2009 Valley Tailings Facility Closure Options, Keno Hill Silver District, YT

- Final Draft -

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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. In 2007/08 SRK reviewed the geochemical stability, local hydrogeological and geotechnical conditions of the Valley Tailings Facility (VTF) as part of the closure studies (SRK 2008a, 2008b, 2009a). The results of these investigations showed the main issues that require consideration in selection of a closure option for the VTF are:

- Prevention of wind dispersion of tailings and erosion of tailings by surface runoff; and
- Management of surface water through and/or around the VTF.

ERDC requested SRK carry out a closure options analysis to support the selection of the preferred closure option for the VTF.

2 Estimated Volumes and Quantities

2.1 Introduction

The quantities and volumes used for costing of closure options were estimated based on the results of prior field investigations by Alexco, BGC, and SRK. Details of how these results were used are described in the following sections. All volumes are reported as in place volumes; no bulking factors have been applied.

2.2 Volume of Tailings within the VTF

The VTF was divided into four regions based on tailings retained behind the dams as well as potential closure options being considered (Figure 1). The results from the SRK's previous field investigations were combined with BGC's Tailings Disposal Study to develop a computer generated model in GEMS© to estimate the volume of tailings within the VTF (BGC 1996; SRK 2008a, 2009a, Appendix A). The estimated volume of retained tailings within each region is summarized in Table 1.

Table 1: Summary of Estimated Tailings Volumes within the VTF.

VTF Region	Area (m^2)	Volume (m^3)	Volume with 0.5 m over-excavation (m^3)
Pond 1			
Proposed Consolidated Tailings Region	297,000	1,205,000	
Proposed Relocated Tailings Region	252,000	1,030,000	1,148,000
Pond 2	13,000	37,000	43,000
Pond 3	222,000	359,000	468,000
Total	**784,000**	**2,631,000**	**1,659,000**

There is an estimated 2,600,000 m^3 of tailings stored within the VTF. This does not include tailings submerged within the Ponds. Examination of the underlying peat indicated contamination by tailings near the interface. If partial tailings relocation is the selected closure option, over-excavation of the tailings into the peat by 0.5 m is expected to remove the majority of the tailings contamination. If partial relocation of the tailings is to be considered as indicated in Figure 1, an estimated total volume of 1,700,000 m^3 of tailings and over-excavated soil would be relocated to the Proposed Consolidated Tailings Area.

Reconnaissance of the hillside below the town of Elsa indicates there are discontinuous dispersed tailings present in the area near the former tailings discharge. For costing purposes, the dispersed tailings were assumed to be 0.5 m thick and to cover an area of 163,000 m^2 for a total volume of 82,000 m^3. These tailings would require relocation during closure.

The extent of tailings west of Dam #3 was better defined as a part of the 2008 VTF Site Investigation (Appendix A). The volume of spilled tailings was not estimated as these tailings will be relocated due to the natural re-vegetation that is occurring.

2.3 Potential Borrow Source

The results from the SRK's previous field investigations were combined with Alexco's Soils Characterization and Drilling Report to develop a computer generated model in GEMS© that was used to estimate the volume of cover material within the Potential Borrow Area (Alexco 2007; SRK 2008a, Appendix A). Using the approximate limits shown in Figure 1 as a borrow source boundary there is an estimated 1,523,000 m^3 of potential cover material available.

The subaerial tailings within the VTF cover an area of approximately 780,000 m^2. If the selected closure option were to leave the tailings in-place and constructed a 0.5 m thick cover, 392,000 m^3 of cover material would be required. In that case, around 1,200,000 m^3 of borrow material would remain for establishing the stable channels proposed in the closure options.

2.4 Lime Addition

Addition of lime during tailings relocation is an appropriate way to minimize short term metal release from existing pore water and stored salts. The lime could either be added at the source, prior to excavation, using a grid to determine the correct dosage or at the relocated tailings area while reworking the tailings. It should be noted that control of future long-term geochemical conditions is not the objective of the proposed lime addition

Testing was conducted to develop site specific lime demands for the VTF tailings as a part of the 2008 VTF site investigation (Appendix A). Based on the samples tested, an average of 5.0 kg of $Ca(OH)_2$ per dry tonne of tailings was required to raise the pH of a tailings slurry to the target of pH 9.5.

To estimate the quantity of lime required to amend the relocated tailings and over excavated material within the VTF, an estimate of the tailings mass to be relocated is required. It has been estimated 1,700,000 m^3 of tailings and over excavated soil could be relocated within the VTF. An additional 82,000 m^3 of tailings would be relocated from the hill side below the town of Elsa. The estimated total volume of relocated tailings and over excavated soil is 1,700,000 m^3.

The field bulk density of the VTF tailings was determined to be 1.97 tonnes/m^3, therefore the 1,700,000 m^3 of relocated tailings and over excavated soil is estimated to weigh 3,400,000 tonnes. Based on an application rate of 5 kg $Ca(OH)_2$ per tonne of tailings, the total amount of lime required is estimated to be 18,000 tonnes of $Ca(OH)_2$. To account for nonreactive lime and for incomplete mixing, a 10% increased in application rate of 6 kg $Ca(OH)_2$ per tonne of tailings will require an estimated 21,000 tonnes of $Ca(OH)_2$.

3 VTF Closure Options

3.1 Introduction

Two broad options that meet the requirements for closure of the VTF have been identified. The first option (Option 1) consists of leaving the tailings in place and constructing a soil cover over the tailings. There are two variants, to Option 1 that define how surface water in and around the VTF will be managed. The second option (Option 2) consists of relocating the older thin tailings located behind Dams #2 and #3 as well as along the south east quadrant of the VTF to behind Dam #1.

Both options will require the discontinuous dispersed tailings located on the hillside below the town of Elsa to be relocated.

3.2 Option 1A: Cover in Place

The concepts for Option 1A are shown in Figure 2. The tailings surface would be regraded to eliminate major depressions and hummocks prior to cover placement. The discontinuous dispersed tailings located on the hillside below Elsa would be relocated the base of the hillside and spread to create a uniform surface.

Cover material, sourced from the Potential Borrow Area, would be placed over the regraded tailings surface to prevent wind dispersion of tailings and erosion of tailings by surface runoff. A 0.5 m thick cover has been assumed for costing purposes.

The crests of Dams #1, 2, and 3 would be lowered by approximately 2 m and the profiles flattened by placing the scalped material from the dam crests onto the downstream face to increase dam stability.

One component of surface water management would consist of selecting the final alignment of the Porcupine Creek Diversion. The diversion would be upgraded to pass design flows and to prevent erosion of adjacent tailings deposits. The conceptual designs of the Porcupine Diversion and other channels described in this report are discussed in Appendix B. The conceptual design for the Porcupine Diversion includes a 5 m wide with side slopes 3H:1V. The upgraded channel bed would be lined with riprap of appropriate diameter (D_{50} = 100 to 350 mm) to a thickness of 1 m. The riprap would be sourced from the existing rock quarry north of the Potential Borrow Area. The new channel bed would be revegetated with willows to control erosion. Streams would be allowed to migrate within the base of the channel.

Another component of surface water management would be to establish North Fork Flat Creek as a stable channel following the north edge of the VTF. Like the Porcupine Creek Diversion Channel, the North Fork Flat Creek channel would be sized to pass design flows with the channel base 5 m wide; however side slopes would be graded at 5H:1V to promote surface water drainage towards the new channel and allow revegetation to become established. The new North Fork Flat Creek Channel would be protected by a 1 m thick layer of riprap. Revegetation of the channel would consist of willows to prevent erosion but still allow streams to migrate within the base of the channel.

The current water management would be maintained for water impounded behind Dams #1, 2, and 3.

3.3 Option 1B: Cover in Place with Spillway

This option would include the existing tailings surface, dispersed hillside tailings, cover placement, North Fork Flat Creek, and Dam profiles prepared as for Option 1A (Figure 3).

The primary difference from Option 1A would be how Porcupine and Brefalt Creek flows are handled. Under Option 1B, Porcupine and Brefalt Creeks would follow pre-mining alignment along a stable channel designed to pass design flows over the covered tailings. The new channel would measure 5 m wide across the base with side slopes 5H:1V. The new channel would be covered by riprap of appropriate diameter to a thickness of 1 m. Revegetation of the channel would consist of willows to prevent erosion and streams would be allowed to migrate within the base of the channel. The surrounding regraded and covered tailings surface would promote surface water drainage towards the Porcupine and Brefalt Creek channel.

Flat Creek would continue to follow the lower Porcupine Creek Diversion since a significant amount of earthworks would be required to excavate a channel to join Flat Creek with Porcupine and Brefalt Creeks passing through the VTF. The entire Porcupine Creek Diversion would be upgraded as described in Option 1A to prevent erosion of adjacent tailings deposits.

To manage water retained behind the dams, Lower North Fork Flat Creek channel would be constructed along the North edge of the VTF through the Potential Borrow Area were material has been removed for tailings cover and channel bed material. The channel would allow excess water, retained by the dams to pass downstream of the VTF. This would eliminate the requirement to pump water between ponds. The Lower North Fork Flat Creek channel would have a channel base 10 m wide and side slopes 3H:1V. Like all other channels, the channel bed would be lined with a 1 m thick layer of riprap (D_{50} = 220 to 300 mm). The new channel bed would also be revegetated with willows to prevent erosion. Streams would be allowed to migrate within the base of the channel.

The construction of Lower North Flat Creek could be considered as part of the closure option or implemented at a later date, if water management requirements prevent ongoing release of water to downstream.

3.4 Option 2: Partial Relocation

Option 2 would see the older, thin tailings retained behind Dams #2 and #3 relocated to the Northeast quadrant of the VTF. Tailings from the Southeast quadrant as well as from the hill side below the town of Elsa would also be relocated to the Northeast quadrant (Figure 4). During the 2008 VTF field investigation trafficability by heavy equipment over most of the exposed tailings within the VTF did not present any problems. The existing ground conditions were wet with some soft ground in areas. Trafficability over the tailings surface between Dams #1 and #2 was a problem. Ground conditions were very soft and wet. Dewatering measures or winter excavation may be required for successful tailings relocation in this area.

Over-excavation of the tailings into the peat by 0.5 m is expected to remove the majority of the tailings contamination of the original ground. It is recognized it may be difficult to only excavate 0.5 m of peat within areas of the VTF. It may be difficult to excavate 0.5 m of peat in the wet areas of the VTF so the entire peat horizon may need to be removed.

The total volume of tailings and over-excavated material to be relocated to the Northeast quadrant has been estimated to be 1,700,000 m^3; however, the proposed area for tailings consolidation is estimated to be 300,000 m^2. Therefore, the estimated height of the relocated tailings would measure 6 m. Recent experience with tailings relocation, at the Cork Province Tailings Relocation and Containment System project in southeast B.C., showed the need for a containment berm constructed of coarser dryer tailings is required to retain the finer wetter tailings (SRK, 2009c). Applying this to the VTF, drier tailings from the Proposed Relocated Tailings Region can be used to construct a containment berm around the Consolidated Tailings Area to retain relocated wetter tailings from behind Dams #2 and #3. A conceptual berm would have the following dimensions: 7 m in height; a crown width of 5 m; downstream side slope of 3H:1V and an upstream side slope of 2H:1V. This containment berm would separate the Consolidated Tailings Area from the Relocated Tailings area and could potentially tie in with Dam #1. The volume of tailings required to construct the containment berm would not have a significant impact in lowering the overall height of the relocated tailings and over excavated soil. Additional coarse tailings material would be required to construct roadways within the relocated tailings containment area to allow heavy equipment access.

As a part of tailings relocation, lime amendment would be conducted as described in Section 2.4. After lime addition and tailings relocation, the tailings surface would be prepared to be as uniform as necessary for successful cover placement. Cover material would be placed over the consolidated tailings. It has been assumed a 0.5 m thick cover is to be placed over the 300,000 m^2 area of exposed tailings within the VTF.

Options for the original ground exposed by tailings relocation would include active revegetation or leaving exposed soil to revegetate naturally. Stable water features such as ponds, wetlands, and channels could also be established depending on final grades.

Surface water management would consist of Porcupine and Brefalt Creeks following the pre-mining alignment along a stable channel sized to pass design flows over the original ground exposed by tailings relocation. A new channel measuring 5 m wide across the base with side slopes 5H:1V would be constructed. A 1 m thick layer of riprap would line the channel to prevent erosion of the original ground. The channel would also be revegetated with willows. Streams would be allowed to migrate within the base of the channel.

The North Fork Flat Creek would be established as stable channel following the southeastern edge of the VTF. Once past the relocated tailings area, North Fork Flat Creek would continue over the covered tailings for a short distance before turning west to pass over the original ground exposed by tailings relocation. Like the Brefalt and Porcupine Creek channel, the North Fork Flat Creek channel would be sized to pass design flows and have the same channel geometry and construction, with the possible exception of a broad wetland area that may be developed depending on final grades.

Flat Creek would continue to flow down the lower Porcupine Diversion. The Flat Creek catchment area has been estimated to be 5.6 km^2 with a 200 year return flood estimate of 9 m^3/s (Appendix B). To allow Flat Creek to continue to flow down the Porcupine Diversion, this section of the diversion ditch would require upgrading as described in Options 1A/B. It has been assumed the easiest access would be along the current diversion alignment. To allow construction equipment access the entire length of the alignment would be upgraded.

As for Option 1B, water retained behind the dams would be managed by the construction of Lower North Fork Flat Creek channel along the North edge of the VTF through the Potential Borrow Area were material has been removed for tailings cover and channel bed material. The channel would prevent accumulation of excess water behind the dams, and instead allow that water to pass downstream of the VTF. This would eliminate the requirement to transfer water between ponds.

The crests of Dams #1, 2, and 3 would be lowered by approximately 2 m and the profiles flattened by placing the scalped material from the dam crests onto the downstream face to increase dam stability.

4 Comparative Cost Estimate and Project Duration

4.1 Comparative Cost Estimates

The objective of the cost estimates is to establish, in 2008 dollars, the cost for closure at the prefeasibility level of accuracy. This allows for a cost comparison between the three closure options described above.

4.1.1 Basis of Estimates

The estimate of closure cost estimates were compiled in MS Excel. Details of the closure cost estimates are provided in Appendix C and summarized in Table 2. Also listed in this Table 2 are the key features, advantages and disadvantages for each option. Earthworks included in the closure cost estimates are tailings relocation including excavation of underlying contaminated soils; cover placement and revegetation; and construction of water management structures. It should be noted that costs are based on the execution of the earthworks by an experienced earthworks contractor using appropriate equipment. For example, it has been assumed that the contractor will use a CAT 938F loader with CAT D250E haul trucks. Also assumed are a CAT D7R dozer with a Universal Blade and a CAT 325BL excavator with a General Purpose bucket.

The size of the construction fleet has a significant impact on project costs and duration. An optimal construction fleet consisting of the appropriate number of larger vehicles would have higher productivity rates which would lower unit rates, shorten the project duration, and reduce the overall project cost.

Direct Costs

The sources of the estimated direct costs are as follows:

- Procurement and transportation of lime to site was provided by ERDC;
- Some direct costs were taken from cost estimates provided for closure planning at the Faro Mine Complex. Some of the cost components may not be current;
- Seeding and fertilizing costs from SRK experience with work conducted at the Faro Mine complex;
- Direct costs for tailings relocation and covers were estimated by SRK from:
  - Volumes calculated by GEMS® based on previous test pit and borehole data;

  - Equipment fleets and productivities estimated from excavate-load-haul-dump-spread-compact calculations with cover material obtained from the Potential Borrow Area. The excavate-load-haul-dump-spread-compact calculations follow standard methods, as used by earthworks contractors. The calculations make use of equipment specifications obtained from manufacturer's data, in this case the Caterpillar Handbook; and
  - All-in equipment unit rates provided by The Blue Book 2007 – 2008 Equipment Rental Rate Guide (BCRBHCA, 2008). The all-in rates include equipment, operator, maintenance, parts, insurance, home office overhead and contractor profit.

- Direct costs for regrading were estimated by SRK using a regrading productivity spreadsheet and all-in equipment unit rates provided by The Blue Book 2007 – 2008 Equipment Rental Rate Guide.

Indirect Costs

Indirect costs were estimated deterministically. The following items were applied as part of the indirect costs:

- Indirect costs were from cost estimates provided for closure planning at the Faro Mine Complex. Some of the cost components may not be current;
- The costs for project management, contractor profit and home office overhead, insurance, bonding, and field engineering and QA were estimated as percentages of total direct costs. The percentages were adjusted to reach levels that were consistent with SRK experience of similar projects;
- A lump sum cost of $356,723 was included for the mod-demob cost to allow for specialized equipment to be sourced. It is assumed the ERDC construction fleet will be used for closure activities and subcontractors from the Yukon Territory will be sourced. The mob-demob cost was estimated using a mob-demob spreadsheet with unit rates provided by CostWorks, Winnipeg MB;
- Applicable taxes are estimated at 7% of the taxable direct costs. The taxable portion of other closure costs was estimated at 85% of direct and indirect costs;
- GST is charged but will be 100% reimbursable to ERDC, and therefore is excluded from the estimate; and
- Contingency was added to the direct costs and is an integral part of the estimate. The contingency is 20% of the direct cost and is intended to offset the risk of unforeseen or under-predicted circumstances or conditions which experience shows will likely result, in aggregate, in additional costs.

4.1.2 Exclusions

The following items have not been included as a part of the closure cost estimates:

- The cost of reprocessing the relocated tailings as well as the sale of processed metals from tailings reprocessing have not been included in the cost estimate;
- The removal and/or salvage of materials (i.e. pipelines and transmission lines) have not been included in the cost estimate;
- Post closure activities and administration would be by ERDC staff; and
- Field supervision and living out allowances was not included as part of the indirect costs as these were included in the major tasks and heavy equipment costs respectively.

Table 2: Summary of Closure Options

Option	Key Features	Advantages	Disadvantages	Comparative Cost
1A	• Cover tailings in-place. • Maintain current water management.	• Least effort to complete closure option. • Minimal disturbance of tailings.	• Disrupt established revegetation by placing cover. • Reduced opportunities for wetland development. • Active management of surface water is required. • Continued reliance on Porcupine Diversion. • No opportunity for tailings reprocessing.	$13,223,000
1B	• Cover tailings in-place. • Abandon Porcupine Creek Diversion and develop stable channel over tailings cover. • Construct Lower North Fork Flat Creek channel through borrow area.	• Minimal disturbance of tailings. • Eliminate dependence on Porcupine Creek Diversion. • Eliminate dependence on active water management.	• Disrupt established revegetation by placing cover. • Reduced opportunities for wetland development. • No opportunity for tailings reprocessing.	$16,739,000
2	• Relocate tailings to NE quadrant of VTF and cover. • Abandon Porcupine Creek Diversion and develop stable channel over original ground. • Construct Lower North Fork Flat Creek Channel through borrow area.	• Consolidates tailings footprint. • Eliminate dependence on Porcupine Creek Diversion. • Eliminate dependence on active water management.	• Disrupt established revegetation by tailings relocation. • Disturbance of tailings will cause short term release of sediment and dissolved solids to surface water. • Potential for release of pore water as tailings are consolidated. • Requires lime addition during tailings relocation	$60,785,000

4.2 Project Duration

The development of the cost estimates required the selection of a construction fleet. The construction fleet combined with the estimated quantities for each task in a closure option allowed for the duration for each task and sub-task to be estimated.

The duration required to complete the major remediation tasks is summarized in Table 3. To determine the number of days to complete each major task it was assumed work would occur over a seven day work week with one 12 hour shift. The duration of each task would be cut in half if two 12 hour shifts per day was used. For each option, the total project duration is estimated to be:

- Option 1A: 352 days;
- Option 1B: 384 days; and
- Option 2: 512 days.

Not included is the time required to clear and grub the Potential Borrow Area prior to excavation as it is assumed preparation of the working area will be concurrent with excavation of cover and channel bed material. The total duration listed above for each option does not assume tasks and sub-tasks being conducted concurrently. This would reduce the overall project duration significantly.

The total project duration for Option 2 does not take into consideration the time required to amend the relocated tailings with lime addition even though it is a part of the cost estimate. It is assumed lime amendment would be concurrent with the placement of tailings in the Northeast quadrant of the VTF during relocation activities.

Table 3: Major Remediation Task Duration

Option	Task	Sub-Task	Duration	Total
For All Options	Relocation of South Valley Hillside Tailings	Relocation by Dozer [CAT D9]	18 days	18 days
			Total	**18 days**
For All Options	Porcupine Creek Diversion Tailings Removal	Tailings removal by excavator [CAT365BL]	7 days	
		Place channel bed material by excavator [CAT 365BL]	6 days	
		Revegetate channel	2 days	
			Total	**15 days**
For All Options	Lower Dam Crests by 2 m	Push dam crest material onto downstream face [3H:1V] [CAT D9]	4 days	4 days
			Total	**4 days**
1A/B	Place Cover Over VTF Tailings	Regrade tailings surface to a depth of 0.5 m [CATD9]	84 days	
		Place cover by Heavy Fleet 1 – CAT 994D Loader 5 – CAT D400 Haul Trucks	203 days	
			Total	**287 days**
2	Relocation of the older, thin tailing deposits in the west part of the VTF	Relocation by Heavy Fleet 1 – CAT 994D Loader 10 – CAT D4000 Haul Trucks	347 days	347 days
			Total	**347 days**
2	Place Cover Over Relocated VTF Tailings	Place cover by Heavy Fleet 1 – CAT 994D Loader 5 – CAT D400 Haul Trucks	77 days	77 days
			Total	**77 days**
1A/B	Stabilize North Fork Flat Creek Channel	Excavate channel in tailings [CAT 365BL]	14 days	
		Place channel bed material by excavator [CAT 365BL]	12 days	
		Revegetate channel	2 days	
			Total	**28 days**

Table 3: Major Remediation Task Duration (Cont'd.)

2	Stabilize North Fork Flat Creek Channel	Excavate channel in tailings and mineral soil [CAT 365BL]	9 days	
		Place channel bed material by excavator [CAT 365BL]	8 days	
		Revegetate channel	2 days	
			Total	**19 days**
1B	Develop Brefalt and Porcupine Creek through VTF	Excavate channel in tailings [CAT 365BL]	10 days	
		Place channel bed material by excavator [CAT 365BL]	9 days	
		Revegetate channel	2 days	
			Total	**21 days**
2	Develop Brefalt and Porcupine Creek through VTF	Excavate channel in mineral soil [CAT 365BL]	10 days	
		Place channel bed material by excavator [CAT 365BL]	9 days	
		Revegetate channel	2 days	
			Total	**21 days**
1B/2	Develop Lower North Fork Flat Creek	Excavate channel in till [CAT 265BL]	5 days	
		Place channel bed material by excavator [CAT 365BL]	4 days	
		Revegetate channel	2 days	
			Total	**11 days**

5 Summary

Two primary closure options have been proposed for the UKHM Valley Tailings Facility. Option 1 is to leave the tailings in place and construct a soil cover over the tailings. There are two variants, to Option 1 that allow for management of surface water in and around the VTF. Option 2 consists of relocating the older thin tailings located behind Dams #2 and #3 as well as along the southeast quadrant of the VTF to behind Dam #1. Surface water management would be similar to that described for one of the Option 1 variants.

Both options will require the dispersed tailings located on the hillside below the town of Elsa to be relocated.

Closure Option 1A proposes to cover the tailings in place. Upgrades to the existing surface water management are limited to upgrading the existing North Fork Flat Creek channel and the Porcupine Diversion. The existing water management behind the dams would be maintained. This variant of

Option 1A would require the shortest duration to complete with the lowest estimated cost to complete. No long term costs for maintaining the current water management behind the dams was considered.

Closure Option 1B also proposes to cover the tailings in place. Upgrades to the existing surface water management include upgrading the existing North Fork Flat Creek channel and Porcupine Diversion as well as developing a stable channel through the VTF to allow Brefalt and Porcupine Creeks to follow their pre-mining alignment. This would reduce the dependency on the Porcupine Diversion to manage surface water as only Flat Creek would continue to follow the lower reach of the diversion past Dam #3.

Surface water management behind the dams would be passively managed by the construction of the Lower North Fork Flat Creek channel. This channel would pass through the Potential Borrow Area along the north edge of the VTF.

Option 1B would take slightly longer to complete than Option 1A (by approximately one month) and the increase in the estimated cost reflects the construction of the Lower North Fork Flat Creek channel.

Option 2 proposes to relocate the older thin tailings to the Northeast quadrant of the VTF. By relocating the tailings there may be the opportunity for reprocessing the tailings and for consolidation of the tailings footprint. There may also be opportunities to develop wetland features within the exposed original ground. Surface water management would be the same as for Option 1B.

Option 2 would require the longest period of time to complete and is has the greatest estimated cost. Lime addition is a significant cost for Option 2. ERDC estimated the cost of purchasing and transporting 18,000 tonnes of $Ca(OH_2)$ to site is $500 per tonne for a total estimated cost of $8,545,000 (based on a requirement for 18,000 tonnes of $Ca(OH)_2$). This includes procuring and transporting the lime to site.

This report, **"2009 Valley Tailings Facility Closure Options, Keno Hill, YT"**, has been prepared by SRK Consulting (Canada) Inc.

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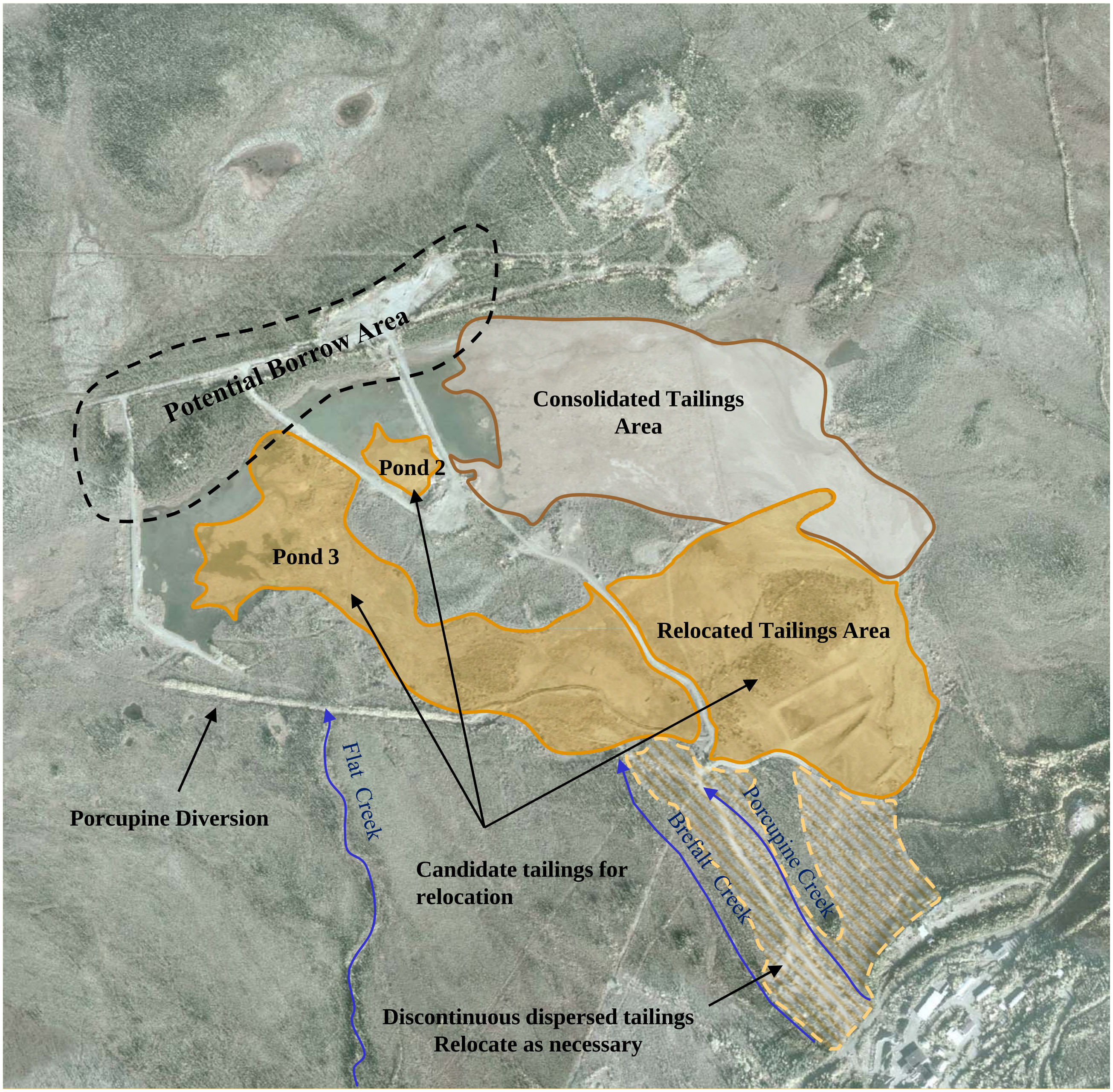
Figures



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ERDC

VTF Tailing Areas Defined for the Closure Options

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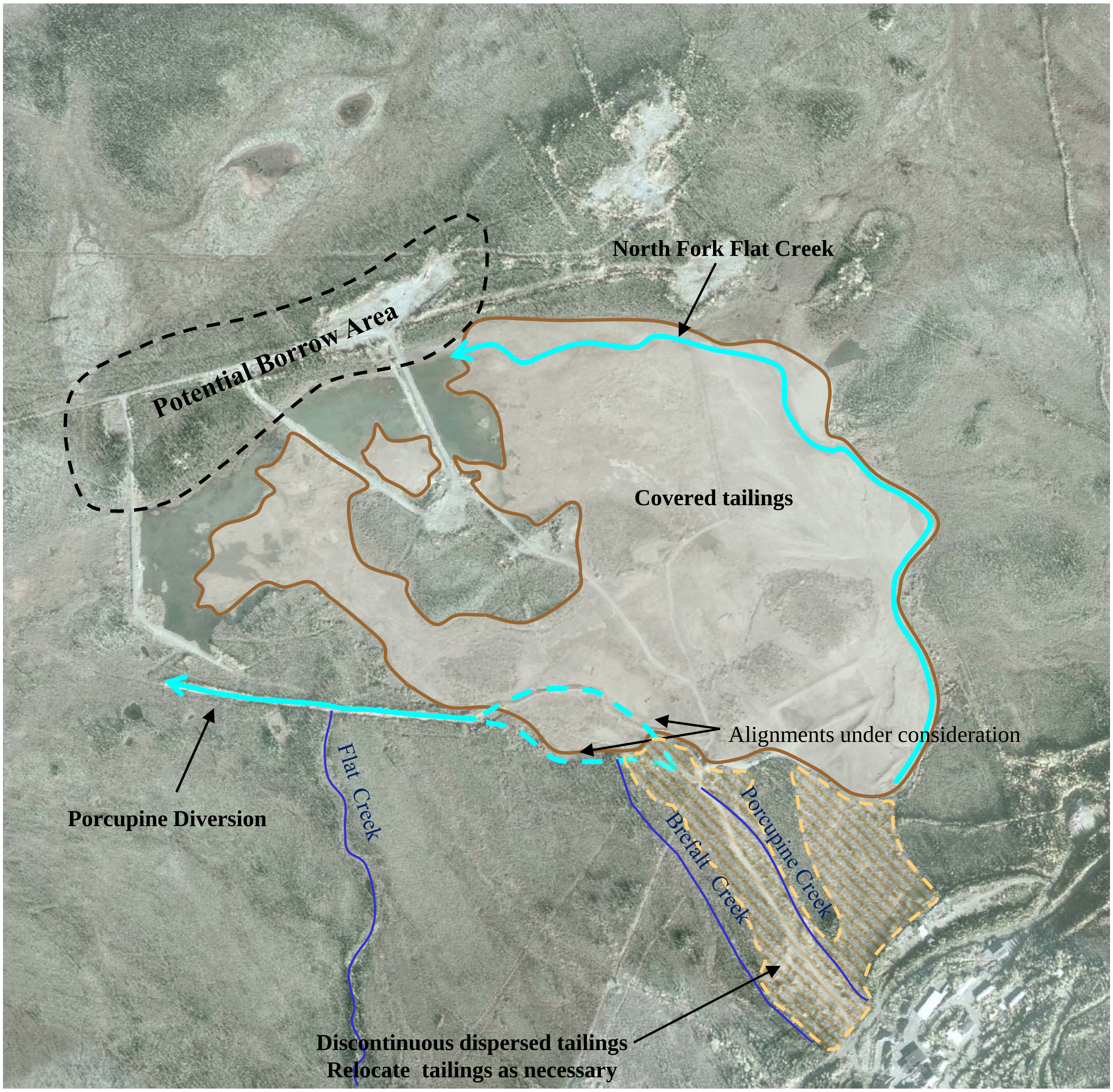

