the dump face, and as surface flow over the dump crest, and downgradient deposits of waste rock indicate the occurrence of intermittent erosional events. In all these cases, the final closure measure selected will need to incorporate water management considerations.

5.3 Deterioration of Wooden Support Structures

Most of the underground mines have associated wooden loadout structures that are presently retaining up to 5 m of waste rock. Timber cribbing was also used to retain waste rock terraces within the Elsa and Calumet townsites. The loadout structures and cribbing are in various states of decay, and will continue to deteriorate with time. As the loadout structures in particular attract public attention, the physical deterioration of various loadouts represent risks that have not at this time been incorporated into the ‘Reduction of Physical Hazards’ program.

5.4 Resloping Considerations

Scoping estimates of increased waste rock pile surface areas at the largest and selected other dumps under three resloping scenarios are presented in Table 4. These dumps encompass more than 85% of the total waste rock tonnage on the property and represent the most significant locations where resloping is considered to be a closure option. For several of the larger waste rock piles, regrading from the present configuration to a final 2.5H:1V slope will increase the waste rock footprint area by around 40 to 70% for individual dumps, with percentage increases for some of the smaller dumps that are higher still. An assessment of the realistic outcomes of resloping and revegetation needs to be weighed against the present value of the vegetation and additional land that will be covered during resloping.

Several of the larger dumps are situated on slopes steeper than 3H:1V (Black Cap, Hector 400 adit, Sime dumps, Calumet 1-15) and the Onek SE dump is situated on a slope steeper than 2.5H:1V. A few smaller waste rock piles (e.g. Shamrock, Keno No. 9 waste rock on Faro Gulch talus slope) are similarly situated. Physical processes operating on steep slopes will limit the longevity of any growth media placed to enhance revegetation. If resloping is to be carried out on these steep slopes, direct revegetation of resloped waste rock will likely be as successful as placement of growth media with revegetation.

5.5 Summary of Waste Rock Pile Stability Assessment

The history of the waste rock piles in general indicates that, for most sites, the long-term geotechnical stability of waste rock piles is of little concern as the potential consequences of failure are likely to be minor and quite localized. For stable waste rock piles, the selection of a waste rock pile closure measure will be driven by geochemical loading, esthetic objectives, or revegetation goals.

For the Hector # 1 Vein waste rock pile, the ongoing erosion and recent evidence of slope movement indicate that there is a high likelihood of failure of this dump over the long term; however consequences of failure would be very low, and limited to downslope movement of waste rock covering a limited area that is presently vegetated.

For the Keno 700, No Cash 500, Silver King 100, and Bellekeno 625 adit waste rock piles, permanent streams at the base of the piles will necessitate relocation of some waste rock if a closure measure other than ‘Do nothing’ is selected. These waste rock piles are at risk of future undercutting during periods of high stream discharge. No Cash 500 and Keno 700 have the added risk of erosion arising from uncontrolled discharge from the respective adits.

5.6 Selection of Waste Rock Pile Closure Options

Selection of a closure measure for a given waste rock pile requires consideration of the geotechnical considerations discussed above, as well as other aspects including geochemical loading, aesthetic factors, and desired revegetation outcomes. During the planning sessions for 2007/08 closure studies, development of a decision tree for facilitating that closure measure selection was contemplated. Through subsequent efforts, it was found that the structure of a decision matrix would likely be a better decision-making tool.

An example of how a decision matrix for the former UKHM waste rock piles could look is presented in Appendix E. This tool is intended to provide a framework for stakeholders to assess the requirements for closure, and is not intended to be taken as complete at this time. This decision matrix ranks all the waste rock piles on the basis of contained tonnage and groups the waste rock piles into four size categories to allow closure options for dumps of similar sizes to be considered together.

Although the closure requirements for waste rock piles have not yet been established, four likely candidate closure requirements have been included for illustrative purposes. One of these candidate requirements is ‘Ensure Geotechnical Stability’- this column has been populated for those dumps identified as having stability risks that will need to be mitigated if geotechnical stability is selected as a closure requirement.

Also included in the example decision matrix are a number of considerations for implementation of a closure measure for a given waste rock pile. For example, one closure option might be to reslope the waste rock to 2.5H:1V. A consideration in this case might be the value of the additional land that would be covered during the resloping exercise. Stakeholders may wish to consider weighing the benefits of resloping against covering the additional footprint area with waste rock.

Finally, the example decision matrix includes six candidate waste rock pile closure options, spanning a range of possible closure measures from ‘Do Nothing’ to ‘Relocate’ to ‘Reslope and Revegetate’. SRK understands that these candidate closure options for waste rock piles were discussed in a meeting between various stakeholders in July 2007 and are to be carried forward to public consultation. As such, recommended closure options have been specified only for those sites where ‘Do Nothing’ is the clear choice, based on a combination of small dump size, minimal initial disturbance and degree of natural reclamation. Input from stakeholders will be required to select closure options for the remaining sites.

This report, **"2007 Geotechnical Closure Studies, Keno Hill, YT"**, has been prepared by SRK Consulting (Canada) Inc.

Prepared by:

Original signed by

Lowell Wade. M.Sc., E.I.T. (B.C.)
Consultant

Original signed by

Dylan MacGregor, G.I.T. (B.C.)
Senior Consultant

Reviewed by:

Original signed by

Cam Scott, P.Eng. (B.C.)
Principal Consultant

6 References

Access Mining Consultants Ltd., (1996). Closure Plan for Current Operations. Appendix B. Proposed Flood Protection for Elsa Tailings Impoundment. Report prepared for United Keno Hill Mines Ltd. Report number: UKH/96/02, June 6, 1996.

Adams, J, & Halchuk, S., (2004). Fourth Generation Seismic Hazard Maps for the 2005 National building Code of Canada. Proceedings of the 13th World Conference on Earthquake Engineering, Vancouver, Canada. Paper 2502 on CD-ROM. August 1st – 6th, 2004.

BGC (1996). Conceptual Design report, Tailing Disposal Study for United Keno Hill Mines Ltd., Report prepared for United Keno Hill Mines Ltd., Project number: 107 001 01, September 5, 1996.

CDA (2007). Dam Safety Guidelines, 2007. Canadian Dam Association.

EBA (1981). Interim Report on Keno Hill – Tailings System. Report prepared for United Keno Hill Mines Ltd., Report No. 108-3438, December 1981.

EBA Engineering Consultants Ltd., (1982). Geotechnical Evaluation, Existing Tailings Dams, United Keno Hill Mines Ltd., Elsa, Yukon. Report prepared for united Keno Hills Mines Ltd., March 1982.

EBA (1983). Geotechnical Evaluation: Existing Tailings Dams, United Keno Hill Mines Ltd., Elsa, Yukon Territory. Report prepared for United Keno Hill Mines Ltd., Report No. 209-3438, March 1983.

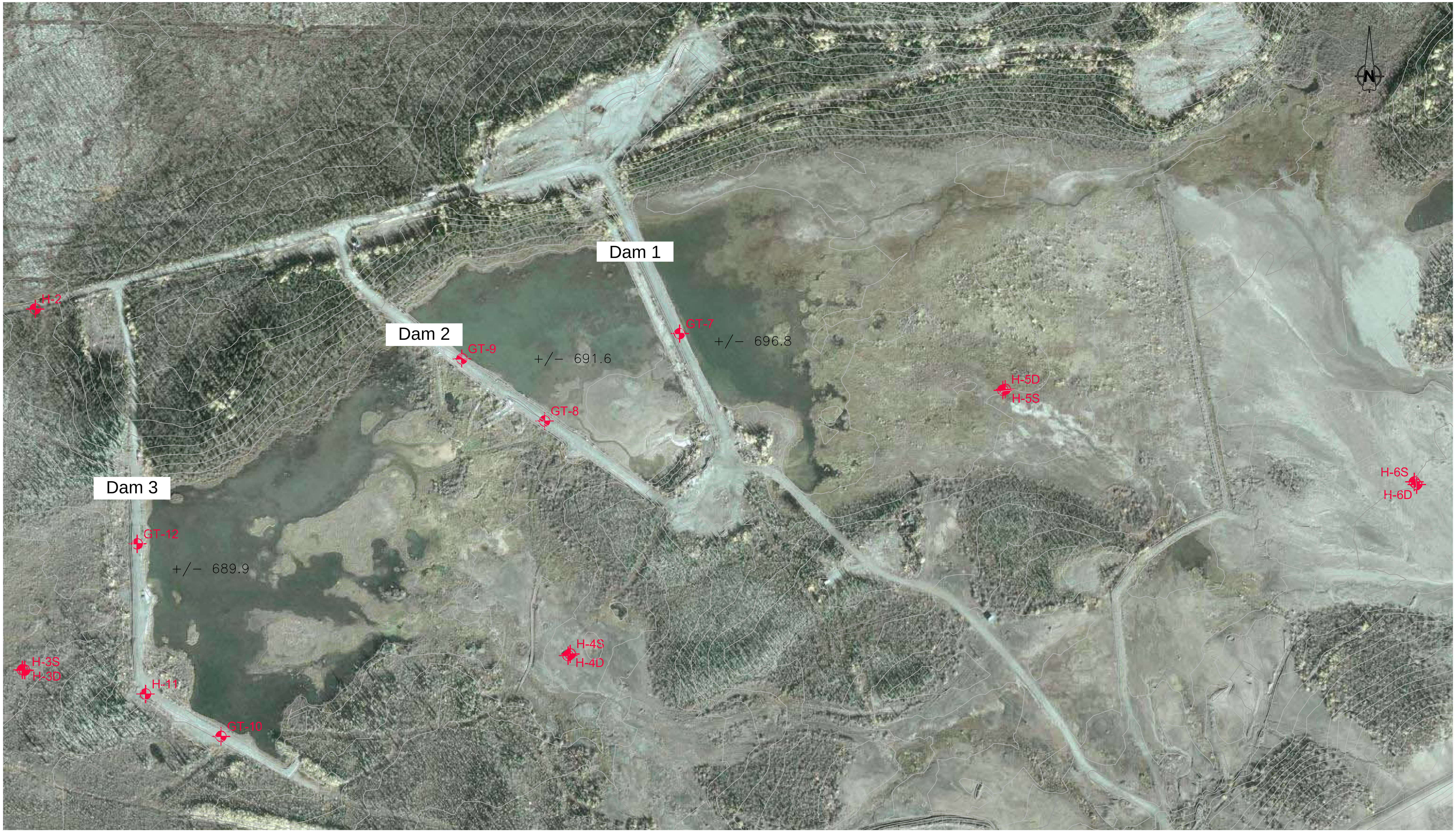
NRCAN (2007). http://earthquakescanada.nrcan.gc.ca/hazard/interpolator/index_e.php.

Pihlainen, J.A.; Johnston, G.H. (1963). Guide to a Field Description of Permafrost for Engineering Purposes. NRCC Tech. Memo. 79. 21 pp.

SRK (2007). 2007 Geotechnical Report and Hydrogeological Field Investigation. Report prepared for Elsa Reclamation and Development Company. Project No. 1CE012.000.0GT2. December 18, 2007.

Trimble, R. Telephone conversation, December 18, 2007.

Figures



LEGEND

GT-10 Completed Well Locations (Installed Oct. 2007)

Note:
GT-* locations also contain Thermistor Strings
H-* locations are Monitoring Wells only

NOTES

1. Base drawing and orthophoto provided by ERDC. Orthophoto prepared by Aero Geometrics, from photos flown September 2006 by Geodesy Remote Sensing Inc, Calgary, AB.
2. Coordinate projection is NAD83, UTM projection.
3. Contour interval is 1 metre.

0 40 80 120 160 200
Scale in Metres

SRK Consulting
Engineers and Scientists
Vancouver B.C.

SRK JOB NO.: 1CE12.000.GT2
FILE NAME: 1CE012_000–GT2–6.dwg

ERDC

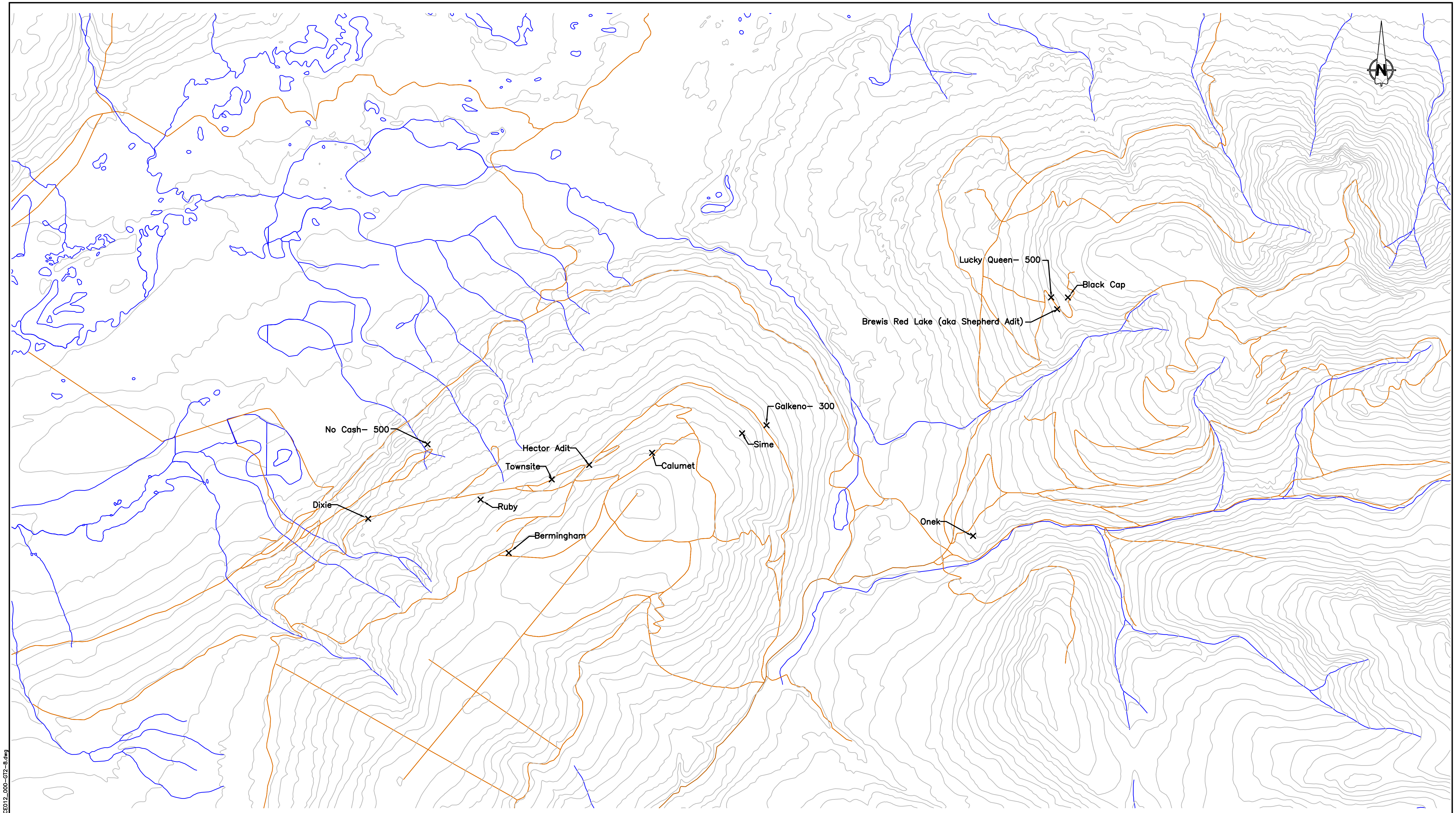
Keno Hill

2007 Geotechnical Field Investigation

Fall 2007 Borehole Locations

DATE:	APPROVED:	FIGURE:
Feb. 2008	LW	1

J:\01_SITES\UKHM\ACAD\Acad 2007\1CE012_000–GT2–6.dwg



SRK Consulting
Engineers and Scientists
Vancouver B.C.

SRK JOB NO.: 1CE12.000.GT2
FILE NAME: 1CE012_000–GT2–8.dwg

ERDC

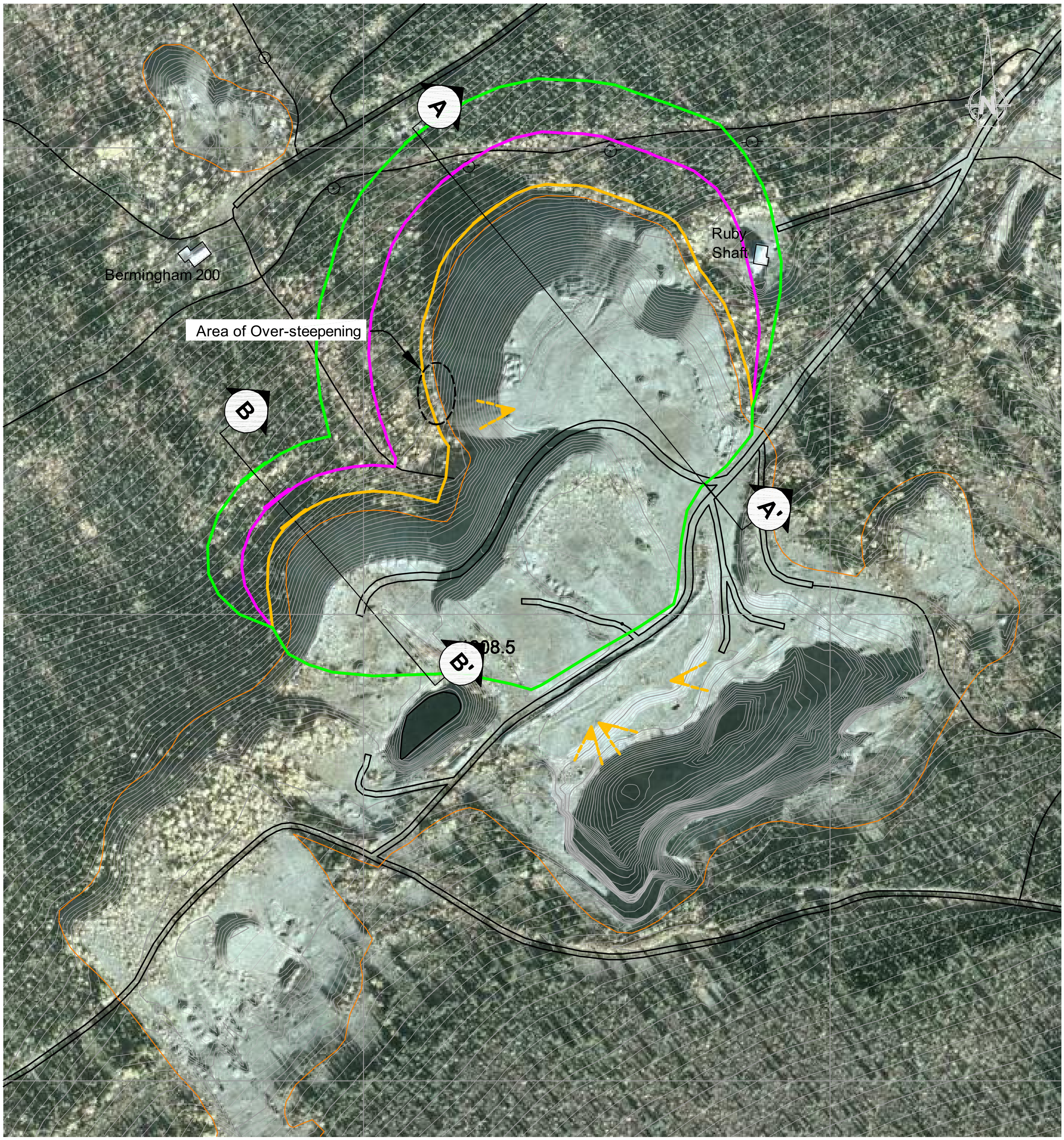
Keno Hill Project

2007 Geotechnical Closure Studies

Locations of Waste Rock Piles Inspected

DATE:	APPROVED:	FIGURE:
March 2008	DBM	2

J:\01_SITES\UKHM\!ACAD\Acad 2007\1CE012_000–GT2–8.dwg



LEGEND

- 🟩 Projected 3 to 1 Resloping Toe
- 🟪 Projected 2.5 to 1 Resloping Toe
- 🟧 Projected 2 to 1 Resloping Toe
- < Observation Point

NOTES

1. Base drawing and orthophoto provided by ERDC. Orthophoto prepared by Aero Geometrics, from photos flown September 2006 by Geodesy Remote Sensing Inc, Calgary, AB.
2. Coordinate projection is NAD83, UTM projection.
3. Contour interval is 1 metre.

0 30 60 90 120 150
Scale in Metres

SRK Consulting
Engineers and Scientists
Vancouver B.C.

ERDC

SRK JOB NO.: 1CE12.000.GT3
FILE NAME: 1CE012_000-GT2-1.dwg

Keno Hill

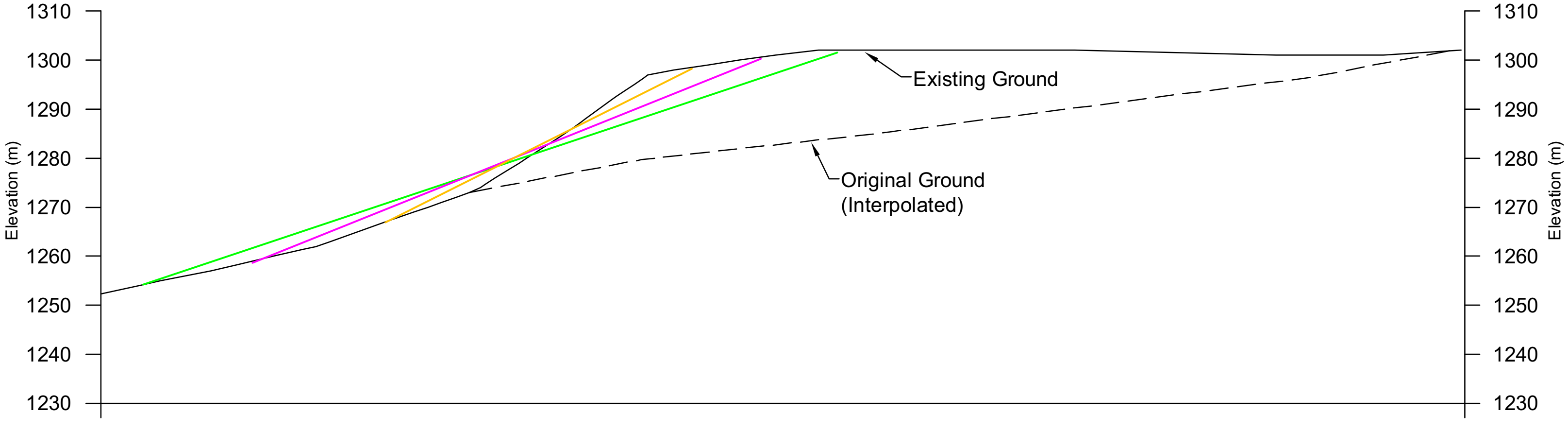
2007 Geotechnical Field Investigation

Bermingham Waste Rock Pile

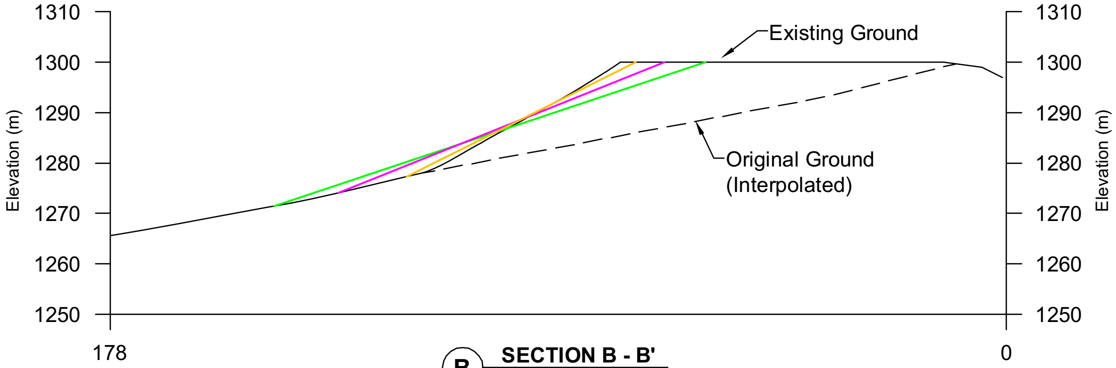
DATE: Feb. 2008
APPROVED: LW
FIGURE: 3A

J:\01_SITES\UKHM\!ACAD\Acad 2007\1CE012_000-GT2-1.dwg

J:\01_SITES\UKHM\ACAD\Acad 2007\1CE012_000-GT2-1.dwg



A SECTION A - A'



B SECTION B - B'

LEGEND

🟧	2 to 1 Resloping Line
🟪	2.5 to 1 Resloping Line
🟩	3 to 1 Resloping Line

0 10 20 30 40 50

Scale in Metres

SRK Consulting
Engineers and Scientists
Vancouver B.C.

ERDC

SRK JOB NO.: 1CE12.000.GT3

FILE NAME: 1CE012_000-GT2-1.dwg

Keno Hill

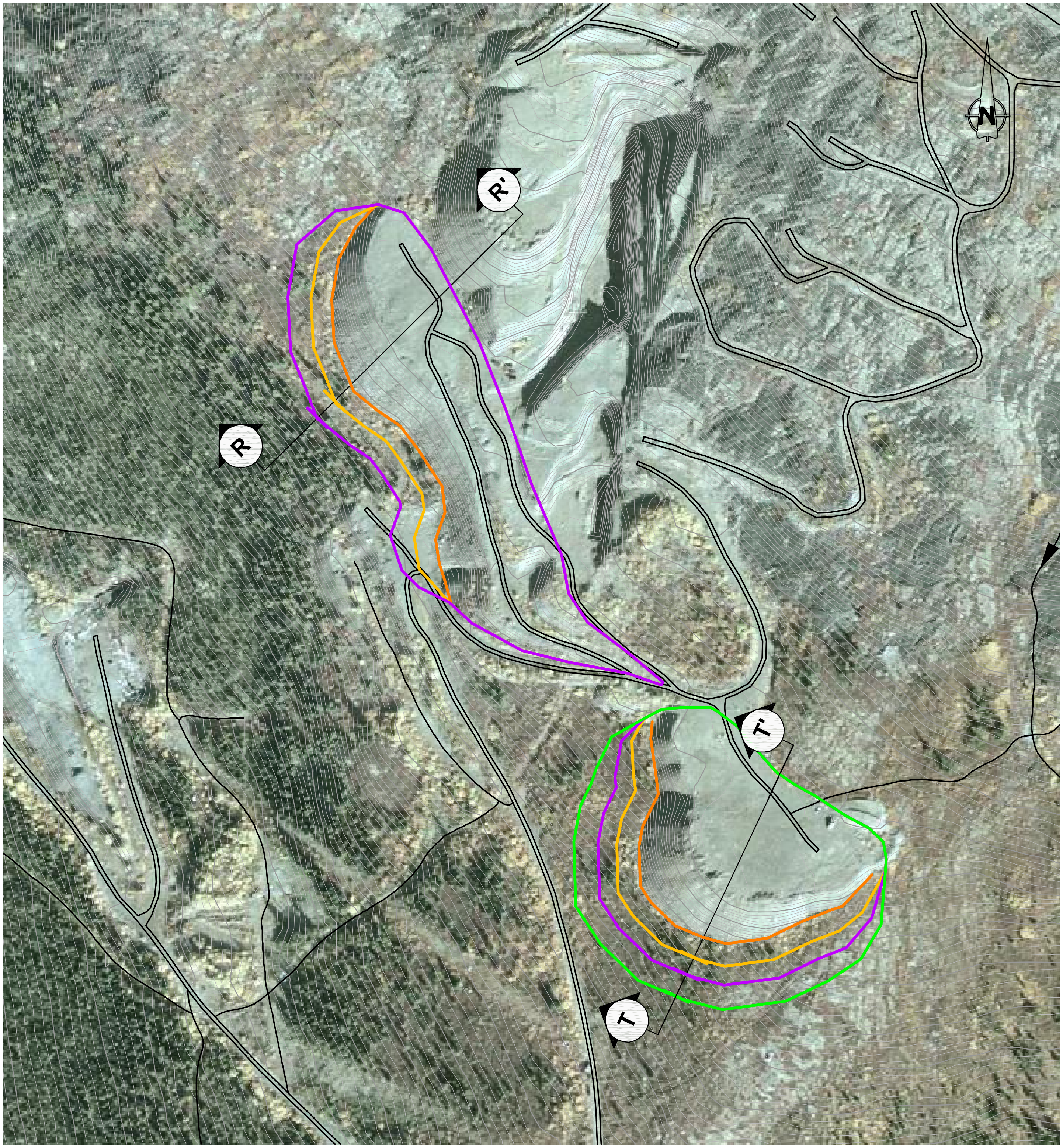
2007 Geotechnical Field Investigation

Bermingham Sections

DATE: Feb. 2008

APPROVED: LW

FIGURE: 3B



LEGEND

🟩 Projected 3 to 1 Resloping Toe
🟪 Projected 2.5 to 1 Resloping Toe
🟧 Projected 2 to 1 Resloping Toe
< Observation Point

NOTES

1. Base drawing and orthophoto provided by ERDC. Orthophoto prepared by Aero Geometrics, from photos flown September 2006 by Geodesy Remote Sensing Inc, Calgary, AB.
2. Coordinate projection is NAD83, UTM projection.
3. Contour interval is 1 metre.

0 30 60 90 120 150
Scale in Metres

SRK Consulting
Engineers and Scientists
Vancouver B.C.

ERDC

2007 Geotechnical Field Investigation

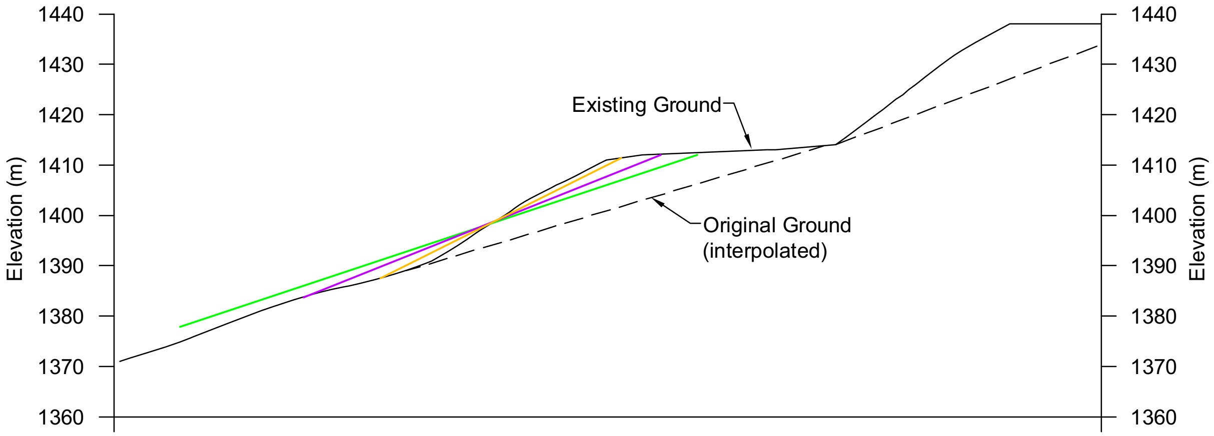
Black Cap Waste Rock Pile

SRK JOB NO.: 1CE12.000.GT3
FILE NAME: 1CE012_000-GT2-5.dwg

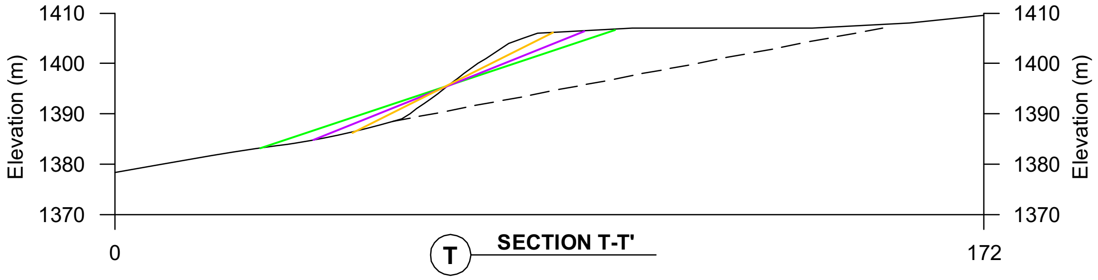
Keno Hill

DATE:	APPROVED:	FIGURE:
Feb. 2008	LW	4A

J:\01_SITES\UKHM\ACAD\Acad 2007\1CE012_000-GT2-5.dwg



R **SECTION R-R'**



T **SECTION T-T'**

LEGEND

🟨 2 to 1 Resloping Line

🟪 2.5 to 1 Resloping Line

🟩 3 to 1 Resloping Line

0 10 20 30 40 50
Scale in Metres

SRK Consulting
Engineers and Scientists
Vancouver B.C.