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Closure Option 1A

Job No: 1CE012.002.400	2009 Valley Tailings Facility Closure Options	Date: April 2009	Approved: LW	Figure: 2
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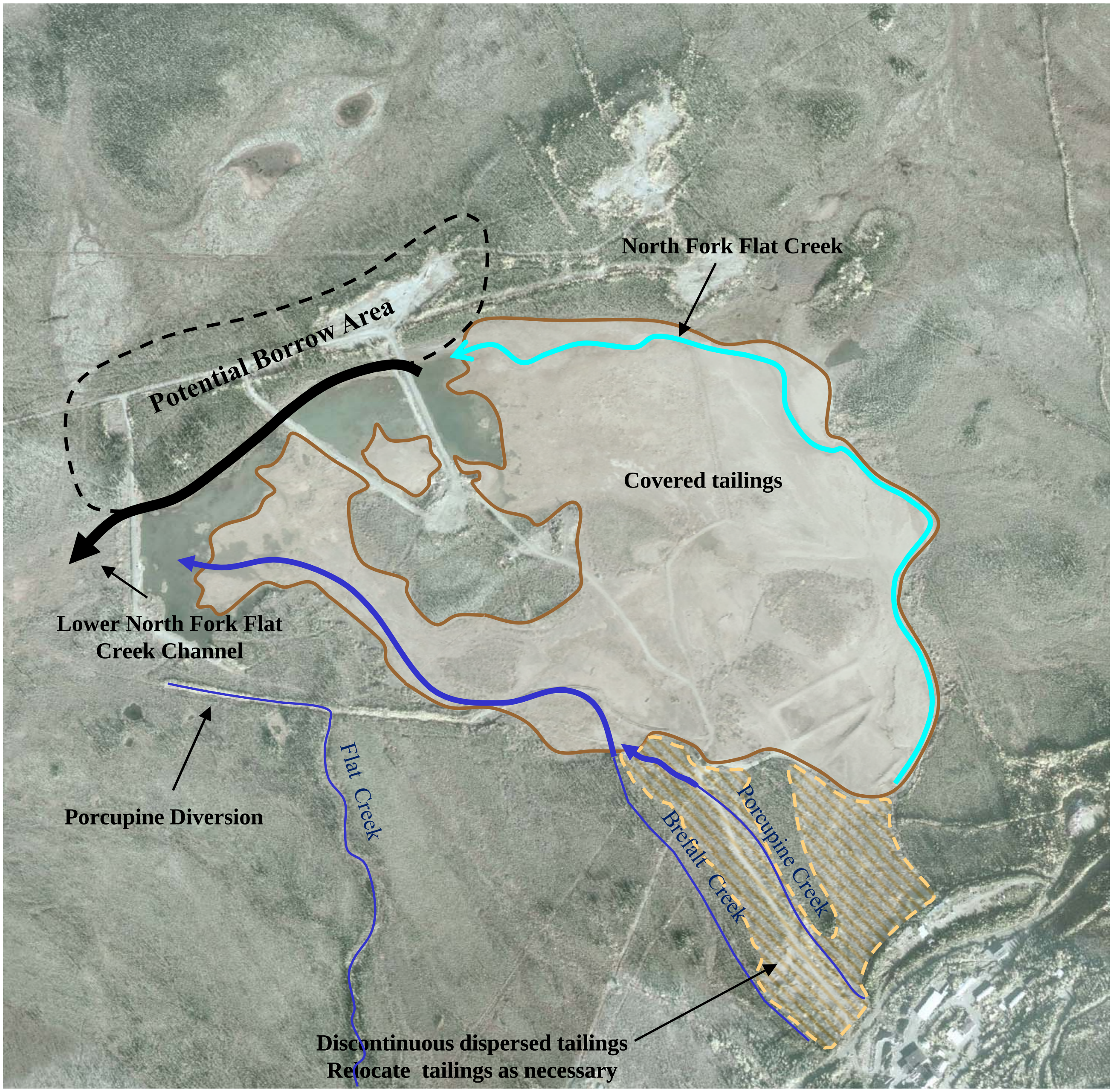
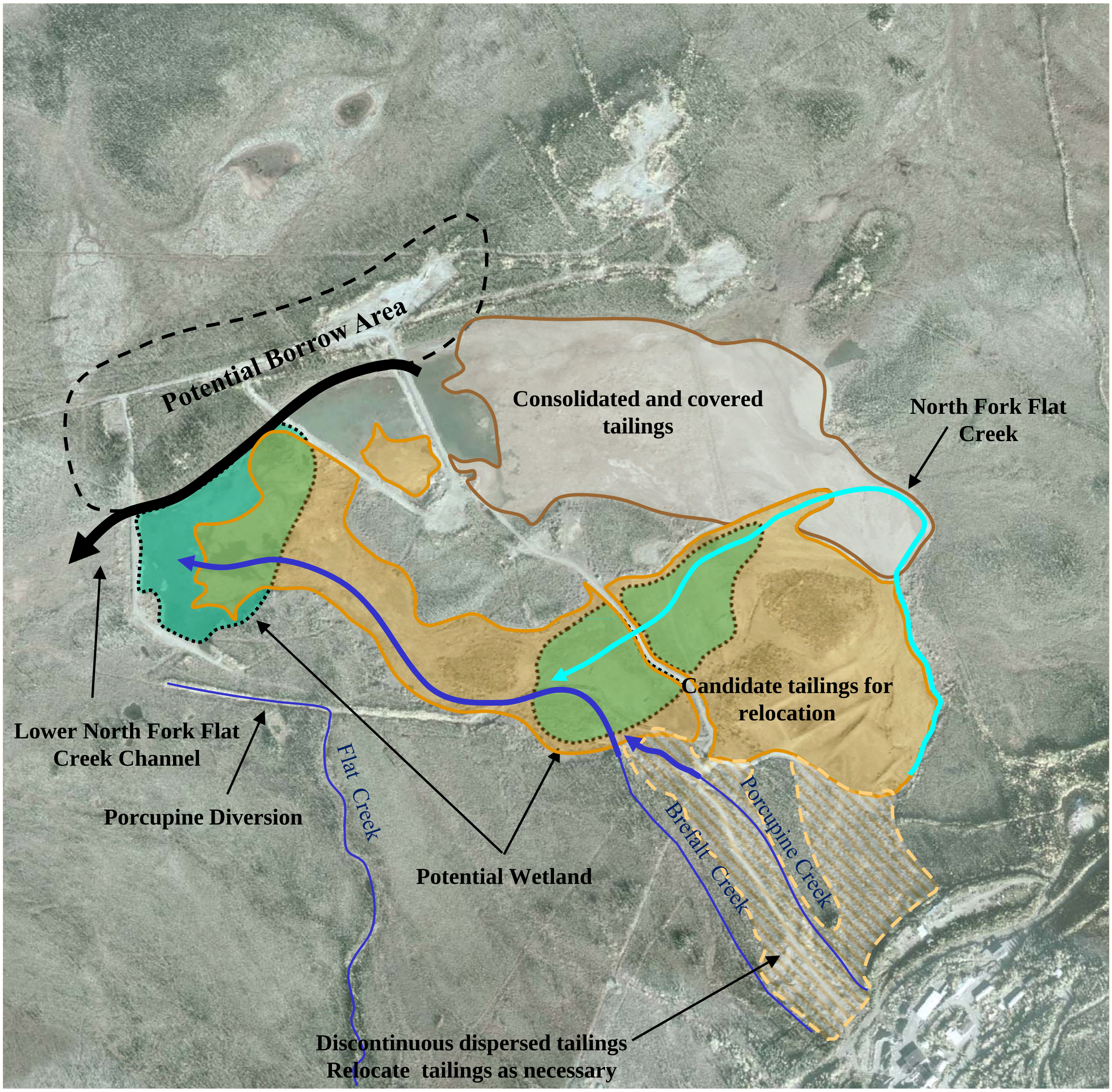


SRK Consulting Engineers and Scientists	ERDC	**Closure Option 1B**
Job No: 1CE012.002.400 Filename: VTF.ClosureOptions.CompiledFigures.1CE012.002.LW.rev03	2009 Valley Tailings Facility Closure Options	Date: April 2009 | Approved: LW | Figure: 3



SRK Consulting Engineers and Scientists	ERDC	**Closure Option 2**
Job No: 1CE012.002.400 Filename: VTF.ClosureOptions.CompiledFigures.1CE012.002.LW.rev03	2009 Valley Tailings Facility Closure Options	Date: April 2009 | Approved: LW | Figure: 4

Appendices

Appendix A
2008 VTF Site Investigation

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Technical Memorandum

To:	File	**Date:**	April 16, 2009
cc:		**From:**	Lowell Wade
Subject:	2008 VTF Site Investigation	**Project #:**	1CE002.002.400

1 Introduction

1.1 Background

Elsa Reclamation and Development Company Ltd. (ERDC) are in the process of preparing a closure plan for Valley Tailings Facility (VTF) of the former United Keno Hill Mine (UKHM) property in the Yukon. In 2007/08 SRK reviewed the geochemical stability, local hydrogeological and geotechnical conditions of the VTF as part of the closure studies (SRK 2008a, 2008b, 2008c). From these closure studies, information gaps were identified relating to borrow material and tailings to proceed to evaluation of closure options. This memo presents the results of the field investigation and related assessments to address these information gaps.

1.2 Overview of Field Program

From July 7th to 13th 2008, a site inspection of the VTF was conducted with the following objectives.

1.2.1 Tailings Investigation

One of the closure options under consideration includes partial relocation of tailings. To support and evaluation of the closure options a 32 test pit investigation was conducted, on July 8^{th} and 9^{th}, to define relocation volumes and the chemical characteristics of the tailings and the peat underlying the tailings. Samples were collected to:

- Characterize the basic geotechnical properties of the tailings;
- Characterize the pore water extracted from tailings and peat samples as well as attenuation of contaminant metals into the peat underlying the tailings;
- Characterize the lime required to neutralize existing acidity and control release of soluble metals in the tailings. The cost implications of lime addition can be significant; and
- Characterize the field bulk density of the tailings.

1.2.2 Potential Borrow Source Investigation

The ridge immediately north of the VTF has been identified as the primary borrow candidate for tailings cover and channel bed material. An 11 test pit investigation was conducted, on July 9th and 10th to better define the available quantities of till available. Bulk samples were collected for geotechnical characterization and evaluation of whether this material is suitable for use as a tailings cover. If this source is not suitable an alternate source of cover material would need to be identified. The cost of constructing the tailings covers would likely be much higher and would influence the evaluation process.

1.2.3 Site Reconnaissance

On July 11th a site reconnaissance of the VTF focused on five areas:

1) The tailings discharge on the hillside below the town of Elsa;
2) The east side of the VTF, following the North Fork Flat Creek;
3) Potential routes of water conveyance around the abutments of the tailings dams;
4) An overview of the tailings area above and below Dam 2; and
5) The Porcupine Diversion.

The observations made during the site reconnaissance will assist in developing closure options by considering:

- Upgrades to the existing water management features;
- Development of new water management features
- Selection of candidate areas to receive relocated tailings; and
- Determine the extent of tailings that require relocation.

1.2.4 Site Conditions

Throughout the field program the winds were generally slight with daytime temperatures reaching highs of 24°C (average) and lows down to 2.4°C (average). Conditions ranged from sunny clear skies to overcast with periods of rain.

2 Methods

2.1 Valley Tailings Facility Investigation

Twenty four potential test pit locations within the VTF and four test pit locations were identified in the old tailings patties on the hillside below the town of Elsa were identified prior to the field program. The number of test pits and their locations were adjusted in the field to suite site conditions. The completed test pits were marked using a hand held GPS [Garmin 76CSx] set to UTM NAD83 (Table 1). The locations of the completed test pits are shown in Figure 1.

During the test pit program the test pits were logged and the physical characteristics of the tailings and underlying soils were described. The field bulk density of the tailings was determined at several test pit locations within the VTF.

Table 1: Completed Test Pits within the VTF

Hole ID	Northing[1]	Easting[1]	Collar Elevation (m)	Depth (m)
TP_08-01	7088473	474615	702	1.6
TP-08-02	7088474	474738	700	0.9
TP-08-03	7088404	474602	702	2.1
TP-08-04	7088377	474562	701	2.1
TP-08-05	7088350	474495	690	2.2
TP-08-06	7088236	474490	698	1.0
TP-08-07	7088265	474629	697	1.3
TP-08-08	7088302	474646	698	1.0
TP-08-09	7088407	474744	706	0.7
TP-08-10	7088370	474678	698	1.15
TP-08-11	7088276	474734	700	2.5
TP-08-12	7088255	474712	701	2.4
TP-08-13	7088316	474762	697	1.1
TP-08-14	7088172	474754	694	1.8
TP-08-15	7088230	474843	698	2.3
TP-08-16	7088023	474925	722	2.9
TP-08-17	7088138	474934	705	0.3
TP-08-18	7088066	475186	713	1.8
TP-08-19	7088122	475137	711	0.6
TP-08-20	7088168	475274	711	1.45
TP-08-21	7088017	475296	713	2.4
TP-08-22	7088080	475286	712	1.6
TP-08-23	7088052	475223	711	2.6
TP-08-24	7088132	475312	712	1.2
TP-08-25	7087963	475390	713	2.2
TP-08-26	7087952	475425	718	1.3
TP-08-27	7087453	475648	766	0.4
TP-08-28	7087413	475674	771	2.45
TP-08-29	7088206	475472	712	1.5
TP-08-30	7088265	475475	710	1.6
TP-08-31	7088194	475375	711	1.6
TP-08-32	7088508	474868	704	4.0

1. UTM Projection NAD 83 Zone 8.

2.2 Potential Borrow Source Investigation

Twelve potential test pit locations within the potential borrow source were identified prior to the field program. Figure 1 also shows the number and location of completed test pits that were adjusted in the field to suite site conditions. The completed test pits were marked using a hand held GPS [Garmin 76CSx] set to UTM NAD83 Zone 8. The test pit locations and depth are listed in Table 2.

Table 2: Completed Test Pits within the Potential Borrow Area

Hole ID	Northing[1]	Easting[1]	Collar Elevation (m)	Depth (m)
TP-08-33	7088707	474830	701	7.5
TP-08-34	7088804	474858	709	4.3
TP-08-35	7088875	474940	707	3.8
TP-08-36	7088855	474855	710	5.4
TP-08-37	7088788	474737	708	5.4
TP-08-38	7088754	474737	703	4.6
TP-08-39	7088622	474581	701	5.8
TP-08-40	7088675	474520	706	5.8
TP-08-41	7088586	474395	710	1.7
TP-08-42	7088652	474387	721	6.3
TP-08-43	7088707	474645	706	6.3

1. UTM Projection NAD 83 Zone 8.

2.3 Spilled Tailings West of Dam #3 Investigation

Seven potential test pit locations west of Dam #3 were identified prior to the field program. Due to the heavy vegetation, hummocky terrain and high water levels, the location and number of test pits were adjusted in the field to suite site conditions. Test pits were completed using a hand shovel and marked using a hand held GPS [Garmin 76CSx] set to UTM NAD83 Zone 8 (Table 3). The location of these test pits are shown in Figure 1.

Table 3: Completed Test Pits Downstream of Dam #3

Hole ID	Northing[1]	Easting[1]	Collar Elevation (m)	Depth (m)
TP-08-44	7088314	474254	696	0.4
TP-08-45	7088276	474145	695	0.6
TP-08-46	7088235	474084	695	0.9
TP-08-47	7088224	474047	696	0.8
TP-08-48	7088177	473919	695	0.8
TP-08-49	7088062	473739	694	0.3
TP-08-50	7088034	473616	693	0.3
TP-08-51	7087881	473367	687	0.5

1. UTM Projection NAD 83 Zone 8.

2.4 Site Reconnaissance

A site reconnaissance survey was conducted of the following areas.

2.4.1 Reconnaissance of the Hillside below the Town of Elsa

A reconnaissance to determine the extent of tailings deposited on the hillside below the town of Elsa was conducted. The extent of the reconnaissance area is shown in Figure 1. The reconnaissance extends from the 1950's tailings patties on to below the Framing Mill as these are locations of former main tailings discharge. Relocation of these tailings will be considered as part of a closure plan for the VTF.

2.4.2 Reconnaissance of North Fork Flat Creek

A reconnaissance along the east side of the VTF followed the path of surface water flow from the upper tailings below the framing mill. This is the path of North Fork Flat Creek. Establishing North Fork Flat Creek as a stable channel through the VTF will be considered as part of a closure plan for the VTF.

2.4.3 Reconnaissance of Potential Lower North Fork Flat Creek

Potential routes of water conveyance around the dams were examined with a detailed look at the north side of the valley beyond the abutments of Dams #1, # 2, and #3. The north side of the VTF is the preferred location for the construction of Lower North Fork Flat Creek channel (Figure 2). The construction of this channel is part of the closure options being considered which would be used to convey water retained in Ponds 1 to 3 downstream of Dam #3.

2.4.4 Reconnaissance of Porcupine Diversion

A reconnaissance of Porcupine Diversion was completed from the access road at the base hill side below the town of Elsa (i.e. were Porcupine Creek passed under the access road) as well as from the start of the ditch excavated in the tailings in the VTF to the western limits of the diversion ditch excavation. The reconnaissance focused on features relevant to open channel design and civil works necessary to route water in any breach scenarios and where Brefalt Creek and Flat Creek enters the Porcupine Diversion.

2.5 Laboratory Testing

2.5.1 Geotechnical Analyses

A total of 39 bulk (i.e. disturbed) soil samples were collected and shipped to the EBA testing laboratory in Whitehorse for geotechnical analysis. Table 4 summarizes the samples selected for laboratory testing and the laboratory program.

Table 4: Laboratory Program for Geotechnical Analyses

Sample [ID:Depth (Type)]	Atterberg Limits	Sieve	Hydrometer	Moisture Content	Standard Proctor	Specific Gravity
TP-08-08: 0.7 m (SM - Tailings)				✓		✓
TP-08-10: 0.5 m (SM - Tailings)				✓		✓
TP-08-15: 0.9 m (SM - Tailings)				✓		✓
TP-08-18: 1.3 m (SM - Tailings)				✓		✓
TP-08-20: 0.45 m (SM - Taillings)				✓		✓
TP-08-20: 1.0 m (SM - Tailings)				✓		✓
TP-08-33: 0.0 - 3.9 m (GM)				✓		
TP-08-33: 3.9 - 7.5 m (GM)				✓		
TP-08-34: 0.0 - 4.3 m (GM)				✓		
TP-08-35: 0.0 - 3.8 m (GM)	✓	✓	✓	✓	✓	
TP-08-36: 0.0 - 2.5 m (GM)	✓	✓		✓		
TP-08-37: 0.0 - 5.4 m (GM)				✓		
TP-08-38: 0.0 - 4.6 m (GM)				✓		
TP-08-39: 0.3 - 5.8 m (GM)	✓	✓		✓		
TP-08-40: 0.0 5.8 m (GM)				✓		
TP-08-41: 0.5 - 1.7 (GM)				✓		
TP-08-42: 0.2 - 6.3 m (GM)	✓	✓	✓	✓	✓	
TP-08-43: 0.0 - 6.3 m (GM)	✓	✓	✓	✓	✓	

Soil type is designated soil symbol according to the Unified Soil Classification System (USCS).
GM = Gravel, silt, (Till).
SM = Sand, silty.
PT = Peat.

2.5.2 Pore Water and Attenuation Analyses

A total of eleven bulk soil samples were collected and shipped to Cantest in Burnaby, B.C. to characterize the pore water extracted from tailings and peat samples collected as well as attenuation of contaminant metals into the peat underlying the tailings. Table 5 summarizes the samples selected for laboratory testing.

Table 5: Laboratory Program for Pore Water and Peat Characterization

Sample [ID:Depth (Type)]	Porewater Extraction(1)	Metals by Aqua Regia(2)
TP-08-08: 1.0 m (SM-Tailings)	✓	
TP-08-08: 1.5 m (SM-Tailings)	✓	
TP-08-08: 2.0 m (Pt)	✓	✓
TP-08-10: 0.3 m (SM - Tailings)	✓	
TP-08-10: 2.15 m (Pt)	✓	✓
TP-08-15: 2.3 m (SM - Tailings)	✓	
TP-08-15: 3.0 m (Pt)	✓	✓
TP-08-18: 1.8 m (SM - Tailings)	✓	
TP-08-18: 2.8 m (Pt)	✓	✓
TP-08-20: 1.35 m (SM - Tailings)	✓	
TP-08-20: 2.25 m (Pt)	✓	✓

(1) Extract porewater from sample by vacuum filtration or centrifuge. Analyze for the following parameters (in the order listed if recovered porewater is limited):
   a. Dissolved metals (trace levels not required)
   b. Sulphate
   c. pH, conductivity
   d. total alkalinity
   e. chloride

(2). Prepare an aliquot of each indicated sample for metals analysis by aqua regia digestion with ICP finish. The indicated samples are all peat samples, and we will want to run subsequent tests on the remaining sample- do not mechanically homogenize sample. Prepare aliquot for metal analysis by subsampling several locations from the sample provided.

Soil type is designated soil symbol according to the Unified Soil Classification System (USCS).

1. GM = Gravel, silt, (Till).
2. SM = Sand, silty.
3. PT = Peat.

2.5.3 Lime Addition Analyses

A total of six bulk tailing samples were collected and shipped to Canadian Environmental & Metallurgical Inc. in Burnaby, B.C. for moisture determination, pH and lime neutralization analyses, as well as chemical characterization of the settled supernatant. These samples were collected specifically for lime addition analyses and were channel samples measuring approximately 0.3 m wide by 0.3 m deep over the entire length of tailings in the test pit. Table 6 summarizes the samples selected for laboratory testing.

Table 6: Laboratory Program for Moisture Content, Lime Addition and Settled Supernatant Characterization

Sample [ID:Depth (Type)]	Moisture Content	Lime Demand	ICP Analysis
TP-08-08: 0.1-1.0 m (SM-Tailings)	✓	✓	✓
TP-08-10: 0.25-0.7 m (SM-Tailings)	✓	✓	✓
TP-08-15: 0.9-1.5 m (SM-Tailings)	✓	✓	✓
TP-08-18: 0.0-1.8 m (SM - Tailings)	✓	✓	✓
TP-08-20: 0.1-1.0 m (SM-Tailings) Above water table	✓	✓	✓
TP-08-20: 1.0-1.45 m (SM - Tailings) Below water table	✓	✓	✓

Soil type is designated soil symbol according to the Unified Soil Classification System (USCS).

1. GM = Gravel, silt, (Till).
2. SM = Sand, silty.
3. PT = Peat.

3 Results and Discussion

3.1 Valley Tailings Facility Investigation Results

To support an evaluation of tailings relocation as a potential closure option, the test pit program was used to estimate the volume of tailings within the VTF and determine if tailings have mixed with the underlying peat. If the peat underlying the tailings is contaminated, over-excavation will be required to achieve a suitable final surface. This additional excavated volume will be important to estimate the additional costs.

Logs of the test pits completed within the VTF as a part of the 2008 field investigation are provided in Attachment 1A. All VTF test pits were terminated in original ground. In most cases, test pits were terminated in the peat underlying the tailings but several test pits were terminated in silty sand or well graded gravel below the peat unit. The only test pit which did not encounter peat was TP-08-28 located on within the old tailings patties.

The VTF was divided into four areas based on tailings retained behind the dams as well as potential closure options being considered. These regions are shown in Figure 2. The results from the SRK's field investigations were combined with BGC's Tailings Disposal Study to develop a computer generated model in GEMS© to estimate the volume of tailings within the VTF (BGC 1996; SRK 2008a, 2009a). The estimated volume of retained tailings within each area is summarized in Table 12.

Table 7: Summary of Estimated Tailings Volumes within the VTF

VTF Region	Area (m^2)	Volume (m^3)	Volume with 0.5 m over-excavation (m^3)
Pond 1			
Consolidated Tailings Area	297,000	1,205,000	
Relocated Tailings Area	252,000	1,030,000	1,148,000
Pond 2	13,000	37,000	43,000
Pond 3	222,000	359,000	468,000
Total	**784,000**	**2,631,000**	**1,659,000**

There is an estimated 2,631,000 m^3 of tailings stored within the VTF. This does not include tailings submerged within the Ponds. Examination of the underlying peat indicated the possibility of contamination by tailings. If partial tailings relocation is the selected closure option, over excavation of the tailings into the peat by 0.5 m should remove the majority of the tailings contamination. If partial relocation of the tailings is to be considered, an estimated total volume of 1,659,000 m^3 of tailings and over excavated soil would be relocated to the Consolidated Tailings Area shown in Figure 2.

The test pit program also allowed for the assessment of ground conditions for trafficablity by heavy equipment for the placement of a cover over the tailings or tailings relocation. Trafficability by the Hitachi Zaxis 270 LC excavator over most of the exposed tailings within the VTF did not present any problems. The existing ground conditions were wet with some soft ground in areas close to the downstream face of Dam #2. Trafficability over the tailings between Dams #1 and #2 was a problem. Ground conditions were very soft and wet. Dewatering measures or winter conditions may have to be considered for placing a tailings cover or conducting tailings relocation in this area.

3.2 Potential Borrow Source Investigation Results

The ridge immediately north of the VTF is the primary borrow candidate for cover material. The approximate limits of the potential borrow source are shown on Figure 1. The borrow source investigation is required to provide geotechnical characteristics and confirm available quantities of the material suitable for use in tailings covers.

With the exception of two test pits, excavation of test pits within the potential borrow source area were terminated in very compact silty gravel. Test pit TP-08-33 reached the extent of the excavator and TP-08-41 met refusal in permafrost. Both of these test pits also terminated in silty gravel. The test pit logs are provided in Attachment 1B. As a general observation, the overburden till became significantly compact with increasing depth. Most test pits were terminated as a result of the excavator not being able to remove material from the test pit. It was confirmed there was no permafrost at the base of these test pits.

The results from the SRK's previous field investigations were combined with Alexco's Soils Characterization and Drilling Report to develop a computer generated model in GEMS© to estimate the volume of cover material within the Potential Borrow Area (Alexco 2007; SRK 2008a). Using the approximate limits shown in Figure 1 as a borrow source boundary there is an estimated 1,523,000 m^3 of potential cover material that can be used for the selected closure option.

3.3 Spilled Tailings West of Dam #3 Investigation Results

The extent of spilled tailings west of Dam #3 can be estimated based on air photo interpretation but has not been confirmed. Standing water up to approximately 0.75 m deep combined with heavy vegetation and hummocky terrain made reconnaissance of tailings distribution downstream of Dam #3 difficult. Test pits were excavated using a hand shovel. Digging of the test pits proved to be labour intensive due to the approximately 0.05 m thick dense root mat at the surface at some locations and the high-water table caused the test pits to fill with water and collapse quickly. As a result none of the test pits reached original ground surface. These test pits only confirmed presence of tailings downstream of Dam #3 and extent of tailings deposited. The logs of these shallow test pits are in Attachment 1C. The western extent of tailings encountered in test pit TP-08-51 is shown on Figure 1.

The volume of spilled tailings was not estimated as it is unlikely these tailings will be relocated due to the natural re-vegetation that is occurring.

3.4 Site Reconnaissance

3.4.1 Reconnaissance of the Hillside below the Town of Elsa

Discontinuous tailing deposits were observed through the re-established vegetation due to the historic discharge of tailings. The two test pits (TP-08-27 and TP-08-28) were completed in the 1950's tailings patties. The test pit completed in the lower tailings patty (TP-08-27) showed 0.3 m of retained tailings which is consistent with the observed thickness of tailings within the reconnaissance area. The test pit completed in the upper tailings patty (TP-08-28) showed 2.5 m of retained tailings which is may represent the maximum depth of tailings encountered in this area.

It is estimated the average depth of the dispersed tailings within this reconnaissance area is 0.5 m and the tailings cover an area of 163,000 m^2 for a total volume of 82,000 m^3. These tailings would require relocation as necessary as part of a closure plan.

3.4.2 Reconnaissance of North Fork Flat Creek

North Fork Flat creek is confined to an excavated channel between the tailings and original ground from the base of the hillside below the framing Mill heading northwards until it reaches the midpoint of the eastern limit of the VTF. From this point northwards, North Fork Flat Creek flows over the VTF tailings surface as a series of braided streams in a channel approximately 20 m wide. The channel widens as North Fork Flat Creek reached the northern extent of the VTF. At this point, North Fork Flat Creek turns west and becomes a diffuse surface flow over the tailings surface until it flows into Pond 1.

3.4.3 Reconnaissance of Potential Lower North Fork Flat Creek

The Lower North Fork Flat Creek channel would be constructed through the Potential Borrow Area along the Northern edge of the VTF. Excavation of material from the Potential Borrow Area would facilitate the construction of the Lower North Fork Flat Creek Channel. Clearing and grubbing would be required prior to excavation of borrow material and channel construction.

Permafrost was encountered in test pit TP-08-41, 2 m below the surface. The presence of permafrost in this test pit may indicate drilling a blasting may be required to construct the Lower North Fork Flat Creek through this area of the Potential Borrow Area.

3.4.4 Reconnaissance of Porcupine Diversion

It appears Porcupine Diversion starts at two locations. The first location is along Porcupine Creek as it follows its existing streambed through a culvert under the access road leading from Elsa to the VTF and flows into Brefalt Creek. These two creeks then are directed by the Porcupine Diversion along the south side of the VTF to discharge downstream of Dam #3. The second location is a channel that has been excavated in the older tailings at the south end of the VTF to divert surface water flow towards the Porcupine Diversion downstream of Brefalt Creek.

As part of the Porcupine Diversion upgrade, the final alignment of the start of the diversion must be selected. The start of the diversion must either follow the existing Porcupine Creek and Brefalt Creek alignment or the excavated channel through the tailings. The existing channel though which Porcupine Creek flows would not require the removal of tailings for the first 200 m of the upgraded diversion. Should tailings relocation be considered the preferred closure option, upgrading the start of the diversion through the VTF would not have to be considered.

Porcupine Diversion very quickly becomes narrow and steep sided as it heads west. Heavy vegetation has covered most of the hillsides. Were Flat Creek flows into Porcupine Diversion the side slopes were very steep, about 4 m in height and heavily overgrown. At the time of the inspection of the channel was approximately one metre wide and less than a metre deep.

Upgrading the Porcupine Diversion would require:

- Widening the channel base and remove tailings from the streambed;
- Lining and armouring the diversion would be required to prevent erosion; and
- Re-contouring the channel side slopes would also be required to prevent sloughing of hillside material into the channel.

To reduce the dependency on Porcupine Diversion to manage surface water flow, it would be possible to develop a stable channel for Brefalt and Porcupine Creeks to follow their pre-mining alignment through the VTF. Flat Creek would continue to follow the lower Porcupine Creek Diversion since a significant amount of earthworks would be required to excavate a channel to join Flat Creek with Porcupine and Brefalt Creeks passing through the VTF.

3.5 Laboratory Testing Results

3.5.1 Geotechnical Results

Eleven samples were subjected to basic geotechnical classification testing, with the results summarized in Table 7. Complete laboratory data sheets are included as Attachment 2. Also included in Attachment 2 are the results of the field bulk density determinations.

Table 8: Results of 2008 Geotechnical Closure Study Testing

	Atterberg Limits			Grain Size Analysis					Standard Proctor[1]		
Sample [ID:Depth (Type)]	**Liquid Limit (%)**	**Plastic Limit (%)**	**Plasticity Index (%)**	**Gravel (%)**	**Sand (%)**	**Silt (%)**	**Clay (%)**	**Moisture Content**	**Max Dry Density kg/m^3**	**Opt. Moisture Content (%)**	**Specific Gravity**
TP-08-08: 0.7 m (SM - Tailings)								27.7			2.7
TP-08-10: 0.5 m (SM - Tailings)								29.2			2.4
TP-08-15: 0.9 m (SM - Tailings)								25.8			2.6
TP-08-18: 1.3 m (SM - Tailings)								26.3			2.6
TP-08-20: 0.45 m (SM - Tailings)								21.0			2.7
TP-08-20: 1.0 m (SM - Tailings)								29.8			2.8
TP-08-33: 0.0 - 3.9 m (GM)								6.3			
TP-08-33: 3.9 - 7.5 m (GM)								16.6			
TP-08-34: 0.0 - 4.3 m (GM)								4.8			
TP-08-35: 0.0 - 3.8 m (GM)	18.0	14.0	4.0	0.0	38.0	52.0	10.0	6.0	2175.0	8.5	
TP-08-36: 0.0 - 2.5 m (GM)	17.0	13.0	4.0	23.0	31.6	45.4		7.4			
TP-08-37: 0.0 - 5.4 m (GM)								7.1			
TP-08-38: 0.0 - 4.6 m (GM)								7.8			
TP-08-39: 0.3 - 5.8 m (GM)	17.0	14.0	3.0	47.0	24.7	28.3		5.2			
TP-08-40: 0.0 5.8 m (GM)								7.3			
TP-08-41: 0.5 - 1.7 (GM)								18.4			
TP-08-42: 0.2 - 6.3 m (GM)	16.0	13.0	3.0	0.0	41.0	51.0	8.0	8.8	2175.0	8.5	
TP-08-43: 0.0 - 6.3 m (GM)	16.0	14.0	2.0	0.0	41.0	49.0	10.0	6.9	2175.0	8.5	

Notes:

1. Standard Proctor Analysis was performed on the homogenized samples TP-08-35, TP-08-42, and TP-08-43 to provide enough sample to perform the test.

In general the tailings in the VTF showed consistent physical properties. The moisture content ranged from 21.0% to 29.8% with average moisture content of 26.6%. The calculated specific gravity ranged from 2.37 to 2.84 an average of 2.65. The field bulk density was found to vary from 1.8 to 2.1tonnes/m^3 with an average field bulk density of 1.9 tonnes/m^3.

The silty gravel from the potential borrow source also showed consistent moisture content with an average of 8.6%. A standard proctor analysis was performed on the homogenized samples TP-08-42, TP-08-42, and TP-08-43 as there was not enough material in the individual samples to conduct separate tests. The results of the Standard Proctor indicate the silty gravel has a maximum dry density of 2175 kg/m^3 and an optimum moisture content of 8.5% which is close to the average moisture content for existing conditions.

The grain size distributions of the silty gravel did not show the uniformity expected based on field observations. The sand, silt and clay fractions of these samples showed some variability but the larger gravel and cobble fraction were absent in three samples (TP-08-35, TP-08-42, and TP-08-43). Confirmation with the lab indicated that the samples collected neglected to include the large soil fraction which is present in the test pit photos. Atterberg Limits on the silty gravel were also consistent with an average liquid limit of 16.8%, an average plastic limit of 13.6%, and a plasticity Index of 3.2%. The fine fraction of the silty clay was classified as CL of low plasticity. The silty gravel showed consistent Atterberg Limit values with an average of 16.8% for the Liquid Limit; 13.6% for the Plastic Limit; and 3.2% for the Plasticity Index.

3.5.2 Pore Water and Attenuation Results

Of the eleven bulk soil samples submitted for pore water extraction and characterization, only two tailings samples contained enough pore water to conduct the required analyses. Complete laboratory data sheets are included as Attachment 3. A summary of characteristic parameters and dissolved metals is provided in Table 8.

Table 9: Summary of Characteristic Parameters and Dissolved Metals in Pore Water

Parameter	Units	TP-08-08 1.0 m (SM-Tailings)	TP-8-15 2.3 m (SM-Tailings)
pH	pH Units	7.8	7.2
Conductivity	μS/cm	1642	5120
Alkalinity (to pH 4.5)	mg $CaCO_3$/l	256	38
Sulphate (SO_4^{2-})	mg/l	604	4370
Dissolved Cloride Cl	mg/l	7.87	7.07
Dissolved Metals			
Dissolved Cadmium Cd	mg/l	0.1	12.2
Dissolved Iron Fe	mg/l	<0.1	<0.1
Dissolved Lead Pb	mg/l	0.8	2.1
Dissolved Magnesium Mg	mg/l	63.4	344
Dissolved Zinc Zn	mg/l	3.47	431

Five of the eleven samples submitted for were of peat to determine the attenuation of contaminant metals into the peat underlying the tailings. A summary of characteristic metal concentrations is provided in Table 9.