ERDC

SRK JOB NO.: 1CE12.000.GT3
FILE NAME: 1CE012_000-GT2-5.dwg

Keno Hill

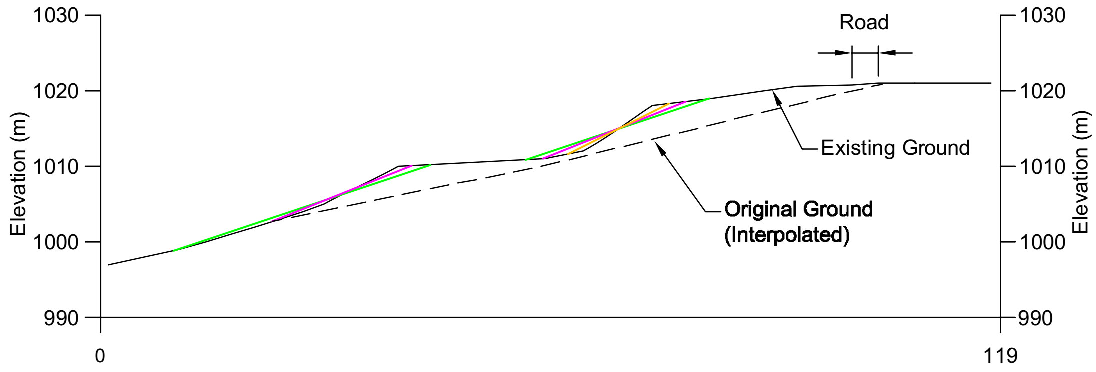
2007 Geotechnical Field Investigation

Black Cap Sections

DATE:	APPROVED:	FIGURE:
Feb. 2008	LW	4B

J:\01_SITES\UKHM\ACAD\Acad 2007\1CE012_000-GT2-5.dwg

PLAN



U SECTION U - U'

LEGEND

- 🟩 Projected 3 to 1 Resloping Line
- 🟪 Projected 2.5 to 1 Resloping Line
- 🟧 Projected 2 to 1 Resloping Line
- < Observation Point

NOTES

1. Base drawing and orthophoto provided by ERDC. Orthophoto prepared by Aero Geometrics, from photos flown September 2006 by Geodesy Remote Sensing Inc, Calgary, AB.
2. Coordinate projection is NAD83, UTM projection.
3. Contour interval is 1 metre.

0 10 20 30 40 50

Scale in Metres

SRK Consulting
Engineers and Scientists
Vancouver B.C.

ERDC

2007 Geotechnical Field Investigation

Dixie Waste Rock Pile
Plan and Section

SRK JOB NO.: 1CE12.000.GT3

FILE NAME: 1CE012_000-GT2-1.dwg

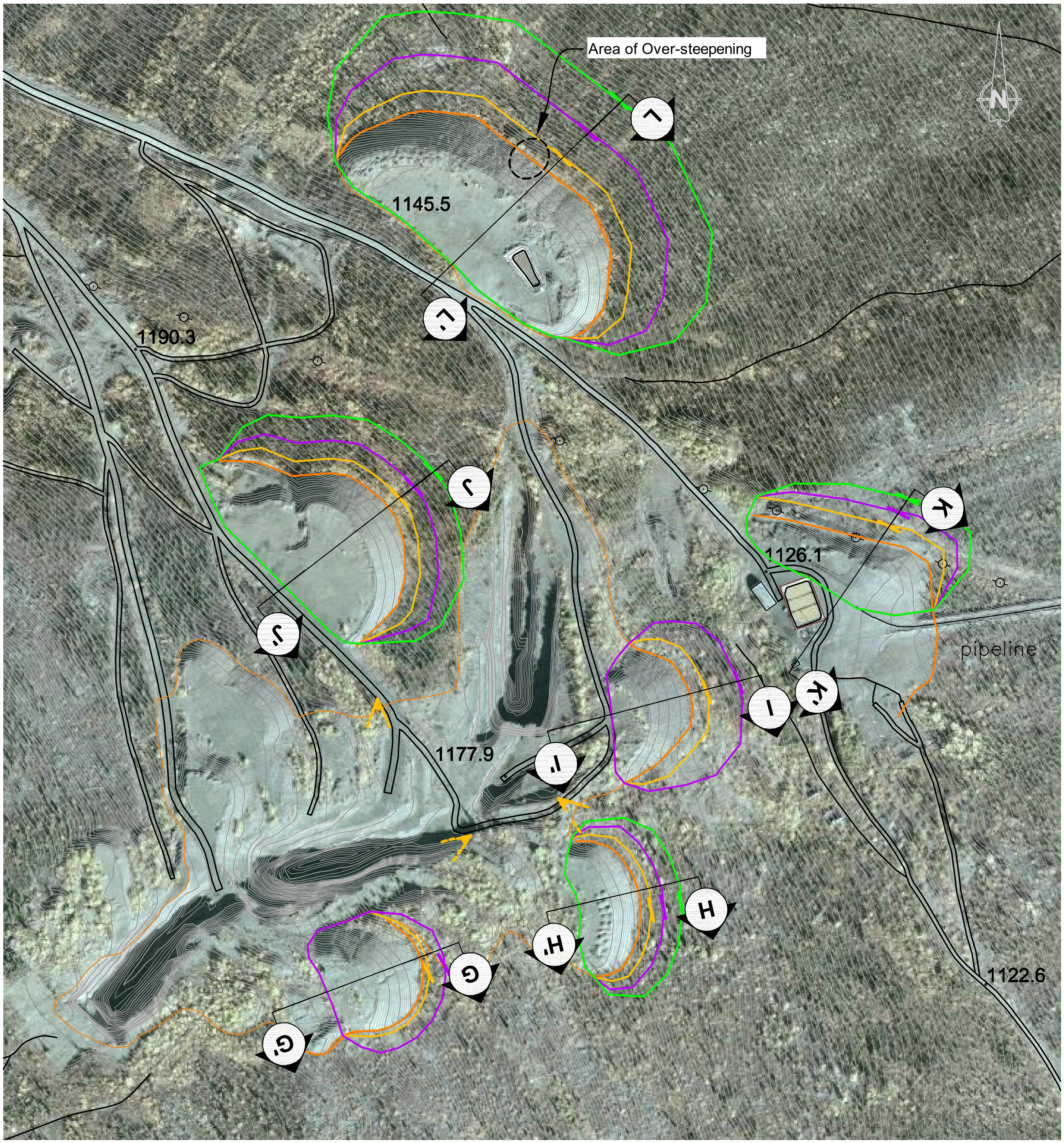
Keno Hill

DATE: Feb. 2008

APPROVED: LW

FIGURE: 5

J:\01_SITES\UKHM\ACAD\Acad 2007\1CE012_000-GT2-1.dwg



LEGEND

🟩	Projected 3 to 1 Resloping Toe
🟪	Projected 2.5 to 1 Resloping Toe
🟨	Projected 2 to 1 Resloping Toe
<	Observation Point

NOTES

1. Base drawing and orthophoto provided by ERDC. Orthophoto prepared by Aero Geometrics, from photos flown September 2006 by Geodesy Remote Sensing Inc, Calgary, AB.
2. Coordinate projection is NAD83, UTM projection.
3. Contour interval is 1 metre.

0 40 80 120 160 200
Scale in Metres

SRK Consulting
Engineers and Scientists
Vancouver B.C.

ERDC

Keno Hill

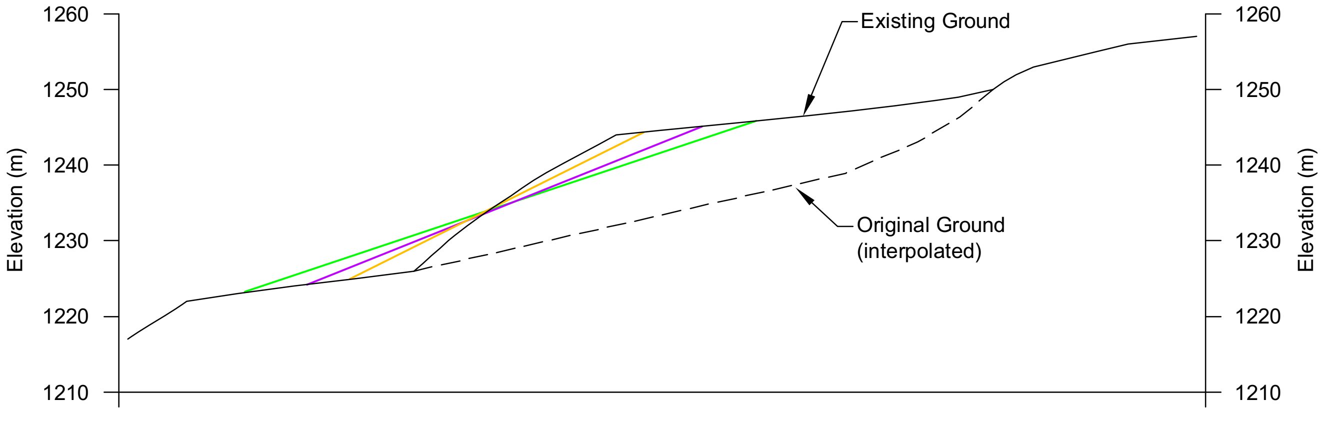
2007 Geotechnical Field Investigation

Galkeno 300 and Sime
Waste Rock Piles

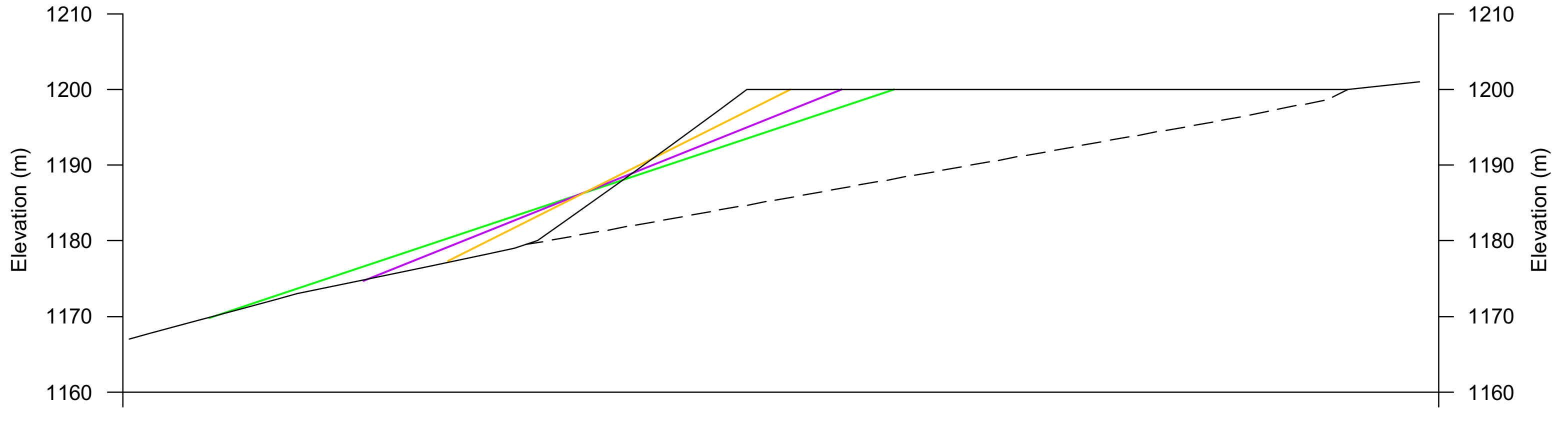
SRK JOB NO.:	1CE12.000.GT3
FILE NAME:	1CE012_000-GT2-2.dwg

DATE:	APPROVED:	FIGURE:
Feb. 2008	LW	6A

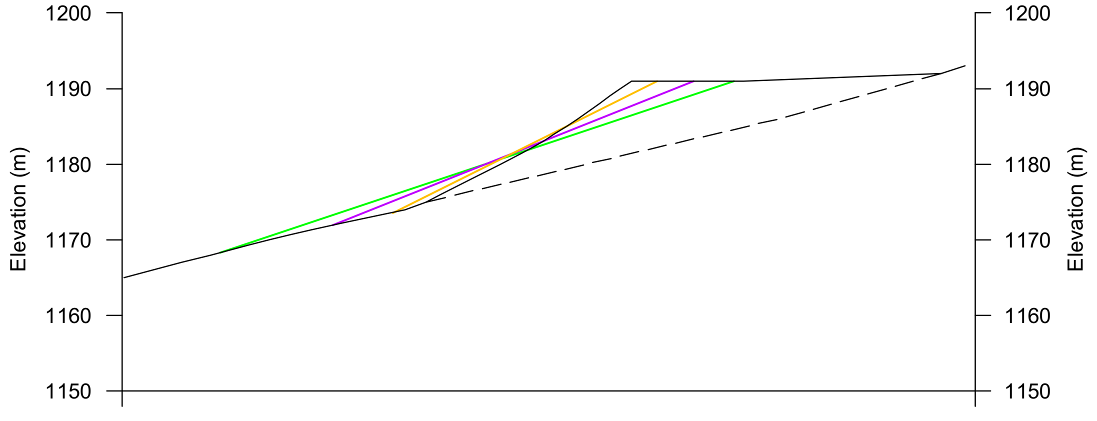
J:\01_SITES\UKHM\ACAD\Acad 2007\1CE012_000-GT2-2.dwg



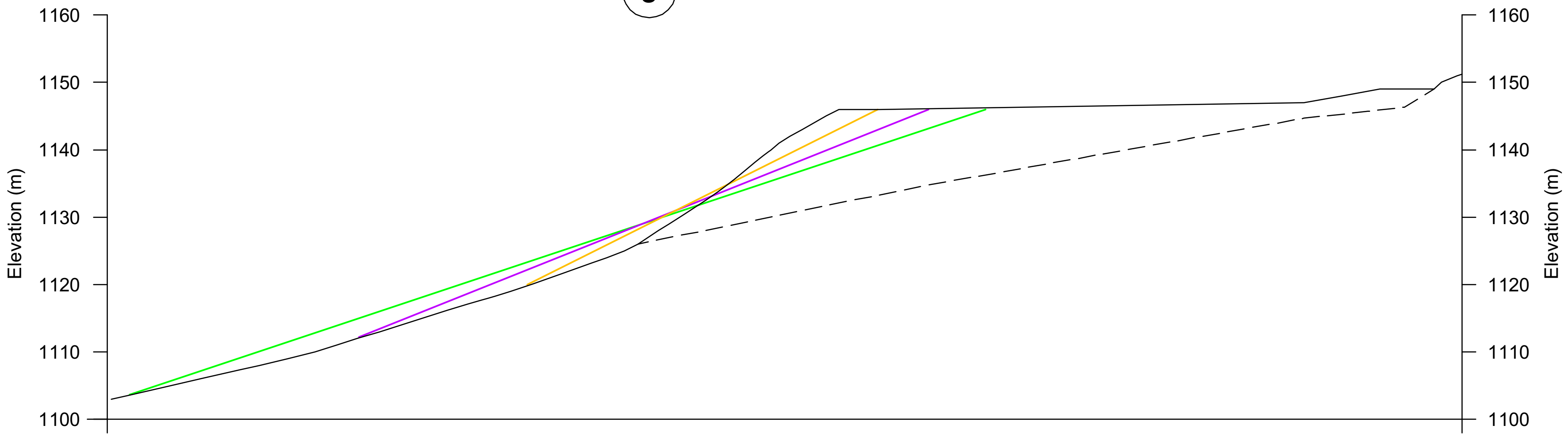
G SECTION G-G'



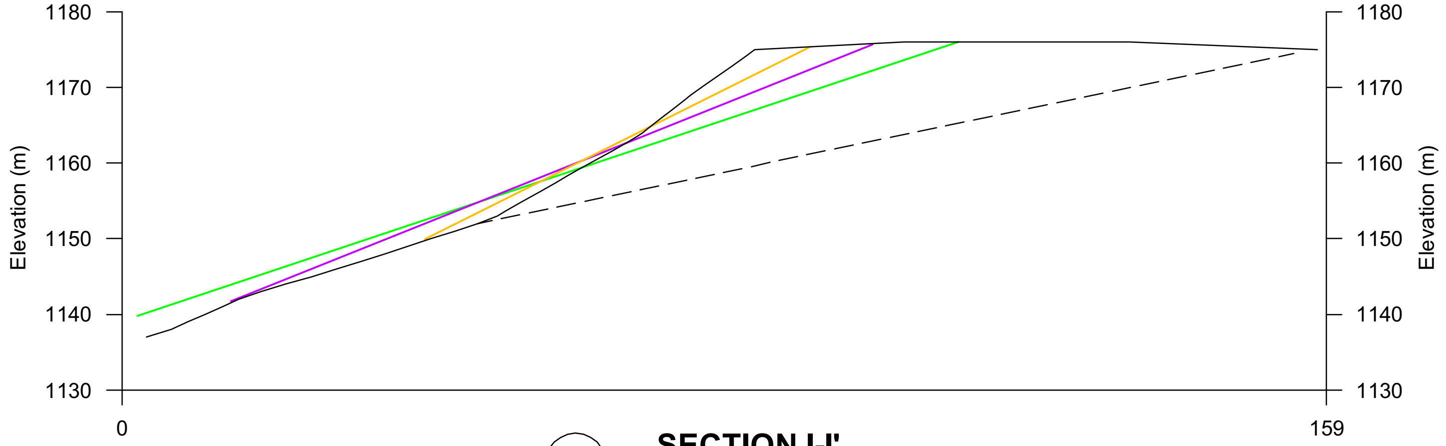
J SECTION J-J'



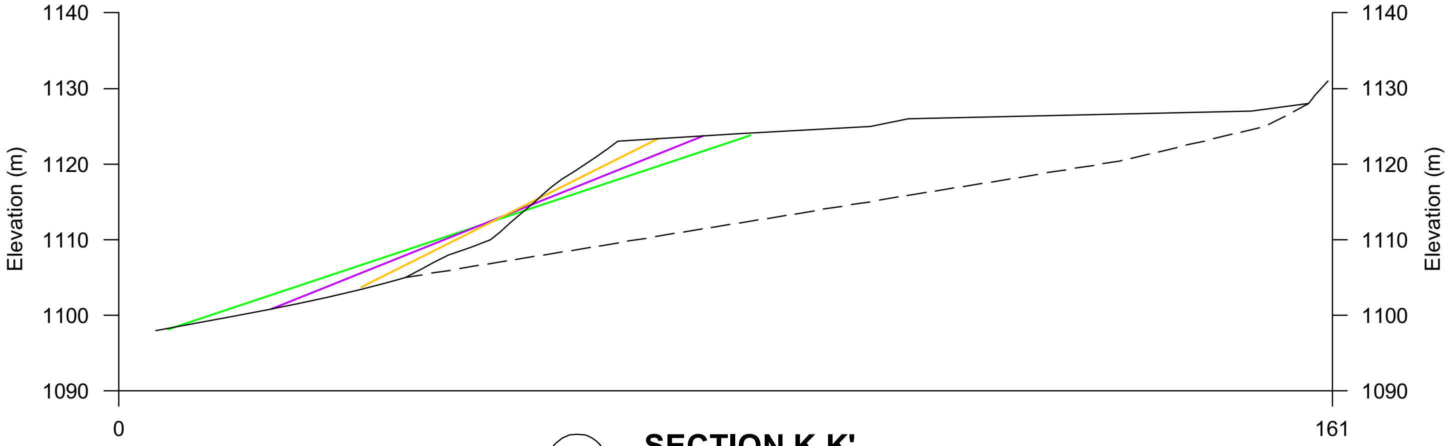
H SECTION H-H'



L SECTION L-L'



I SECTION I-I'



K SECTION K-K'

LEGEND

🟨	2 to 1 Resloping Line
🟪	2.5 to 1 Resloping Line
🟩	3 to 1 Resloping Line

0 10 20 30 40 50
Scale in Metres

SRK Consulting
Engineers and Scientists
Vancouver B.C.

SRK JOB NO.: 1CE12.000.GT3
FILE NAME: 1CE012_000-GT2-2.dwg

ERDC

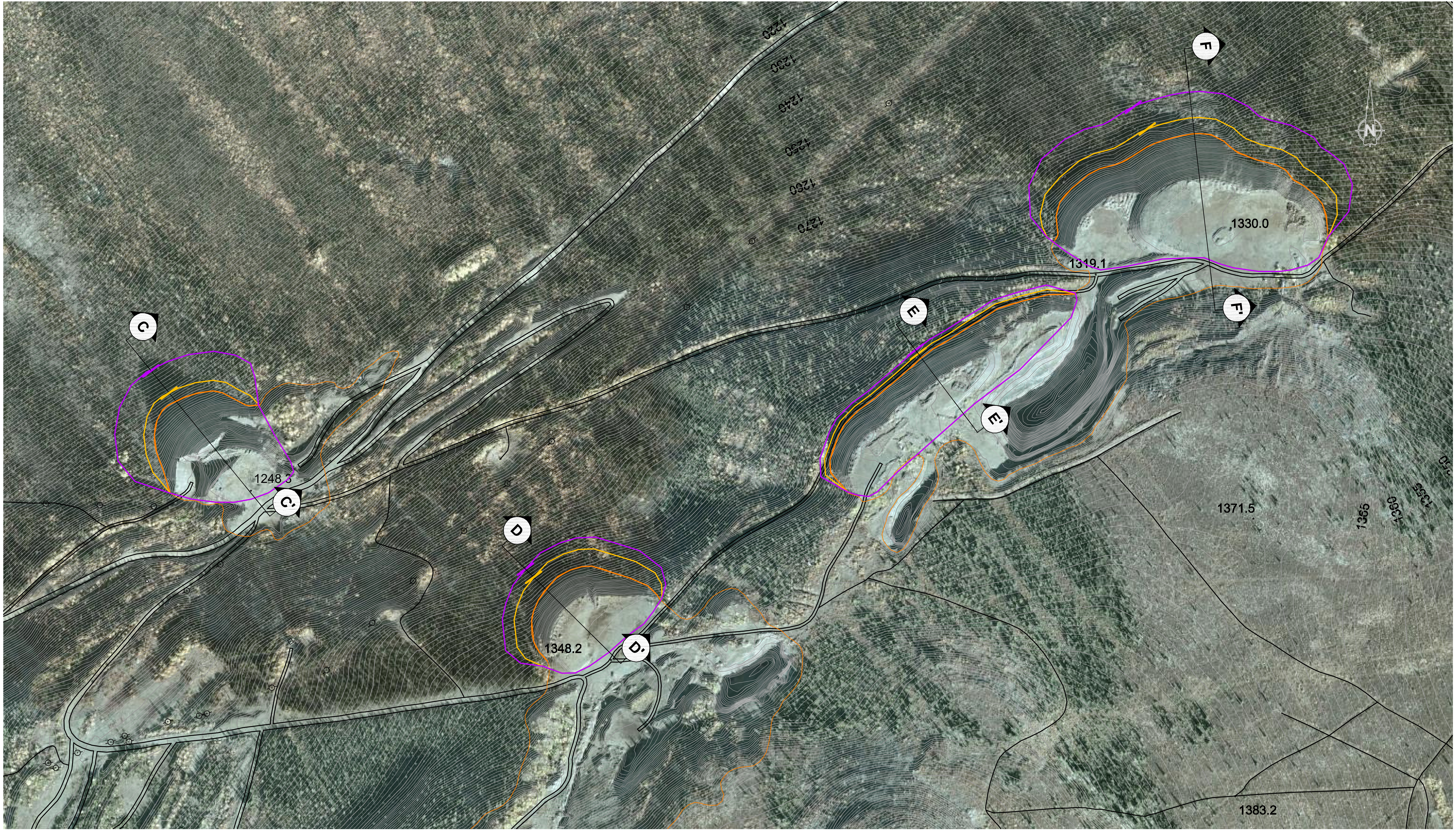
Keno Hill

2007 Geotechnical Field Investigation

Galkeno 300 and Sime Sections

DATE: Feb. 2008
APPROVED: LW
FIGURE: 6B

J:\01_SITES\UKHM\ACAD\Acad 2007\1CE012_000-GT2-2.dwg



LEGEND

- 🟩 Projected 3 to 1 Resloping Toe
- 🟪 Projected 2.5 to 1 Resloping Toe
- 🟨 Projected 2 to 1 Resloping Toe

NOTES

1. Base drawing and orthophoto provided by ERDC. Orthophoto prepared by Aero Geometrics, from photos flown September 2006 by Geodesy Remote Sensing Inc, Calgary, AB.
2. Coordinate projection is NAD83, UTM projection.
3. Contour interval is 1 metre.

0 40 80 120 160 200
Scale in Metres

SRK Consulting
Engineers and Scientists
Vancouver B.C.

SRK JOB NO.: 1CE12.000.GT3
FILE NAME: 1CE012_000-GT2-2.dwg

ERDC

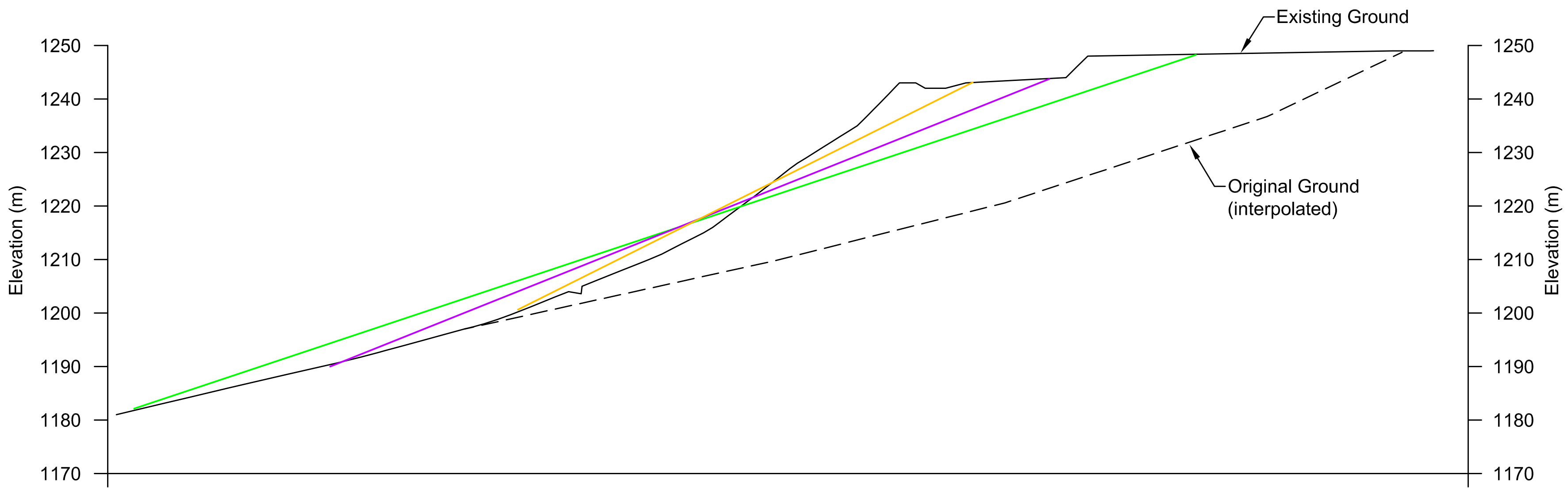
Keno Hill

2007 Geotechnical Field Investigation

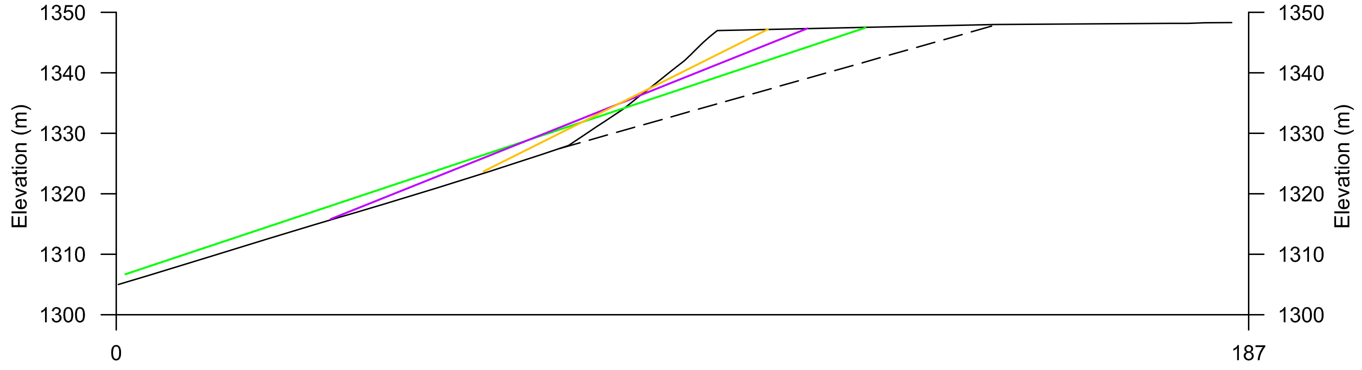
Hector and Calumet
Waste Rock Piles

DATE: Feb. 2008
APPROVED: LW
FIGURE: 7A

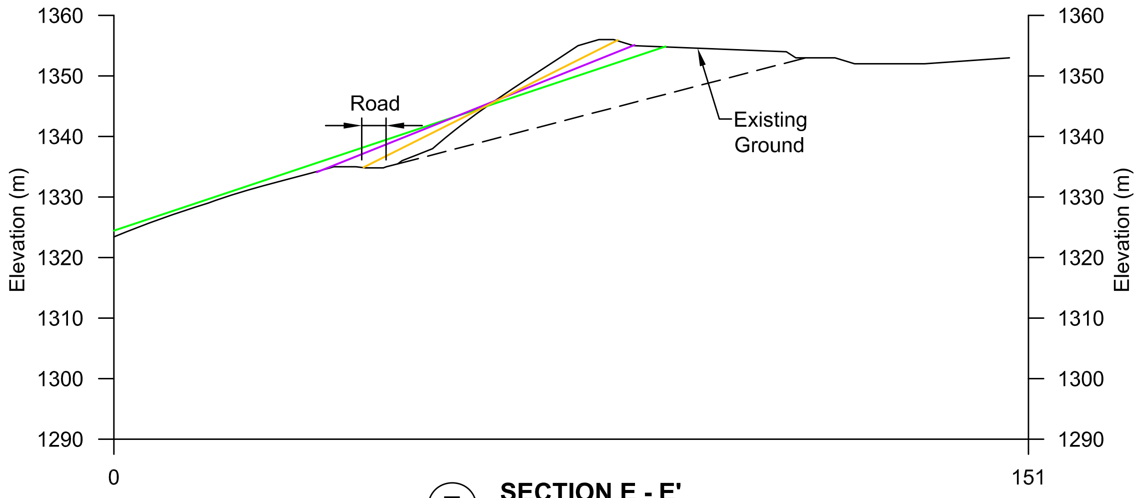
J:\01_SITES\UKHM\!ACAD\Acad 2007\1CE012_000-GT2-2.dwg



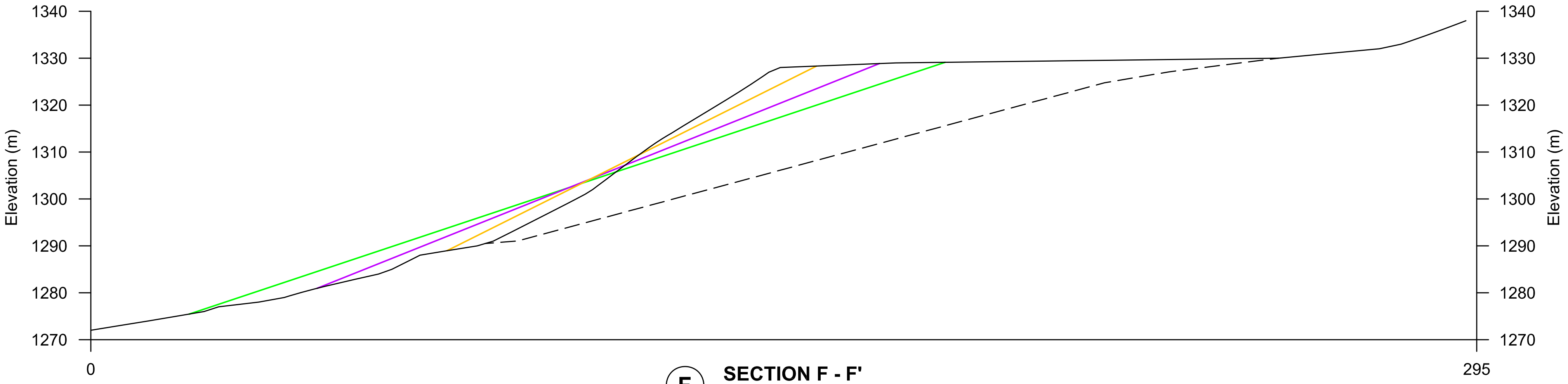
C **SECTION C - C'**



D **SECTION D - D'**



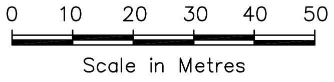
E **SECTION E - E'**



F **SECTION F - F'**

LEGEND

🟧	2 to 1 Resloping Line
🟪	2.5 to 1 Resloping Line
🟩	3 to 1 Resloping Line



SRK Consulting
Engineers and Scientists
Vancouver B.C.

ERDC

2007 Geotechnical Field Investigation

Hector and Calumet Sections

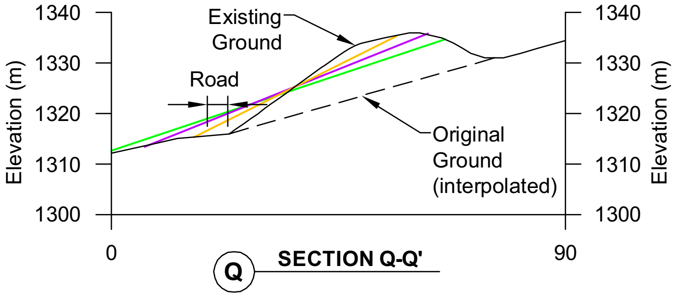
SRK JOB NO.: 1CE12.000.GT3
FILE NAME: 1CE012_000-GT2-2.dwg

Keno Hill

DATE: Feb. 2008
APPROVED: LW
FIGURE: 7B

J:\01_SITES\UKHM\ACAD\Acad 2007\1CE012_000-GT2-2.dwg

PLAN



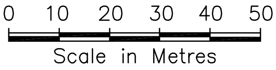
SECTION Q-Q'

LEGEND

🟩	Projected 3 to 1 Resloping Line
🟪	Projected 2.5 to 1 Resloping Line
🟧	Projected 2 to 1 Resloping Line
<	Observation Point

NOTES

1. Base drawing and orthophoto provided by ERDC. Orthophoto prepared by Aero Geometrics, from photos flown September 2006 by Geodesy Remote Sensing Inc, Calgary, AB.
2. Coordinate projection is NAD83, UTM projection.
3. Contour interval is 1 metre.



SRK Consulting
Engineers and Scientists
Vancouver B.C.