Table 10: Summary of Characteristic Metal Concentrations in the Underlying Peat

Dissolved Metals	Units	TP-08-08 2.0 m (Pt)	TP-08-10 2.15 m (Pt)	TP-08-15 3.0 m (Pt)	TP-08-18 2.8 m (Pt)	TP-08-20 2.25 m (Pt)
Cadmium Cd	ppm	1.8	3.0	4.5	<1.4	2.1
Iron Fe	%	2.11	0.55	1.93	1.66	2.96
Lead Pb	ppm	69.0	299.0	352.0	234.0	80.0
Magnesium Mg	%	0.41	0.30	0.50	0.36	0.45
Zinc Zn	ppm	252	155	288	197	253

3.5.3 Lime Addition Results

Addition of lime during tailings relocation is an appropriate way to precipitate the soluble metals and neutralize acidity. It is also theoretically possible to add lime to treat acidity generated by future oxidation. The lime could either be added at the source, prior to excavation, using a grid to determine the correct dosage or at the relocated tailings area while reworking the tailings.

Lime addition testing was conducted to develop site specific lime demands for the VTF tailings. The lime addition testing used hydrated lime $Ca(OH)_2$ added to 1.0 kg tailings samples placed in a 2 litre tank and gently agitated during the analyses. This ensured complete mixing and homogenization of the tailings and lime. The lime usage was calculated for dry tailings weight of 1 kg. Complete results are provided in Attachment 4 with a summary of the lime addition is provided in Table 10.

Table 11: Summary of Hydrated Lime $Ca(OH)_2$ Addition Analysis

Sample	Lime Usage [Ca(OH)2] (kg/ton)[1]
TP-08-08 0.1 – 1.0 m (SM-Tailings) Above Water Table	3.5
TP-08-10 0.25 – 0.7 m (SM-Tailings) Above Water Table	3.9
TP-08-15 0.9 – 1.5 m (SM-Tailings) Below Water Table	4.9
TP-08-18 0.0 – 1.8 m (SM-Tailings) Above Water Table	6.8
TP-08-20 0.1 – 1.0 m (SM-Tailings) Above Water Table	4.9
TP-08-20 1.0 – 1.45 m (SM-Tailings) Below Water Table	6.9

Notes:
1. The lime usage was calculated for dry tailings weight of 1 kg.

The results of the lime addition analyses do not indicate any significant difference between the lime requirements for tailings located above or below the water table. An average lime demand of 5.0 kg $Ca(OH)_2$ per try tonne of tailings with a maximum of 6.9 kg $Ca(OH)_2$ per dry tonne was determined for tailings from the VTF.

To estimate the quantity of lime required to amend the relocated tailings and over excavated material within the VTF the estimated total mass of relocated tailings and over excavated material is required. It has been estimated 1,659,000 m^3 of tailings and over excavated soil could be relocated within the VTF. An additional 82,000 m^3 of tailings relocated from the hill side below the town of Elsa. The estimated total volume of relocated tailings and over excavated soil is 1,740,000 m^3.

It is estimated the field bulk density of the VTF tailings is 1.97 tonnes/m^3, therefore the 1,740,000 m^3 of relocated tailings and over excavated soil is estimated to weigh 3,422,000 tonnes. Based on an application rate of 5 kg $Ca(OH_2)$ per tonne of tailings, the total amount of lime required is estimated to be 18,000 tonnes of $Ca(OH_2)$. Allowing for nonreactive lime and incomplete mixing, a 10% increased application rate of $Ca(OH)_2$ per tonne of tailings should be considered.

As a part of the lime demand analysis, the moisture content was also determined. The range of moisture contents the tailings samples submitted for lime demand testing ranged from 14% to 29%. This range in values was consistent with moisture contents measured from tailing samples submitted for geotechnical testing which ranged from 21.0% to 29.8%.

The dissolved metals in the settled supernatant were determined by ICP analysis. A summary of dissolved metals is provided in Table 11. The concentrations of characteristic dissolved metals are lower compared to the same dissolved metals in the extracted pore water analysis.

Table 12: Summary of Dissolved Metal Concentrations in the Settled Supernatant

Dissolved Metals	Units	TP-08-08 0.1-1.0 m	TP-08-10 0.25-0.7 m	TP-08-15 0.9-1.5 m	TP-08-18 0.0-1.8 m	TP-08-20 0.1-1.0 m	TP-08-20 1.0-1.45 m
Cadmium Cd	mg/l	0.00029	0.00026	0.00043	0.00044	0.00134	0.00309
Iron Fe	mg/l	0.017	0.011	0.015	0.025	0.011	0.011
Lead Pb	mg/l	0.0301	0.028	0.0411	0.0366	0.0401	0.0392
Magnesium Mg	mg/l	9.77	7.73	24.8	30.3	63.8	60.3
Zinc Zn	mg/l	0.011	0.007	0.006	0.005	0.007	0.007

4 References

Alexco, 2007. Soils Characterization and Drilling Report. Report prepared for Elsa Reclamation and Development Company. March 2007.

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.

SRK (2008a). 2007 Geotechnical Closure Studies, Keno Hill, YT. Report prepared for Elsa Reclamation and Development Company. Project No. 1CE012.000.0GT2. March 2008.

SRK (2008b). Assessment of Groundwater Regime at the Valley Tailings Facility. Technical Memorandum prepared for Elsa Reclamation and Development Company. Project No. 1CE012.000.0H6. February 12, 2008.

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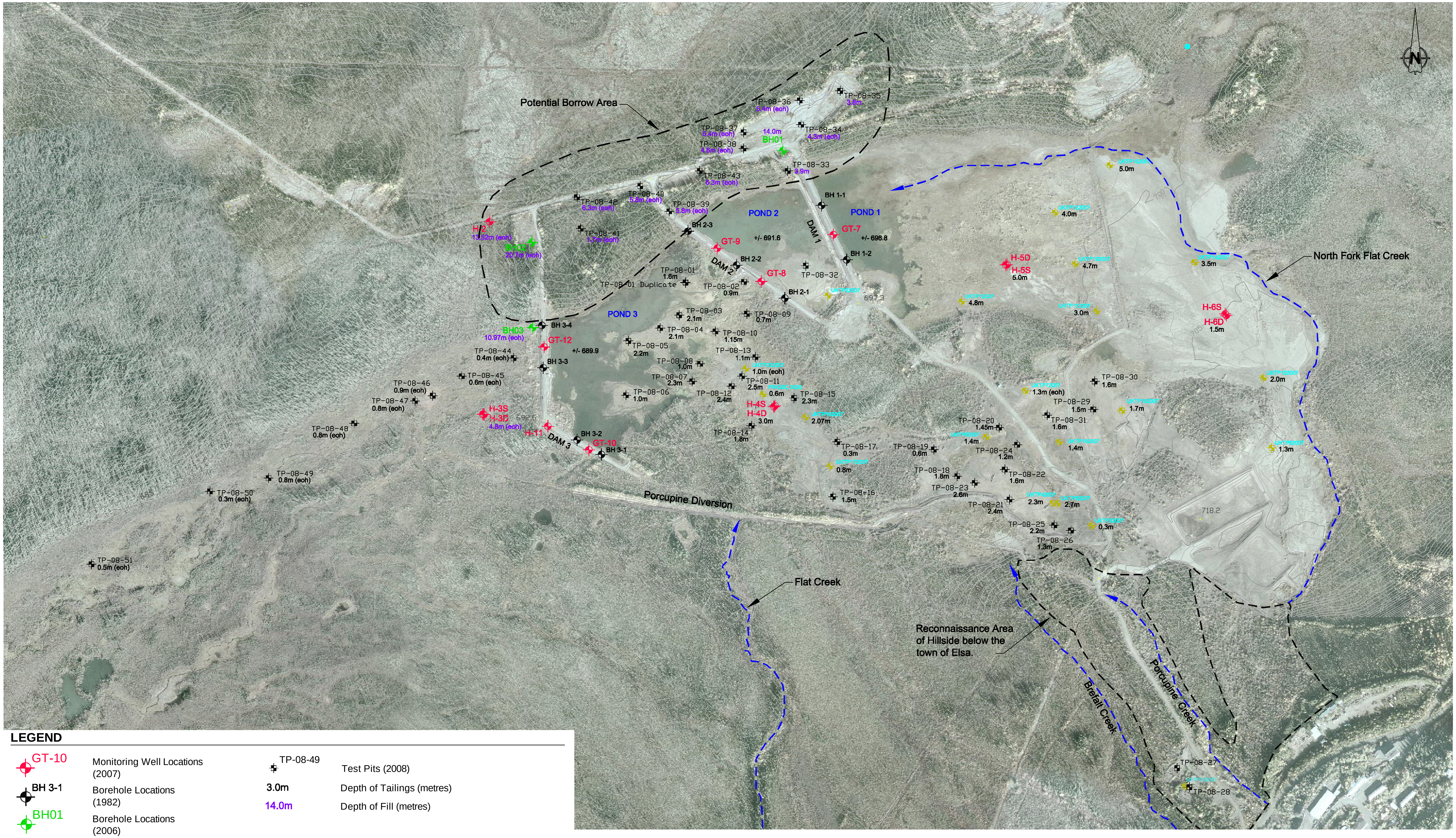
SRK (2009a). 2007/08 Geochemical Studies, Keno Hill Silver District, YT. Report prepared for Elsa Reclamation and Development Company. Project No. 1CE012.001. February 2009.

SRK (2009b). Cork Province Tailings Relocation and Containment System, Kaslo, British Columbia. Draft Report prepared for Morrow Environmental Consultants Inc. Project No. 1CB019.001. January 2009.

Figure



LEGEND

GT-10	Monitoring Well Locations (2007)	TP-08-49	Test Pits (2008)
BH 3-1	Borehole Locations (1982)	3.0m	Depth of Tailings (metres)
BH01	Borehole Locations (2006)	14.0m	Depth of Fill (metres)
UKTP182007	Test Pit Locations (2007)		
MDP10	Manual Drive Points		

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 AeroGeometric, 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 50 100 150 200 250
Scale in Metres

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Vancouver B.C.

ERDC

SRK JOB NO.: 1CE012.002.400
FILE NAME: Hole locations.dwg

Keno Hill Project

2008 VTF Site investigation

Summary of VTF
Site Investifgations

DATE:	APPROVED:	FIGURE:
Apr. 2009	LW	1

J:\01_SITES\UKHA\ACAD\Acad 2008\Hole locations.dwg

Attachment 1A
VTF Tailings Test Pit 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]

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SRK Consulting Engineers and Scientists Vancouver B.C.	ERDC	2007 Geotechnical Report and Hydrogeological Field Investigation
SRK JOB NO.: 1CE12.000.GT2	Keno Hill	Borehole Log Legend
FILE NAME: DrillLogLegend.dwg		DATE: Feb. 08 / APPROVED: LW / FIGURE: -

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TEST PIT LOG

PROJECT :	Tailings and Soil Excavation and Consolidation	**TEST PIT :**	***TP-08-01***
SITE :	Subaerial tailings bewteen Dam #2 and Dam #3	**PAGE :**	1 **OF** 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	**DATE :**	2008-07-08
DATUM :	NAD83	**COORDINATES :**	7088472.00 N 474616.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

ELEVATION - m / DEPTH - m	DESCRIPTION	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
702.00 / 0.00	Silty sand, brown moist, occasional rootllets [SM]	BS-1	Remoulded	
701.50 / 0.50	Silty sand, grey, moist [SM]	BS-2	Remoulded	
700.40 / 1.60	Peat, black, fibrous, moist [Pt]	BS-3	Remoulded	
700.20 / 1.80	Termination in peat			

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

Columns: SYMBOL, WATER INFLOW

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TEST PIT LOG

PROJECT :	Tailings and Soil Excavation and Consolidation	TEST PIT :	TP-08-02
SITE :	Subaerial tailings bewteen Dam #2 and Dam #3	PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	DATE :	2008-07-08
DATUM :	NAD83	COORDINATES :	7088474.00 N 474738.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

ELEVATION - m / DEPTH. - m	STRATIGRAPHY: DESCRIPTION	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
700.00 / 0.00	Silty sand, brown, moist, uniform, rootlets [SM]			BS-1	Remoulded	
699.70 / 0.30	Silty sand, grey, moist. uniform, [SM]			BS-2	Remoulded	
699.10 / 0.90	Peat, black, fibrous, rootlets [Pt]			BS-3	Remoulded	
698.90 / 1.10	Termination in peat					

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

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PROJECT :	Tailings and Soil Excavation and Consolidation	**TEST PIT :**	*TP-08-03*
SITE :	Subaerial tailings bewteen Dam #2 and Dam #3	**PAGE :**	1 **OF** 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	**DATE :**	2008-07-08
DATUM :	NAD83	**COORDINATES :**	7088404.00 N 474602.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

STRATIGRAPHY

ELEVATION - m / DEPTH. - m	DESCRIPTION	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
702.00 / 0.00	Silty sand, brown, moist, uniform [SM]			BS-1	Remoulded	
701.40 / 0.60	Silty sand, grey, moist, black lenses (~2 cm in length) [SM]			BS-2	Remoulded	
700.50 / 1.50	Silty sand, light brown with black mottling (~1cm in diameter) [SM]		2.10m depth on 2008-07-08	BS-3	Remoulded	
699.90 / 2.10	Peat, black, fibrous, moist [Pt]			BS-4	Remoulded	
699.60 / 2.40	Termination in peat					

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

PROJECT :	Tailings and Soil Excavation and Consolidation	**TEST PIT :**	***TP-08-04***
SITE :	Subaerial tailings bewteen Dam #2 and Dam #3	**PAGE :**	1 **OF** 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	**DATE :**	2008-07-08
DATUM :	NAD83	**COORDINATES :**	7088377.00 N 474562.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

ELEVATION - m / DEPTH. - m	STRATIGRAPHY: DESCRIPTION	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
701.00 / 0.00	Silty sand, brown, moist, uniform, rootlets [SM]		BS-1	Remoulded	
700.90 / 0.10	Silty sand, light grey, moist, uniform [SM]		BS-2	Remoulded	
700.80 / 0.20	Silty sand, light brown, wet, uniform [SM]	2.00m depth on 2008-07-08	BS-3	Remoulded	
698.90 / 2.10	Peat, black, fibrous, uniform, wet [Pt]		BS-4	Remoulded	
698.40 / 2.60	Termination in peat				

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

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PROJECT :	Tailings and Soil Excavation and Consolidation
TEST PIT :	*TP-08-05*
SITE :	Subaerial tailings bewteen Dam #2 and Dam #3
PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)
DATE :	2008-07-08
DATUM :	NAD83
COORDINATES :	7088350.00 N 474495.00 E

SAMPLE CONDITION

Remoulded (sample box with an X)

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

ELEVATION - m / DEPTH - m	DESCRIPTION (STRATIGRAPHY)	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
690.00 / 0.00	Silty sand, brown, moist, uniform, rootlets [SM]			BS-1	Remoulded	
689.60 / 0.40	Silty sand, light grey, moist, uniform [SM]			BS-2	Remoulded	
688.80 / 1.20	Silty sand, light brown with black mottling (~2 cm diameter) [SM]			BS-3	Remoulded	
687.80 / 2.20	Peat, black, fibrous, moist, uniform [Pt]			BS-4	Remoulded	
687.30 / 2.70	Termination in peat					

DEPTH - m scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

PROJECT :	Tailings and Soil Excavation and Consolidation	**TEST PIT :**	***TP-08-06***
SITE :	Subaerial tailings bewteen Dam #2 and Dam #3	**PAGE :**	1 **OF** 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	**DATE :**	2008-07-08
DATUM :	NAD83	**COORDINATES :**	7088236.00 N 474490.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

STRATIGRAPHY / **SAMPLE**

ELEVATION - m / DEPTH. - m	DESCRIPTION	NUMBER	CONDITION
698.00 / 0.00	Peat, dark brown, moist, rootmat [Pt]	BS-1	Remoulded
697.95 / 0.05	Silty sand, brown, moist, uniform [SM]	BS-2	Remoulded
697.60 / 0.40	Silty sand, light grey, moist, uniform [SM]	BS-3	Remoulded
697.00 / 1.00	Peat, black, fibrous, moist, uniform [Pt]	BS-4	Remoulded
696.70 / 1.30	Gravel, well graded, light grey, wet, gravel sub rounded [GW]	BS-5	Remoulded
696.30 / 1.70	Termination in well graded gravel		

WATER INFLOW: 1.70m depth on 2008-07-08

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

LABORATORY AND IN SITU TESTS

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TEST PIT LOG

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PROJECT :	Tailings and Soil Excavation and Consolidation	TEST PIT :	*TP-08-07*
SITE :	Subaerial tailings bewteen Dam #2 and Dam #3	PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	DATE :	2008-07-08
DATUM :	NAD83	COORDINATES :	7088265.00 N 474629.00 E

SAMPLE CONDITION

☒ Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

ELEVATION - m / DEPTH - m	STRATIGRAPHY – DESCRIPTION	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
697.00 / 0.00	Silty sand, brown, moist, uniform [SM]			BS-1	☒	
696.80 / 0.20	Silty sand, light grey, moist, uniform [SM]			BS-2	☒	
695.70 / 1.30	Peat, black, moist, fibrous with wood fragments, uniform [Pt]			BS-3	☒	
695.40 / 1.60	Silty clay, dark grey, moist, uniform [CL]			BS-4	☒	
693.90 / 3.10	Peat, brown, fibrous, moist, uniform [Pt]			BS-5	☒	
693.70 / 3.30	Termination in peat					

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

PROJECT : Tailings and Soil Excavation and Consolidation
TEST PIT : *TP-08-08*
SITE : Subaerial tailings bewteen Dam #2 and Dam #3
PAGE : 1 **OF** 1
FILE NO : UNITED KENO HILL (1CE012.002.02)
DATE : 2008-07-08
DATUM : NAD83
COORDINATES : 7088302.00 N 474646.00 E

SAMPLE CONDITION	LABORATORY AND IN SITU TESTS					
☒ Remoulded	W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
	GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
	D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

ELEVATION - m / DEPTH - m	DESCRIPTION	WATER INFLOW	SAMPLE NUMBER	CONDITION	LABORATORY AND IN SITU TESTS
698.00 / 0.00	Peat, dark brown, rootmat [Pt]		BS-1	Remoulded	
697.90 / 0.10	Silty sand, grey, wet, uniform [SM]		BS-2	Remoulded	w = 27.7% D = 1987.37 SG = 2.7
697.00 / 1.00	Peat, black, fibrous, moist, roots and wood fragments [Pt]		BS-3	Remoulded	
696.90 / 1.10	Silty clay, grey, moist, uniform (0.05 m thick) [CL], layered with Silty sand, light brown, moist, uniform, (0.05 m thick) [SM]	2.00m depth on 2008-07-08	BS-4	Remoulded	
696.00 / 2.00	Peat, black, fibrous, uniform [Pt]		BS-5	Remoulded	
695.80 / 2.20	Termination in peat				

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

PROJECT :	Tailings and Soil Excavation and Consolidation	TEST PIT :	TP-08-09
SITE :	Subaerial tailings bewteen Dam #2 and Dam #3	PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	DATE :	2008-07-08
DATUM :	NAD83	COORDINATES :	7088407.00 N 474744.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

DEPTH - m	ELEVATION - m / DEPTH. - m	STRATIGRAPHY: DESCRIPTION	SYMBOL	WATER INFLOW	SAMPLE: NUMBER	SAMPLE: CONDITION	LABORATORY AND IN SITU TESTS
	706.00						
	0.20	Peat, dark brown, rootmat [Pt]		0.20m depth on 2008-07-08	BS-1	Remoulded	
0.5	705.60 / 0.40	Silty clay, grey, wet, uniform [CL]			BS-2	Remoulded	
	705.30 / 0.70	Peat, black, fibrous, permafrost (Vx = 50%) [Pt]			BS-3		
	705.29 / 0.71	Refusal in peat / permafrost					
1.0							
1.5							
2.0							
2.5							
3.0							
3.5							
4.0							
4.5							

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TEST PIT LOG

SRK Consulting — Engineers and Scientists

PROJECT :	Tailings and Soil Excavation and Consolidation	TEST PIT :	*TP-08-10*
SITE :	Subaerial tailings bewteen Dam #2 and Dam #3	PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	DATE :	2008-07-08
DATUM :	NAD83	COORDINATES :	7088370.00 N 474678.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

DEPTH - m	ELEVATION - m / DEPTH. - m	STRATIGRAPHY: DESCRIPTION	SYMBOL	WATER INFLOW	SAMPLE: NUMBER	SAMPLE: CONDITION	LABORATORY AND IN SITU TESTS
	698.00 / 0.00	Peat, dark brown, rootmat [Pt]			BS-1	Remoulded	
0.5	697.75 / 0.25	Silty sand, grey with black mottling (~ 2 cm diameter), moist [SM]			BS-2	Remoulded	w = 29.2% D = 1811.86 SG = 2.4
1.0 / 1.5 / 2.0	696.85 / 1.15	Peat, black, fibrous, moist, uniform with Silty sand, grey, moist [Pt, SM]			BS-3	Remoulded	
	695.85 / 2.15	Peat, brown, fibrous, moist, uniform [Pt]			BS-4	Remoulded	
2.5 / 3.0 / 3.5 / 4.0 / 4.5	695.75 / 2.25	Termination in peat					

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TEST PIT LOG

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PROJECT :	Tailings and Soil Excavation and Consolidation	TEST PIT :	TP-08-11
SITE :	Subaerial tailings bewteen Dam #2 and Dam #3	PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	DATE :	2008-07-08
DATUM :	NAD83	COORDINATES :	7088276.00 N 474734.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

DEPTH - m	ELEVATION - m / DEPTH. - m	STRATIGRAPHY: DESCRIPTION	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
	700.00 / 0.00	Silty sand, dark grey, dry, uniform [SM]			BS-1	Remoulded	
	699.80 / 0.20	Silty sand, reddish brown, dry, uniform [SM]			BS-2	Remoulded	
0.5	699.40 / 0.60	Silty sand, dark grey with black mottling (~2 cm in diameter), moist, [SM]			BS-3	Remoulded	
2.5	697.50 / 2.50	Peat, black, fibrous, uniform [Pt]			BS-4	Remoulded	
	697.30 / 2.70	Termination in peat					

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

SRK Consulting — Engineers and Scientists

PROJECT :	Tailings and Soil Excavation and Consolidation	**TEST PIT :**	***TP-08-12***
SITE :	Subaerial tailings bewteen Dam #2 and Dam #3	**PAGE :**	1 **OF** 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	**DATE :**	2008-07-08
DATUM :	NAD83	**COORDINATES :**	7088255.00 N 474712.00 E

SAMPLE CONDITION	**LABORATORY AND IN SITU TESTS**		
Remoulded	W Water content (%)	P Proctor test	wL Liquid limit (%)
	GS Grain size analysis	wOPT Optimum water content (%)	wP Plastic limit (%)
	D Unit weight (kN/m³)	Dmax Max. Dry unit weight (kN/m³)	

ELEVATION - m / DEPTH - m	DESCRIPTION (STRATIGRAPHY)	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
701.00 / 0.00	Silty sand, brown, moist, uniform [SM]		BS-1	Remoulded	
700.70 / 0.30	Silty sand, light grey, moist, occassional black lenses (~ 2 cm in length) [SM]	1.00m depth on 2008-07-08	BS-2	Remoulded	
699.70 / 1.30	Peat, black, fibrous, moist, uniform with Silty sand, grey, moist [Pt, SM]		BS-3	Remoulded	
698.60 / 2.40	Peat, black, fibrous, moist, uniform [Pt]		BS-4	Remoulded	
698.40 / 2.60	Termination in peat				

DEPTH - m scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

PROJECT : Tailings and Soil Excavation and Consolidation
TEST PIT : *TP-08-13*
SITE : Subaerial tailings bewteen Dam #2 and Dam #3
PAGE : 1 **OF** 1
FILE NO : UNITED KENO HILL (1CE012.002.02)
DATE : 2008-07-08
DATUM : NAD83
COORDINATES : 7088316.00 N 474762.00 E

SAMPLE CONDITION	LABORATORY AND IN SITU TESTS					
Remoulded	W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
	GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
	D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

DEPTH - m	ELEVATION - m / DEPTH. - m	DESCRIPTION (STRATIGRAPHY)	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
	697.00 / 0.00	Silty sand, brown, moist, uniform [SM]			BS-1	Remoulded	
0.5	696.50 / 0.50	Silty sand, light grey, moist, uniform [SM]			BS-2	Remoulded	
1.0	695.90 / 1.10	Peat, black, fibrous, moist, uniform [Pt]			BS-3	Remoulded	
	695.70 / 1.30	Termination in peat					
1.5							
2.0							
2.5							
3.0							
3.5							
4.0							
4.5							

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TEST PIT LOG

SRK Consulting — Engineers and Scientists

PROJECT : Tailings and Soil Excavation and Consolidation
TEST PIT : *TP-08-14*
SITE : Subaerial old tailings North of VTF
PAGE : 1 **OF** 1
FILE NO : UNITED KENO HILL (1CE012.002.02)
DATE : 2008-07-08
DATUM : NAD83
COORDINATES : 7088172.00 N 474754.00 E

SAMPLE CONDITION	LABORATORY AND IN SITU TESTS					
Remoulded	W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
	GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
	D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

ELEVATION - m / DEPTH. - m	DESCRIPTION (STRATIGRAPHY)	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
694.00 / 0.00	Silty sand, brown, moist, uniform [SM]		BS-1	Remoulded	
693.70 / 0.30	Silty sand, light grey, wet, uniform [SM]	0.30m depth on 2008-07-08	BS-2	Remoulded	
692.20 / 1.80	Peat, black, fibrous, moist, uniform [Pt]		BS-3	Remoulded	
691.90 / 2.10	Sandy silt, dark grey, moist, uniform [ML]		BS-4	Remoulded	
691.40 / 2.60	Termination in sandy silt				

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

PROJECT :	Tailings and Soil Excavation and Consolidation	**TEST PIT :**	***TP-08-15***
SITE :	Subaerial old tailings South of VTF	**PAGE :**	1 **OF** 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	**DATE :**	2008-07-08
DATUM :	NAD83	**COORDINATES :**	7088230.00 N 474843.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

STRATIGRAPHY

ELEVATION - m / DEPTH - m	DESCRIPTION	SAMPLE NUMBER	CONDITION	LABORATORY AND IN SITU TESTS
698.00 / 0.00	Silty sand, dark grey, moist, uniform [SM]	BS-1	Remoulded	
697.60 / 0.40	Silty sand, light brown, moistm iniform [SM]	BS-2	Remoulded	
697.30 / 0.70	Silty sand, light grey, wet, uniform [SM]	BS-3	Remoulded	w = 25.8% D = 1963.83 SG = 2.6
695.70 / 2.30	Peat, black, moist, fibrous, rootmat [Pt]	BS-4	Remoulded	
695.60 / 2.40	Sandy silt, dark grey, moist, uniform [ML]	BS-5	Remoulded	
695.10 / 2.90	Peat, dark brown, fibrous, moist, uniform [Pt]	BS-6	Remoulded	
694.40 / 3.60	Termination in peat			

WATER INFLOW: 2.30m depth on 2008-07-08

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

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PROJECT :	Tailings and Soil Excavation and Consolidation	TEST PIT :	TP-08-16
SITE :	Subaerial old tailings South of VTF	PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	DATE :	2008-07-08
DATUM :	NAD83	COORDINATES :	7088023.00 N 474925.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

ELEVATION - m / DEPTH - m	DESCRIPTION (STRATIGRAPHY)	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
722.00 / 0.00	Silty sand, dark grey, moist, uniform [SM]		BS-1	Remoulded	
721.60 / 0.40	Silty sand, light brown with black mottling (~ 2 cm in diameter), moist [SM]		BS-2	Remoulded	
720.50 / 1.50	Peat, black, fibrous, rootmat [Pt]		BS-3	Remoulded	
720.49 / 1.60	Peat, black, fibrous, moist, uniform with Silty sand, grey, moist [Pt, SM]		BS-4	Remoulded	
719.10 / 2.90	Peat, black, fibrous, moist [Pt]		BS-5	Remoulded	
718.70 / 3.30	Termination in peat				

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

PROJECT :	Tailings and Soil Excavation and Consolidation
TEST PIT :	TP-08-17
SITE :	Subaerial old tailings South of VTF
PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)
DATE :	2008-07-08
DATUM :	NAD83
COORDINATES :	7088138.00 N 474934.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

DEPTH - m	ELEVATION - m / DEPTH. - m	DESCRIPTION (STRATIGRAPHY)	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
	705.00 / 0.00	Silty sand. brown, moist, uniform [SM]			BS-1	Remoulded	
	704.70 / 0.30	Peat, black, fibrous, moist, uniform [Pt]			BS-2	Remoulded	
0.5	704.40 / 0.60	Silty gravel, well graded with pebbles (~25%) and occasional cobble, subrounded [GM]			BS-3	Remoulded	
1.0	703.80 / 1.20	Termination in silty gravel					
1.5							
2.0							
2.5							
3.0							
3.5							
4.0							
4.5							

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TEST PIT LOG

PROJECT :	Tailings and Soil Excavation and Consolidation	**TEST PIT :**	***TP-08-18***
SITE :	Subaerial old tailings South of VTF	**PAGE :**	1 **OF** 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	**DATE :**	2008-07-09
DATUM :	NAD83	**COORDINATES :**	7088066.00 N 475186.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

STRATIGRAPHY

ELEVATION - m / DEPTH - m	DESCRIPTION	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
713.00 / 0.00	Silty sand, black, dry, uniform [SM]		BS-1	Remoulded	
712.70 / 0.30	Silty sand, brown, dry, uniform [SM]		BS-2	Remoulded	
712.40 / 0.60	Silty sand, grey, dry, uniform [SM]		BS-3	Remoulded	w = 26.3% D = 1958.48 SG = 2.6
711.20 / 1.80	Peat, black, fibrous, moist, rootmat [Pt]	1.80m depth on 2008-07-09	BS-4	Remoulded	
711.10 / 1.90	Peat, black, fibrous, moist, uniform with Silty sand, grey, moist [Pt, SM]		BS-5	Remoulded	
710.20 / 2.80	Termination in silty sand, organic rich				

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

PROJECT : Tailings and Soil Excavation and Consolidation
TEST PIT : *TP-08-19*
SITE : Subaerial old tailings South of VTF
PAGE : 1 **OF** 1
FILE NO : UNITED KENO HILL (1CE012.002.02)
DATE : 2008-07-09
DATUM : NAD83
COORDINATES : 7088122.00 N 475137.00 E

SAMPLE CONDITION	LABORATORY AND IN SITU TESTS					
Remoulded	W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
	GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
	D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

ELEVATION - m / DEPTH. - m	DESCRIPTION (STRATIGRAPHY)	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
711.00 / 0.00	Silty sand, black, dry, uniform, rootlets [SM]			BS-1	Remoulded	
710.90 / 0.10	Silty sand, reddish brown, dry, uniform [SM]			BS-2	Remoulded	
710.70 / 0.30	Silty sand, light brown, dry, uniform [SM]			BS-3	Remoulded	
710.60 / 0.40	Silty sand, light greyish brown, dry, uniform [SM]			BS-4	Remoulded	
710.40 / 0.60	Peat, black, fiborus, moist, rootmat [Pt]			BS-5	Remoulded	
710.30 / 0.70	Peat, black, fibrous, moist, uniform with Silty sand, grey, moist [Pt, SM]			BS-6	Remoulded	
710.00 / 1.00	Termination in silty sand, organic rich					

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

PROJECT : Tailings and Soil Excavation and Consolidation
TEST PIT : TP-08-20
SITE : Subaerial old tailings South of VTF
PAGE : 1 **OF** 1
FILE NO : UNITED KENO HILL (1CE012.002.02)
DATE : 2008-07-09
DATUM : NAD83
COORDINATES : 7088168.00 N 475274.00 E

SAMPLE CONDITION	LABORATORY AND IN SITU TESTS					
Remoulded	W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
	GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
	D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

DEPTH - m	ELEVATION - m / DEPTH. - m	DESCRIPTION (STRATIGRAPHY)	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
	711.00 / 0.00	Silty sand, light brown, moist, uniform [SM]		1.00m depth on 2008-07-09	BS-1	Remoulded	
0.5	710.55 / 0.45	Silty sand, light grey, moist, uniform [SM]			BS-2	Remoulded	w = 21% D = 2089.04 SG = 2.7
1.0	710.00 / 1.00	Silty clay, grey, wet, uniform [CL]			BS-3	Remoulded	
	709.95 / 1.05	Silty sand, light grey, moist, uniform [SM]			BS-4	Remoulded	w = 29.8% D = 1994.86 SG = 2.8
1.5	709.55 / 1.45	Peat, black, fibrous, moist, rootmat [Pt]			BS-5	Remoulded	
	709.45 / 1.55	Peat, black, fibrous, moist, uniform with Silty sand, grey, moist [Pt, SM]			BS-6	Remoulded	
2.0							
	708.75 / 2.25	Termination in silty sand, organic rich					
2.5							
3.0							
3.5							
4.0							
4.5							

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TEST PIT LOG

PROJECT : Tailings and Soil Excavation and Consolidation
TEST PIT : *TP-08-21*
SITE : Subaerial old tailings South of VTF
PAGE : 1 **OF** 1
FILE NO : UNITED KENO HILL (1CE012.002.02)
DATE : 2008-07-09
DATUM : NAD83
COORDINATES : 7088017.00 N 475296.00 E

SAMPLE CONDITION	LABORATORY AND IN SITU TESTS					
☒ Remoulded	W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
	GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
	D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

STRATIGRAPHY / **SAMPLE**

ELEVATION - m / DEPTH. - m	DESCRIPTION	SYMBOL	WATER INFLOW	NUMBER	CONDITION	LABORATORY AND IN SITU TESTS
713.00 / 0.00	Silty sand, light brown, dry, uniform [SM]			BS-1	Remoulded	
712.20 / 0.80	Silty sand, light grey, dry, uniform [SM]			BS-2	Remoulded	
710.60 / 2.40	Peat, black, fibrous with wood fragments, moist, uniform with Silty sand, grey, moist [Pt, SM]			BS-3	Remoulded	
710.40 / 2.60	Termination in peat					

DEPTH - m scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

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PROJECT :	Tailings and Soil Excavation and Consolidation	**TEST PIT :**	*TP-08-22*
SITE :	Subaerial old tailings South of VTF	**PAGE :**	1 **OF** 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	**DATE :**	2008-07-09
DATUM :	NAD83	**COORDINATES :**	7088080.00 N 475286.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