ERDC

2007 Geotechnical Field Investigation

Lucky Queen Waste Rock Pile
Plan and Section

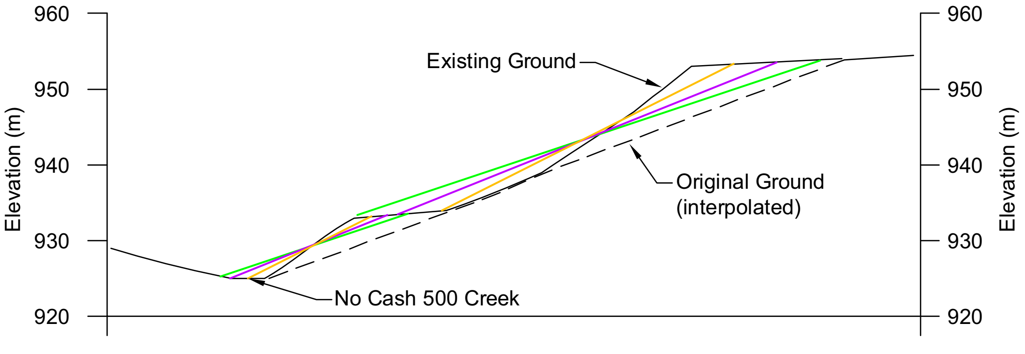
SRK JOB NO.: 1CE12.000.GT3
FILE NAME: 1CE012_000-GT2-5.dwg

Keno Hill

DATE: Feb. 2008
APPROVED: LW
FIGURE: 8

J:\01_SITES\UKHM\ACAD\Acad 2007\1CE012_000-GT2-5.dwg

PLAN



SECTION Y - Y'

LEGEND

- Projected 3 to 1 Resloping Line
- Projected 2.5 to 1 Resloping Line
- Projected 2 to 1 Resloping Line
- Observation Point

NOTES

1. Base drawing and orthophoto provided by ERDC. Orthophoto prepared by Aero Geometrics, from photos flown September 2006 by Geodesy Remote Sensing Inc, Calgary, AB.
2. Coordinate projection is NAD83, UTM projection.
3. Contour interval is 1 metre.

0 10 20 30 40 50
Scale in Metres

J:\01_SITES\UKHM\ACAD\Acad 2007\1CE012_000-GT2-2.dwg

SRK Consulting
Engineers and Scientists
Vancouver B.C.

SRK JOB NO.: 1CE12.000.GT3
FILE NAME: 1CE012_000-GT2-2.dwg

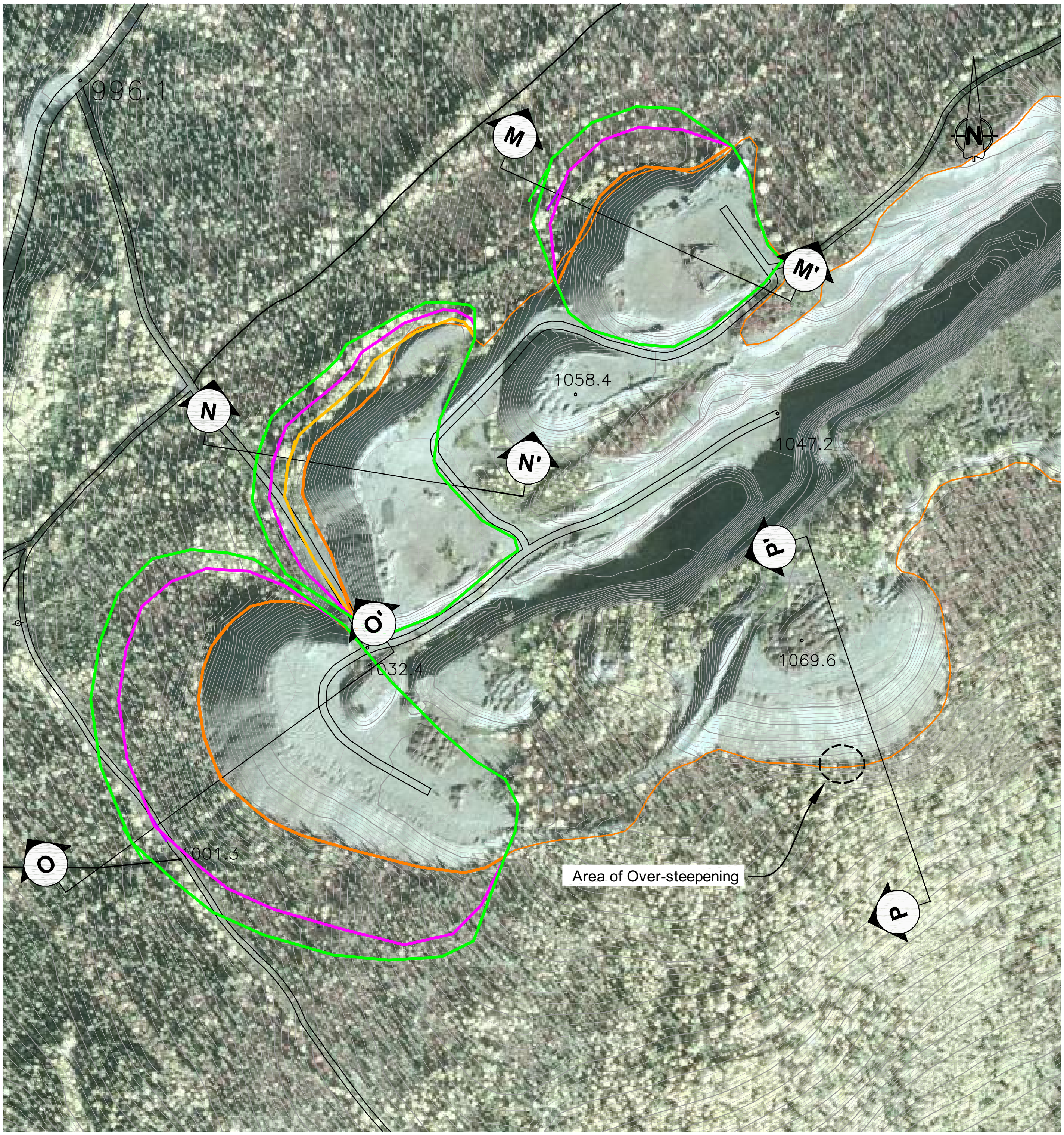
ERDC

Keno Hill

2007 Geotechnical Field Investigation

No Cash 500 Waste Rock Pile
Plan and Section

DATE: Feb. 2008
APPROVED: LW
FIGURE: 9



LEGEND

🟩	Projected 3 to 1 Resloping Toe
🟪	Projected 2.5 to 1 Resloping Toe
🟧	Projected 2 to 1 Resloping Toe
<	Observation Point

NOTES

1. Base drawing and orthophoto provided by ERDC. Orthophoto prepared by Aero Geometrics, from photos flown September 2006 by Geodesy Remote Sensing Inc, Calgary, AB.
2. Coordinate projection is NAD83, UTM projection.
3. Contour interval is 1 metre.

0 30 60 90 120 150
Scale in Metres

SRK Consulting
Engineers and Scientists
Vancouver B.C.

ERDC

2007 Geotechnical Field Investigation

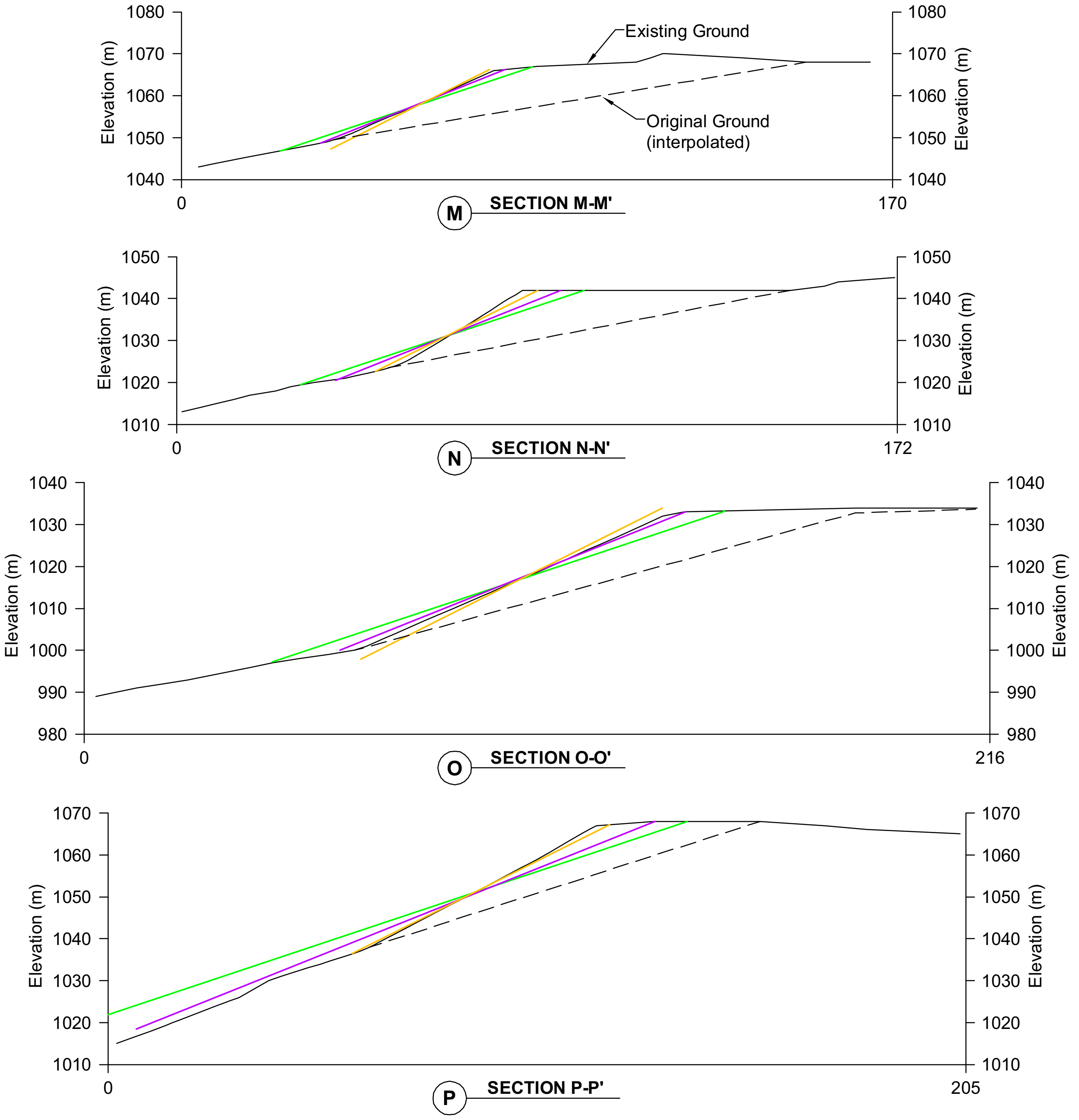
Onek Waste Rock Piles

Keno Hill

SRK JOB NO.: 1CE12.000.GT3
FILE NAME: 1CE012_000-GT2-3.dwg

DATE: Feb. 2008
APPROVED: LW
FIGURE: 10A

J:\01_SITES\UKHM\ACAD\Acad 2007\1CE012_000-GT2-3.dwg



LEGEND

- 2 to 1 Resloping Line
- 2.5 to 1 Resloping Line
- 3 to 1 Resloping Line

0 10 20 30 40 50
Scale in Metres

J:\01_SITES\UKHM\ACAD\Acad 2007\1CE012_000-GT2-3.dwg

SRK Consulting
Engineers and Scientists
Vancouver B.C.

ERDC

2007 Geotechnical Field Investigation

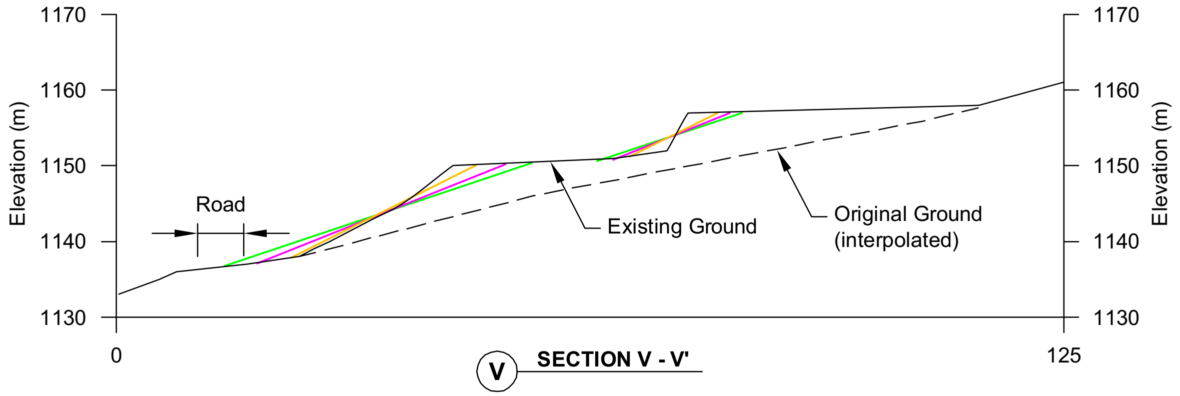
Onek Sections

SRK JOB NO.: 1CE12.000.GT3
FILE NAME: 1CE012_000-GT2-3.dwg

Keno Hill

DATE:	APPROVED:	FIGURE:
Feb. 2008	LW	10B

PLAN



SECTION V - V'

LEGEND

🟩	Projected 3 to 1 Resloping Line
🟪	Projected 2.5 to 1 Resloping Line
🟧	Projected 2 to 1 Resloping Line
<	Observation Point

NOTES

1. Base drawing and orthophoto provided by ERDC. Orthophoto prepared by Aero Geometrics, from photos flown September 2006 by Geodesy Remote Sensing Inc, Calgary, AB.
2. Coordinate projection is NAD83, UTM projection.
3. Contour interval is 1 metre.

0 10 20 30 40 50
Scale in Metres

SRK Consulting
Engineers and Scientists
Vancouver B.C.

ERDC

2007 Geotechnical Field Investigation

Ruby Waste Rock Pile
Plan and Section

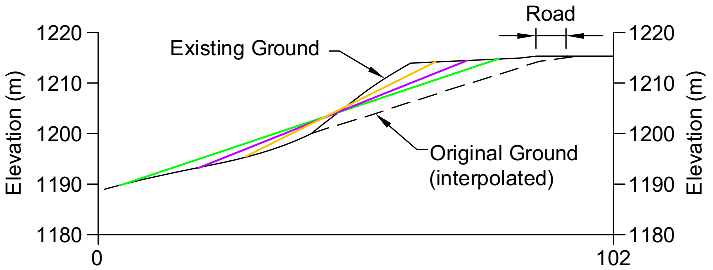
SRK JOB NO.: 1CE12.000.GT3
FILE NAME: 1CE012_000-GT2-1.dwg

Keno Hill

DATE: Feb. 2008
APPROVED: LW
FIGURE: 11

J:\01_SITES\UKHM\ACAD\Acad 2007\1CE012_000-GT2-1.dwg

PLAN



X SECTION X - X'

LEGEND

—	Projected 3 to 1 Resloping Line
—	Projected 2.5 to 1 Resloping Line
—	Projected 2 to 1 Resloping Line
<	Observation Point

NOTES

1. Base drawing and orthophoto provided by ERDC. Orthophoto prepared by Aero Geometrics, from photos flown September 2006 by Geodesy Remote Sensing Inc, Calgary, AB.
2. Coordinate projection is NAD83, UTM projection.
3. Contour interval is 1 metre.

0 10 20 30 40 50
Scale in Metres

J:\01_SITES\UKHM\ACAD\Acad 2007\1CE012_000-GT2-2.dwg

SRK Consulting
Engineers and Scientists
Vancouver B.C.

SRK JOB NO.: 1CE12.000.GT3
FILE NAME: 1CE012_000-GT2-2.dwg

ERDC

Keno Hill

2007 Geotechnical Field Investigation

Townsite Waste Rock Pile
Plan and Section

DATE:	APPROVED:	FIGURE:
Feb. 2008	LW	12

Appendices

Appendix A

Drill Logs

BOREHOLE LOG LEGEND

▩	Ice lens [Vs]
▨	Gravel, grey, well graded, trace fines [GW].
▨	Gravel, light brown, well graded, trace fines, some organics (~10%) [GW]
▨	Gravel, grey, well graded, trace fines, wet [GW]
≈	Peat, black, fibrous [Pt]
≈	Peat, black, fibrous with wood fragments, wet [Pt]
▤	Bedrock, greenstone
⁘	Sand, coarse, light grey, some gravel [SP]
▥	Silty sand, grey [SM]
▨	Silty sand, brown, compact [SM]
▨	Sand, grey, well graded, wet [SW]
▤	Tailings, silty sand, brown [SM]
▤	No recovery [assumed tailings and peat, SM/Pt]
▤	No recovery, water returned [assumed tailings and peat, SM/Pt]
▤	Tailings, silty sand, brown, very loose, wet [SM]

J:\01_SITES\UKHM\ACAD\Acad 2007\DrillLogLegend.dwg

SRK Consulting
Engineers and Scientists
Vancouver B.C.

SRK JOB NO.: 1CE12.000.GT2
FILE NAME: DrillLogLegend.dwg

ERDC

Keno Hill

2007 Geotechnical Report and
Hydrogeological Field Investigation

Borehole Log Legend

DATE: Feb. 08
APPROVED: LW
FIGURE: -

PIEZOMETER WELL LEGEND

▨	Bentonite
◬	Cement
⁘	Clean sand, grey, poorly graded, little or no fines [SP]
○	Gravel, grey, well graded, trace fines [GW]
〰	Peat, black, fibrous [Pt]
▩	Sloughed material
‖	PVC Pipe
☰	PVC Screen

SRK Consulting
Engineers and Scientists
Vancouver B.C.

ERDC

SRK JOB NO.: 1CE12.000.GT2
FILE NAME: Piezo Well Legend.dwg

Keno Hill

2007 Geotechnical Report and Hydrogeological Field Investigation

Piezometer Well Legend

DATE:	APPROVED:	FIGURE:
Feb. 08	LW	-

J:\01_SITES\UKHM\ACAD\Acad 2007\Piezo Well Legend.dwg

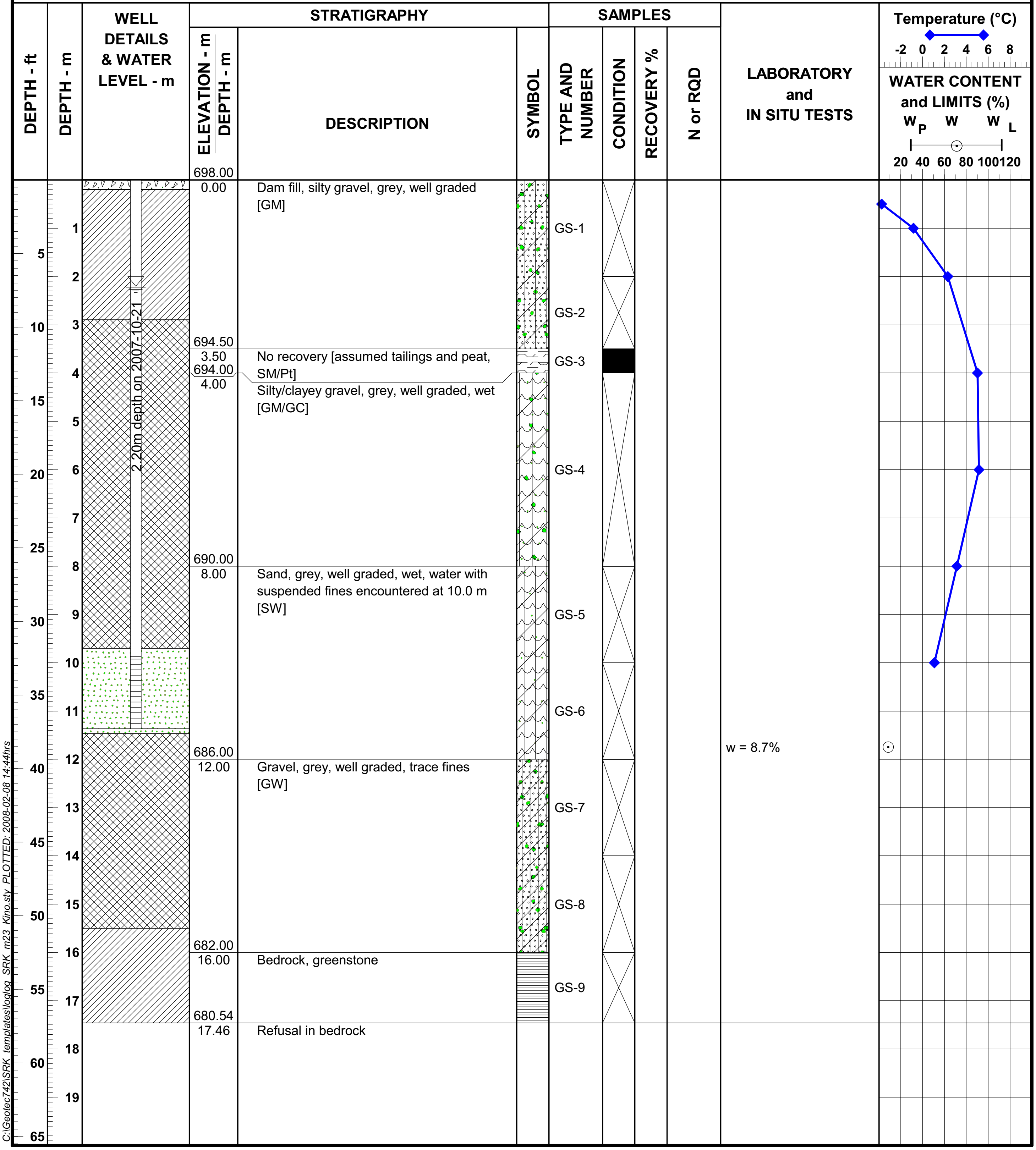
SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT: Keno Hill
LOCATION: Middle of Dam #1
FILE No: UNITED KENO HILL (1CE012.000)
BORING DATE: 2007-10-21 **TO** 2007-10-21
DIP: 90.00 **AZIMUTH:**
COORDINATES: 7088572.99 N 474925.82 E **DATUM:** NAD83

BOREHOLE: GT7
PAGE: 1 **OF** 1
DRILL TYPE: Air Return
DRILL: Becker Hammer
CASING: Double Walled

SAMPLE CONDITION		TYPE OF SAMPLER		LABORATORY AND IN SITU TESTS			
☒	Remoulded	DC	Diamond core barrel	C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
▨	Undisturbed	GS	Grab sample	D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
■	Lost	SS	Split spoon	Dr	Specific gravity	PS	Particle size analysis
◧	Core			Ksat	Saturated hydraulic cond. (cm/s)		



ELEVATION - m DEPTH - m	DESCRIPTION
698.00 0.00	Dam fill, silty gravel, grey, well graded [GM]
694.50 3.50	No recovery [assumed tailings and peat, SM/Pt]
694.00 4.00	Silty/clayey gravel, grey, well graded, wet [GM/GC]
690.00 8.00	Sand, grey, well graded, wet, water with suspended fines encountered at 10.0 m [SW]
686.00 12.00	Gravel, grey, well graded, trace fines [GW]
682.00 16.00	Bedrock, greenstone
680.54 17.46	Refusal in bedrock

TYPE AND NUMBER	CONDITION
GS-1	☒
GS-2	☒
GS-3	■
GS-4	☒
GS-5	☒
GS-6	☒
GS-7	☒
GS-8	☒
GS-9	☒

DEPTH - m	LABORATORY and IN SITU TESTS
11.7	w = 8.7%

C:\Geotec742\SRK templates\loglog SRK m23 Kino.sty PLOTTED: 2008-02-08 14:44hrs

SRK Consulting
Engineers and Scientists

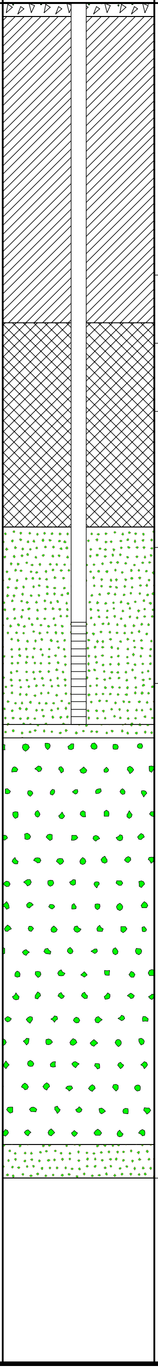
BOREHOLE LOG

PROJECT: Keno Hill
LOCATION: Crest of Dam #2 at South end
FILE No: UNITED KENO HILL (1CE012.000)
BORING DATE: 2007-10-20 **TO** 2007-10-20
DIP: 90.00 **AZIMUTH:**
COORDINATES: 7088474.99 N 474774.58 E **DATUM:** NAD83

BOREHOLE: GT8
PAGE: 1 **OF** 1
DRILL TYPE: Air Return
DRILL: Becker Hammer
CASING: Double Walled

SAMPLE CONDITION		TYPE OF SAMPLER		LABORATORY AND IN SITU TESTS			
☒	Remoulded	DC	Diamond core barrel	C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
▨	Undisturbed	GS	Grab sample	D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
■	Lost	SS	Split spoon	Dr	Specific gravity	PS	Particle size analysis
◧	Core			Ksat	Saturated hydraulic cond. (cm/s)		

WELL DETAILS & WATER LEVEL - m



STRATIGRAPHY

ELEVATION - m DEPTH - m	DESCRIPTION
695.24 0.00	Dam fill, silty gravel, grey, well graded [GM]
691.24 4.00	No recovery [assumed tailings and peat, SM/Pt]
690.24 5.00	Sand, dark grey, well graded, moist [SW]
689.24 6.00	Gravel, grey, well graded, trace fines, loose, poor recovery [GW]
687.24 8.00	Gravelly sand, dark grey, poorly graded, few fines [SP]. Water encountered at 8.6 m
685.24 10.00	Gravel, grey, well graded, trace fines grading to silty gravel with depth [GW/GM]
677.97 17.27	Refusal - no sample collected [assumed bedrock based on drill response]

SAMPLES

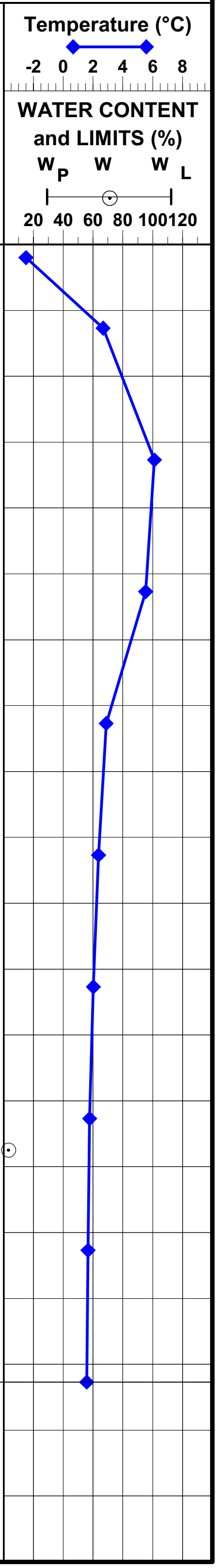
TYPE AND NUMBER	CONDITION	RECOVERY %	N or RQD
GS-1	☒		
GS-2	☒		
GS-3	☒		
GS-4	■		
GS-5	☒		
GS-6	☒		
GS-7	☒		
GS-8	☒		
GS-9	☒		

LABORATORY and IN SITU TESTS

25 drill blows between 7.2 - 7.5 m

w = 3.4%

73 drill blows between 12.2 - 12.5 m



C:\Geotec742\SRK templates\loglog SRK m23 Kino.sty PLOTTED: 2008-02-08 14:44hrs

SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT: Keno Hill
LOCATION: Crest of Dam #2 at North end
FILE No: UNITED KENO HILL (1CE012.000)
BORING DATE: 2007-10-19 **TO** 2007-10-19
DIP: 90.00 **AZIMUTH:**
COORDINATES: 7088544.67 N 474681.70 E **DATUM:** NAD83

BOREHOLE: GT9
PAGE: 1 **OF** 1
DRILL TYPE: Air Return
DRILL: Becker Hammer
CASING: Double Walled

SAMPLE CONDITION

☒	Remoulded
▨	Undisturbed
■	Lost
◧	Core

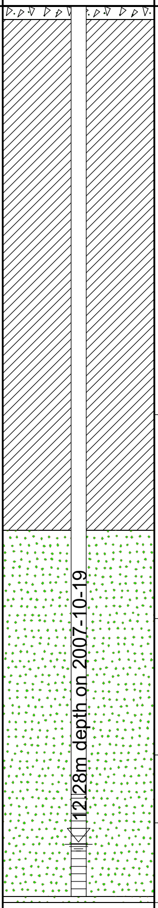
TYPE OF SAMPLER

DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

LABORATORY AND IN SITU TESTS

C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
Dr	Specific gravity	PS	Particle size analysis
Ksat	Saturated hydraulic cond. (cm/s)		

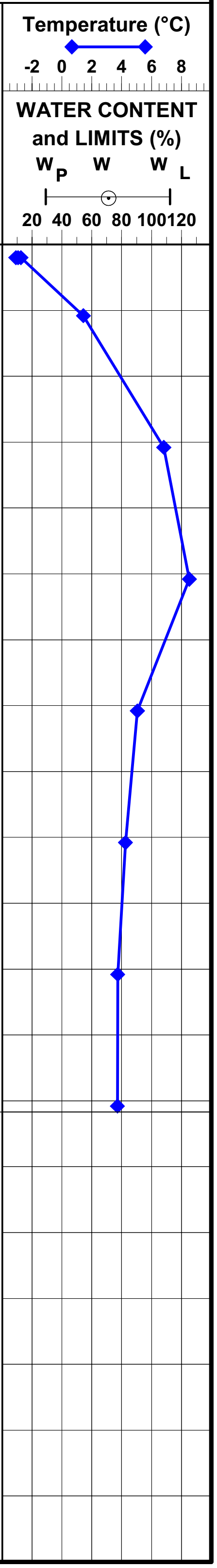
WELL DETAILS & WATER LEVEL - m



STRATIGRAPHY / **SAMPLES**

ELEVATION - m DEPTH - m	DESCRIPTION	TYPE AND NUMBER	CONDITION	RECOVERY %	N or RQD	LABORATORY and IN SITU TESTS
694.51 0.00	Dam fill, silty gravel, grey, well graded [GM]	GS-1 GS-2 GS-3 GS-4	☒ ☒ ☒ ☒			
688.51 6.00	Gravel, grey, well graded, trace silts and clays, water with suspended fines [GW]	GS-5 GS-6	☒ ☒			
685.51 9.00	Gravelly sand, dark grey, trace fines, poorly graded [SP]. Water encountered at 10.0 m	GS-7	☒			
683.51 11.00	Gravel, grey, well graded, trace fines, water with suspended fines [GW]	GS-8	☒			
682.51 12.00	Silty gravel, grey, well graded with fines [GM]	GS-9	☒			
681.34 13.17	Refusal in bedrock, greenstone					

DEPTH - ft: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65
DEPTH - m: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19



C:\Geotec742\SRK templates\loglog SRK m23 Kino.sty PLOTTED: 2008-02-08 14:44hrs

SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT: Keno Hill
LOCATION: Crest of Dam #3 at South end
FILE No: UNITED KENO HILL (1CE012.000)
BORING DATE: 2007-10-17 **TO** 2007-10-17
DIP: 90.00 **AZIMUTH:**
COORDINATES: 7088121.33 N 474411.93 E **DATUM:** NAD83

BOREHOLE: GT10
PAGE: 1 **OF** 1
DRILL TYPE: Air Return
DRILL: Becker Hammer
CASING: Double Walled

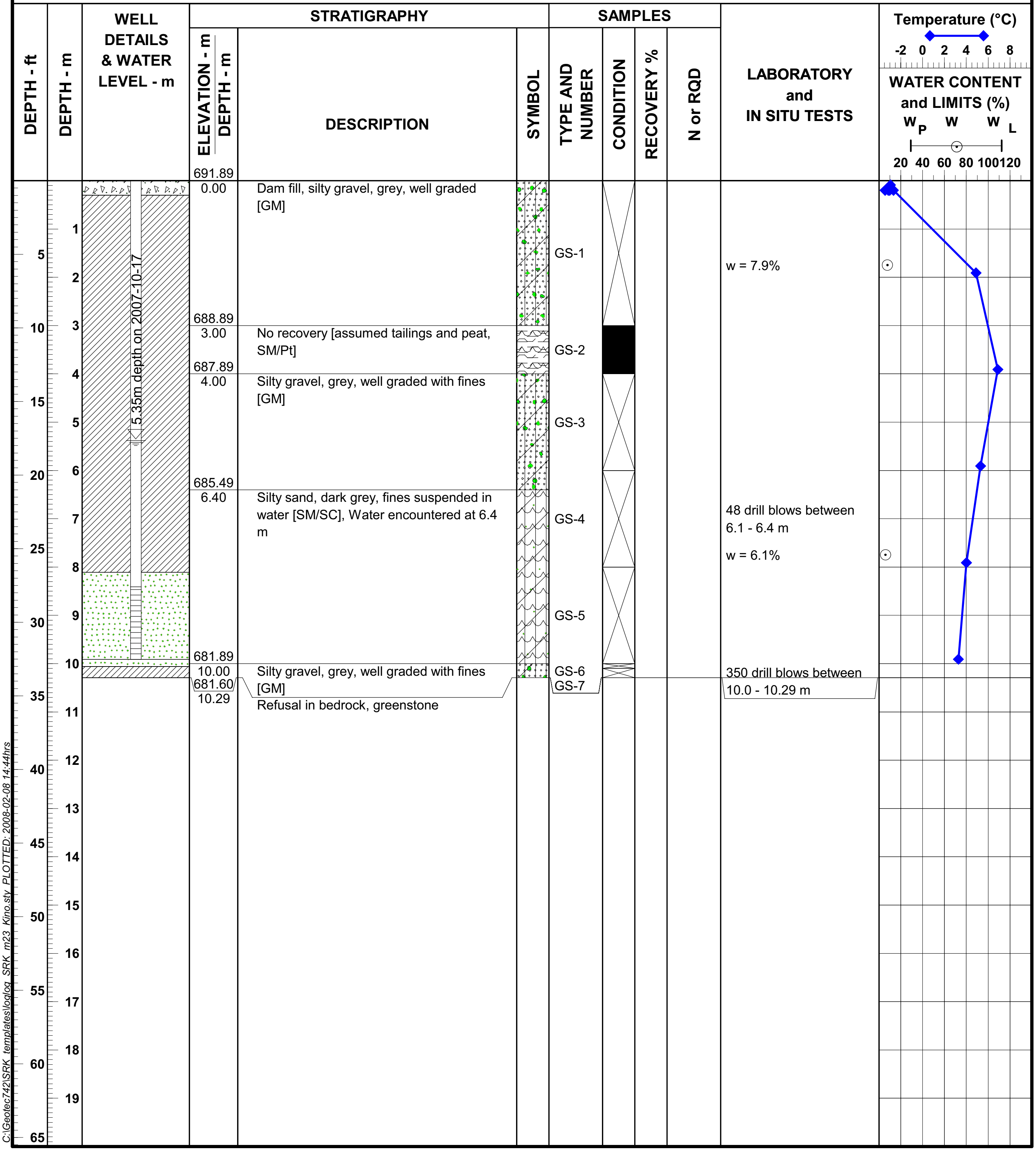
SAMPLE CONDITION
- ☒ Remoulded
- ▨ Undisturbed
- ■ Lost
- ◧ Core