ELEVATION - m / DEPTH - m	DESCRIPTION (STRATIGRAPHY)	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
712.00 / 0.00	Clay, light brown, moist, uniform [CL]		BS-1	Remoulded	
711.60 / 0.40	Clay, light grey, moist, uniform [CL]		BS-2	Remoulded	
711.55 / 0.45	Silty sand, reddish brown, moist, uniform [SM]		BS-3	Remoulded	
711.30 / 0.70	Sandy silt, dark grey, moist, uniform [ML]		BS-4	Remoulded	
711.10 / 0.90	Silty sand, light grey, moist, uniform [SM]		BS-5	Remoulded	
710.90 / 1.10	Sandy silt, light greyish brown, moist, uniform [ML]		BS-6	Remoulded	
710.40 / 1.60	Peat, black, fibrous, moist, rootmat [Pt]		BS-7	Remoulded	
710.30 / 1.70	Peat, black, fibrous, moist, uniform with Silty sand, grey, moist [Pt, SM]		BS-8	Remoulded	
710.00 / 2.00	Termination in silty sand, organic rich				

DEPTH - m scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

PROJECT : Tailings and Soil Excavation and Consolidation		**TEST PIT :**	***TP-08-23***
SITE : Subaerial old tailings South of VTF		**PAGE :** 1 **OF** 1	
FILE NO : UNITED KENO HILL (1CE012.002.02)		**DATE :**	2008-07-09
DATUM : NAD83	**COORDINATES :**	7088052.00 N	475223.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

ELEVATION - m / DEPTH. - m	DESCRIPTION (STRATIGRAPHY)	WATER INFLOW	SAMPLE NUMBER	LABORATORY AND IN SITU TESTS
711.00 / 0.00	Silty sand, light brown, moist, uniform [SM]		BS-1	
710.70 / 0.30	Silty sand, light brown (0.10 m thick) with light grey (0.05 m thick) layers, moist [SM]		BS-2	
710.30 / 0.70	Silty sand, light grey, moist, uniform [SM]		BS-3	
709.20 / 1.80	Peat, black, fibrous, moist, rootmat [Pt]		BS-4	
709.10 / 1.90	Termination in silty sand, organic rich			
1.90	Silty sand, light grey with black mottling (~ 2 cm in diameter), moist [SM]		BS-5	
708.40 / 2.60	Peat, black, fibrous, moist, uniform with Silty sand, grey, moist [Pt, SM]	2.60m depth on 2008-07-09	BS-6	
708.20				

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

PROJECT : Tailings and Soil Excavation and Consolidation
TEST PIT : *TP-08-24*
SITE : Subaerial old tailings South of VTF
PAGE : 1 **OF** 1
FILE NO : UNITED KENO HILL (1CE012.002.02)
DATE : 2008-07-09
DATUM : NAD83
COORDINATES : 7088132.00 N 475312.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

ELEVATION - m / DEPTH. - m	DESCRIPTION (STRATIGRAPHY)	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
712.00 / 0.00	Silty sand, reddish brown, dry, uniform [SM]		BS-1	Remoulded	
711.60 / 0.40	Silty sand, light grey, moist, uniform [SM]		BS-2	Remoulded	
711.30 / 0.70	Silty sand, grey, moist, uniform [SM]		BS-3	Remoulded	
711.20 / 0.80	Peat, black, fibrous, moist, rootmat [Pt]		BS-4	Remoulded	
711.10 / 0.90	Silty clay, dark grey, moist, unifrom [CL]		BS-5	Remoulded	
710.80 / 1.20	Peat, dark brown, non-fibrous, moist, uniform [Pt]		BS-6	Remoulded	
710.60 / 1.40	Termination in peat				

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

PROJECT :	Tailings and Soil Excavation and Consolidation	**TEST PIT :**	***TP-08-25***
SITE :	Subaerial old tailings South of VTF	**PAGE :**	1 **OF** 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	**DATE :**	2008-07-09
DATUM :	NAD83	**COORDINATES :**	7087963.00 N 475390.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

STRATIGRAPHY

ELEVATION - m / DEPTH. - m	DESCRIPTION	SAMPLE NUMBER	SAMPLE CONDITION
713.00 / 0.00	Silty sand, dark grey, dry, uniform [SM]	BS-1	Remoulded
712.50 / 0.50	Silty sand, reddish brown, dry, uniform [SM]	BS-2	Remoulded
712.00 / 1.00	Silty sand, light grey, dry, uniform [SM]	BS-3	Remoulded
711.70 / 1.30	Silty sand, dark grey, dry, uniform [SM]	BS-4	Remoulded
711.40 / 1.60	Peat, black, fibrous with wood fragments, moist, rootmat [Pt]	BS-5	Remoulded
711.20 / 1.80	Silty sand, light reddish brown, moist, uniform [SM]	BS-6	Remoulded
710.80 / 2.20	Peat, black, fibrous, moist, uniform [Pt]	BS-7	Remoulded
710.60 / 2.40	Silty Gravel, well graded, grey, moist, gravel rounded [GM]	BS-8	Remoulded
710.40 / 2.60	Termination in well graded gravel		

Columns: DEPTH - m (scale 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5); SYMBOL; WATER INFLOW; LABORATORY AND IN SITU TESTS

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TEST PIT LOG

SRK Consulting — Engineers and Scientists

PROJECT :	Tailings and Soil Excavation and Consolidation	TEST PIT :	TP-08-26
SITE :	Subaerial old tailings South of VTF	PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	DATE :	2008-07-09
DATUM :	NAD83	COORDINATES :	7087952.00 N 475426.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

ELEVATION - m / DEPTH - m	STRATIGRAPHY – DESCRIPTION	SAMPLE NUMBER	LABORATORY AND IN SITU TESTS
718.00 / 0.00	Silty sand, brown, dry, uniform [SM]	BS-1	
717.40 / 0.60	Sand, reddish brown, well graded, dry, uniform [SW]	BS-2	
716.80 / 1.20	Silty clay, grey dry, uniform [CL]	BS-3	
716.75 / 1.25	Sitly sand, light brown with flecks of pyrite, dry, uniform [SM]	BS-4	
716.70 / 1.30	Peat, black, fibrous, moist, uniform [Pt]	BS-5	
716.55 / 1.45	Cobbles, well rounded	BS-6	
716.35 / 1.65	Silty gravel, well graded, light grey, moist, gravel sub rounded [GM]	BS-7	
716.05 / 1.95	Termination in well graded gravel		

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

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PROJECT :	Tailings and Soil Excavation and Consolidation
TEST PIT :	TP-08-27
SITE :	Subaerial tailings in the old tailings patties on the hillside below Elsa
PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)
DATE :	2008-07-09
DATUM :	NAD83
COORDINATES :	7087453.00 N 475648.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

ELEVATION - m / DEPTH - m	DESCRIPTION (STRATIGRAPHY)	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
766.00 / 0.00	Silty sand, brown, dry, occasional gravel [SM]		BS-1	Remoulded	
765.85 / 0.15	Silty sand, light brown, dry, uniform [SM]		BS-2	Remoulded	
765.70 / 0.30	Silty sand, greyish brown, dry, uniform [SM]		BS-3	Remoulded	
765.60 / 0.40	Peat, black, fibrous, moist, uniform [Pt]		BS-4	Remoulded	
765.50 / 0.50	Peat, dark brown, non-fibrous, moist, uniform [Pt]		BS-5	Remoulded	
765.40 / 0.60	Silty gravel, well graded, grey, moist, cobbles (~15%) rounded [GM]		BS-6	Remoulded	
765.10 / 0.90	Termination in well graded gravel				

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

SRK Consulting — Engineers and Scientists

PROJECT : Tailings and Soil Excavation and Consolidation
TEST PIT : *TP-08-28*
SITE : Subaerial tailings in the old tailings patties on the hillside below Elsa
PAGE : 1 **OF** 1
FILE NO : UNITED KENO HILL (1CE012.002.02)
DATE : 2008-07-09
DATUM : NAD83
COORDINATES : 7087413.00 N 475675.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

ELEVATION - m / DEPTH - m	DESCRIPTION (STRATIGRAPHY)	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
771.00 / 0.00	Silty sand, light brown, dry, uniform [SM]	BS-1	Remoulded	
769.10 / 1.90	Silty clay, grey, dry, uniform [CL]	BS-2	Remoulded	
768.70 / 2.30	Silty sand, light brown, dry, uniform [SM]	BS-3	Remoulded	
768.55 / 2.45	Silty gravel, grey, well graded, cobbles (~5%) rounded [GM]	BS-4	Remoulded	
768.10 / 2.90	Termination in well graded gravel			

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

SRK Consulting — Engineers and Scientists

PROJECT : Tailings and Soil Excavation and Consolidation
TEST PIT : *TP-08-29*
SITE : Subaerial tailings South of VTF
PAGE : 1 **OF** 1
FILE NO : UNITED KENO HILL (1CE012.002.02)
DATE : 2008-07-09
DATUM : NAD83
COORDINATES : 7088206.00 N 475472.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

STRATIGRAPHY

ELEVATION - m / DEPTH - m	DESCRIPTION
712.00 / 0.00	Silty sand, light brown, moist, uniform [SM]
711.60 / 0.40	Silty sand, light grey, moist [SM], Silty clay, dark grey, lenses (~2 cm thick) [CL]
710.70 / 1.30	Sand, light grey, well graded, wet, uniform [SW]
710.50 / 1.50	Peat, black, fibrous, moist, rootmat [Pt]
710.20 / 1.80	Peat, black, fibrous, moist, uniform with Silty sand, grey, moist [Pt, SM]
709.90 / 2.10	Termination in sandy silt, organic rich

WATER INFLOW: 1.30m depth on 2008-07-09

SAMPLE

NUMBER	CONDITION
BS-1	Remoulded
BS-2	Remoulded
BS-3	Remoulded
BS-4	Remoulded
BS-5	Remoulded

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

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PROJECT : Tailings and Soil Excavation and Consolidation		**TEST PIT :**	*TP-08-30*
SITE : Subaerial tailings South of VTF		**PAGE :** 1 **OF** 1	
FILE NO : UNITED KENO HILL (1CE012.002.02)		**DATE :**	2008-07-09
DATUM : NAD83	**COORDINATES :**	7088265.00 N	475475.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

ELEVATION - m / DEPTH. - m	DESCRIPTION	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
710.00 / 0.00	Silty sand, reddish brown with dark red layers (~2 cm thick), moist [SM]			BS-1	Remoulded	
709.70 / 0.30	Silty sand, light grey, moist [SM], Silty clay, light grey, moist, lenses (~2 cm thick) [CL]			BS-2	Remoulded	
708.40 / 1.60	Peat, black, fibrous, moist, rootmat [Pt]			BS-3	Remoulded	
708.20 / 1.80	Peat, black with brown layers (~4 cm thick), non-fibrous, moist [Pt]			BS-4	Remoulded	
708.00 / 2.00	Termination in peat					

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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TEST PIT LOG

PROJECT : Tailings and Soil Excavation and Consolidation		**TEST PIT :** *TP-08-31*	
SITE : Subaerial tailings South of VTF		**PAGE :** 1 **OF** 1	
FILE NO : UNITED KENO HILL (1CE012.002.02)		**DATE :** 2008-07-09	
DATUM : NAD83	**COORDINATES :** 7088194.00 N 475375.00 E		

SAMPLE CONDITION

- Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

DEPTH - m	ELEVATION - m / DEPTH. - m	STRATIGRAPHY: DESCRIPTION	SYMBOL	WATER INFLOW	SAMPLE: NUMBER	SAMPLE: CONDITION	LABORATORY AND IN SITU TESTS
	711.00 / 0.00	Silty sand, light brown, dry, uniform [SM]			BS-1	Remoulded	
0.5	710.60 / 0.40	Silty sand, light grey, dry, uniform [SM]			BS-2	Remoulded	
	710.45 / 0.55	Silty sand, reddish brown, dry, uniform [SM]			BS-3	Remoulded	
1.0	710.25 / 0.75	Silty sand, light grey, dry, uniform [SM]			BS-4	Remoulded	
1.5	709.75 / 1.25	Silty sand, grey, moist, uniform [SM]			BS-5	Remoulded	
	709.40 / 1.60	Peat, black, fibrous, moist, uniform [Pt]			BS-6	Remoulded	
2.0	709.20 / 1.80	Peat, black, fibrous, moist, uniform with Silty sand, grey, moist [Pt, SM]			BS-7	Remoulded	
	708.95 / 2.05	Termination in silty sand, organic rich					
2.5							
3.0							
3.5							
4.0							
4.5							

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TEST PIT LOG

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PROJECT :	Tailings and Soil Excavation and Consolidation	TEST PIT :	*TP-08-32*
SITE :	Subaerial tailings between Dam #1and Dam #2	PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	DATE :	2008-07-09
DATUM :	NAD83	COORDINATES :	7088508.00 N 474868.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

DEPTH - m	ELEVATION - m / DEPTH. - m	DESCRIPTION (STRATIGRAPHY)	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
	704.00 / 0.00	Silty sand, light brown, moist, uniform [SM]			BS-1	Remoulded	
0.5	703.40 / 0.60	Silty sand, dark brown, moist, uniform [SM]					
		Silty sand, flight grey, fine, moist, uniform [SM]			BS-2	Remoulded	
1.0	702.70 / 0.70				BS-3	Remoulded	
1.5							
	702.10 / 1.90	Silty sand, light brown with dark grey layers (~2 cm thick), moist [SM]			BS-4	Remoulded	
2.0							
2.5	701.50 / 2.50	Silty sand, light grey, fine, moist, uniform [SM]			BS-5	Remoulded	
3.0	700.90 / 3.10	Sand, grey, well graded, wet, uniform [SW]		3.10m depth on 2008-07-09	BS-6	Remoulded	
3.5	700.60 / 3.40	Peat, black, fibrous, moist, uniform [Pt]			BS-7	Remoulded	
	700.40 / 3.60	Peat, black, fibrous, moist, uniform with Silty sand, grey, moist [Pt, SM]			BS-8	Remoulded	
4.0	700.00 / 4.00	Termination in silty sand, organic rich					
4.5							

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Attachment 1B
Potential Borrow Source Test Pit 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]

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SRK JOB NO.: 1CE12.000.GT2

FILE NAME: DrillLogLegend.dwg

Keno Hill

2007 Geotechnical Report and Hydrogeological Field Investigation

Borehole Log Legend

DATE:	APPROVED:	FIGURE:
Feb. 08	LW	-

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TEST PIT LOG

PROJECT :	Tailings and Soil Excavation and Consolidation
TEST PIT :	TP-08-33
SITE :	Borrow source down stream toe North end of Dam #1
PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)
DATE :	2008-07-09
DATUM :	NAD83
COORDINATES :	7088707.00 N 474830.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

DEPTH - m	ELEVATION - m / DEPTH - m	STRATIGRAPHY: DESCRIPTION	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
0.00	709.00 / 0.00	Silty gravel, grey, well graded, soft, silt/clay = 30%, sand = 30%, gravel = 30%, cobbles = 10%, occassional boulder, rounded [GM]					
2.0					BS-1	Remoulded	w = 6.3%
3.90	705.10 / 3.90	Silty sand, grey, wet, dilatancy = rapid, plasticity = low, firm, silt/clay = 45%, sand = 45%, gravel = 10%, uniform [SM]		3.90m depth on 2008-07-09			
5.7					BS-2	Remoulded	w = 16.6%
7.50	701.50 / 7.50	Termination in silty gravel					

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5

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TEST PIT LOG

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PROJECT :	Tailings and Soil Excavation and Consolidation
TEST PIT :	TP-08-34
SITE :	Borrow source in gravel quarry North of VTF
PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)
DATE :	2008-07-09
DATUM :	NAD83
COORDINATES :	7088804.00 N 474857.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

DEPTH - m	ELEVATION - m / DEPTH. - m	STRATIGRAPHY: DESCRIPTION	SYMBOL	WATER INFLOW	SAMPLE: NUMBER	SAMPLE: CONDITION	LABORATORY AND IN SITU TESTS
	709.00 / 0.00	Silty gravel, grey, well graded, dry, uniform, compact, silt/clay = 30%, sand = 35%, gravel = 30%, cobble = 5% [GM]			BS-1	Remoulded	w = 4.8%
	704.70 / 4.30	Termination in silty gravel					

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5

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TEST PIT LOG

PROJECT :	Tailings and Soil Excavation and Consolidation	TEST PIT :	*TP-08-35*
SITE :	Borrow source in gravel quarry North of VTF	PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	DATE :	2008-07-10
DATUM :	NAD83	COORDINATES :	7088875.00 N 474940.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

DEPTH - m	ELEVATION - m / DEPTH. - m	DESCRIPTION (STRATIGRAPHY)	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
	707.00 / 0.00	Silty gravel, grey, well graded, moist, uniform, compact, silt/clay = 30%, sand = 30%, gravel = 25%, cobbles = 15%, gravel and cobbles are rounded and elongate [GM]				Remoulded	
2.0					BS-1		w = 6% wL = 18% wP = 14% PI = 4% Std. Proctor Dmax = 21.34 wOPT = 8.5%
	703.20 / 3.80	Termination in silty gravel					

Depth scale (m): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5

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TEST PIT LOG

PROJECT :	Tailings and Soil Excavation and Consolidation	**TEST PIT :**	***TP-08-36***
SITE :	Borrow source in gravel quarry North of VTF	**PAGE :**	1 **OF** 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	**DATE :**	2008-07-10
DATUM :	NAD83	**COORDINATES :**	7088855.00 N 474855.00 E

SAMPLE CONDITION	**LABORATORY AND IN SITU TESTS**		
☒ Remoulded	W Water content (%)	P Proctor test	wL Liquid limit (%)
	GS Grain size analysis	wOPT Optimum water content (%)	wP Plastic limit (%)
	D Unit weight (kN/m³)	Dmax Max. Dry unit weight (kN/m³)	

DEPTH - m	ELEVATION - m / DEPTH. - m	DESCRIPTION	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
0.00	710.00 / 0.00	Silty gravel, grey, well graded, moist, uniform, loose, silt/clay = 40%, sand = 40%, gravel = 15%, cobbles = 5%, well graded sand (fine to medium), gravel and cobbles round and elongate [GM]			BS-1	Remoulded	w = 7.4% wL = 17% wP = 13% PI = 4%
2.50	707.50 / 2.50	Silty gravel, grey, well graded, moist, uniform, compact, silt/clay = 40%, sand = 40%, gravel = 15%, cobbles = 5%, well graded sand (fine to medium), gravel and cobbles round and elongate [GM]			BS-2	Remoulded	
5.40	704.60 / 5.40	Termination in silty gravel					

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5

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TEST PIT LOG

PROJECT : Tailings and Soil Excavation and Consolidation
TEST PIT : *TP-08-37*
SITE : Borrow source in gravel quarry North of VTF
PAGE : 1 **OF** 1
FILE NO : UNITED KENO HILL (1CE012.002.02)
DATE : 2008-07-10
DATUM : NAD83
COORDINATES : 7088788.00 N 474737.00 E

SAMPLE CONDITION	LABORATORY AND IN SITU TESTS					
☒ Remoulded	W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
	GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
	D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

DEPTH - m	ELEVATION - m / DEPTH. - m	DESCRIPTION	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
	708.00 0.00	Silty gravel, grey, well graded, moist, uniform, firm, silt/clay = 40%, sand = 40%, gravel = 15%, cobbles = 5%, well graded sand (fine to medium), gravel and cobbles round [GM]			BS-1	☒	w = 7.1%
	702.60 5.40	Termination in silty gravel					

Depth scale (m): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5

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TEST PIT LOG

PROJECT :	Tailings and Soil Excavation and Consolidation
TEST PIT :	TP-08-38
SITE :	Borrow source in gravel quarry North of VTF
PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)
DATE :	2008-07-10
DATUM :	NAD83
COORDINATES :	7088754.00 N 474737.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

DEPTH - m	ELEVATION - m / DEPTH. - m	DESCRIPTION (STRATIGRAPHY)	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
0.0–2.0	703.00 / 0.00	Silty gravel, grey, well graded, moist, uniform, loose, silt/clay = 35%, sand = 35%, gravel = 25%, cobbles = 5%, well graded sand (fine to medium), gravel and cobbles round [GM]			BS-1	Remoulded	
2.0–4.6	701.00 / 2.00	Silty gravel, grey, well graded, moist, uniform, compact, silt/clay = 35%, sand = 35%, gravel = 25%, cobbles = 5%, well graded sand (fine to medium), gravel and cobbles round [GM]			BS-2	Remoulded	w = 7.8%
4.6	698.40 / 4.60	Termination in silty gravel					

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5

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TEST PIT LOG

PROJECT :	Tailings and Soil Excavation and Consolidation
TEST PIT :	TP-08-39
SITE :	Borrow source up stream of North end of Dam #2
PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)
DATE :	2008-07-10
DATUM :	NAD83
COORDINATES :	7088622.00 N 474581.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
701.00 / 0.00	Peat, black, non-fibrous, moist [Pt]			BS-1	Remoulded	
700.70 / 0.30	Silty gravel, grey, well graded, moist, uniform, firm, silt/clay = 35%, sand = 35%, gravel = 25%, cobbles = 5%, well graded sand (fine to medium), gravel and cobbles round [GM]			BS-2	Remoulded	w = 5.2% wL = 17% wP = 14% PI = 3%
695.20 / 5.80	Termination in silty gravel					

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5

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TEST PIT LOG

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PROJECT :	Tailings and Soil Excavation and Consolidation	**TEST PIT :**	*TP-08-40*
SITE :	Borrow source North of Dam #2	**PAGE :**	1 **OF** 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	**DATE :**	2008-07-10
DATUM :	NAD83	**COORDINATES :**	7088675.00 N 474520.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

DEPTH - m	ELEVATION - m / DEPTH. - m	DESCRIPTION	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
	706.00						
0.0–3.5	0.00	Silty gravel, grey, well graded, moist, uniform, loose, silt/clay = 35%, sand = 35%, gravel = 25%, cobbles = 5%, well graded sand (fine to medium), gravel and cobbles round [GM]	GM		BS-1	Remoulded	w = 7.3%
3.5	702.50 / 3.50	Silty gravel, grey, well graded, moist, uniform, compact, silt/clay = 35%, sand = 35%, gravel = 25%, cobbles = 5%, well graded sand (fine to medium), gravel and cobbles round [GM]	GM		BS-2	Remoulded	
5.8	700.20 / 5.80	Termination in silty gravel					

Depth scale (m): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5

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TEST PIT LOG

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PROJECT :	Tailings and Soil Excavation and Consolidation	TEST PIT :	TP-08-41
SITE :	Borrow source between Dam #2 and Dam #3	PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	DATE :	2008-07-10
DATUM :	NAD83	COORDINATES :	7088586.00 N 474395.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

DEPTH - m	ELEVATION - m / DEPTH. - m	DESCRIPTION	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
	710.00 / 0.00	Peat, black, moist, rootmat [Pt]		0.30m depth on 2008-07-10	BS-1	Remoulded	
	709.70 / 0.30	Silty sand, grey, well graded [SM], permafrost (Nb)			BS-2	Remoulded	
0.5	709.50 / 0.50	Silty gravel, light brown, well graded, uniform, silt/clay = 35%, sand = 35%, gravel = 25%, cobbles = 5%, well graded sand (fine to medium), gravel and cobbles round [GM], permafrost (Nb)			BS-3	Remoulded	w = 18.4%
	707.80 / 2.20	Refusal in silty gravel / permafrost					

Depth scale (m): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5

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TEST PIT LOG

PROJECT :	Tailings and Soil Excavation and Consolidation	TEST PIT :	*TP-08-42*
SITE :	Borrow source between Dam #2 and Dam #3	PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	DATE :	2008-07-10
DATUM :	NAD83	COORDINATES :	7088652.00 N 474387.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

ELEVATION - m / DEPTH - m	DESCRIPTION	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
721.00 / 0.00	Peat, black, moist, rootmat [Pt]		BS-1	Remoulded	
720.80 / 0.20	Silty gravel, light brown, well graded, moist, uniform, loose, silt/clay = 30%, sand = 50%, gravel = 15%, cobbles = 5%, well graded sand (fine to medium), gravel and cobbles round [GM]		BS-2	Remoulded	w = 8.8% wL = 16% wP = 13% PI = 3% Std. Proctor Dmax = 21.34 wOPT = 8.5%
717.50 / 3.50	Silty gravel, light brown, well graded, moist, uniform, compact, silt/clay = 30%, sand = 50%, gravel = 15%, cobbles = 5%, well graded sand (fine to medium), gravel and cobbles round [GM]	6.30m depth on 2008-07-10	BS-3	Remoulded	
714.70 / 6.30	Termination in silty gravel				

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5

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TEST PIT LOG

PROJECT : Tailings and Soil Excavation and Consolidation
TEST PIT : *TP-08-43*

SITE : Borrow source between Dam #1 and Dam #2
PAGE : 1 **OF** 1

FILE NO : UNITED KENO HILL (1CE012.002.02)
DATE : 2008-07-10

DATUM : NAD83
COORDINATES : 7088707.00 N 474645.00 E

SAMPLE CONDITION	LABORATORY AND IN SITU TESTS					
☒ Remoulded	W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
	GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
	D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

ELEVATION - m / DEPTH. - m	STRATIGRAPHY – DESCRIPTION	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
706.00 / 0.00	Silty gravel, grey, well graded, moist, uniform, loose, silt/clay = 25%, sand = 45%, gravel = 25%, cobbles = 5%, well graded sand (fine to medium), gravel and cobbles sub-angular [GM]			BS-1	Remoulded	Std. Proctor Dmax = 21.34 wOPT = 8.5% w = 6.9% wL = 16% wP = 14% PI = 2%
702.50 / 3.50	Silty gravel, grey, well graded, moist, uniform, compact, silt/clay = 25%, sand = 45%, gravel = 25%, cobbles = 5%, well graded sand (fine to medium), gravel and cobbles sub-angular [GM]			BS-2	Remoulded	
699.70 / 6.30	Termination in silty gravel					

DEPTH - m: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5

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Attachment 1C

Spilled Tailings West of Dam #3 Test Pit 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]

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2007 Geotechnical Report and Hydrogeological Field Investigation

Borehole Log Legend

SRK JOB NO.: 1CE12.000.GT2	Keno Hill	DATE: Feb. 08
FILE NAME: DrillLogLegend.dwg		APPROVED: LW
		FIGURE: -

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TEST PIT LOG

PROJECT :	Tailings and Soil Excavation and Consolidation	**TEST PIT :**	***TP-08-44***
SITE :	Old tailings west of Dam #3	**PAGE :**	1 **OF** 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	**DATE :**	2008-07-12
DATUM :	NAD83	**COORDINATES :**	7088314.00 N 474254.00 E

SAMPLE CONDITION	LABORATORY AND IN SITU TESTS		
Remoulded	W Water content (%)	P Proctor test	wL Liquid limit (%)
	GS Grain size analysis	wOPT Optimum water content (%)	wP Plastic limit (%)
	D Unit weight (kN/m³)	Dmax Max. Dry unit weight (kN/m³)	

DEPTH - m	ELEVATION - m / DEPTH. - m	DESCRIPTION (STRATIGRAPHY)	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
	696.00 / 0.00	Peat, black, wet, rootmat [Pt]			BS-1	Remoulded	
	695.95 / 0.05	Silty sand, brown, wet, uniform [SM]			BS-2	Remoulded	
	695.80 / 0.20	Silty sand, grey, wet, uniform [SM]		0.40m depth on 2008-07-12	BS-3	Remoulded	
	695.60 / 0.40	Termination in silty sand					
0.5							

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TEST PIT LOG

PROJECT : Tailings and Soil Excavation and Consolidation
TEST PIT : *TP-08-45*
SITE : Old tailings west of Dam #3
PAGE : 1 **OF** 1
FILE NO : UNITED KENO HILL (1CE012.002.02)
DATE : 2008-07-12
DATUM : NAD83
COORDINATES : 7088276.00 N 474145.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

STRATIGRAPHY

DEPTH - m	ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
	695.00						
	0.00	Peat, black, moist, rootmat [Pt]			BS-1	Remoulded	
	694.97 / 0.03	Silty sand, reddisih brown, moist, uniform [SM]			BS-2	Remoulded	
	694.95 / 0.05	Silty sand, light grey with reddish brown mottling (~1 cm in diameter), moist [SM]			BS-3	Remoulded	
0.5				0.60m depth on 2008-07-12			
	694.40 / 0.60	Termination in silty sand					

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TEST PIT LOG

PROJECT :	Tailings and Soil Excavation and Consolidation
TEST PIT :	TP-08-46
SITE :	Old tailings west of Dam #3
PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)
DATE :	2008-07-12
DATUM :	NAD83
COORDINATES :	7088235.00 N 474084.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

DEPTH - m	ELEVATION - m / DEPTH. - m	DESCRIPTION (STRATIGRAPHY)	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
	695.00 / 0.00	Silty sand, reddisih brown, moist, uniform [SM]			BS-1	Remoulded	
	694.90 / 0.10	Silty sand, brown, moist, uniform [SM]			BS-2	Remoulded	
0.5	694.80 / 0.20	Silty sand, dark grey, moist, uniform [SM]		0.90m depth on 2008-07-12	BS-3	Remoulded	
	694.10 / 0.90	Termination in silty sand					

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TEST PIT LOG

PROJECT : Tailings and Soil Excavation and Consolidation
TEST PIT : *TP-08-47*
SITE : Old tailings west of Dam #3
PAGE : 1 **OF** 1
FILE NO : UNITED KENO HILL (1CE012.002.02)
DATE : 2008-07-12
DATUM : NAD83
COORDINATES : 7088224.00 N 474047.00 E

SAMPLE CONDITION	LABORATORY AND IN SITU TESTS		
Remoulded	W Water content (%)	P Proctor test	wL Liquid limit (%)
	GS Grain size analysis	wOPT Optimum water content (%)	wP Plastic limit (%)
	D Unit weight (kN/m³)	Dmax Max. Dry unit weight (kN/m³)	

DEPTH - m	ELEVATION - m / DEPTH. - m	DESCRIPTION (STRATIGRAPHY)	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
	696.00 / 0.00	Silty sand, reddisih brown, moist, uniform [SM]			BS-1	Remoulded	
	695.85 / 0.15	Silty sand, light grey with reddish brown mottling (~1 cm in diameter), moist [SM]			BS-2	Remoulded	
0.5	695.80 / 0.20	Silty sand, dark grey, moist, uniform [SM]		0.80m depth on 2008-07-12	BS-3	Remoulded	
	695.20 / 0.80	Termination in silty sand					

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TEST PIT LOG

PROJECT :	Tailings and Soil Excavation and Consolidation	TEST PIT :	*TP-08-48*
SITE :	Old tailings west of Dam #3	PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	DATE :	2008-07-12
DATUM :	NAD83	COORDINATES :	7088177.00 N 473919.00 E

SAMPLE CONDITION	LABORATORY AND IN SITU TESTS					
Remoulded	W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
	GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
	D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

DEPTH - m	ELEVATION - m / DEPTH. - m	DESCRIPTION	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
	695.00 / 0.00	Silty sand, light brown, moist, uniform [SM]		0.10m depth on 2008-07-12	BS-1	Remoulded	
0.5	694.50 / 0.50	Silty sand, light grey, wet, uniform [SM]			BS-2	Remoulded	
	694.20 / 0.80	Termination in silty sand					

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TEST PIT LOG

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PROJECT :	Tailings and Soil Excavation and Consolidation	TEST PIT :	*TP-08-49*
SITE :	Old tailings west of Dam #3	PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	DATE :	2008-07-12
DATUM :	NAD83	COORDINATES :	7088062.00 N 473738.00 E

SAMPLE CONDITION

Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

DEPTH - m	ELEVATION - m / DEPTH. - m	DESCRIPTION (STRATIGRAPHY)	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
	694.00 / 0.00	Peat, black, wet, rootmat [Pt]			BS-1	Remoulded	
	693.95 / 0.05	Silty sand, dark grey, wet, uniform [SM]		0.10m depth on 2008-07-12	BS-2	Remoulded	
	693.70 / 0.30	Termination in silty sand					
0.5							

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TEST PIT LOG

PROJECT :	Tailings and Soil Excavation and Consolidation	TEST PIT :	*TP-08-50*
SITE :	Old tailings west of Dam #3	PAGE :	1 OF 1
FILE NO :	UNITED KENO HILL (1CE012.002.02)	DATE :	2008-07-12
DATUM :	NAD83	COORDINATES :	7088034.00 N 473616.00 E

SAMPLE CONDITION	LABORATORY AND IN SITU TESTS					
Remoulded	W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
	GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
	D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

DEPTH - m	ELEVATION - m / DEPTH. - m	DESCRIPTION (STRATIGRAPHY)	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
	693.00 / 0.00	Peat, black, wet, rootmat [Pt]		0.00m depth on 2008-07-12	BS-1	Remoulded	
	692.95 / 0.05	Silty sand, dark grey, wet, uniform [SM]			BS-2	Remoulded	
	692.70 / 0.30	Termination in silty sand					
0.5							

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TEST PIT LOG

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PROJECT : Tailings and Soil Excavation and Consolidation		**TEST PIT :**	***TP-08-51***
SITE : Old tailings west of Dam #3		**PAGE :** 1	**OF** 1
FILE NO : UNITED KENO HILL (1CE012.002.02)		**DATE :**	2008-07-12
DATUM : NAD83	**COORDINATES :**	7087881.00 N	473368.00 E

SAMPLE CONDITION: Remoulded

LABORATORY AND IN SITU TESTS

W	Water content (%)	P	Proctor test	wL	Liquid limit (%)
GS	Grain size analysis	wOPT	Optimum water content (%)	wP	Plastic limit (%)
D	Unit weight (kN/m³)	Dmax	Max. Dry unit weight (kN/m³)		

DEPTH - m	ELEVATION - m / DEPTH. - m	DESCRIPTION (STRATIGRAPHY)	SYMBOL	WATER INFLOW	SAMPLE NUMBER	SAMPLE CONDITION	LABORATORY AND IN SITU TESTS
	687.00 / 0.00	Peat, black, moist, rootmat [Pt]		0.20m depth on 2008-07-12	BS-1	Remoulded	
	686.95 / 0.05	Silty sand, light grey with reddish brown mottling (~1 cm in diameter), moist [SM]			BS-2	Remoulded	
	686.80 / 0.20	Silty sand, dark grey, wet, uniform [SM]			BS-3	Remoulded	
0.5	686.50 / 0.50	Termination in silty sand					

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Attachment 2
Geotechnical Laboratory Testing Results

MOISTURE CONTENT TEST RESULTS

Project: UKHM Soil Testing - 2008
Sample No.:
Project No.: W14101175
Date Tested: August, 2008
Client: SRK Consulting
Tested By: NSP
Address: Keno, Yukon
Page: 1 of 1

B.H. Number	Sample Number (depth)	Tare Number	Tare Mass (g)	Mass of Wet Soil & Tare (g)	Mass of Dry Soil & Tare (g)	Moisture Content (%)	Visual Description of Soil EBA Work Method WM4400
TP08-08	0.7 m					27.7	
TP08-10	0.5 m					29.2	
TP08-15	0.9 m					25.8	
TP08-18	1.3 m					26.3	
TP08-20	0.45 m					21.0	
TP08-20	1.0 m					29.8	
TP08-33	0.0 to 3.9 m					6.3	
TP08-33	3.9 to 7.5 m					16.6	
TP08-34	0.0 to 4.3 m					4.8	
TP08-35	0.0 to 3.8 m					6.0	
TP08-36	0.0 to 2.5 m					7.4	
TP08-37	0.0 to 5.4 m					7.1	
TP08-38	0.0 to 4.6 m					7.8	
TP08-39	0.3 to 5.8 m					5.2	
TP08-40	0.0 to 5.8 m					7.3	
TP08-41	0.5 to 1.7 m					18.4	
TP08-42	0.2 to 6.3 m					8.8	
TP08-43	0.0 to 6.3 m					6.9	

Tested in accordance with ASTM standard D2216, subject to review .
issued for internal use

EBA Engineering Consultants Ltd.