TYPE OF SAMPLER

DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

LABORATORY AND IN SITU TESTS

C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
Dr	Specific gravity	PS	Particle size analysis
Ksat	Saturated hydraulic cond. (cm/s)		



ELEVATION - m / DEPTH - m	DESCRIPTION	SAMPLES TYPE AND NUMBER	LABORATORY and IN SITU TESTS
691.89 0.00	Dam fill, silty gravel, grey, well graded [GM]	GS-1	w = 7.9%
688.89 3.00	No recovery [assumed tailings and peat, SM/Pt]	GS-2	
687.89 4.00	Silty gravel, grey, well graded with fines [GM]	GS-3	
685.49 6.40	Silty sand, dark grey, fines suspended in water [SM/SC], Water encountered at 6.4 m	GS-4 GS-5	48 drill blows between 6.1 - 6.4 m w = 6.1%
681.89 10.00	Silty gravel, grey, well graded with fines [GM]	GS-6	350 drill blows between 10.0 - 10.29 m
681.60 10.29	Refusal in bedrock, greenstone	GS-7	

C:\Geotec742\SRK templates\loglog SRK m23 Kino.sty PLOTTED: 2008-02-08 14:44hrs

SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT: Keno Hill
LOCATION: Dam #3
FILE No: UNITED KENO HILL (1CE012.000)
BORING DATE: 2007-10-16 **TO** 2007-10-16
DIP: 90.00 **AZIMUTH:**
COORDINATES: 7088170.76 N 474325.89 E **DATUM:** NAD83

BOREHOLE: H11
PAGE: 1 **OF** 1
DRILL TYPE: Air Return
DRILL: Becker Hammer
CASING: Double Walled

SAMPLE CONDITION
☒ Remoulded
▨ Undisturbed
■ Lost
◧ Core

TYPE OF SAMPLER
DC Diamond core barrel
GS Grab sample
SS Split spoon

LABORATORY AND IN SITU TESTS

C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
Dr	Specific gravity	PS	Particle size analysis
Ksat	Saturated hydraulic cond. (cm/s)		

WELL DETAILS & WATER LEVEL - m	ELEVATION - m DEPTH - m	DESCRIPTION
4.33m depth on 2007-10-17 ▽	692.89 0.00	Silty gravel, light grey, well graded with fines [GM]
	678.89 14.00	Gravelly sand, light grey, water with suspended fines [SP]. Water encountered at 14.0 m
	678.69 14.20	Silty gravel, light grey, well graded with fines [GM]
	677.09 15.80	Refusal in bedrock, greenstone

DEPTH - m	TYPE AND NUMBER	CONDITION	RECOVERY %	N or RQD	LABORATORY and IN SITU TESTS
1	GS-1	☒			38 drill blows between 1.0 - 1.3 m
3	GS-2	☒			
5	GS-3	☒			60 drill blows between 4.7 - 5.0 m
7	GS-4	☒			124 drill blows between 6.2 - 6.5 m
9	GS-5	☒			
11	GS-6	☒			
13	GS-7	☒			
15	GS-8	☒			

Temperature (°C)
-2 0 2 4 6 8

WATER CONTENT and LIMITS (%)
W_P W W_L
20 40 60 80 100 120

DEPTH - ft: 5 10 15 20 25 30 35 40 45 50 55 60 65
DEPTH - m: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

C:\Geotec742\SRK templates\loglog SRK m23 Kino.sty PLOTTED: 2008-02-08 14:44hrs

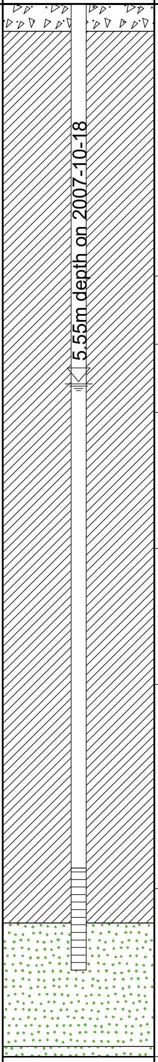
SRK Consulting
Engineers and Scientists

BOREHOLE LOG

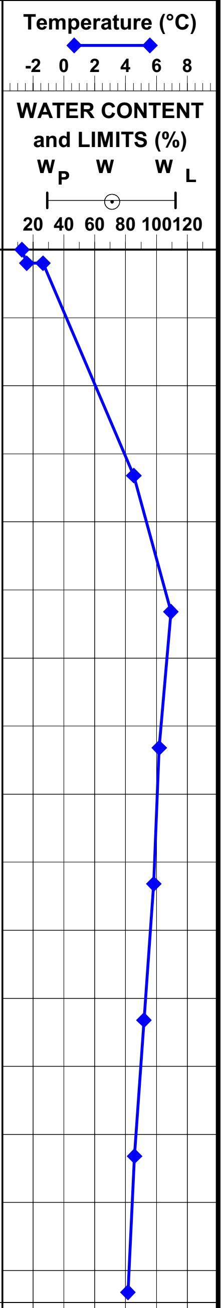
PROJECT: Keno Hill
LOCATION: Crest of Dam #3 at North end
FILE No: UNITED KENO HILL (1CE012.000)
BORING DATE: 2007-10-18 **TO** 2007-10-18
DIP: 90.00 **AZIMUTH:**
COORDINATES: 7088337.30 N 474318.02 E **DATUM:** NAD83

BOREHOLE: GT12
PAGE: 1 **OF** 1
DRILL TYPE: Air Return
DRILL: Becker Hammer
CASING: Double Walled

SAMPLE CONDITION		**TYPE OF SAMPLER**		**LABORATORY AND IN SITU TESTS**			
☒	Remoulded	DC	Diamond core barrel	C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
▨	Undisturbed	GS	Grab sample	D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
■	Lost	SS	Split spoon	Dr	Specific gravity	PS	Particle size analysis
◧	Core			Ksat	Saturated hydraulic cond. (cm/s)		



ELEVATION - m DEPTH - m	DESCRIPTION	TYPE AND NUMBER	CONDITION	LABORATORY and IN SITU TESTS
692.43 0.00	Dam fill, silty gravel, grey, well graded [GM]	GS-1 GS-2	☒ ☒	
688.43 4.00	Peat, brown, fine fibrous with silty sand [tailings], light brown, very loose, wet [Pt/SM]	GS-3	☒	
687.43 5.00	Peat, brown, fine fibrous [Pt]. Water encountered at 6.0 m	GS-4	☒	
686.43 6.00	Gravelly sand, brown, water with suspended fines [SP].	GS-5	☒	26 drill blows between 6.7 - 7.0 m
684.43 8.00	Silty gravel, light brown, well graded, water with suspended fines [GW]	GS-6	☒	
682.43 10.00	Silty gravel, grey, well graded, with fines [GM]	GS-7 GS-8	☒ ☒	160 drill blows between 11.7 - 12.0 m
679.43 13.00	Silty sand, brown, compact [SM]	GS-9	☒	
676.96 15.47	Refusal in bedrock, greenstone			



C:\Geotec742\SRK templates\loglog SRK m23 Kino.sty PLOTTED: 2008-02-08 14:44hrs

Appendix B

Laboratory Test Results

United Keno Hill – Winter 2007, Valley Tailings Drill Program

Laboratory Testing Program

Location	Sample [ID:Depth]	Natural Moisture Content	Particle Size Distribution		
			Gravel	Sand	Silt
Dam #1	GT7: 12.0 m	8.7%	50%	44%	6%
Dam #2	GT8: 14.0 m	3.4%	42%	35%	23%
Dam #3	GT10: 2.0 m	7.9%			
	GT10: 8.0 m	6.1%	70%	23%	7%
Valley Tailings	H4 DEEP: 0.5 m	7.5%			
	H4 DEEP: 1.5 m	6.7%			
	H4 DEEP: 2.5 m	23.3%			
	H4 DEEP: 6.7 m	6.1%			
	H5 DEEP: 7.0 m	67.0%			
	H5 DEEP: 9.0 m	19.8%			
	H5 DEEP: 11.0 m	3.9%			
	H6 DEEP: 3.0 m	5.6%			

PARTICLE SIZE DISTRIBUTION

ASTM C136 & D422

Project: **United Keno Hill Mines**

Project Number: W14101104

Date Tested: 11/17/2007

Borehole Number: GT 7

Depth: 12 m

Soil Description: GRAVEL AND SAND - trace of silt

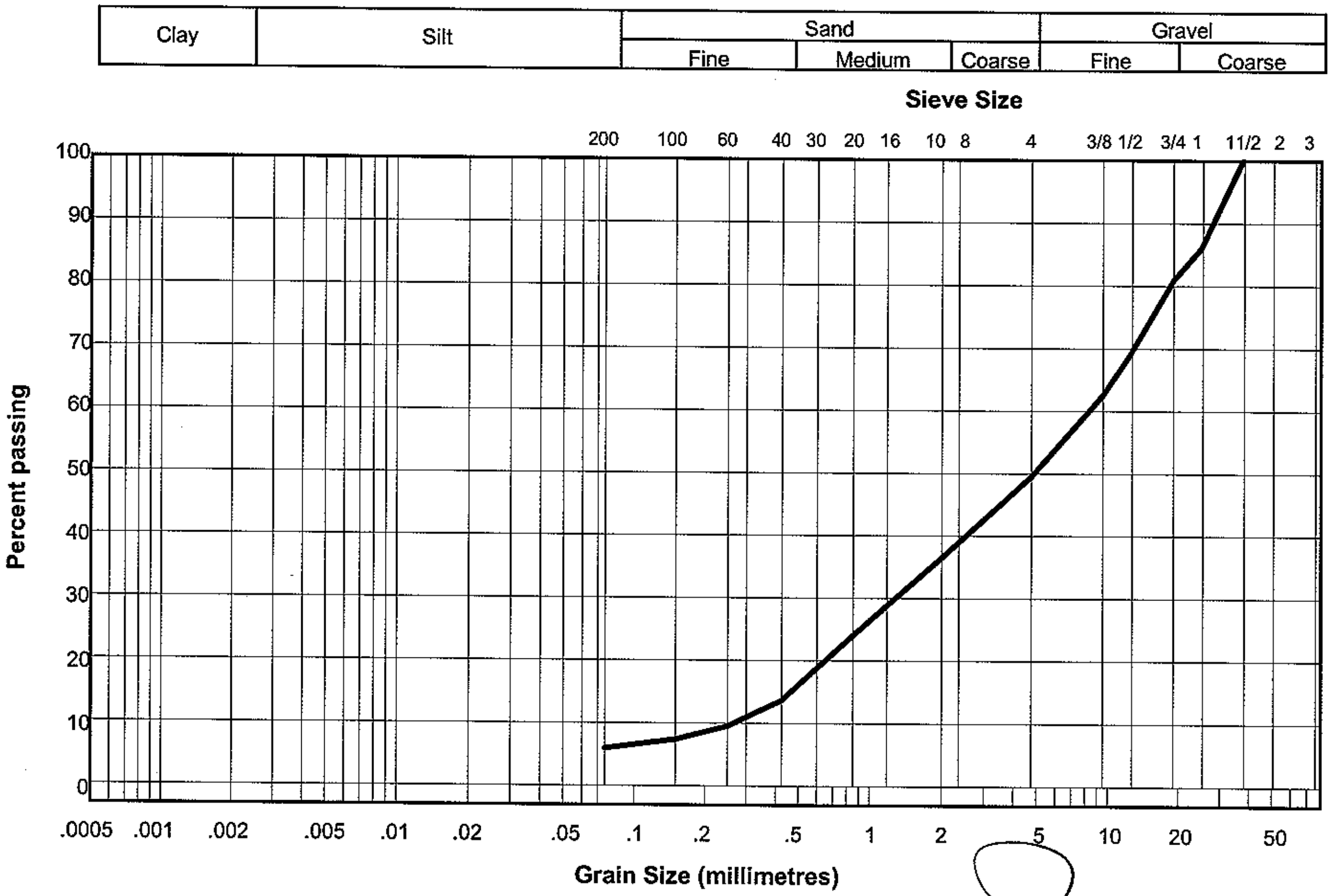
Cu:

Cc:

Natural Moisture Content: 8.7%

Remarks:

Sieve Size	Percent Passing
50.000	#N/A
37.500	100
25.000	86
19.000	81
12.500	69
9.500	63
4.750	50
2.000	37
0.850	24
0.425	14
0.250	10
0.150	7
0.075	5.9



Reviewed By:

PARTICLE SIZE DISTRIBUTION

ASTM C136 & D422

Project: **United Keno Hill Mines**

Project Number: W14101104

Date Tested: 11/17/2007

Borehole Number: GT 8

Depth: 14 m

Soil Description: GRAVEL AND SAND - silty

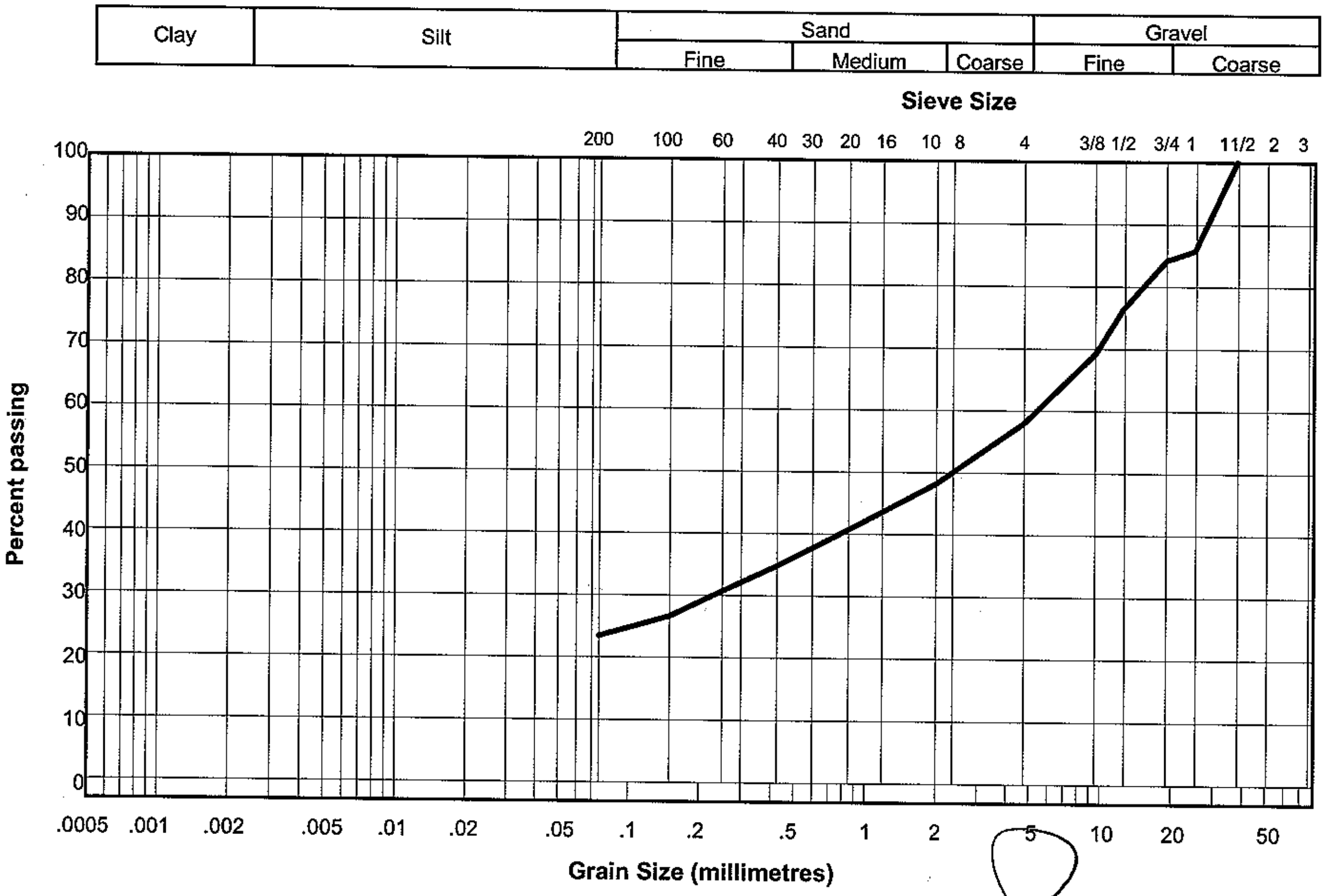
Cu:

Cc:

Natural Moisture Content: 3.4%

Remarks:

Sieve Size	Percent Passing
50.000	#N/A
37.500	100
25.000	86
19.000	84
12.500	76
9.500	69
4.750	58
2.000	48
0.850	41
0.425	35
0.250	31
0.150	27
0.075	23.4



Reviewed By:

EBA Engineering
Consultants Ltd.