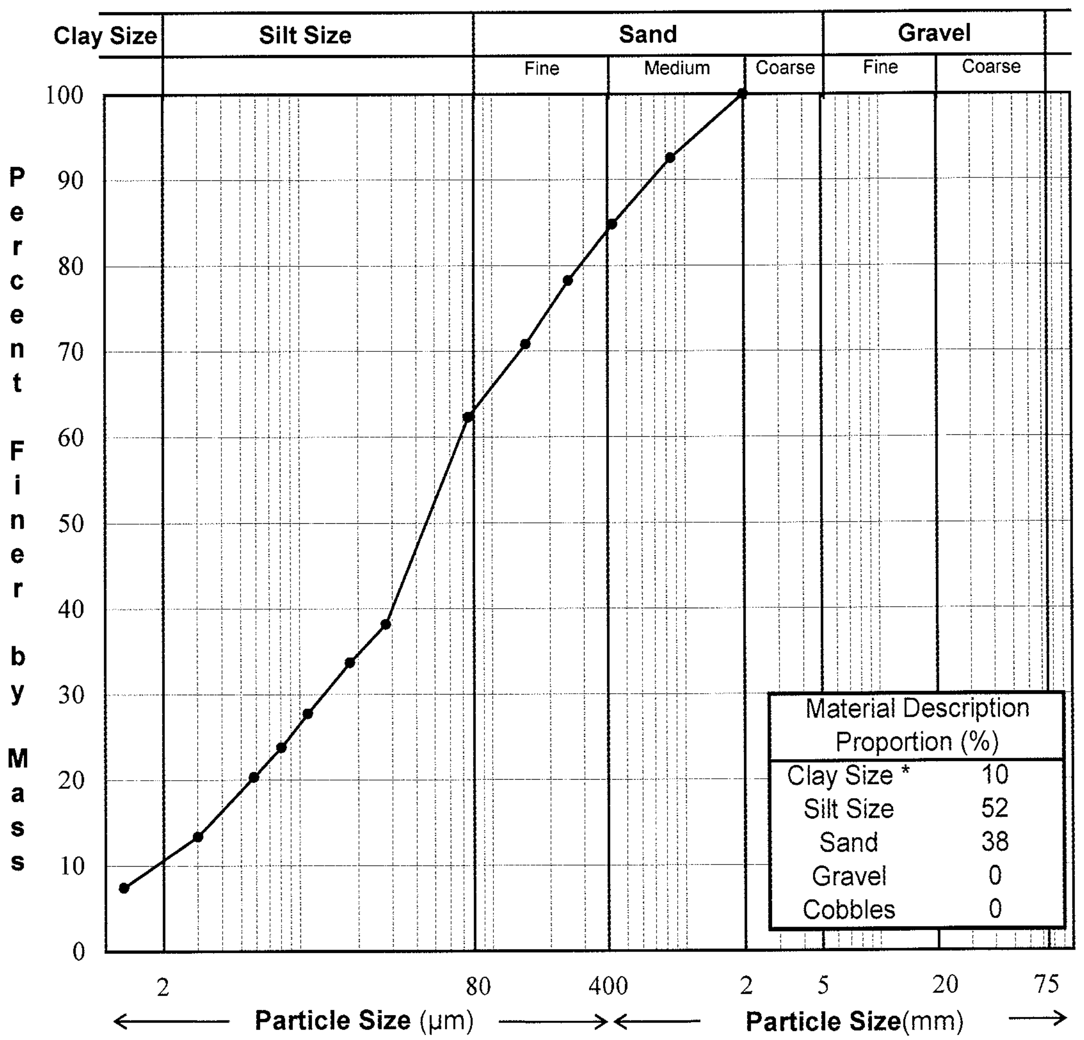
PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	**UKHM Soil Testing 2008**
Client:	SRK Consulting
Project No.:	W14101175
Location:	Keno
Sample No.:	35
Depth:	3.8 m
Description**:	SILT AND SAND - trace clay

Date Tested: 2008/07/31

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	
25 mm	
19 mm	
13 mm	
10 mm	
5 mm	
2 mm	100
850 μm	93
425 μm	85
250 μm	78
150 μm	71
75 μm	62
28 μm	38
18 μm	34
11 μm	28
8 μm	24
6 μm	20
3 μm	13
1 μm	7



Material Description	Proportion (%)
Clay Size *	10
Silt Size	52
Sand	38
Gravel	0
Cobbles	0

Remarks: * The upper clay size of 2 μm, per the Canadian Foundation Engineering Manual.
** The description is visually based & subject to EBA description protocols.

Reviewed By: ____________

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EBA Engineering Consultants Ltd.

Atterberg Limits Test Form

ASTM D4318

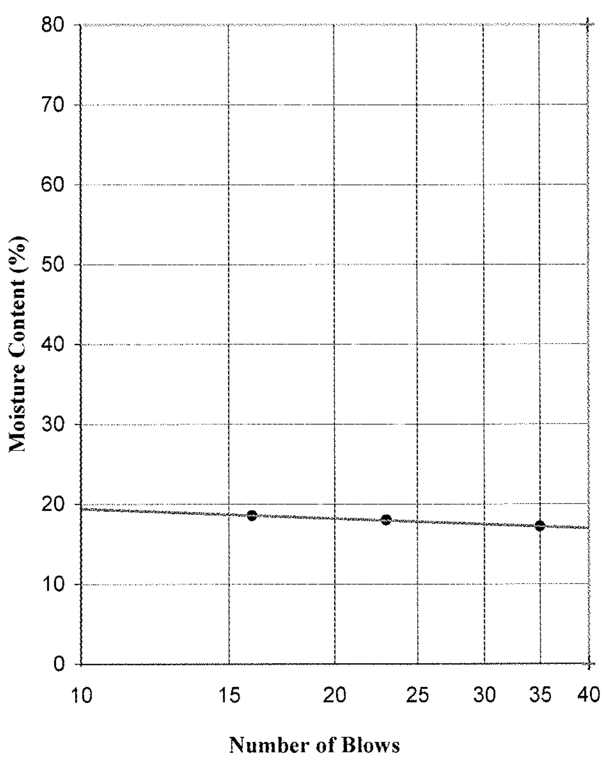
Project:	UKHM Soil Testing 2008	Sample Number:	SA 35
		Borehole Number:	TP-08-35
Project Number:	W14101175	Depth:	3.8 m
Sample Description:		Date Tested:	6/8/2008
		Tested By:	NSP

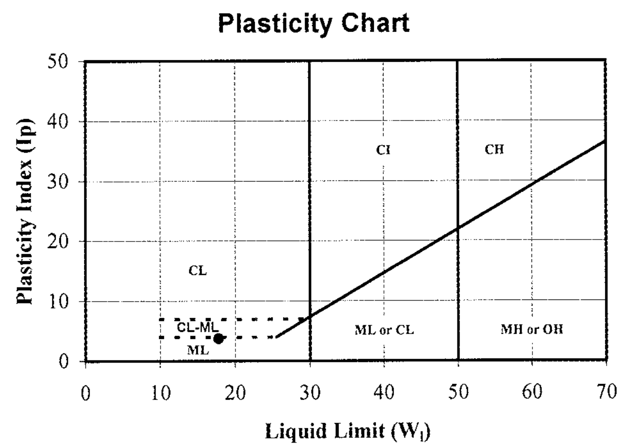
Plastic Limit Test

Trial Number	1	2	3
Tare Number	a	b	
Wt. Wet Soil + Tare	8.93	5.57	
Wt. Dry Soil + Tare	7.97	5.07	
Wt. of Tare	1.44	1.36	
Wt. of Water	0.96	0.50	
Wt. of Dry Soil	6.53	3.71	
Moisture Content (%)	14.7	13.5	

Liquid Limit Test

Trial Number	1	2	3
No. of Blows	16	23	35
Tare Number	c	d	e
Wt. Wet Soil + Tare	12.52	14.06	13.72
Wt. Dry Soil + Tare	11.21	12.51	12.29
Wt. of Tare	4.15	3.90	3.97
Wt. of Water	1.31	1.55	1.43
Wt. of Dry Soil	7.06	8.61	8.32
Moisture Content (%)	18.6	18.0	17.2





LIQUID LIMIT (%)	18
PLASTIC LIMIT (%)	14
PLASTICITY INDEX (%)	**4**

Soil Description: Low Plasticity

USCS Symbol: CL

Remarks:

EBA Engineering Consultants Ltd.

PARTICLE SIZE DISTRIBUTION

ASTM C136 & D422

Project: **UKHM Soil Testing 2008**

Project Number: W14101175

Date Tested: 7/31/2008

Borehole Number: TP-08 SA-36

Depth: 2.5 m

Soil Description: SILT AND SAND - gravelly

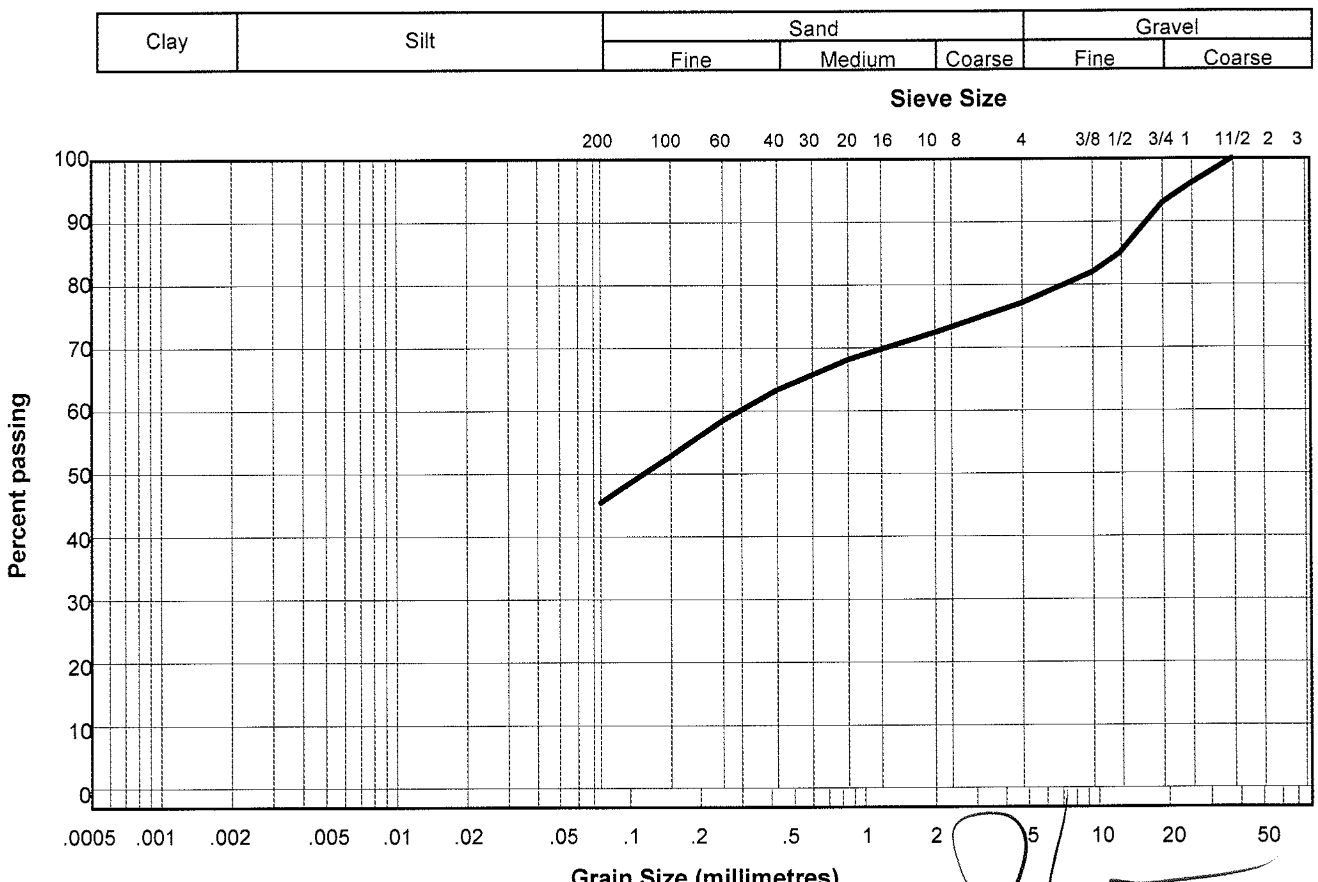
Cu:

Cc:

Natural Moisture Content: 7.4%

Remarks:

Sieve Size	Percent Passing
50.000	#N/A
37.500	100
25.000	96
19.000	93
12.500	85
9.500	82
4.750	77
2.000	72
0.850	68
0.425	63
0.250	59
0.150	53
0.075	45.4



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EBA Engineering Consultants Ltd.

Atterberg Limits Test Form

ASTM D4318

Project:	UKHM Soil Testing 2008	Sample Number:	SA 36
		Borehole Number:	TP-08-36
Project Number:	W14101175	Depth:	2.5 m
Sample Description:		Date Tested:	6/8/2008
		Tested By:	NSP

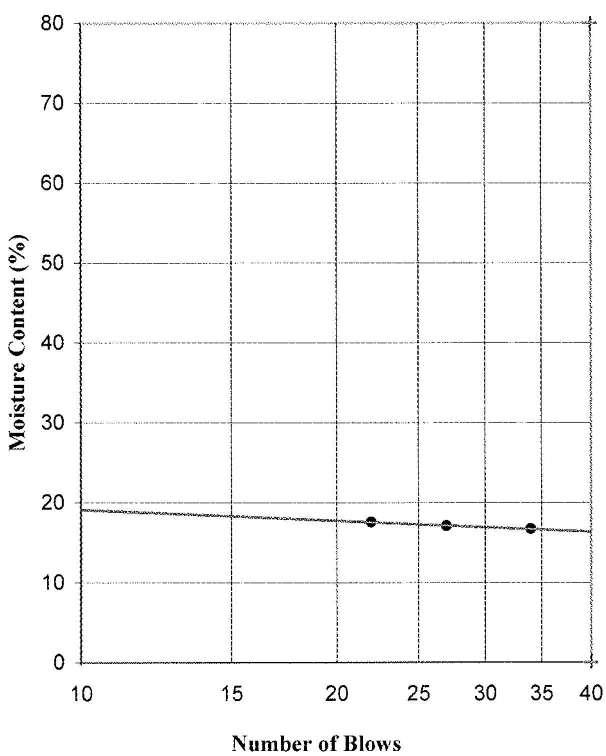
Plastic Limit Test

Trial Number	1	2	3
Tare Number	a	b	
Wt. Wet Soil + Tare	6.24	7.27	
Wt. Dry Soil + Tare	5.68	6.56	
Wt. of Tare	1.35	1.40	
Wt. of Water	0.56	0.71	
Wt. of Dry Soil	4.33	5.16	
Moisture Content (%)	12.9	13.8	

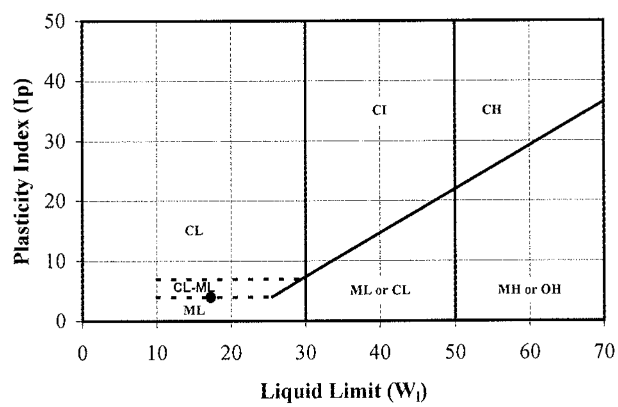
Liquid Limit Test

Trial Number	1	2	3
No. of Blows	22	27	34
Tare Number	c	d	e
Wt. Wet Soil + Tare	13.48	12.49	13.24
Wt. Dry Soil + Tare	12.05	11.23	11.90
Wt. of Tare	3.90	3.85	3.86
Wt. of Water	1.43	1.26	1.34
Wt. of Dry Soil	8.15	7.38	8.04
Moisture Content (%)	17.5	17.1	16.7

Liquid Limit (W_l)



Plasticity Chart



LIQUID LIMIT (%)	17
PLASTIC LIMIT (%)	13
PLASTICITY INDEX (%)	**4**

Soil Description: Low Plasticity

USCS Symbol: CL

Remarks:

EBA Engineering Consultants Ltd.

PARTICLE SIZE DISTRIBUTION

ASTM C136 & D422

Project: **UKHM Soil Testing 2008**

Project Number: W14101175

Date Tested: 7/31/2008

Borehole Number: TP-08 SA-39

Depth: 2.5 m

Soil Description: GRAVEL - silty, sandy

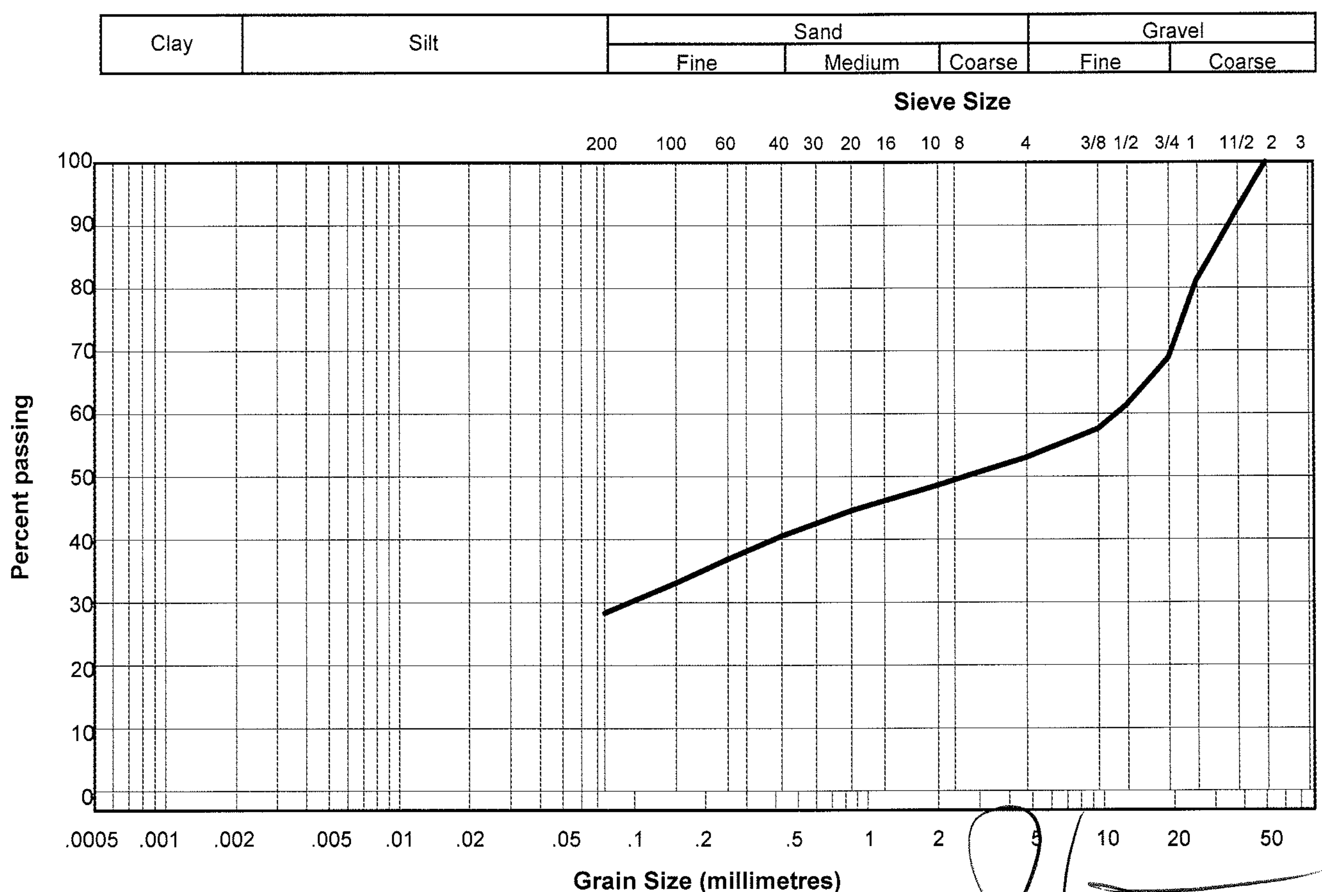
Cu:

Cc:

Natural Moisture Content: 5.2%

Remarks:

Sieve Size	Percent Passing
50.000	100
37.500	92
25.000	81
19.000	69
12.500	61
9.500	58
4.750	53
2.000	49
0.850	45
0.425	41
0.250	37
0.150	33
0.075	28.3



Reviewed By: ______

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EBA Engineering Consultants Ltd.

Atterberg Limits Test Form

ASTM D4318

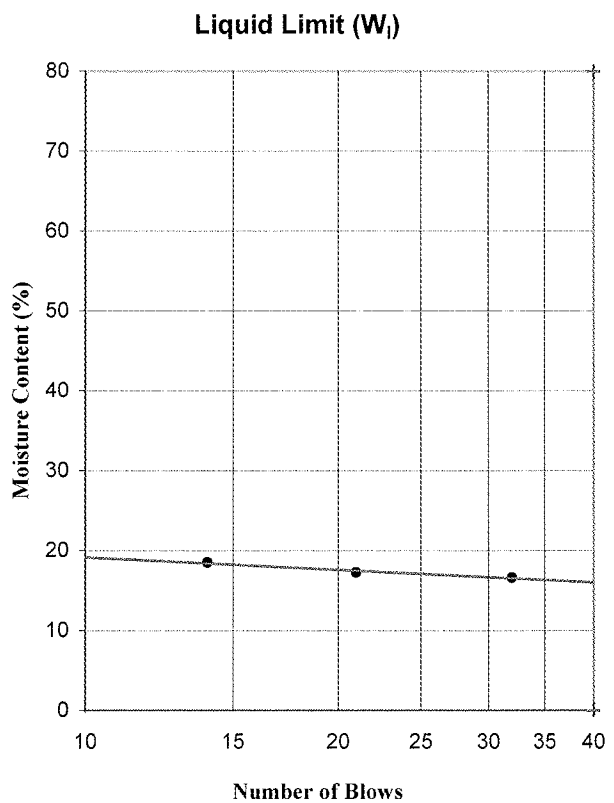
Project:	UKHM Soil Testing 2008	Sample Number:	SA 39
		Borehole Number:	TP-08-39
Project Number:	W14101175	Depth:	5.8 m
Sample Description:		Date Tested:	6/8/2008
		Tested By:	NSP

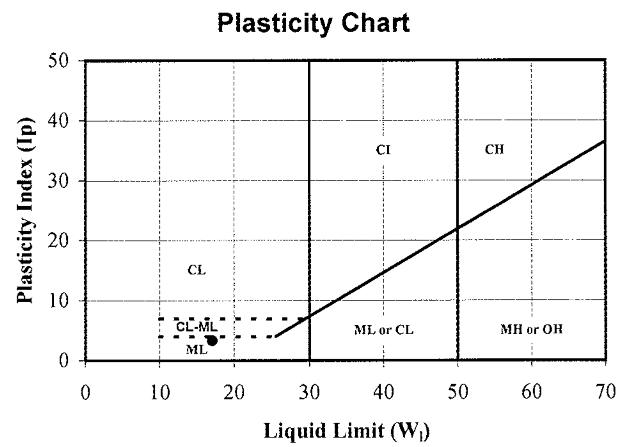
Plastic Limit Test

Trial Number	1	2	3
Tare Number	a	b	
Wt. Wet Soil + Tare	6.93	8.03	
Wt. Dry Soil + Tare	6.23	7.54	
Wt. of Tare	1.26	3.90	
Wt. of Water	0.70	0.49	
Wt. of Dry Soil	4.97	3.64	
Moisture Content (%)	14.1	13.5	

Liquid Limit Test

Trial Number	1	2	3
No. of Blows	14	21	32
Tare Number	c	d	e
Wt. Wet Soil + Tare	12.00	13.06	13.80
Wt. Dry Soil + Tare	10.75	11.71	12.40
Wt. of Tare	3.98	3.88	3.97
Wt. of Water	1.25	1.35	1.40
Wt. of Dry Soil	6.77	7.83	8.43
Moisture Content (%)	18.5	17.2	16.6





LIQUID LIMIT (%)	17
PLASTIC LIMIT (%)	14
PLASTICITY INDEX (%)	**3**

Soil Description: Low Plasticity

USCS Symbol: CL

Remarks:

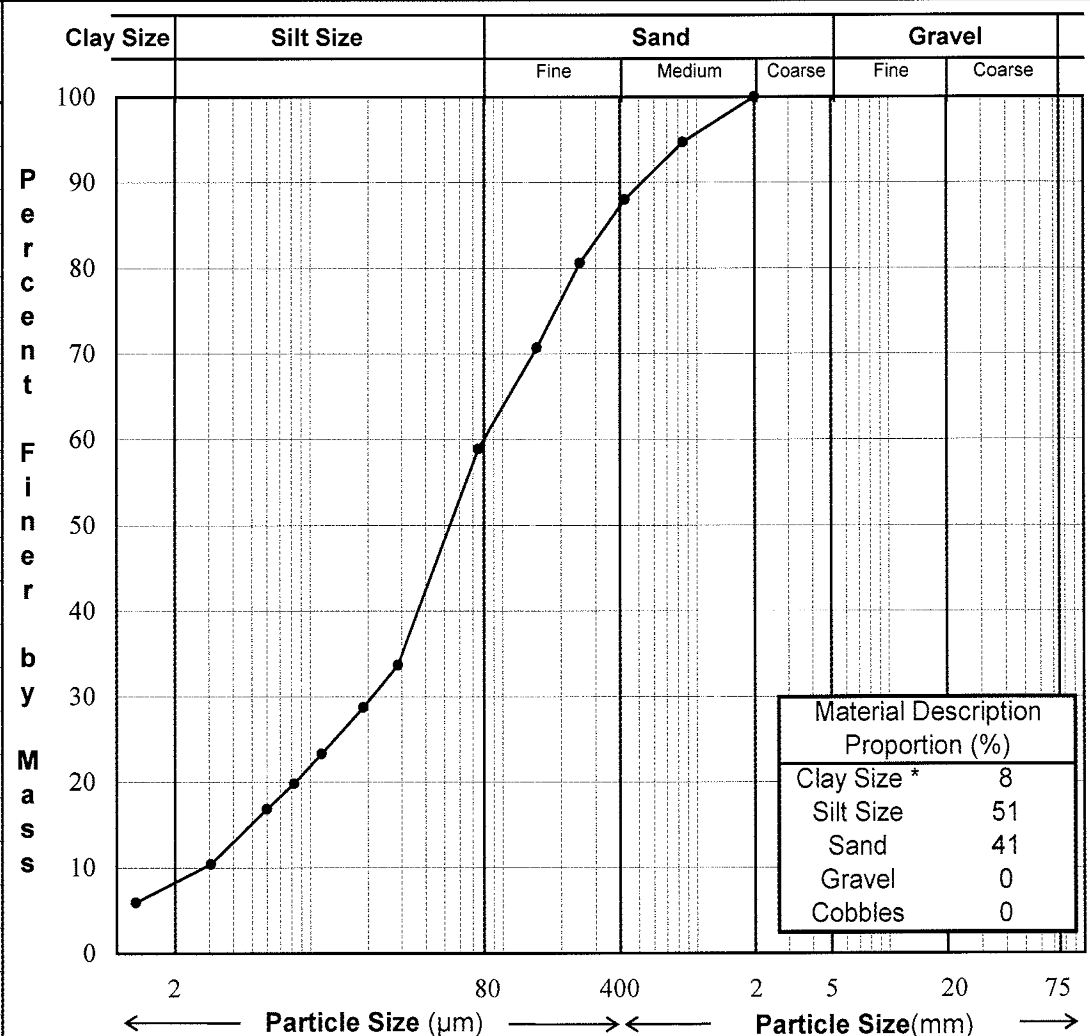
EBA Engineering Consultants Ltd.

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project: **UKHM Soil Testing 2008**
Date Tested: 2008/07/31
Client: SRK Consulting
Project No.: W14101175
Location: Keno
Sample No.: 42
Depth: 6.3 m
Description**: SILT AND SAND - trace clay

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	
25 mm	
19 mm	
13 mm	
10 mm	
5 mm	
2 mm	100
850 μm	95
425 μm	88
250 μm	81
150 μm	71
75 μm	59
29 μm	34
19 μm	29
11 μm	23
8 μm	20
6 μm	17
3 μm	10
1 μm	6



Material Description	Proportion (%)
Clay Size *	8
Silt Size	51
Sand	41
Gravel	0
Cobbles	0

Remarks: * The upper clay size of 2 μm, per the Canadian Foundation Engineering Manual.
** The description is visually based & subject to EBA description protocols.

Reviewed By: [signature]

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EBA Engineering Consultants Ltd.

Atterberg Limits Test Form

ASTM D4318

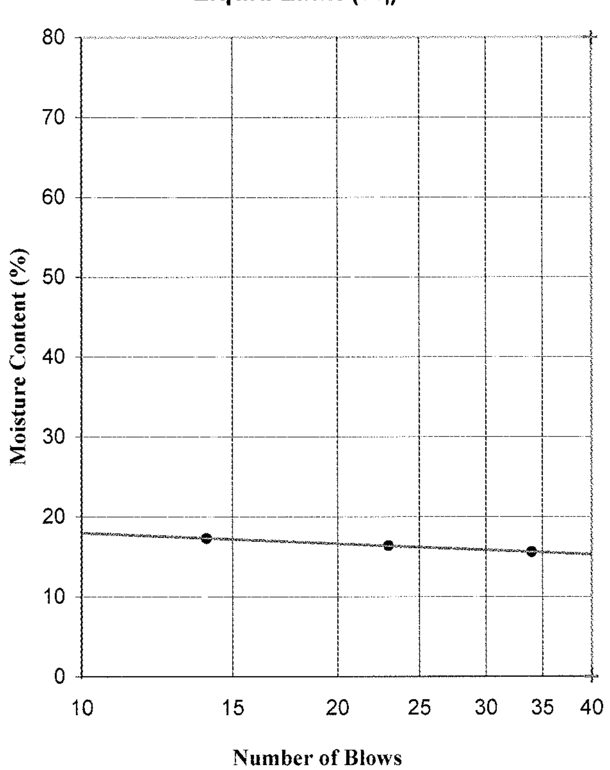
Project:	UKHM Soil Testing 2008	Sample Number:	SA 42
		Borehole Number:	TP-08-42
Project Number:	W14101175	Depth:	6.3 m
Sample Description:		Date Tested:	7/8/2008
		Tested By:	NSP

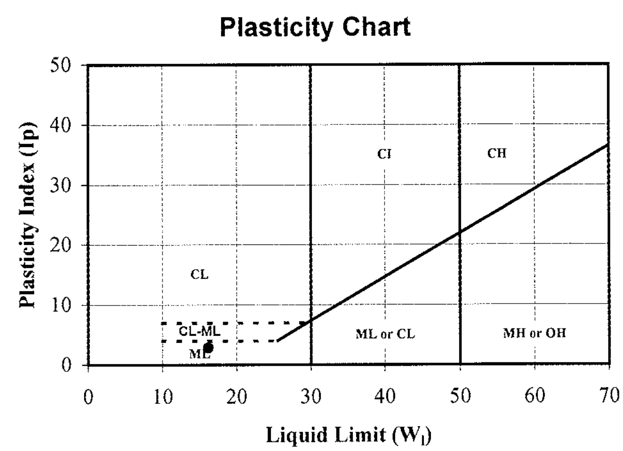
Plastic Limit Test

Trial Number	1	2	3
Tare Number	a	b	
Wt. Wet Soil + Tare	7.56	7.19	
Wt. Dry Soil + Tare	7.15	6.80	
Wt. of Tare	4.06	3.91	
Wt. of Water	0.41	0.39	
Wt. of Dry Soil	3.09	2.89	
Moisture Content (%)	13.3	13.5	

Liquid Limit Test

Trial Number	1	2	3
No. of Blows	14	34	23
Tare Number	c	d	e
Wt. Wet Soil + Tare	12.29	15.12	12.56
Wt. Dry Soil + Tare	11.08	13.63	11.35
Wt. of Tare	4.08	4.05	3.96
Wt. of Water	1.21	1.49	1.21
Wt. of Dry Soil	7.00	9.58	7.39
Moisture Content (%)	17.3	15.6	16.4





LIQUID LIMIT (%)	16
PLASTIC LIMIT (%)	13
PLASTICITY INDEX (%)	**3**

Soil Description: Low Plasticity

USCS Symbol: CL

Remarks:

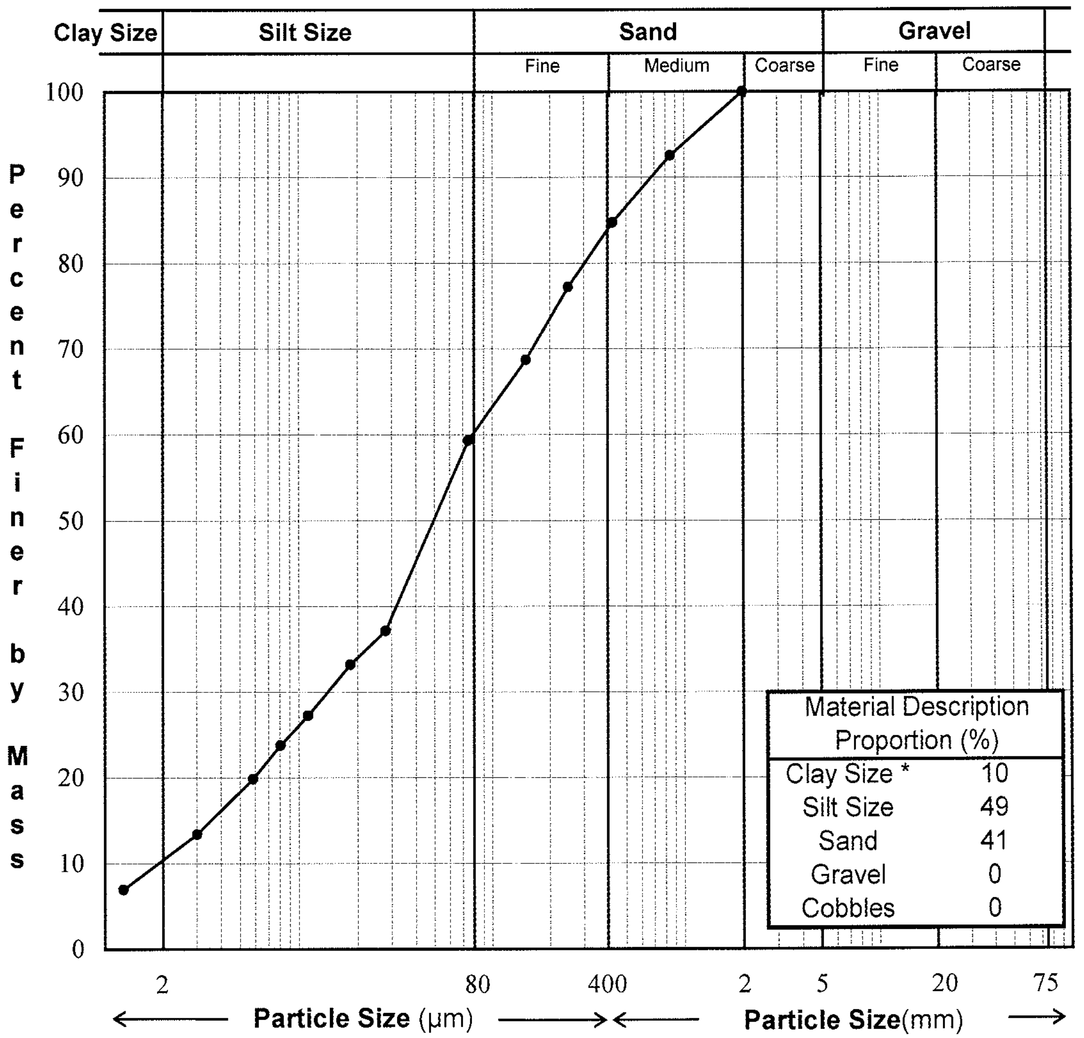
EBA Engineering Consultants Ltd.