PARTICLE SIZE DISTRIBUTION

ASTM C136 & D422

Project: **United Keno Hill Mines**

Project Number: W14101104

Date Tested: 11/17/2007

Borehole Number: GT 10

Depth: 8 m

Soil Description: GRAVEL - sandy, trace of silt

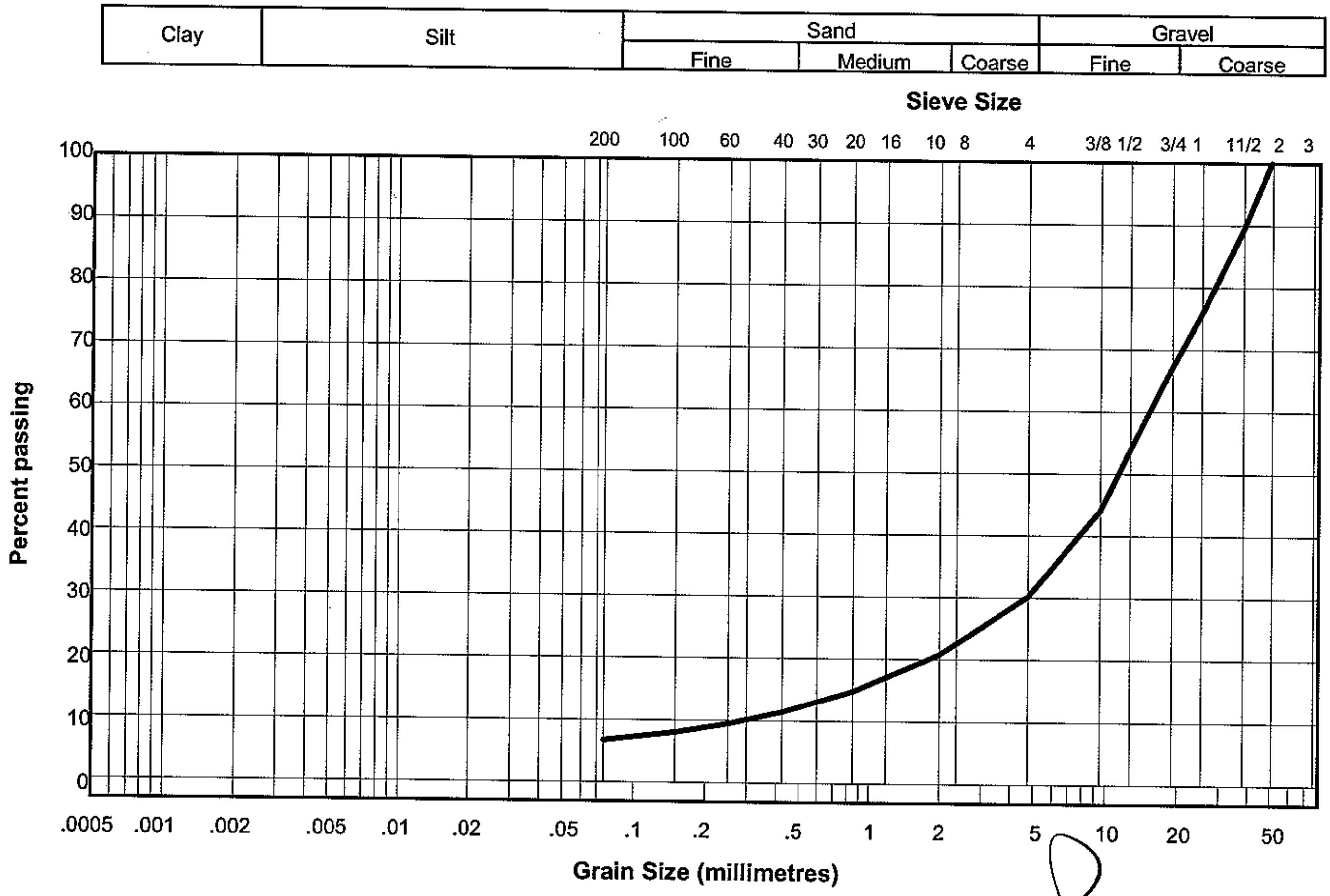
Cu:

Cc:

Natural Moisture Content: 6.1%

Remarks:

Sieve Size	Percent Passing
50.000	100
37.500	89
25.000	75
19.000	67
12.500	53
9.500	44
4.750	30
2.000	21
0.850	15
0.425	11
0.250	9
0.150	8
0.075	6.7



Reviewed By:

EBA Engineering
Consultants Ltd.

Appendix C

Waste Rock Pile Resloping Footprint Areas

Location	Figure & Section Line		Area (m^2) (Existing Footprint)	Area (m^2) (Resloped 2H:1V)	Δ Area (m^2)	Area (m^2) (Resloped 2.5H:1V)	Δ Area (m^2)	Area (m^2) (Resloped 3H:1V)	Δ Area (m^2)
Bermingham									
	3a	Sec A & B	39,500	43,500		55,600		69,600	
		TOTAL	**39,500**	**43,500**	**4,000**	**55,600**	**16,100**	**69,600**	**30,100**
Black Cap									
	4A	Sec R	14,950	17,400		20,300		NA	
	4A	Sec T	10,900	13,800		16,300		19,800	
		TOTAL	**25,850**	**31,200**	**5,350**	**36,600**	**10,750**	**NA**	**NA**
Dixie									
	5a	Sec U	1,950	1,950		2,300		3,750	
		TOTAL	**1,950**	**1,950**	**0**	**2,300**	**350**	**3,750**	**1,800**
Simes									
	6A	Sec G	5,200	5,700		7,350		NA	
	6A	Sec H	3,800	4,800		6,200		8,300	
	6A	Sec I	4,250	5,950		9,500		NA	
	6A	Sec J	11,700	14,150		17,300		21,900	
	6A	Sec L	18,000	22,600		31,600		44,600	
		TOTAL	**42,950**	**53,200**	**10,250**	**71,950**	**29,000**	**NA**	**NA**
Galkeno 300									
	6A	Sec K	5,400	7,500		9,200		10,900	
		TOTAL	**5,400**	**7,500**	**2,100**	**9,200**	**3,800**	**10,900**	**5,500**
Hector									
	7A	Sec C	14,500	17,000		25,000		NA	
		TOTAL	**14,500**	**17,000**	**2,500**	**25,000**	**10,500**	**NA**	**NA**
Calumet									
	7A	Sec D	11,500	16,300		19,900		NA	
	7A	Sec E	22,600	24,800		26,700		NA	
	7A	Sec F	34,500	42,200		55,000		NA	
		TOTAL	**97,600**	**117,300**	**19,700**	**151,600**	**54,000**	**NA**	**NA**
Lucky Queen									
	8A	Sec Q	9,700	10,200		10,950		12,000	
		TOTAL	**9,700**	**10,200**	**500**	**10,950**	**1,250**	**12,000**	**2,300**
Onek									
	10A	Sec M	8,400	8,400		10,650		12,000	
	10A	Sec N	10,000	11,550		13,200		15,000	
	10A	Sec O	15,000	15,000		27,800		33,300	
	10A	Sec P	12,300	12,180		NA		NA	
		TOTAL	**45,700**	**47,130**	**1,430**	**NA**	**NA**	**NA**	**NA**
Ruby									
	11A	Sec V	2,000	2,000		6,300		7,100	
		TOTAL	**2,000**	**2,000**	**0**	**6,300**	**4,300**	**7,100**	**5,100**
Townsite									
	12a	Sec X	5,400	5,400		6,550		8,650	
		TOTAL	**5,400**	**5,400**	**0**	**6,550**	**1,150**	**8,650**	**3,250**

Notes:

1) NA indicates resloping did not intersect the original ground topography as a result a total area andΔ Area would not be representative

Appendix D

Dam Classification

SRK Consulting
Engineers and Scientists

SRK Consulting (Canada) Inc.
Suite 800 – 1066 West Hastings Street
Vancouver, B.C. V6E 3X2
Canada

vancouver@srk.com
www.srk.com

Tel: 604.681.4196
Fax: 604.687.5532

Technical Memorandum

To: File
Date: March 31, 2008
cc:
From: Lowell Wade, Dylan MacGregor, Cam Scott
Subject: Dam Classification, Valley Tailings Area, Keno Hill, YT
Project #: 1CE012.000.0GT2

1 Dam Classification

The dams within the Valley Tailings Area have never been classified according to the stability specified in the 2007 Dam Safety Guidelines prepared by the Canadian Dam Association (CDA, 2007). To assist in the selection of closure measures for the VTA dams, classification was undertaken for each of the dams following the Fall 2007 field investigations.

The CDA first recommends classifying a dam according to consequences of failure. The recommended classification criteria are summarized in Table 1. Although the three dams were constructed to work in series, each dam will be evaluated individually as this approach is more conservative.

In general, failure of Dams #1, #2 and #3 is unlikely to result in fatalities of a population at risk. There are an unspecified number of people temporarily at risk depending on the nature of activity in and around the Valley Tailings Area. There are low infrastructure and economic losses as the Valley Tailings Area contains limited infrastructure and no services. The incremental loss of environmental and cultural values will vary depending on the dam but varies between the low to significant consequence class.

SRK's evaluation has concluded that Dam #2 and Dam #3 fall within the low consequence category (Table 2). Geotechnical risks for Dam #1 were considered to be similar to those at Dam #2 and Dam #3. However, a failure at Dam #1 would likely result in a loss of a minor quantity of tailings solids to the downstream environment. This potential loss poses an additional risk to fish or wildlife habitat, and as a result, the failure consequence category was elevated to significant.

Table 1 Canadian Dam Association Dam Classification Criteria (CDA, 2007)

Dam Class	**Population at risk**[1]	**Incremental losses**		
		Loss of life[2]	**Environmental and cultural values**	**Infrastructure and economics**
Low	None	0	Minimal short-term loss No long-term loss	Low economic losses; area contains limited infrastructure or services
Significant	Temporary only	Unspecified	No significant loss or deterioration of fish or wildlife habitat Loss of marginal habitat only Restoration or compensation in kind highly possible	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes
High	Permanent	10 or fewer	Significant loss or deterioration of important fish or wildlife habitat Restoration or compensation in kind highly possible	High economic losses affection infrastructure, public transportation, and commercial facilities
Very high	Permanent	100 or fewer	Significant loss or deterioration of critical fish or wildlife habitat Restoration or compensation in kind possible but impractical	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances)
Extreme	Permanent	More than 100	Major loss of critical fish or wildlife habitat Restoration or compensation in kind impossible	Extreme losses affecting critical infrastructure or services (e.g., hospital, major industrial complex, major storage facilities for dangerous substances)

[1] Definitions for population at risk:
None – There is no identifiable population at risk, so there is no possibility of loss of life other then through unforeseeable misadventure.
Temporary – People are only temporarily in the dam-breach inundation zone (e.g., seasonal cottage use, passing through on transportation routes, participating in recreational activities).
Permanent – The population at risk is ordinarily located in the dam-breach inundation zone (e.g., as permanent residents); three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).

[2] Implications for loss of life:
Unspecified – The appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season.

Table 2 Consequence Categories for VTA Dams

Dam	Consequence Category
Dam #1	Significant
Dam #2	Low
Dam #3	Low

2 Reference

CDA (2007). Dam Safety Guidelines, 2007. Canadian Dam Association.

Appendix E

Waste Rock Closure Options Decision Matrix

Table 1 Example decision matrix to be used for review of conceptual closure options for waste rock piles
Keno Hill Closure Planning
Rev. 00, March 2008

			Waste Rock Dump Closure Requirements				Considerations for implementation									Waste Rock Dump Closure Options					
																1. Reslope 2.5:1, revegetate	2. Reslope 2.5:1, growth media, revegetate	3. Reslope 2.5:1, soil cover, revegetate	4. Relocate	5. Reprocess high grade waste dumps	6. Do nothing
																Suitable for dumps without ARD concerns and sufficient fines to promote revegetation without additional growth media	Suitable for dumps with no compelling ARD concerns	Suitable for dumps that have ARD concern that require reduction or mitigation of metals load		Potential option that can be incorporated into remaining scenario, very specific to only 1 or 2 dumps, may not carry forward into options analysis	
Waste Rock Dump	Size Category[1]	Tonnage[2]	Ensure geotechnical stability	Reduce chemical loading	Revegetate	Esthetic improvement	Water course near toe	Adit discharging	Steep dump face angle	Can dump be used for borrow source?	Steep slopes below dump (<3H:1V)	Status of adjacent vegetation	Adjacent surface materials similar to coarse waste rock	Value of area to be covered by resloping	Increase in load due to disturbance, or to increased surface area						
Bermingham pit dumps	A	1,500,000																			
Calumet 1-15 pit (2 dumps)	A	1,000,000							X		X		X								
Onek	A	600,000							X		X (SE only)										
Sime dumps	A	450,000									X		X								
Black Cap	A	390,000	X						X		X		X								
Hector 400 adit dump	A	198,000	X						X		X		X		X						
Galkeno 100/200/300	A	150,000	X					X													
No Cash 500	A	138,100	X				X	X	X					Creek							
Silver King pit dump	A	120,000																			
Hector #1 Vein Pit	A	100,000	X						X		X		X								
Stone (3 piles)	B	84,540																			
Coral & Wigwam	B	75,000											X								
Miller	B	63,000											X								
Lucky Queen 500 adit dump	B	61,900																			
Bellekeno 625	B	48,000	X (erosion)				X	X						Creek							
Elsa 400	B	44,100																			
Silver King 100 adit	B	43,000	X (erosion)				X	X						Creek							
Ruby	B	28,900						X													
Keno 700	B	27,500	X (erosion)				X	X	X					Creek							
Calumet C-Structure	B	25,000																			
Sadie Ladue (Wernecke)	B	24,500																			
Galkeno 900	B	20,800						X													
Dixie	B	19,800																			
Husky SW	B	17,000																			
Shamrock King	B	16,200											X								
Highlander	B	15,000					X	X													
Keno 200	B	14,600											X								
Townsite	B	14,300											X								
Bellekeno 200	B	13,000																			
Gerlitski	B	10,281																			
Hector 4-11 pits	B	10,000											X								
Sadie Ladue 600	C	9,500	X (erosion)					X													
Shamrock	C	9,000	X (erosion)						X				X								
Onek 400 adit dump	C	7,500	X (erosion)					X													
Bermingham adit dump	C	7,000						X	X												
No Cash 100	C	6,500																			
Elsa 200	C	6,000																			
Lucky Queen shaft area	C	5,000											X								
Husky	C	4,600																			
Porcupine Pit Dump	C	3,400											X								
UN adit dump	C	3,200																			
Comstock 150	C	3,100											X								
Comstock 275	C	3,100											X								
Lake	C	2,550																			
Bellekeno 100 (48 Vein)	C	2,450																			
Klondike Keno	C	2,000						X													
Elsa +50	C	1,550																			
Cub & Bunny (pit dump)	C	1,350																			
Flame & Moth	C	small- est. >1000 t																			
Bellekeno 100 (50 Vein)	D	500																			
Monument & Ladue Fraction adit	D	500											X								
Nabob No. 2	D	480											X								
Gold Hill No. 2	D	100 t + trenching											X								
Keno No. 9 System	D	Many small piles											X								
Apex	D	trenching																			
Divide	D	trenching																			
Fox	D	trenching																			
Lake View	D	trenching											X								
Nabob	D	trenching											X								
Silver Basin	D	trenching											X								
Betty	D	none											X								
Christal (Dorothy)	D	minimal																			
Duncan Creek	D	none																			
Blue Bird	D	minimal																			
Croesus No. 1	D	minimal																			
Kijo	D	minimal																			
Rico	D	minimal																			
Shepherd	D	minimal																			
Tin Can	D	minimal																			

Notes

1. Size Category: A= >100,000 tonnes; B= 10,000 to 100,000 tonnes; C= 1,000 to 10,000 tonnes; D= <1000 tonnes
2. Tonnage- short tons (Source: Primary 1996 SCR, secondary PWGSC 2000 and estimates from SRK inspections)