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project: **UKHM Soil Testing 2008**
Date Tested: 2008/07/31
Client: SRK Consulting
Project No.: W14101175
Location: Keno
Sample No.: 43
Depth: 6.3 m
Description**: SILT AND SAND - trace clay

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	
25 mm	
19 mm	
13 mm	
10 mm	
5 mm	
2 mm	100
850 μm	93
425 μm	85
250 μm	77
150 μm	69
75 μm	59
28 μm	37
18 μm	33
11 μm	27
8 μm	24
6 μm	20
3 μm	13
1 μm	7



Material Description	Proportion (%)
Clay Size *	10
Silt Size	49
Sand	41
Gravel	0
Cobbles	0

Remarks: * The upper clay size of 2 μm, per the Canadian Foundation Engineering Manual.
** The description is visually based & subject to EBA description protocols.

Reviewed By: [signature]

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EBA Engineering Consultants Ltd.

Atterberg Limits Test Form

ASTM D4318

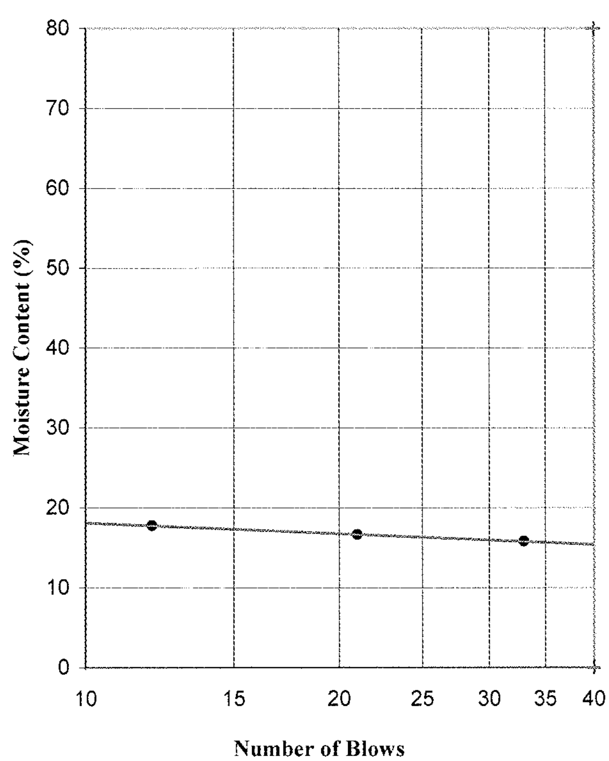
Project:	UKHM Soil Testing 2008	Sample Number:	SA 43
		Borehole Number:	TP-08-43
Project Number:	W14101175	Depth:	6.3 m
Sample Description:		Date Tested:	7/8/2008
		Tested By:	NSP

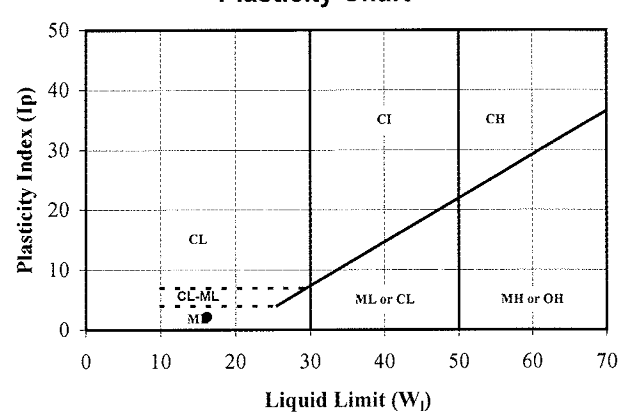
Plastic Limit Test

Trial Number	1	2	3
Tare Number	a	b	
Wt. Wet Soil + Tare	6.85	8.88	
Wt. Dry Soil + Tare	6.55	8.30	
Wt. of Tare	4.42	4.16	
Wt. of Water	0.30	0.58	
Wt. of Dry Soil	2.13	4.14	
Moisture Content (%)	14.1	14.0	

Liquid Limit Test

Trial Number	1	2	3
No. of Blows	12	21	33
Tare Number	c	d	e
Wt. Wet Soil + Tare	11.68	14.04	12.97
Wt. Dry Soil + Tare	10.51	12.62	11.71
Wt. of Tare	3.92	4.08	3.73
Wt. of Water	1.17	1.42	1.26
Wt. of Dry Soil	6.59	8.54	7.98
Moisture Content (%)	17.8	16.6	15.8





LIQUID LIMIT (%)	16
PLASTIC LIMIT (%)	14
PLASTICITY INDEX (%)	**2**

Soil Description: Low Plasticity

USCS Symbol: CL

Remarks:

EBA Engineering Consultants Ltd.

eba

MOISTURE-DENSITY RELATIONSHIP (Proctor) REPORT

ASTM D698

Project: **UKHM Soil Testing 2008**

Client: SRK Consulting

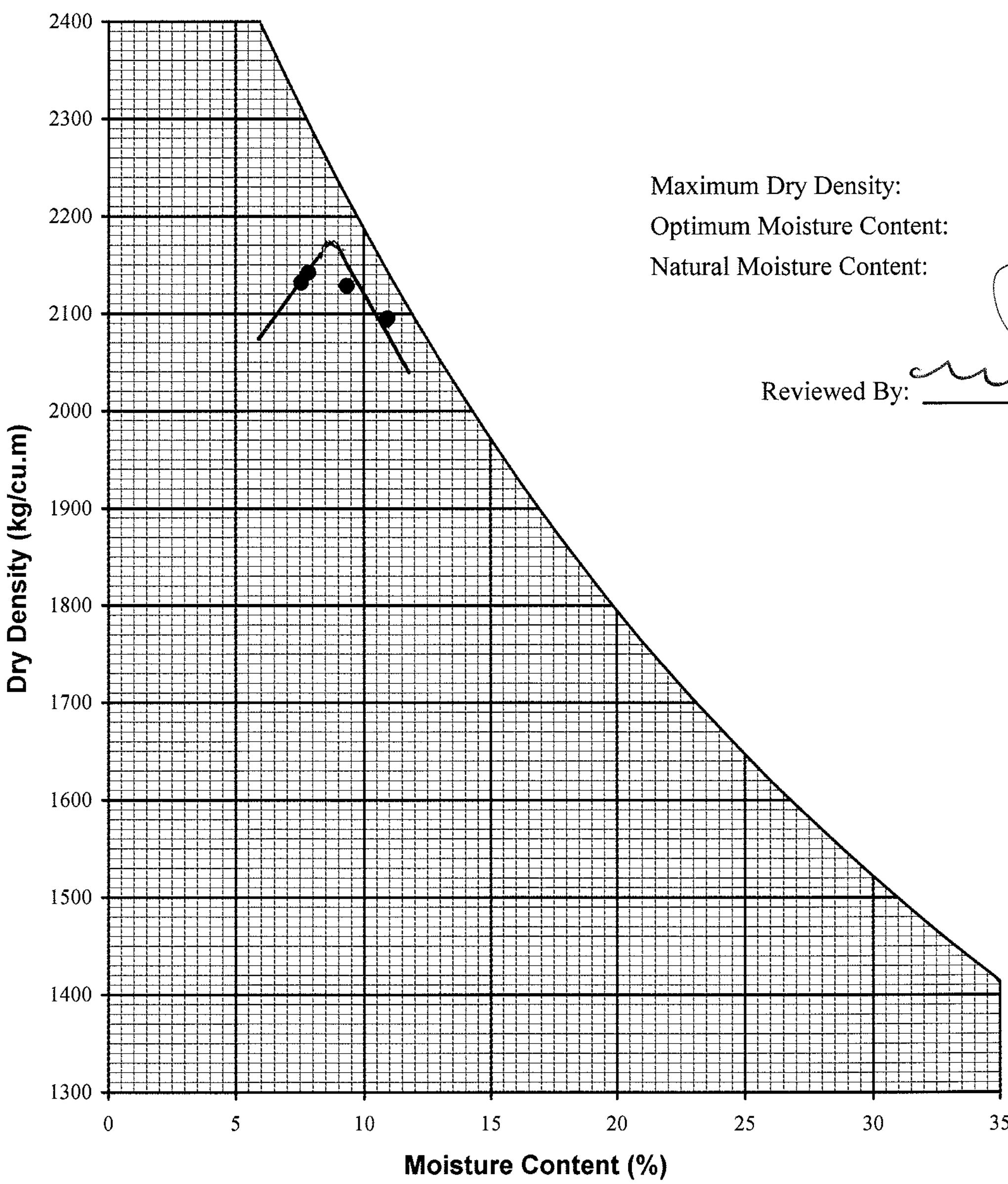
Project No.: W14101175

Description: TP-08 SA 35, 42 & 43

Source: SILT - sandy, gravelly

Test Date: August 14, 2008

Sample No.: SA 35, 42 & 43



Maximum Dry Density: 2175 kg/cu.m

Optimum Moisture Content: 8.5 %

Natural Moisture Content:

Reviewed By:

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Weight of Density Tube:	708	g
Volume of Density Tube:	0.000934	m^3
Average Field Bulk Tensity of VTF Tailings:	1967.57	kg/m^3
Median Field bulk Density of VTF Tailings:	1975.60	kg/m^3
Density of water (ρ_w):	1000.00	kg/m^3
Average Specific Gravity of VTF Tailings:	2.65	
Median Specific Gravity of VTF Tailings:	2.66	

Sample ID	Depth (m)	Measured Weight (g)	Bulk Density (ρ) (kg/m^3)	Moisture (%)	Specific Gravity	Description
TP-08-08 0.7 m	0.7 m	2565	1987.37	27.7%	2.74	Bulk Density Cylinder Sample of tailings
TP-08-10 0.5 m Bulk Density	0.5	2401	1811.86	29.2%	2.37	Bulk Density Cylinder Sample of tailings
TP-08-15 0.9 m Bulk Density	0.9	2543	1963.83	25.8%	2.61	Bulk Density Cylinder Sample of tailings
TP-08-18 1.3 m Bulk Density	1.3	2538	1958.48	26.3%	2.62	Bulk Density Cylinder Sample of tailings
TP-08-20 0.45 m Bulk Density	0.45	2660	2089.04	21.0%	2.71	Bulk Density Cylinder Sample of tailings [above water level]
TP-08-20 1.0 m Bulk Density	1.0	2572	1994.86	29.8%	2.84	Bulk Density Cylinder Sample of tailings [below water level]

Attachment 3
Pore Water and Attenuation Results

CANTEST Ltd. 4606 Canada Way, Burnaby, BC Canada V5G 1K5 Tel: 604 734 7276 Fax: 604 731 2386 www.cantest.com

SRK Consulting, Keno Hill, 5-Aug-08

Table 1: Results of Pore Water Analysis on 2 (of 11) Keno Hill Samples - August 2008

S. No:				1	2
				Sample ID	
Parameter	**Units**	**Method**	**Detection Limit**	**TP-08-08 1.0 m**	**TP-08-15 2.3 m Pore Water**
Pore Volume Collected	ml	Graduated Cylinder	0.02	300.5	80.5
pH	pH Units	pH Meter	0.5	7.8	7.2
Conductivity	µS/cm	Conductivity Meter	0.5	1642	5120
Alkalinity (to pH 4.5)	mg CaCO3/l	Titration	1	256	38
Sulphate (SO_4^{2-})	mg/l	Auto Turbidity	1	604	4370
Dissolved Chloride Cl	mg/l	IC	0.2	7.87	7.07
Dissolved Metals (Cantest)					
Dissolved Aluminum Al	mg/l	ICP-ES	0.05	< 0.5	< 0.5
Dissolved Antimony Sb	mg/l	ICP-ES	0.05	< 0.5	< 0.5
Dissolved Arsenic As	mg/l	ICP-ES	0.03	< 0.3	< 0.3
Dissolved Barium Ba	mg/l	ICP-ES	0.001	0.19	0.04
Dissolved Beryllium Be	mg/l	ICP-ES	0.003	< 0.03	< 0.03
Dissolved Boron B	mg/l	ICP-ES	0.05	< 0.1	< 0.1
Dissolved Cadmium Cd	mg/l	ICP-ES	0.01	0.1	12.2
Dissolved Calcium Ca	mg/l	ICP-ES	0.01	210	284
Dissolved Chromium Cr	mg/l	ICP-ES	0.01	< 0.1	< 0.1
Dissolved Cobalt Co	mg/l	ICP-ES	0.02	< 0.2	0.3
Dissolved Copper Cu	mg/l	ICP-ES	0.02	< 0.2	< 0.2
Dissolved Iron Fe	mg/l	ICP-ES	0.05	< 0.1	< 0.1
Dissolved Lead Pb	mg/l	ICP-ES	0.03	0.8	2.1
Dissolved Magnesium Mg	mg/l	ICP-ES	0.02	63.4	344
Dissolved Manganese Mn	mg/l	ICP-ES	0.02	3.57	871
Dissolved Molybdenum Mo	mg/l	ICP-ES	0.02	< 0.2	< 0.2
Dissolved Nickel Ni	mg/l	ICP-ES	0.02	< 0.2	0.7
Dissolved Phosphorus P	mg/l	ICP-ES	0.15	< 1.5	< 1.5
Dissolved Potassium K	mg/l	ICP-ES	0.25	< 2.5	< 2.5
Dissolved Silicon Si	mg/l	ICP-ES	0.001	6.9	7.9
Dissolved Silver Ag	mg/l	ICP-ES	0.01	< 0.1	< 0.1
Dissolved Sodium Na	mg/l	ICP-ES	0.005	13	6
Dissolved Strontium Sr	mg/l	ICP-ES	0.01	0.65	0.23
Dissolved Sulphur S	mg/l	ICP-ES	0.005	209	1480
Dissolved Tin Sn	mg/l	ICP-ES	0.03	< 0.3	< 0.3
Dissolved Titanium Ti	mg/l	ICP-ES	0.005	< 0.05	< 0.05
Dissolved Vanadium V	mg/l	ICP-ES	0.01	< 0.1	< 0.1
Dissolved Zinc Zn	mg/l	ICP-ES	0.01	3.47	431
Dissolved Zirconium Zr	mg/l	ICP-ES	0.02	< 0.2	< 0.2

Notes:

Extraction Method Used: Centrifuged the tailing + pete samples at 5000 rpm for 15 min.
We were however only able to extract pore water from 2 of the 11 samples requested.

511 3439

CANTEST Ltd. 4606 Canada Way, Burnaby, BC Canada V5G 1K5 Tel: 604 734 7276 Fax: 604 731 2386 www.cantest.com

SRK Consulting, Keno Hill, 5-Aug-08
Page 2 of 4

Table 2: Trace Metals Using Aqua Regia Digestion with ICP-ES Finish for 5 (of 11) Keno Hill Samples - August 2008
(on 5 Peat Samples)

S. No:	Sample ID	Mo ppm	Cu ppm	Pb ppm	Zn ppm	Ag ppm	Ni ppm	Co ppm	Mn ppm	Fe %	As ppm	U ppm	Au ppm	Th ppm	Sr ppm	Cd ppm	Sb ppm	Bi ppm	V ppm	Ca %	P %	La ppm	Cr ppm	Mg %	Ba ppm	Ti %	B ppm	Al %	Na %	K %	W ppm
1	TP-08-08 2.0 m	2.0	76.0	69.0	252	4.7	53.0	15.0	1739	2.11	55.0	11.0	<2	<2	56	1.8	7.0	<3	29	2.15	0.077	6	28	0.41	114	0.01	<20	0.88	0.01	0.05	<2
2	TP-08-10 2.15 m Attenuation	3.0	19.0	299.0	155	4.2	10.0	2.0	2191	0.55	42.0	10.0	<2	<2	89	3.0	9.0	<3	3	2.61	0.015	<1	34	0.30	105	<0.01	<20	0.10	0.03	0.02	<2
3	TP-08-15 3.0 m Attenuation	3.0	48.0	352.0	288	11.8	33.0	15.0	1788	1.93	56.0	12.0	<2	<2	72	4.5	13.0	<3	28	2.39	0.062	6	30	0.50	93	0.01	<20	0.81	0.01	0.05	<2
4	TP-08-18 2.8 m Attenuation	4.0	74.0	234.0	197	8.4	25.0	12.0	2579	1.66	28.0	<8	<2	4.0	20	<1.4	10.0	<3	31	0.47	0.070	11	67	0.36	216	0.02	<20	0.91	0.01	0.05	<2
5	TP-08-20 2.25 m Attenuation	4.0	51.0	80.0	253	8.1	45.0	20.0	2799	2.96	42.0	<8	<2	4.0	30	2.1	6.0	<3	37	0.91	0.078	11	70	0.45	196	0.02	<20	1.15	0.01	0.06	<2
QA/QC																															
5	TP-08-20 2.25 m Attenuation	4	49	75	253	7.9	44	19	2793	3.00	41	<8	<2	3	30	1.8	5	<3	36	0.88	0.075	10	67	0.45	238	0.02	<20	1.11	0.01	0.06	<2
STANDARD DS7		18	107	65	401	0.9	54	9	662	2.49	45	<8	<2	4	63	5.2	<3	<3	98	0.91	0.072	11	161	1.09	409	0.12	39	1.04	0.08	0.49	4
STANDARD DS7		18	104	64	399	0.9	54	9	641	2.47	47	10	<2	3	63	5.3	5	3	95	0.87	0.072	11	160	1.06	408	0.12	40	1.01	0.08	0.48	3
True Value STD DS7		20.9	109.0	70.6	411.0	0.9	56.0	9.7	627.0	2.4	48.2	4.9	0.1	4.4	68.7	6.4	5.9	4.5	86.0	0.9	0.1	12.7	163.0	1.1	370.3	0.1	38.6	1.0	0.1	0.44	3.8
Percent Difference		-14.0	-4.6	-9.3	-2.9	1.1	-3.6	-7.2	2.2	3.3	-2.5	104.1	######	-31.8	-8.3	-16.9	-14.7	-33.5	10.5	-6.5	-10.0	-13.4	-1.8	1.0	10.2	-3.2	3.6	5.3	9.6	9.1	-21.1
Detection Limits		1	1	3	1	0.3	1	1	2	0.01	2	8	2	2	1	0.5	3	3	1	0.01	0.001	1	1	0.01	1	0.01	20	0.01	0.01	0.01	2
Method		1D	1D	1D	1D	1D	1D	1D	1D	1D	1D	1D	1D	1D	1D	1D	1D	1D	1D	1D	1D	1D	1D	1D	1D	1D	1D	1D	1D	1D	1D

Note:
Analysis done at Acme Labs

Attachment 4
Lime Demand Results

Client : SRK Consulting
Project : Keno Hill Tailings Neutralization
CEMI Project : 08124
Test : Moisture content
Test Date : December 15, 2008

DRAFT COPY

Sample	Wt (g)		%
	Wet	Dry	Moisture
TP-08-08 0.1 - 1.0 m	150.0	116.9	22%
TP-08-10 0.25 - 0.7 m	150.0	128.7	14%
TP-08-15 0.9 - 1.5 m	150.0	116.8	22%
TP-08-18 0.0 - 1.8 m	150.0	116.3	22%
TP-08-20 0.1 - 1.0 m	150.0	121.6	19%
TP-08-20 1.0 - 1.45 m	150.0	107.1	29%

Client : SRK Consulting
Project : Keno Hill Tailings Neutralization
CEMI Project : 08124
Test : Tailings Neutralization
Test Date : December 16, 2008

DRAFT COPY

Sample Size : 1.0 kg
[Lime] : 50 g/L
Hydrated Lime ($Ca(OH)_2$)was used for Netralization Tests

Sample	20 Minutes			4 Hours			24 Hours		
	pH		Lime Addition	pH		Lime Addition	pH		Lime Addition
	Before Lime	After Lime	(mLs)	Before Lime	After Lime	(mLs)	Before Lime	After Lime	(mLs)
TP-08-08 0.1 - 1.0 m	7.13	9.57	18	8.04	9.60	7	7.33	9.76	10
TP-08-10 0.25 - 0.7 m	7.42	9.55	14	7.40	9.72	10	7.56	9.69	15
TP-08-15 0.9 - 1.5 m	5.72	9.75	35	7.71	9.58	8	6.97	9.66	16
TP-08-18 0.0 - 1.8 m	5.79	9.62	40	7.26	9.65	10	7.43	9.57	25
TP-08-20 0.1 - 1.0 m	5.89	9.63	40	7.82	9.68	8	7.11	9.84	13
TP-08-20 1.0 - 1.45 m	6.18	9.89	54	7.41	9.59	8	7.37	9.71	22

Sample	48 Hours			72 Hours			96 Hours			162 Hours		
	pH		Lime Addition	pH		Lime Addition	pH		Lime Addition	pH		Lime Addition
	Before Lime	After Lime	(mLs)	Before Lime	After Lime	(mLs)	Before Lime	After Lime	(mLs)	Before Lime	After Lime	(mLs)
TP-08-08 0.1 - 1.0 m	7.45	9.81	10	7.23	9.59	12	7.48	9.57	12	7.94	-	-
TP-08-10 0.25 - 0.7 m	7.64	9.78	11	7.45	9.54	14	7.56	9.56	13	7.89	-	-
TP-08-15 0.9 - 1.5 m	7.21	9.75	12	7.11	9.57	13	7.39	9.83	14	8.01	-	-
TP-08-18 0.0 - 1.8 m	7.62	9.61	20	7.44	9.56	21	7.66	9.70	20	8.02	-	-
TP-08-20 0.1 - 1.0 m	7.25	9.72	10	7.12	9.52	13	7.42	9.72	14	7.76	-	-
TP-08-20 1.0 - 1.45 m	7.45	9.61	17	7.51	9.71	18	7.49	9.64	19	8.08	-	-

Lime Summary

Sample	Lime added (mls)	[Lime] (g/L)	Lime Added (g)	Lime Usage (kg/ton)[1]
TP-08-08 0.1 - 1.0 m	69	50	3.5	3.5
TP-08-10 0.25 - 0.7 m	77	50	3.9	3.9
TP-08-15 0.9 - 1.5 m	98	50	4.9	4.9
TP-08-18 0.0 - 1.8 m	136	50	6.8	6.8
TP-08-20 0.1 - 1.0 m	98	50	4.9	4.9
TP-08-20 1.0 - 1.45 m	138	50	6.9	6.9

[1] The Lime Usage was calculated for dry talings weight of 1 kg

Client : SRK Consulting
Project : Keno Hill Tailings Neutralization
CEMI Project : 08124
Test : ICP Analyses
Test Date : December 22, 2008

DRAFT COPY

Sample	Al mg/L	Sb mg/L	As mg/L	Ba mg/L	Be mg/L	Bi mg/L	B mg/L	Cd mg/L	Ca mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Mg mg/L	Mn mg/L	Mo mg/L	Ni mg/L
TP-08-08 0.1 - 1.0 m	0.195	0.0507	0.0076	0.029	<0.0001	<0.001	<0.05	0.00029	226	<0.001	0.0016	0.0099	0.017	0.0301	9.77	0.11	0.033	0.003
TP-08-10 0.25 - 0.7 m	0.116	0.0697	0.0056	0.027	<0.0001	<0.001	<0.05	0.00026	138	<0.001	0.0033	0.0064	0.011	0.028	7.73	0.07	0.014	0.001
TP-08-15 0.9 - 1.5 m	0.12	0.0129	0.0047	0.038	<0.0001	<0.001	<0.05	0.00043	794	<0.001	0.0063	0.0135	0.015	0.0411	24.8	0.023	0.015	0.005
TP-08-18 0.0 - 1.8 m	0.156	0.0337	0.0109	0.024	<0.0001	<0.001	<0.05	0.00044	458	<0.001	0.0078	0.0099	0.025	0.0366	30.3	0.024	0.012	<0.001
TP-08-20 0.1 - 1.0 m	0.113	0.0084	0.0061	0.043	<0.0001	<0.001	<0.05	0.00134	590	<0.001	0.0195	0.0083	0.011	0.0401	63.8	0.017	0.011	0.004
TP-08-20 1.0 - 1.45 m	0.061	0.0079	0.005	0.022	<0.0001	<0.001	0.062	0.00309	773	<0.001	0.0071	0.0124	0.011	0.0392	60.3	0.016	0.007	0.005

Sample	P mg/L	K mg/L	Se mg/L	Si mg/L	Ag mg/L	Na mg/L	Sr mg/L	S mg/L	Tl mg/L	Sn mg/L	Ti mg/L	U mg/L	V mg/L	Zn mg/L	Zr mg/L
TP-08-08 0.1 - 1.0 m	0.015	3.35	0.0028	0.205	0.00003	2.02	0.679	206	0.00022	<0.005	<0.005	0.0002	<0.005	0.011	<0.0005
TP-08-10 0.25 - 0.7 m	0.012	1.66	0.0026	0.168	0.00006	2.9	0.42	136	0.0002	<0.005	<0.005	0.0002	<0.005	0.007	<0.0005
TP-08-15 0.9 - 1.5 m	<0.01	4.56	0.0016	<0.1	0.00007	1.47	1.7	736	0.00068	<0.005	0.007	0.0002	<0.005	0.006	<0.0005
TP-08-18 0.0 - 1.8 m	0.012	4.23	0.0015	0.168	0.0002	1.77	0.965	456	0.00044	<0.005	<0.005	0.0003	<0.005	0.005	<0.0005
TP-08-20 0.1 - 1.0 m	<0.01	5.34	0.0011	0.126	0.00025	3.38	1.71	638	0.00111	<0.005	0.006	0.0003	<0.005	0.007	<0.0005
TP-08-20 1.0 - 1.45 m	<0.01	3.8	0.0022	0.134	0.00021	4.68	1.39	831	0.0024	<0.005	0.005	0.0005	<0.005	0.007	<0.0005

Appendix B
Conceptual Design of Open Channels

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Technical Memorandum

To:	File	**Date:**	April 2, 2009
cc:		**From:**	Lowell Wade
Subject:	UKHM Valley Tailings Facility Open Channel Conceptual Design	**Project #:**	1CE012.002.400

1 Introduction

Any closure option selected for the Valley Tailings Facility (VTF) will require establishing stable channels. Either through the VTF, upgrading diversions, or developing new diversions. This technical memorandum summarizes the conceptual design of establishing:

- A stable channel for the North Fork Flat Creek through the VTF;
- A stable channel for Brefalt and Flat Creeks to follow the pre-mining alignment through the VTF;
- Upgrading the Porcupine Creek Diversion;
- Developing the Lower North Fork Flat Creek along the north side of the VTF.

2 Previous Work

Access Mining Consultants Limited developed a closure plan for current conditions in 1996 (AMCL, 1996). Appendix B of this report details the Proposed Flood Protection for Elsa Tailings Impoundment (Attachment 1). Appendix B proposes water management within the VTF will involve:

- Upgrade and extending the Porcupine Diversion Ditch;
- Surface spillway over Dam #1; and
- Surface spillway over Dam #3.

2.1 Porcupine Diversion

The upgraded Porcupine Diversion was designed to pass a 200-year peak instantaneous flood with an adequate depth of freeboard. The objective was to provide conservative estimates so that any structure designed to the 200-year standard would possess and inherent factor of safety. This objective was met by selecting the higher of the two estimates provided by the Rational Method and the Regional Analysis.

The upgraded Porcupine Diversion would have a trapezoidal cross section with side slopes of 2H:1V. The bottom width of the channel would vary from 2.0 m to 3.5 m. The grade of the diversion ditch varies from 6% at the start decreasing to 1% for the remainder. The diversion would be lined with riprap ranging in size from D_{50} = 350 mm at the upstream to D_{50} = 100 mm for the remainder of the diversion. The thickness of the riprap layer would be 0.5 m at the upstream end of the diversion and 0.4 m along the majority of the diversion. Water depth would range from 0.67 m above Brefalt Creek to 1.6 m downstream of Dam #3.

Water velocities would range from 3.5 m/s above Brefalt Creek to 2.7 m/s downstream of Dam #3

2.2 Abandonment Spillways for Dams #1 and #3

The Probable Maximum Flood (PMF) was considered as the design flood for the surface spillway over Dam #1 and #3. This would be a flood that may be expected from the most severe combination of meteorological and hydrologic conditions considered to be reasonably possible in the geographical region encompassing the basin under study. A high level of conservatism is introduced into any design when the PMF is adopted as a design flood. In the Yukon, floods at or near this magnitude are rare. The frequency of PMF appears to rival the time scales of such events such as ice ages and the general denudation of the land surface by erosion.

To accommodate the PMF, two separate structures would be used in combination to convey the flow equal to the PMF through the VTF. These would be:

- A conventional chute-type spillway capable of a 200-year flood event through one of the abutments of the dams; and
- The entire crest length of the dams would be used as an overflow spillway to convey the remaining 60% of the flow.

The chute spillway would have a trapezoidal cross section with side slopes of 2H:1V. The bottom width of the channel would be 10 m wide at Dam #1 increase to 12 m wide at Dam #3. Riprap, with a D_{50} = 220 mm at Dam #1 and D_{50} = 300 mm at Dam #3, would cover the entire perimeter of the cross section with a thickness of 0.4 m. Water depths would be between 0.7 to 0.9 m within the chute spillway while water velocities would range from 2.6 to 3.0 m/s

The overflow spillway would be the entire crest length of the dams. Riprap, of D_{50} = 100 mm, would be required on the upstream face, crest and downstream face of the tailings dams with a thickness of 0.4 m. Water depths would be between 0.13 to 0.16 m with velocities between 1.1 and 1.2 m/s.

3 Discussion

Selection of the 200-year event is a conservative estimate which provides an inherent factor of safety in the conceptual designs of:

- Stabilizing North Fork Flat Creek through the VTF;
- Creating a stable channel for Brefalt and Flat Creeks to follow the pre-mining alignment through the VTF;
- Upgrading the Porcupine Creek Diversion; and
- Developing the Lower North Fork Flat Creek along the north side of the VTF.

To confirm the suggestions made for the surface water management structures below estimates were made using the following parameters:

- A peak instantaneous flow rate of 28 m^3/s. This corresponds to the maximum value of flow at 200-year return period flood listed in Table B-5 in Appendix B of AMCL, 1996;
- A drainage area of 20 km^2 (200 ha). This is greater that the largest drainage area listed in Tables B-1 and B-2 of Appendix B of AMCL, 1996;

- An average grade of 2% which is the weighted average of the grades between the a grade of 6% for segment 1 and 1% for segments 2 through 4 of the upgraded Porcupine Diversion as mentioned in Section 3.1 and Table B-6 of Appendix B of AMCL, 1996;
- A Manning's n of 0.04 $s/m^{1/3}$ which is the maximum value used in Table B-6 of Appendix B of AMCL, 1996;
- A runoff coefficient C of 0.9. For rural catchments it is standard practice to assume a low runoff coefficient for frequent floods and a high coefficient for rare events. A value of 0.9 was adopted to represent the "wetness" of the catchment area for the 200-year flood as mentioned is Section 2.2.1 of Appendix B of AMCL, 1996; and
- The thickness of the till layer is 1.0 m which is double the minimum thickness proposed in either tables B-6 and B-7 of Appendix B of AMCL, 1996.

The results of the open channel flow estimates are provided in Attachment 2. Results indicate the conservative approaches suggested below are in keeping with the intent proposed by AMCL, 1996. The conceptual cross section of the channels is shown in Figure 1.

3.1 Construction of Creeks through the VTF

To stabilize North Fork flat Creek and to create a stable channel for Brefalt and Flat Creeks to follow pre-mining alignment, it is suggested 5 m wide channel with 5H:1V side slopes be constructed. The channel alignment is shown in Figures 3 and 4 of the main report. A riprap layer 1 m thick would line the channel with willows planted to prevent erosion. Seasonal water channels would be allowed to migrate across the 5 m wide channel bed.

3.2 Porcupine Diversion

The selected channel bottom width of 2.0 to 3.0 m described in section 2.1 will pass a 200-year event. It is suggested that the channel bottom width be increased to 5 m to allow for ease of construction. The side slopes would be decreased from 2H:1V to 3H:1V to prevent erosion of a 1 m thick riprap layer placed over an HDPE liner. The alignment is shown in Figure 2 of the main report. Erosion of the riprap material would also be prevented by planting willow trees. Seasonal water channels would be allowed to migrate across the 5 m wide channel bed.

The increase in channel bottom width would reduce the depth velocity of water flow during a 200-year event.

3.3 Lower North Fork Flat Creek

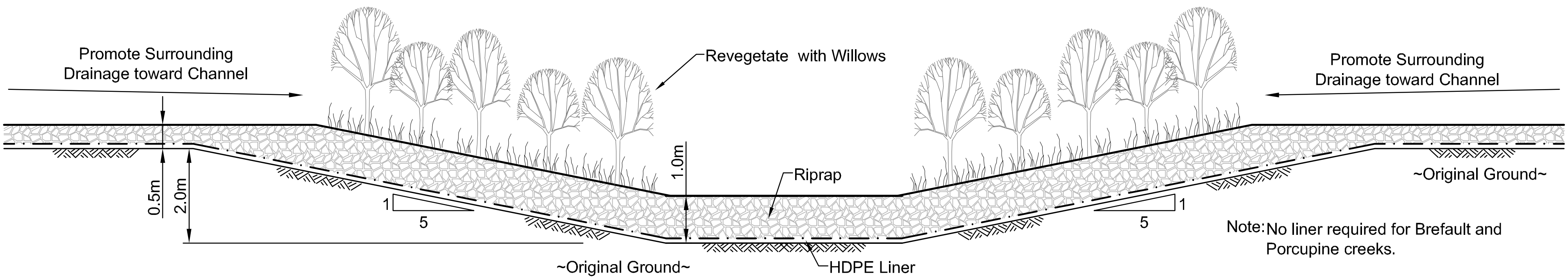
Construction of the Lower North Fork Flat Creek is consistent with the proposed chute spillways described in Section 2.2. It is proposed to maintain the same channel bottom with of 10 m but decrease the side slopes form 2H:1V to 3H:1V for constructability. The proposed alignment is shown in Figures 3 and 4. It is proposed to place a 1 m thick riprap cover over an HDPE liner which will be planted with willows to prevent erosion

4 Reference

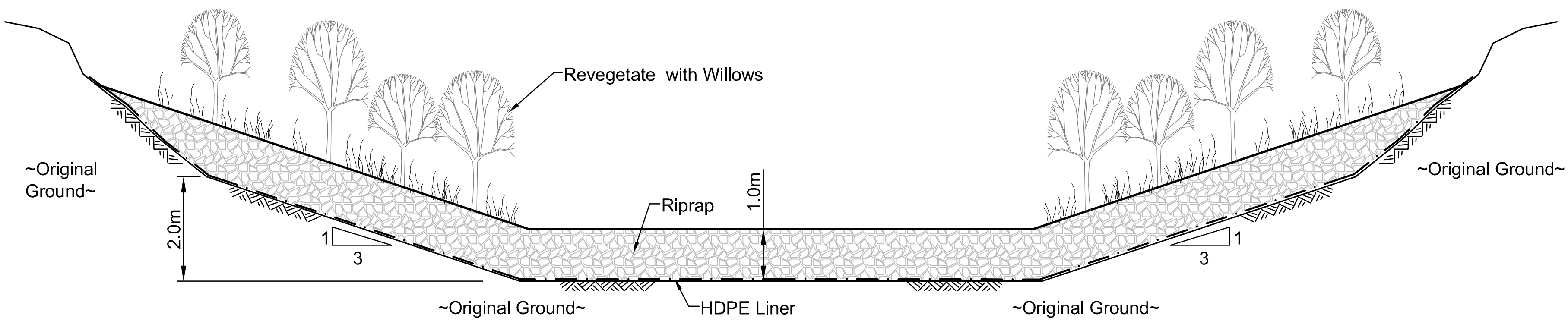
AMCL, 1996. Closure Plan for Current Conditions. United Keno Hill Mines Limited. Report Number UKH/96/02.

Figure

J:\01_SITES\UKHM\ACAD\1CE012.002.302_Sections.dwg



A **Stable Channel Profile for Brefault, Porcupine, North Fork Flat Creeks Through VTF**



B **Stable Channel Profile for Porcupine Diversion and Lower North Fork Flat Creek**

NOT FOR CONSTRUCTION

0 1 2 3 4 5
Scale in Metres

SRK Consulting
Engineers and Scientists
Vancouver B.C.

ERDC

Open Channel Conceptual Design

Conceptual Channel Sections

SRK JOB NO.: 1CE12.002.302
FILE NAME: 1CE012.002.302_Sections.dwg

Keno Hill Project
2009 Valley Tailings Facility Closure Options

DATE:	APPROVED:	FIGURE:
April 2009	LW	1

Attachment 1

Proposed Flood Protection for Elsa Tailings Impoundment

Appendix B

Proposed Flood Protection for Elsa Tailings Impoundment

Proposed Flood Protection for the Elsa Tailings Impoundment

1. INTRODUCTION

As described in Section 7.4 of the main report, a water management system will be implemented to protect the Elsa Tailings Impoundment during times of flooding. The proposed system will safeguard the integrity of the tailings dams and also minimize erosion of the deposited tailings.

The proposed water management system will comprise three main structures, namely:

- an upgraded and extended version of the existing Porcupine Diversion Ditch;
- a new surface spillway for the most upstream tailings embankment (Dam No. 1); and,
- a new surface spillway for the most downstream embankment (Dam No. 3).

Figure 7-4 of the main report provides a plan view of the Elsa Tailings Impoundment showing the proposed alignments for these structures.

Preliminary designs were prepared for the diversion ditch and the two spillways in order to investigate the viability of the proposed water management system, and to provide a basis for estimating the costs of the three structures. This appendix presents the steps undertaken to prepare these preliminary designs. Section 2.0 describes how the design floods for the three structures were estimated while Section 3.0 examines the hydraulics of the Porcupine Diversion Ditch and the proposed surface spillways.

2. DESIGN FLOODS

The estimation of a design flood for a given structure involves two broad steps. Firstly, a definition is prepared for the design flood which specifies the meteorologic and hydrologic conditions which would combine to cause the flood event. Secondly, a study is undertaken to establish the magnitude, or peak discharge, of the design flood. These two steps are discussed below under separate headings.

2.1 Definition of Design Floods

This is, in many ways, the most difficult step in establishing the design flood for a given structure. It is a somewhat subjective exercise and essentially boils down to addressing the question: How extreme should the design flood be? The answer to this question is made after considering various aspects of the structure, such as its cost, its design philosophy, and, most importantly, the consequences of its failure.

Table B-1 summarizes the preliminary definitions adopted for the design floods of the Porcupine Diversion and the two proposed abandonment spillways. These definitions comprise two parts. The first part sets out the "frequency of occurrence" of the design flood, or the average time period between events (e.g., the so-called 200-year flood is an event which is equalled or exceeded, on average, about every 200 years). The second part specifies the total catchment area which would generate the design flood. This catchment area does not necessarily hold a fixed value, as it could increase during a flood event if an upstream structure, such as a diversion channel, fails. Figure B-1 is a topographic map showing the boundaries of the catchments for the upgraded Porcupine Diversion and the two abandonment spillways.

In examining Table B-1, the following items should be noted:

- The catchment area commanded by the proposed Porcupine Diversion increases significantly as one moves downstream from the diversion's entrance to its outlet. Accordingly, the discharge during a given flood event must also significantly increase in the downstream direction. In recognition of this, the diversion was subdivided into four segments for the purpose of estimating the design flows. The upstream and downstream limits of each segment were defined according to the locations of inflowing streams.

- One of the design flows referred to in Table B-1 is known as the probable maximum flood (PMF). The PMF is defined as "the flood that may be expected from the most severe combination of meteorologic and hydrologic conditions that are considered to be *reasonably possible* in the geographical region encompassing the basin under study" (USACE, 1980). The frequency of occurrence of the PMF is difficult to assess because of a lack of historical streamflow record. Based on extrapolation from traditional estimates of storm-induced floods which have more frequent occurrence, the PMF for the study area has a return period which is likely in excess of several thousand years (or perhaps even tens of thousands of years).

To understand the reasoning behind the selection of the various design floods, it is instructive to review the philosophy of the proposed water management system. Perhaps the most logical way to outline this philosophy is to first discuss the Porcupine Diversion and then the two proposed spillways. The Porcupine Diversion would serve to divert the flows of Porcupine

Gulch, Brefalt Creek, and Flat Creek around the tailings facility. This would minimize the flow of water through the tailings facility, thus reducing the potential for erosion of the deposited tailings. The Porcupine Diversion would be designed to convey the 200-year peak instantaneous discharge with an adequate freeboard allowance. On rare occasions (i.e., less frequently than about once every 200 years), the capacity of the diversion ditch may be exceeded, thus allowing excess flood waters to enter the tailings impoundment. This could lead to some scour of the deposited tailings but, for reasons outlined later, should not compromise the integrity of the two tailings dams.

As an alternative to the 200-year design flood, one could perhaps size the Porcupine Diversion to handle the PMF. However, the resulting structure would be enormous and also very costly. The incremental benefit of providing this larger structure would not justify the corresponding additional cost. In any event, a diversion designed for the PMF would not be without an associated risk of failure. Debris torrents or landslides could potentially block or breach the diversion, thus allowing flood waters to overflow into the impoundment area anyways.

The role of the two abandonment spillways will be to prevent erosion and subsequent breaching of Dams Nos. 1 and 3. A breach of either dam has the potential to allow significant quantities of tailings to be transported out of the impoundment area and into the receiving environment. The consequences of a failure of either dam is undoubtedly more serious than a failure of the Porcupine Diversion. Accordingly, these spillways should be designed for a more extreme event than selected for the Porcupine Diversion. For the purpose of this report, the PMF was adopted as the design standard for the spillways.

As an added factor of safety, the design floods for the two spillways were computed on the basis of a worst case scenario in which the Porcupine Diversion was assumed to develop a breach. For the spillway of Dam No. 1, the worst case would be realized if a breach were to develop near the entrance to the diversion. This could potentially allow the full discharge of the Porcupine Gulch to enter the impoundment of Dam No. 1. For the other spillway, a worst case scenario would result from a breach located just below the confluence of Flat Creek, which could potentially allow the combined flows of Porcupine Gulch, Brefalt Creek and Flat Creek to enter the impoundment of Dam No. 3.

Before finalizing the design flood for the spillways, a detailed risk assessment should be undertaken for the Elsa Tailings Impoundment. This should examine other potential failure mechanisms for the tailings dams and also assess the consequences of the PMF actually occurring within the study area.

2.2 Estimation of Design Floods

Flood flow estimates were required at locations that command relatively small catchments (i.e., 2.5 to 14.5 km^2). As no long-term streamflow records exist at the minesite, it was necessary to resort to empirical and modelling procedures to estimate the design floods. Three separate procedures were employed, namely the Rational Method, Regional Analysis, and the Canadian envelope curve of maximum observed floods.

2.2.1 Rational Method

For small catchments in the Yukon, most of the annual floods are caused by snowmelt, as evidenced by the high frequency of annual flood peaks occurring in the months of May and June. Despite this observation, the most extreme floods on small catchments are undoubtedly generated by another mechanism, namely intense rain storms. In recognition of the importance of this second mechanism, the Rational Method was adopted to assess the design floods for the Porcupine Diversion and for the two proposed surface spillways. The Rational Method is essentially a modelling technique which simulates the magnitude of floods caused by intense rain storms.

The Rational Method entails applying the following formula:

$$Q = CIA/3.6$$

where:
- Q is the peak instantaneous discharge of the flood (m^3/s);
- C is a runoff coefficient (dimensionless);
- I is the average rainfall intensity which causes the flood (mm/h); and,
- A is the catchment area (km^2).

The runoff coefficient specifies the proportion of the rainfall that quickly runs off the catchment to form the flood hydrograph. The remainder of the rainfall is retained on the catchment for subsequent evaporation or slow release to the catchment's streams. The value of the runoff coefficient varies from storm to storm depending on the initial moisture content of the soils and the extent of frozen soils within the catchment. For rural catchments, such as those at the minesite, standard practice is to assume a low runoff coefficient for frequent floods and a high coefficient for rare events. Accordingly, values of 0.3, 0.9, and 1.0 were adopted to represent the "wetness" of the study catchments during, respectively, the mean annual flood, the 200-year flood, and the probable maximum flood. A value of C equal to 1.0 implies a very wet catchment in which practically all of the rainfall is converted to flood runoff.

In order to apply the Rational Method, it was necessary to estimate a characteristic of each study catchment known as the "time of concentration". This is a measure of the response time of the catchment. It may be interpreted as the time it takes for the most remote portion of the catchment to contribute to the flow at the outlet of the catchment. The time of concentration was estimated using empirical relationships that depend on the physical characteristics of the catchment (Leopold, 1991 and McCuen, 1982).

Information on design storm rainfalls likely to be experienced at the minesite was obtained from the "Rainfall Frequency Atlas for Canada" (Hogg and Carr, 1985). The data extracted from this publication are presented in Figure B-2 in the form of an intensity-duration-frequency relationship. One of the curves on this figure represents the characteristics of the storm which is believed to generate the PMF, i.e. the so-called probable maximum precipitation event. The rainfall intensities associated with this event were estimated using the Hershfield Method, a statistical procedure based on several hundred thousand station-years of rainfall data from many countries (Hogg and Carr, 1985).

The calculation of flood peaks using the Rational Method is set out in Table B-2. Note that the basic premise of the Rational Method is the largest flood will occur when the selected rainfall intensity has a duration exactly equal to the time of concentration. Furthermore, the computed flood peak is assumed to have the same frequency of occurrence as the causative rainfall intensity.

2.2.2 Regional Analysis

As indicated above, no long-term streamflow records are available at the UKHM minesite. However, the region encompassing the minesite is served by a reasonably dense network of streamflow gauging stations. The data collected at these regional stations were used to estimate the flood hydrology of the minesite streams by means of a technique known as Regional Analysis. Application of this approach involved four steps, as outlined below.

The first step entailed data gathering. A total of 26 regional streamflow gauging stations were selected to provide the necessary data for the Regional Analysis. Table B-3 provides details of these stations. Half of the selected stations were operated by the Water Survey of Canada (WSC) and the other half by the Department of Indian Affairs and Northern Development (DIAND). From the streamflow record of each of the 26 stations, an annual series of flood peaks was extracted. The length of these annual series ranged from 2 to 45 years.

The second step involved a statistical analysis of the assembled data. For each station, the average of its annual series of flood peaks was calculated to provide an estimate of the mean annual flood. For stations with greater than 10 years of record, the annual series was also fitted to a theoretical frequency distribution (Gumbel Extreme Value) to provide an estimate of the 200-year return period flood. Table B-3 presents the estimated mean annual floods and 200-year floods for the regional streamflow gauging stations.

The third step involved transposing the abovementioned flood estimates to the minesite. This was done by exploiting a well-known observation that flood discharge is correlated with catchment area. The most useful way of examining this correlation was to prepare a logarithmic plot of "unit" discharge versus catchment area. Unit discharge means the flood peak is expressed as a flow rate per unit area (i.e., the absolute flood value is divided by the contributing catchment area). Figure B-3 presents the plot used to examine the relationship between unit discharge and catchment area for the region encompassing the minesite. The mean annual floods for all 26 regional stations were plotted on this figure, together with the 200-year flood estimates for those regional stations with greater than 10 years of record. Examination of this figure reveals that the data for both the mean annual and 200-year floods exhibit the expected inverse trend between unit flood discharge and catchment area (i.e., the unit flood discharge increases as catchment area decreases). Two different approaches are commonly used to quantify the correlation between flood discharge and catchment area. One is to fit a linear regression to the data and the other is to draw an upper-bound curve which envelopes all of the data. For the purpose of this study, the latter option was selected as this provided conservative estimates of flood hydrology (i.e., overestimates of the true flood magnitudes). Two upper-bound curves were drawn on Figure B-3, one to envelope all of the mean annual floods and the other to envelope all of the 200-year flood values. It is interesting to note that these upper-bound curves possess a slope of -0.25 on the logarithmic plot. This same slope is common to flood envelope curves for other parts of the Yukon and for British Columbia.

The fourth and final step entailed using the curves on Figure B-3 to provide flood estimates for ungauged points on the minesite. For any ungauged point, this was done by planimetering the catchment area controlled by the point of interest. The plot on Figure B-3 was then referenced to determine a suitable estimate of unit flood discharge for the given catchment area. The product of unit discharge and catchment area was then calculated to provide the required flood estimate.

In this study, Regional Analysis was only used to provide estimates of mean annual and 200-year floods. The streamflow records in the region were of insufficient length to accurately assess the magnitude of the PMF.

2.2.3 Canadian Envelope Curve of Maximum Observed Floods

Two independent methods were used to estimate the magnitude of the probable maximum flood (PMF) at key locations around the minesite. One was the Rational Method, as discussed above in Section 2.2.1, and the other was the Canadian envelope curve, as described in this section.

The Canadian envelope curve is, in effect, an adaptation of the previously described Regional Analysis which allows estimates of PMF to be made. The adaptation takes two forms. Firstly, streamflow gauging stations are selected from a much larger area (i.e., instead of concentrating on stations within a radius of a few hundred kilometres of the minesite, stations within the whole of Canada are utilized). Secondly, only the largest observed flood at each station is of interest, and not the complete series of annual flood peaks.

The most up-to-date and comprehensive version of the Canadian envelope curve appears to be the one contained in the publication entitled "Hydrology of Floods in Canada: A Guide to Planning and Design" (NRCC, 1989). The authors of this publication assembled a list of 22 of the highest known floods to have ever been experienced in Canada (see Table B-4). Figure B-4 shows these flood events plotted on a logarithmic graph of unit flood discharge versus catchment area. Superimposed on this graph is an envelope curve which bounds all of the flood data. The equation for this envelope curve is known as the "Creager Equation" and takes the form of a double exponential. The Creager Equation is an empirical relationship that provides a simple means of comparing floods in different regions and on different sizes of catchment. The relationship is consistent with the observed behaviour that unit flood discharge decreases as drainage area increases. The positioning of the Creager Equation on a logarithmic plot is dictated by a single constant known as the "Creager Constant". The magnitude of the Creager Constant may be used as a measure of the flood-producing characteristics of a region. The higher the constant, the more severe the flood regime is. A Creager Equation with a Creager Constant of 44 envelopes all of the known extreme floods experienced in Canada.

For the purpose of this study, the envelope curve shown on Figure B-4 was used to provide PMF estimates for the minesite. It should be noted that this curve may actually overestimate the true PMF's that are possible in the Yukon. This contention is based on the following observations concerning the 22 unusual floods assembled in Table B-4.

- Not one of the 22 unusual floods occurred in the Yukon.
- All of the floods which plot at or close to the envelope curve occurred on either the coast of British Columbia or the eastern slopes of the Rocky Mountains. These areas are likely subject to more severe storms than experienced in the Yukon. This is because no significant topographic barrier lies between these areas and their prime moisture sources (i.e., the Pacific Ocean for the coast of B.C. and the Gulf of Mexico and the Atlantic Ocean for the eastern slopes of the Rocky Mountains). In contrast, the interior of the Yukon is well protected from major moisture sources by mountain barriers.
- The magnitude of some of the 22 flood events may be overestimated, particulary those which occurred on small catchments. For example, the flood for the smallest catchment (i.e., Harvey Creek on the coast of B.C.) was computed using the slope-area method. The computations were performed assuming clear water but, in reality, the flood waters likely carried a significant sediment load (both bedload and suspended load). This neglect of the sediment load likely led to an overestimation of the true flood peak.
- Some of the more extreme floods were generated in the wettest regions of the country. For example, the flood on the fourth smallest catchment (i.e., Zeballos River) occurred on the western coast of Vancouver Island, an area which receives in excess of 3000 mm of precipitation per year. This is an order of magnitude more precipitation than experienced at the UKHM minesite.

2.2.4 Recommended Design Flood Estimates

Table B-5 summarizes the flood estimates made for the Porcupine Diversion and the two abandonment spillways using all of the techniques described above. Three widely different flood events were assessed for each of these structures, namely the mean annual flood, the 200-year flood, and the probable maximum flood.

Although a total of three estimation techniques were used in this study, they were never all applicable to any one type of flood event. For the mean annual and 200-year floods, only the Rational Method and the Regional Analysis were applicable. For the PMF, the useful techniques were the Rational Method and the Canadian envelope curve of maximum observed floods. Since more than one estimate was provided for each flood event, it was necessary to perform a selection process in which the "best" flood estimate was identified. For all structures and all types of flood events, the Rational Method was judged to provide these best estimates. The reasoning for this is outlined below.

For the mean annual flood (MAF), the objective was to provide the most accurate estimates, as opposed to the most conservative. Because of this, the estimates provided by the Regional Analysis were immediately rejected. These estimates were known to be conservative, owing to the fact that they were based on an envelope curve. In contrast, the estimates made by the Rational Method were judged to be fairly accurate estimates of the true MAF's because they were based on a realistic value of the runoff coefficient (i.e., C=0.3). It should be noted that the Regional Analysis would have provided a more precise set of MAF estimates had a linear regression been fitted to the regional flood data, rather than the envelope curve.

For the 200-year flood, the objective was to provide conservative estimates so that any structure designed to the 200-year standard would, in effect, possess an inherent factor of safety. This objective was met by selecting the higher of the two estimates provided by the Rational Method and the Regional Analysis. In all cases, the estimates made by the Rational Method were higher, being some 30 to 40% greater than those predicted by the Regional Analysis (and this despite the fact that the Regional Analysis was based on an envelope curve).

For the PMF, the focus was returned to accuracy over conservatism. The reason for this is a high level of conservatism is already introduced into any design when the PMF is adopted as the design flood. In the Yukon, floods at or near this magnitude are rare. The frequency of occurrence of the PMF appears to rival the time scales of such events as ice ages and the general denudation of the land surface by erosion.

For reasons outlined in Section 2.2.3, the Canadian flood envelope curve is believed to overestimate the magnitudes of the PMF's which can actually happen within the interior of the Yukon. Accordingly, the estimates provided by this envelope curve were rejected in favour of those predicted by the Rational Method. The flood estimates provided by the Rational Method were roughly half of those predicted by the Canadian flood envelope curve.

3. CONCEPTUAL HYDRAULIC DESIGNS

This section presents the hydraulic designs for the Porcupine Diversion and the two proposed spillways. Conceptual layouts for these structures are presented in Figure 7-4 of the main report.

3.1 Porcupine Diversion

The upgraded version of the Porcupine Diversion will comprise four segments, as dictated by the locations of incoming streams. These segments have been named relative to where these various streams enter the diversion, as follows:

- Segment 1: Above Brefalt Creek;
- Segment 2: Between Brefalt Creek and Flat Creek;
- Segment 3: Between Flat Creek and Dam No. 3 Spillway; and,
- Segment 4: Below Dam No. 3 Spillway

The segments are listed above in upstream to downstream order. The role of the first three segments will be to divert the flows of Porcupine Gulch, Brefalt Creek, and Flat Creek around the Elsa Tailings Impoundment. The last segment of the diversion will continue routing these waters, together with any spillage from the Dam No. 3 spillway, around the proposed engineered wetland in the Flat Creek valley.

As indicated in Section 2.1, the Porcupine Diversion will be designed to handle the 200-year peak instantaneous flood with an adequate depth of freeboard. The magnitude of this design event increases significantly as one moves along the diversion from its entrance to its outlet. The adopted design flow for Segment 1 is 7.8 m^3/s while for Segment 4 it is almost four times greater at 28 m^3/s.

All four segments will have a trapezoidal cross section with sideslopes of 2 horizontal to 1 vertical. The bottom width of the channel will progressively increase from 2.0 m at Segment 1 to 3.5 m at Segment 4. The lengths of the segments vary from about 400 m to 1100 m, with an overall length for the diverion of 2400 m. The slope of the diversion will vary significantly. The most upstream segment will have a steep grade of about 6% while the remainder of the diversion will have a mild slope of approximately 1%.

Water velocities during passage of the design flood event will be high. Therefore, the diversion will have to be lined with riprap. Owing to its steep slope, the first segment of the diversion will have to be lined with fairly large rock (D_{50} of 350 mm) in order to resist the fluid stress of the flowing flood waters. A smaller size of rock (D_{50} of about 100 mm) could be used for erosion protection of the remaining segments of the diversion.

Table B-6 summarizes the conceptual design of the Porcupine Diversion, giving details on hydrology, channel geometry, hydraulics, and erosion protection. Figure B-5 presents a typical cross section of the most upstream segment of the Porcupine Diversion. Detailed engineering studies will be required to provide designs suitable for construction of this diversion. In performing these detailed studies, the following items should be considered:

- Lay out the most upstream segment of the diversion as a large-radius arc so as to minimize the redistribution of the flood waters as they make the turn from the Porcupine Gulch to the diversion ditch. This should reduce the tendency for the flood waters to form a high-velocity filament which could impinge on the diversion's banks downstream of Segment 1.

- Re-align the lower reach of Flat Creek so that this stream enters the diversion at an oblique angle, and not at the right angle it currently does. This will reduce the fluid stress on the diversion's right bank, thus reducing the chances of a breach at this location.

3.2 Abandonment Spillways for Dams Nos. 1 and 3

As discussed in Section 2.1, the spillways for these two dams will be designed to accomodate some flood event that is more extreme than the one selected for the Porcupine Diversion (i.e., an event larger than the 200-year flood). The PMF has been tentatively selected for this purpose. The estimated magnitude of the PMF for each spillway is rather impressive. To date, no flood even close to this magnitude has had to be routed past Dams Nos. 1 and 3. The largest flood ever experienced at these dams was probably still an order of magnitude less than the PMF.

Owing to the sheer size of the PMF, a somewhat unorthodox approach is proposed for providing the abandonment spillways for these two dams. The approach is, in effect, to provide two separate spillways for each dam. One would be a conventional chute-type spillway located in one of the abutments. The other would be an overflow spillway in which flow would be allowed to directly pass over the crest and down the face of the tailings dam. Both types of spillway would be protected from erosive forces using a layer of riprap. For the chute spillway, the riprap would extend over the entire perimeter of the cross section. For the overflow spillway, riprap would be required on the upstream face, the crest, and the downstream face of the tailings dam. The extent of the riprap protection on the crest and the downstream face would depend on what portion of the tailings dam length was designated to serve as the overflow section.

The chute and overflow spillways would be sized to pass a combined flow equal to the PMF. An almost boundless number of alternative configurations are available for laying out these two spillways. Some of the variables involved are:

- the proportion of the PMF handled by each spillway;
- the threshold flow at which the tailings embankment would begin to overtop;
- the length of the tailings dam designated as the overflow section;
- the slope of the downstream face of the dam;
- the bottom width, crest elevation, and sideslopes of the chute spillway; and,
- the quantity and median diameter of available rock riprap.

Table B-7 provides details of one possible configuration for a set of abandonment spillways on each dam. In preparing this table, the following assumptions were made:

- the chute spillway would, on its own, handle all flood events up to the 200-year flood;
- the Porcupine Diversion would be breached during the passage of the 200-year flood and the PMF;
- practically the entire crest length of the tailings dam would be used for the overflow spillway (in order to minimize the depth of water flowing down the dam's downstream face); and,
- at the peak of the PMF, the overflow spillway would handle about 60% of the total flow.

It should be noted that Table B-7 only examines the hydraulics of the spillways at their control sections. For the chute spillway, this would be a weir near the entrance to the spillway. For the overflow spillway, this would be the crest of the tailings dam. No calculations are presented for the hydraulics of the flow on the downstream face of the tailings dam or within the conveyance section of the chute spillway. These calculations will be made during the final design stage, together with an economic analysis to decide on the most cost effective way of configuring the chute and overflow spillways for each dam.

4. REFERENCES

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Table B-1 Preliminary Definitions for Design Floods

Structure	Name of Flood Event	Frequency of Occurrence of Flood Event	Subcatchments Contributing Runoff (see Fig. C-1)	Total Catchment Area (km^2)
Porcupine Diversion, Segment Above Brefalt Creek	200-Year Peak Instantaneous Discharge	200 years	1	2.5
Porcupine Diversion, Segment Between Flat and Brefalt Creeks	200-Year Peak Instantaneous Discharge	200 years	1 + 2	4.5
Porcupine Diversion, Segment Between Dam No. 3 Spillway and Flat Creek	200-Year Peak Instantaneous Discharge	200 years	1 to 3	10.1
Procupine Diversion, Segment Below Dam No. 3 Spillway[1]	200-Year Peak Instantaneous Discharge	200 years	1 to 6	14.5
Dam No. 1 Spillway[2]	Probable Maximum Flood	10,000 years or more	1 + 4	5.5
Dam No. 3 Spillway[3]	Probable Maximum Flood	10,000 years or more	1 to 5	13.7

Notes: 1. This segment will route flood waters around the proposed constructed wetland.

2. Porcupine Diversion is assumed to breach allowing flows of Porcupine Gulch to enter the impoundment of Dam No. 1.

3. Porcupine Diversion is assumed to breach allowing the combined flows of Porcupine Gulch, Brefalt Creek and Flat Creek to enter the impoundment of Dam No. 3.

Table B-2 Flood Peak Estimates Using the Rational Method

Item	Location							
	Porcupine Diversion above Brefalt Creek	Porcupine Diversion above Flat Creek	Porcupine Diversion above Dam No. 3 Spillway	Outlet of Porcupine Diversion	Dam No. 1 Spillway (no breach of diversion)	Dam No. 1 Spillway (with breach of diversion)	Dam No. 3 Spillway (no breach of diversion)	Dam No. 3 Spillway (with breach of diversion)
Contributing subcatchments (see Figure C-1)	1	1 + 2	1 to 3	1 to 6	4	1 + 4	4 + 5	1 to 5
Drainage area (A) - km^2	2.5	4.5	10.1	14.5	3.0	5.5	3.6	13.7
Lag time (T_L) - h	1.3	1.6	2.2	2.6	1.4	1.7	1.5	2.5
Time of concentration (T_c) - h	2.1	2.7	3.7	4.3	2.3	2.9	2.5	4.2
Rational coefficient (C)								
Mean annual maximum	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
200-year maximum	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Probable maximum	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Rainfall intensity (I) - mm/h (for duration = T_c)								
Mean annual maximum	4.8	4.1	3.4	3.1	4.6	3.9	4.4	3.1
200-year maximum	12.5	10.6	8.5	7.6	11.9	10.0	11.3	7.8
Probable maximum	42	35	28	25	40	33	38	26
Flood peak (Q) - m^3/s (Q = CIA/3.6)								
Mean annual maximum	1.0	1.6	2.8	3.7	1.1	1.8	1.3	3.6
200-year maximum	7.8	12	21	28	8.9	14	10	27
Probable maximum	29	44	79	102	33	51	38	98

Notes: 1. $T_L = 0.89\, A^{0.395}$

2. $T_c = 1.67\, T_L$

Table B-3 Estimated Flood Magnitudes at Regional Streamflow Gauging Stations

Streamflow Gauging Station		Period of Record	Catchment Area (km^2)	Maximum Instantaneous Discharge (m^3/s)		Maximum Instantaneous Unit Discharge ($L/s/km^2$)	
ID No.	Name			Mean Annual Flood	200-Year Flood[2]	Mean Annual Flood	200-Year Flood[2]
WATER SURVEY OF CANADA							
10MA003	Blackstone River near Chapman Lake Airstrip	1984 - 1994	1130	95	-	84	-
10MB004	Bonnet Plume River above Gillespie Creek	1981 - 1994	3760	399	824	106	219
09DA001	Hess River above Emerald Creek	1976 - 1994	4840	606	1060	125	219
09EB003	Indian River above the mouth	1982 - 1994	2220	86.5	181	39	82
09EA003	Klondike River above Bonanza Creek	1965 - 1994	7800	419	711	54	91
09EA005	Little South Klondike River below Ross Creek	1983 - 1994	860	120	-	140	-
09BB002	MacMillan River near the mouth	1984 - 1994	13800	785	1440	57	104
09DD004	McQuesten River near the mouth	1979 - 1994	4760	278	509	58	107
09EA004	North Klondike River near the mouth	1974 - 1994	1100	110	248	100	225
09BB001	South MacMillan River at km 407 Canol Road	1974 - 1994	997	133	433	133	434
09DC003/ 09DC002	Stewart River above Fraser Falls[1]	1949 - 1994	30600	2306	5126	75	168
09DD002	Stewart River at Stewart Crossing	1961 - 1973	35000	2644	6780	76	194
09DD003	Stewart River at the mouth	1963 - 1994	51000	2668	9500	52	186
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT							
29EA001	Benson Creek at km 29.6 Dempster Highway	1975 - 1976	93.1	28	-	301	-
30MA001	Blackstone River at km 120.1 Dempster Highway	1975 - 1982	637	68.7	-	108	-
29BB001	Boulder Creek at km 387.0 North Canol Highway	1977 - 1991	84.1	19.8	32.5	235	386
30MA002	Cache Creek at km 132.5 km Dempster Highway	1977 - 1982	240	13.5	-	56	-
30HA001	Dale Creek at ford on Amax Road	1977 - 1983	14.2	3.8	-	268	-
29EA002	Grizzly Creek at km 60.4 Dempster Highway	1975 - 1982	34	7.1	-	209	-
29BB005	MacIntosh Creek at km 448.3 North Canol Highway	1981 - 1982	1.3	0.3	-	231	-
29BA003	Riddell Creek at km 354.1 North Canol Highway	1975 - 1982	53	13.8	-	260	-
29BB002	South MacMillan R. #2 at km 438.6 North Canol Hwy	1975 - 1985	183	28.1	75.3	154	411
29BB013	South MacMillan River #6 at km 462.5 North Canol Hwy	1981 - 1982	13.6	1.3	-	96	-
29DC001	Thistle Creek above Yukon River	1980 - 1993	210	18.2	53.3	87	254
29BA004	Twin Creek #1 at km 343.3 North Canol Highway	1978 - 1982	45.5	3.3	-	73	-
29EA001	Wolf Creek at km 52 Dempster Highway	1975 - 1982	68.8	15.6	-	227	-

Notes:

1. Prior to the opening of Station 09DC003, the flows of the Stewart River were measured at Station 09DC002, located some 40 km down The streamflow data of these two stations were combined to create a flood record which spans 45 years.
2. Estimates of 200-year floods were only made for those stations with greater than 10 years of record.

Table B-4 Extreme Flood Discharges in Canada

Station Name	Year of Flood	Catchment Area (km^2)	Maximum Instantaneous Discharge	
			(m^3/s)	($m^3/s/km^2$)
Harvey Creek (B.C.)	1969	7	127	18.1
Rainy River at the mouth (B.C.)	1958	69.4	428	6.17
Norrish Creek near Dewdney (B.C.)	1984	117	500	4.27
Zeballos River near Zeballos, Vancouver Island (B.C.)	1975	181	1180	6.52
Hirsch Creek near the mouth (B.C.)	1974	347	807	2.33
Humber River at Weston (Southern Ontario)	1954	800	1280	1.60
Castle River at Cowley (Southwestern Alberta)	1923	1130	1250	1.11
Bay du Nord River at Big Falls (Newfoundland)	1983	1340	1840	1.37
Exploits River below Stony Brook (Newfoundland)	1983	3480	2400	0.69
SW Miramichi River at Blackville (New Brunswick)	1973	5050	2790	0.55
Iskut River below Johnson River (B.C.)	1961	9350	7930	0.85
Wapiti River near Grande Prairie (Northwestern Alberta)	1982	11300	6300	0.56
Artic Red River at Martin House (Northwest Territories)	1970	15100	7640	0.51
Oldman River at Lethbridge (Southern Alberta)	1908	17200	5660	0.33
Nass River above Shumal Creek (B.C.)	1961	19200	9460	0.49
Muskwa River near Fort Nelson (B.C.)	1971	19700	4670	0.24
Riviere George aux Chutes Helen (Quebec)	1965	35200	8810	0.25
Fort Nelson River at Fort Nelson (B.C.)	1971	43500	6630	0.15
Smoky River at Watino (Northwestern Alberta)	1972	50200	9200	0.18
Thelon River above Beverley Lake (Northwest Territories)	1984	65300	8290	0.127
Peace River at Peace River (Northern Alberta)	1965	186000	15500	0.083
Liard River near the mouth (Northwest Territories)	1977	277000	16200	0.058

Table B-5 Estimated Peak Instantaneous Flood Discharges for Minesite Drainages

Location	Catchment Area (km^2)	Flood-Prediction Method: Rational Method (m^3/s)	Regional Analysis (m^3/s)	Canadian Flood Envelope Curve (m^3/s)	Adopted Flood Estimate (m^3/s)
MEAN ANNUAL FLOOD					
Porcupine Diversion above Brefalt Creek	2.5	1.0	2.1	-	1.0
Porcupine Diversion above Flat Creek	4.5	1.6	3.2	-	1.6
Porcupine Diversion above Dam No. 3 Spillway	10.1	2.8	5.9	-	2.8
Outlet of Porcupine Diversion	14.5	3.7	7.8	-	3.7
Dam No. 1 Spillway (no breach of diversion)	3.0	1.1	2.4	-	1.1
Dam No. 1 Spillway (with breach of diversion)[1]	5.5	1.8	3.8	-	1.8
Dam No. 3 Spillway (no breach of diversion)	3.6	1.3	2.7	-	1.3
Dam No. 3 Spillway (with breach of diversion)[2]	13.7	3.6	7.5	-	3.6
200-YEAR RETURN PERIOD FLOOD					
Porcupine Diversion above Brefalt Creek	2.5	7.8	5.6	-	7.8
Porcupine Diversion above Flat Creek	4.5	12	8.7	-	12
Porcupine Diversion above Dam No. 3 Spillway	10.1	21	16	-	21
Outlet of Porcupine Diversion	14.5	28	21	-	28
Dam No. 1 Spillway (no breach of diversion)	3.0	8.9	6.4	-	8.9
Dam No. 1 Spillway (with breach of diversion)[1]	5.5	14	10	-	14
Dam No. 3 Spillway (no breach of diversion)	3.6	10	7.3	-	10
Dam No. 3 Spillway (with breach of diversion)[2]	13.7	27	20	-	27
PROBABLE MAXIMUM FLOOD					
Porcupine Diversion above Brefalt Creek	2.5	29	-	56	29
Porcupine Diversion above Flat Creek	4.5	44	-	93	44
Porcupine Diversion above Dam No. 3 Spillway	10.1	79	-	179	79
Outlet of Porcupine Diversion	14.5	102	-	237	102
Dam No. 1 Spillway (no breach of diversion)	3.0	33	-	65	33
Dam No. 1 Spillway (with breach of diversion)[1]	5.5	51	-	110	51
Dam No. 3 Spillway (no breach of diversion)	3.6	38	-	77	38
Dam No. 3 Spillway (with breach of diversion)[2]	13.7	98	-	227	98

Notes: 1. This represents a worst case scenario in which the Porcupine Diversion develops a breach, allowing the total flow of Porcupine Gulch to enter the impoundment of Dam No. 1.

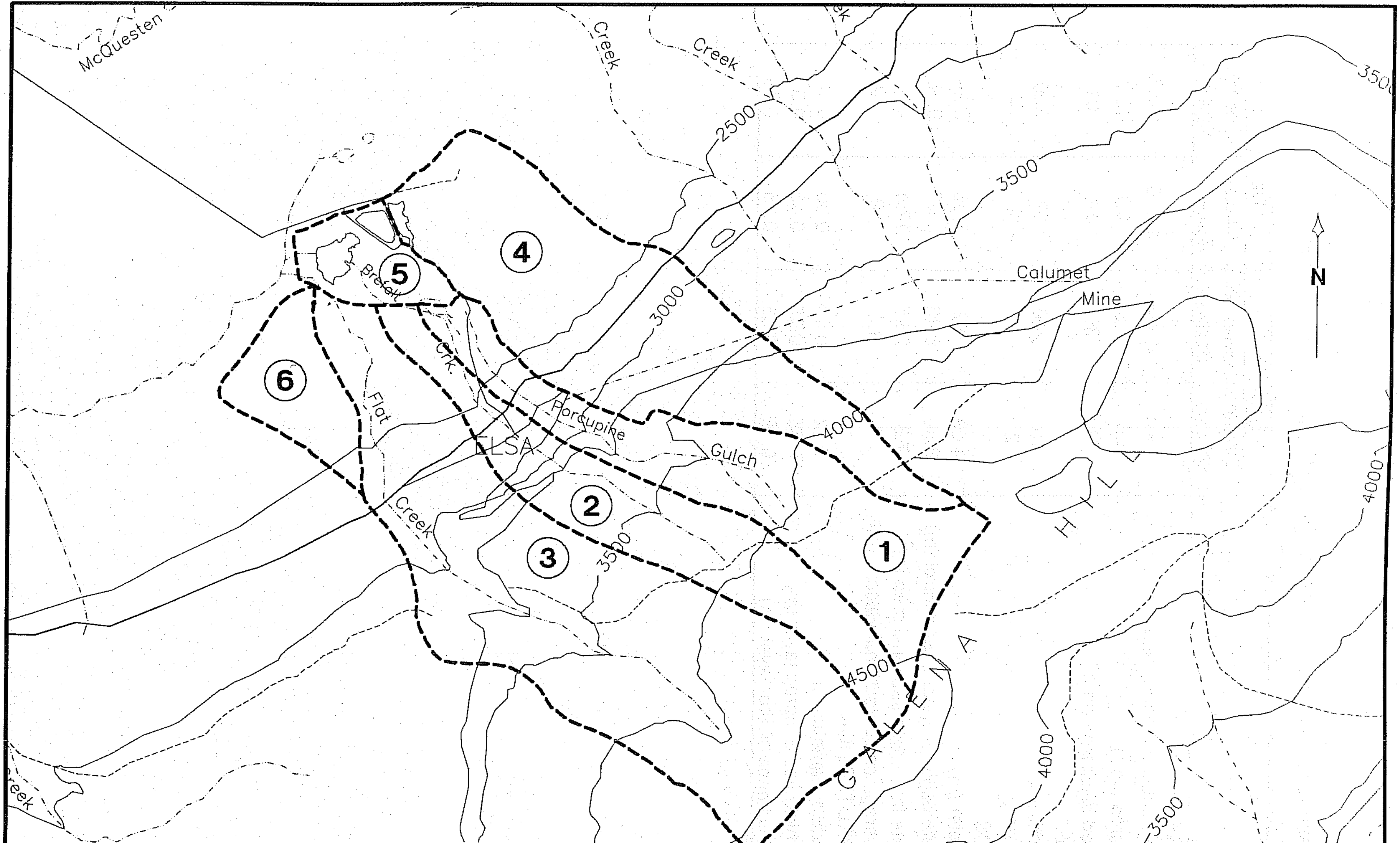
2. This also represents a worst case scenario in which the Porcupine Diversion develops a breach and the combined flows of Porcupine Gulch, Brefalt Creek, and Flat Creek enter the impoundment of Dam No. 3.

Table B-6 Details of Conceptual Design for Upgrade of Porcupine Diversion

Item	Segment of Diversion Channel			
	Above Brefalt Creek	Between Brefalt Creek and Flat Creek	Between Flat Creek and Dam No. 3 Spillway	Below Dam No. 3 Spillway
HYDROLOGY				
Contributing subcatchments (see Fig. C-1)	1	1 + 2	1 to 3	1 to 6
Drainage area (km^2)	2.5	4.5	10.1	14.5
Design flood discharge (m^3/s)	7.8	12	21	28
GEOMETRY				
Approximate channel length (m)	500	400	400	1100
Channel longitudinal slope (m/m)	0.06	0.01	0.008	0.008
Channel bottom width (m)	2	2.5	3	3.5
Channel sideslope (H:V)	2	2	2	2
HYDRAULICS				
Depth of water (m)	0.67	1.09	1.43	1.59
Flow cross-sectional area (m^2)	2.2	5.1	8.4	10.6
Wetted perimeter (m)	5.0	7.4	9.4	10.6
Hydraulic radius (m)	0.45	0.69	0.89	1.00
Manning's n ($s/m^{1/3}$)	0.041	0.033	0.033	0.034
Average cross-sectional velocity (m/s)	3.5	2.4	2.5	2.7
EROSION PROTECTION				
Riprap median diameter (m)	0.35	0.09	0.10	0.11
Minimum thickness of riprap layer (m)	0.52	0.35	0.35	0.35
Minimum thickness of filter layer (m)	0.35	0.35	0.35	0.35

Table B-7 Details of Conceptual Designs for Spillway Control Sections

Item	Dam No. 1		Dam No. 3	
	Chute Spillway	Overflow Spillway	Chute Spillway	Overflow Spillway
HYDROLOGY				
Contributing subcatchments (see Fig. C-1)	1 + 4	1 + 4	1 to 5	1 to 5
Drainage area (km^2)	5.5	5.5	13.7	13.7
Design flood discharge (m^3/s)	21	30	37	61
GEOMETRY				
Bottom width (m)	10	200	12	300
Sideslope (H:V)	2	2	2	2
HYDRAULICS				
Head of water (m)	1.03	0.2	1.35	0.24
Approximate depth of water over control (m)	0.69	0.13	0.90	0.16
Approximate flow cross-sectional area (m^2)	7.8	26.7	12.4	48.1
Approx. average cross-sectional velocity (m/s)	2.6	1.1	3.0	1.2
EROSION PROTECTION				
Riprap median diameter (m)	0.22	0.10	0.30	0.10
Minimum thickness of riprap layer (m)	0.35	0.35	0.45	0.35
Minimum thickness of filter layer (m)	0.35	0.35	0.35	0.35



LEGEND

CREEK, STREAM, RIVER
TERRITORIAL HIGHWAY
SUBCATCHMENT BOUNDARY
① SUBCATCHMENT ID NO.

0 250 500 750 1000
METRES

UNITED KENO HILL MINES LIMITED

Catchment Areas of the Elsa Tailings Impoundment and the Porcupine Diversion

ACCESS MINING CONSULTANTS LTD.

SCALE: 1 : 25 000	FILE: 224-10.DWG	DATE: 06/06/96

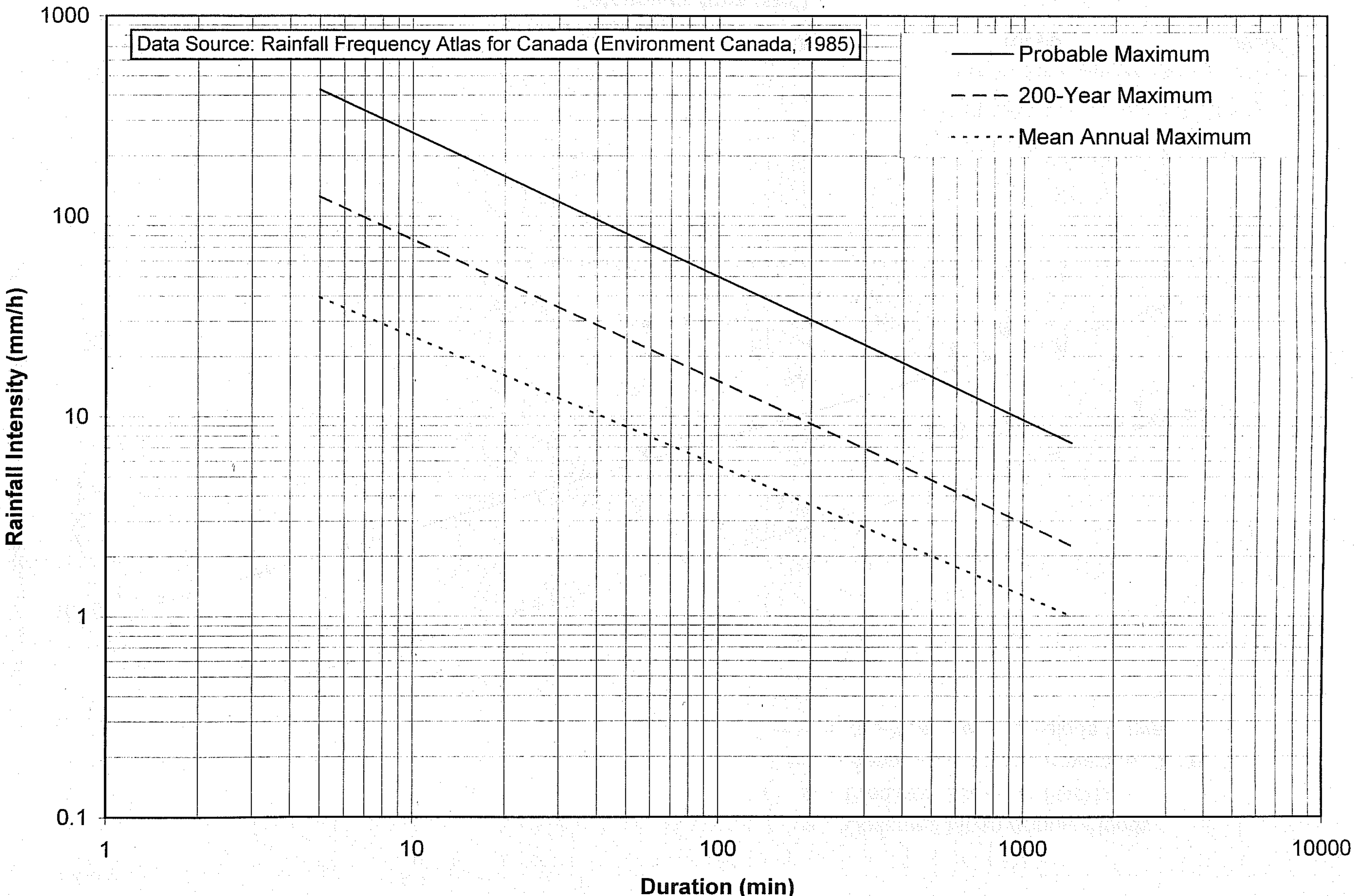


Figure B-2 Estimated Intensity-Duration-Frequency Relationship for UKHM Minesite

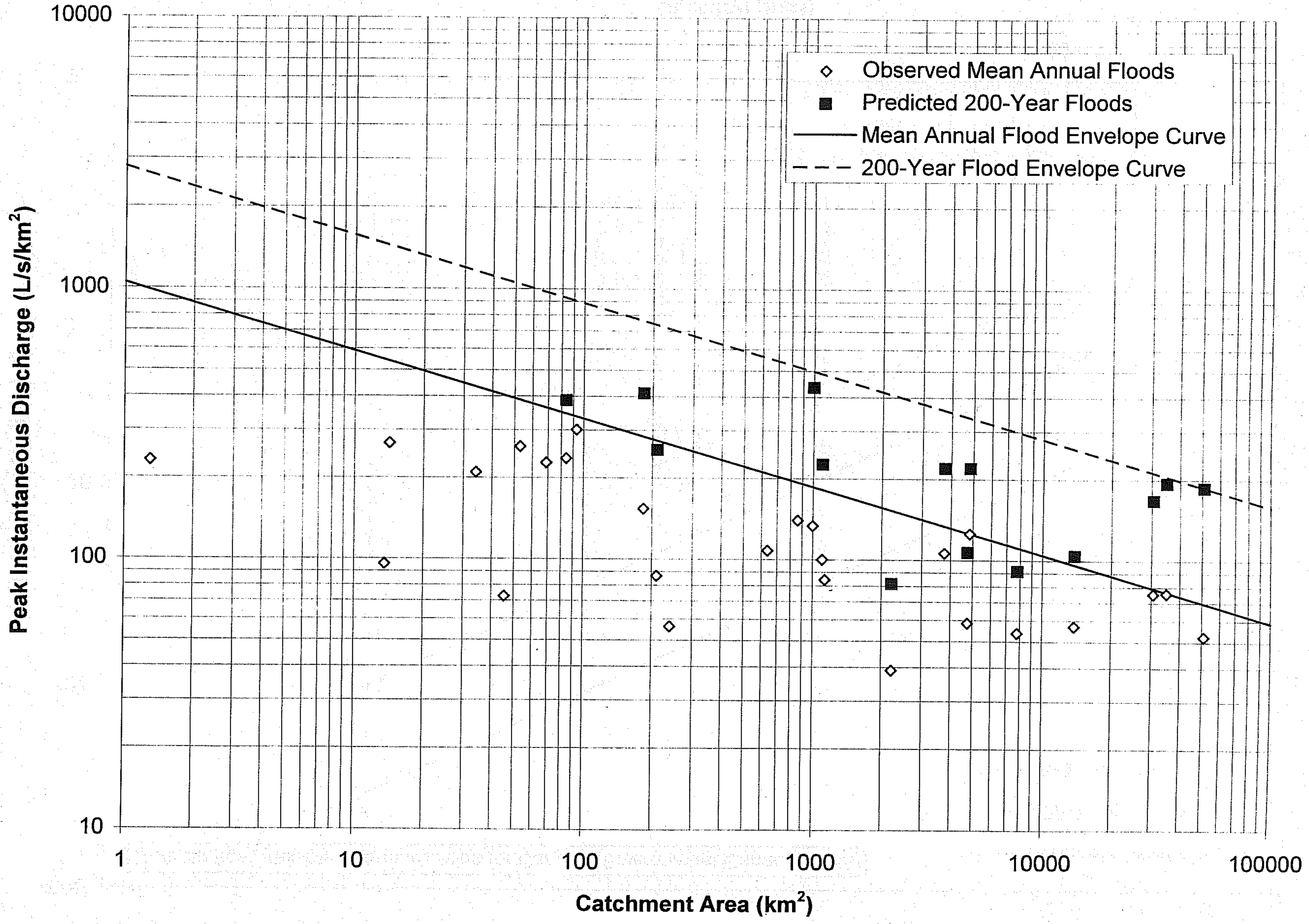


Figure B-3 Extrapolation of Regional Flood Data to UKHM Minesite

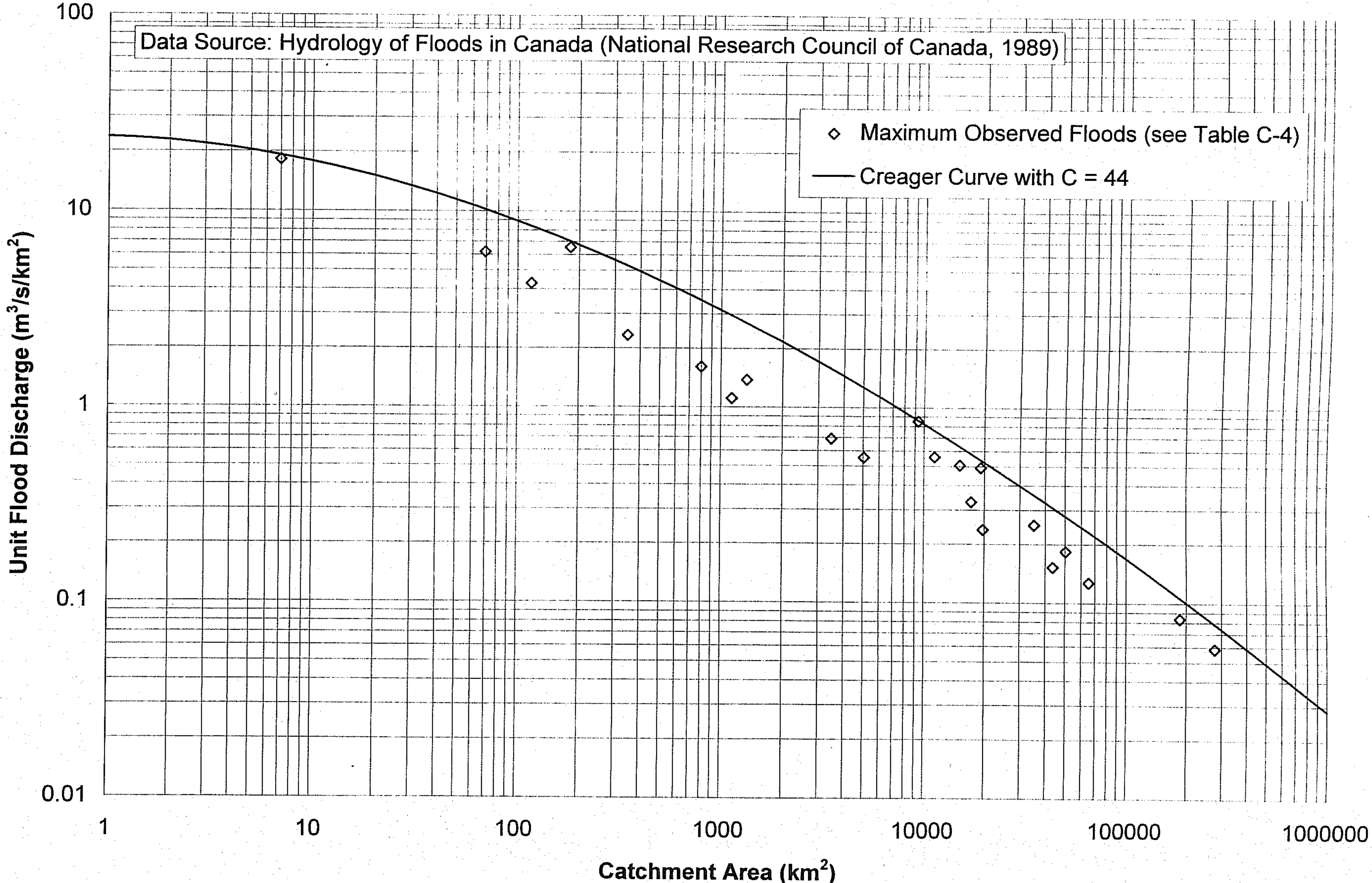
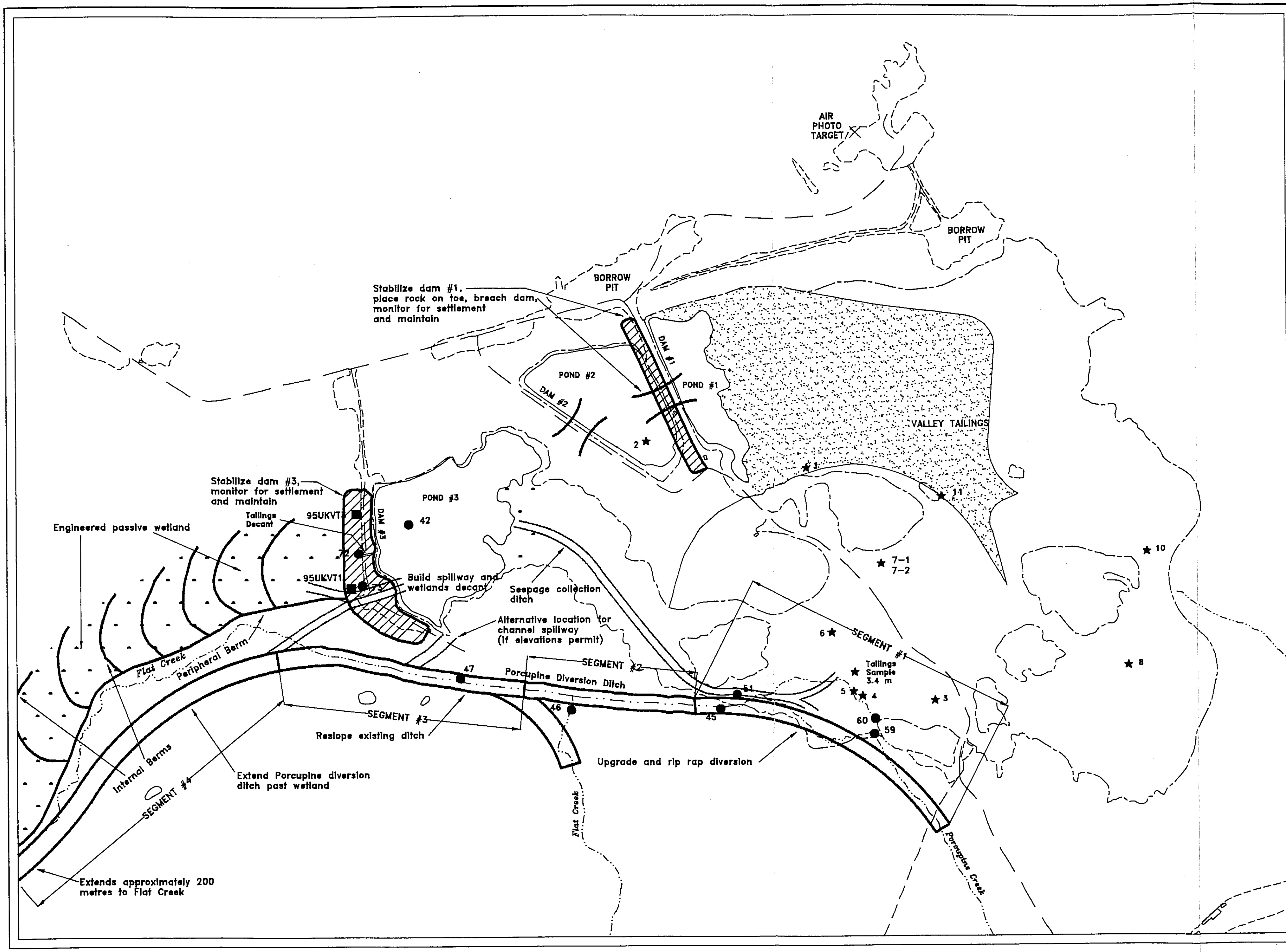


Figure B-4 Envelope Curve of Maximum Observed Floods in Canada



LEGEND

- Soil test pit with piezometer
- Waste rock sample
- Water quality sample site
- Tailings sample
- Disturbed area
- Building
- Power Line
- Tramway Line
- Highway #11
- Road
- Trail
- Stream or River
- Underground Workings
- Open pit, trench
- Waste rock dump
- Tailings area
- Adit entrance
- Shaft location
- Wetlands
- Area already vegetated

UTM N TN MN

0 75 150 225 300

METRES

UNITED KENO HILL MINES LIMITED

VALLEY TAILINGS

PROPOSED LAYOUT FOR WATER MANAGEMENT STRUCTURES

Access Mining Consultants Ltd.

SCALE: 1 : 7,500	FILE: C2VALTAI.DWG	DATE: 06/06/96
DRAWN: LCP Consult	DWG: 95UK04C1	FIGURE: 5

Attachment 2
Open Channel Flow Estimates

Sizing of Stormwater Conveyance for Porcupine Diversior

Design Flow by Rational Methoc

Qp = CIA

C =	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.13	Lawns, sandy soil, Average 2-7%				
I =	81.8	57.5	42.5	29.2	24.9	21.1	19.8	18.7	intensities from Mayo Airport IDF curve (mm/hr)				
	3.2	2.3	1.7	1.1	1.0	0.8	0.8	0.7	in hr-1				
A =	3.0	10.0	30.0	100.0	200.0	300.0	400.0	500.0	ha				
	30,000	100,000	300,000	1,000,000	2,000,000	3,000,000	4,000,000	5,000,000	m2				
	1	1	1	1	1	1	1	1	segments				
	30,000	100,000	300,000	1,000,000	2,000,000	3,000,000	4,000,000	5,000,000	m2				
	7.41	24.71	74.13	247.10	494.20	741.30	988.40	1235.50	acre				
Qp =	21.49	50.34	111.63	255.66	436.02	554.22	693.44	118.25	acre - inches per hour	0.614	1.438	3.188	7.300
	21.5	50.3	111.6	255.7	436.0	554.2	693.4	118.2	ft3 s-1				
	0.608	1.426	3.162	7.240	12.348	15.696	19.639	3.349	m3 s-1				

Channel Sizing by Mannings Equatior

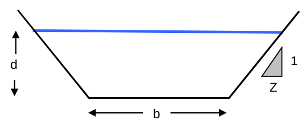
Flow velocity, V = 1/n * R^2/3 * S^1/2

Volumetric flowrate, Q = 1/n * A^5/3 P^-2/3 S^1/2

For trapezoidal cross-section:

Area of flow, A = bd+Zd^2

Wetted Perimeter, P = b+2d*sqrt(Z^2+1)



Slope 2% (i.e. on surfaces of dumps

Inputs										
Design flowrate	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	m3 s-1	
Mannings n	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040		**<-- Select from Table 1**
Slope	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02		
Design Variables										
Depth of flow	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	m	
Width	5	5	5	5	5	5	5	5	m	
Sideslope	3	3	3	3	3	3	3	3	H:1V	
Calculated Values										
Flow area	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	m2	
Wetted perimeter	12	12	12	12	12	12	12	12	m	
Hydraulic radius (A/P)	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78		
Q = 1/n * A^5/3 P^-2/3 S^1/2	**28.00**	**28.00**	**28.00**	**28.00**	**28.00**	**28.00**	**28.00**	**28.00**	m3 s-1	**<-- Adjust design variables and depth of flow until this value matches the design flowra**
V = Q/A	2.98	2.98	2.98	2.98	2.98	2.98	2.98	2.98	m s-1	**<-- Then check this value against Table 2 to ensure that velocities do not cause erosic**

Table 1

Typical Values of Mannings n (from Haan & Barfield 1978

		Min	Design	Max.
	Earth Channels			
	Earth bottom, rubble sides	0.028	0.032	0.035
	Large drainage ditches with no vegetation:			
	A/P < 2.5	0.040		0.045
	2.5 < A/P < 4	0.035		0.040
	4 < A/P < 5	0.030		0.035
	5 < A/P	0.025		0.030
	Small drainage ditches	0.035	0.040	0.040
	Stony bed, weeds on bank	0.025	0.035	0.040
	Straight and uniform	0.017	0.0225	0.025
	Winding, sluggish	0.0225	0.025	0.030
	Lined Channels			
	Concrete	0.012		0.018
	Concrete rubble	0.016		0.029
	Metal, smooth	0.011		0.015
	Metal, corrugated	0.021	0.024	0.026
	Plastic	0.012		0.014
	Shotcrete	0.016		0.017
	Wood flume, planed	0.009	0.012	0.016
	Wood flume, unplaned	0.011	0.013	0.015
	Natural streams			
a	Clean, straight bank, full stage,	0.025		0.033
b	Same as a but some weeds anc	0.030		0.040
c	Winding, some pools and shoals	0.035		0.050
d	Same as c, lower stages, more	0.040		0.055
e	Same as c, some weeds and sto	0.033		0.045
f	Same as d, stony sections	0.045		0.060
g	Sluggish river reaches, rather w	0.050		0.080
h	Very weedy reaches	0.075		0.150

Table 2

Limiting Velocities for Erosion of Non-Vegetated Channels (from Lane 1955

Material	Mannings n	Limiting Velocity (metres per second) Clear Water	Silty Water	Original values (feet per second)	
Fine sand col	0.02	0.5	0.6	1.50	2.00
Sandy loam r	0.02	0.5	0.8	1.75	2.50
Silt loam non	0.02	0.6	0.9	2.00	3.00
Alluvial silts r	0.02	0.6	1.1	2.00	3.50
Ordinary firm	0.02	0.8	1.0	2.50	3.30
Volcanic ash	0.02	0.8	1.1	2.50	3.50
Stiff clay very	0.025	1.1	1.5	3.75	5.00
Alluvial silts c	0.025	1.1	1.5	3.75	5.00
Shales and h	0.025	1.8	1.8	6.00	6.00
Fine gravel	0.02	0.8	1.5	2.50	5.00
Graded loam	0.03	1.1	1.5	3.75	5.00
Graded loam	0.03	1.2	1.7	4.00	5.50
Coarse grave	0.025	1.2	1.8	4.00	6.00
Cobbles and	0.035	1.5	1.7	5.00	5.50

For vegetated channels, typical limiting velocities are 1-2 metres per second

Sizing of Stormwater Conveyance for Brefalt, Porcupine, and North Fork Flat Creek

Design Flow by Rational Methoc

Qp = CIA

C =	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.13	Lawns, sandy soil, Average 2-7%				
I =	81.8	57.5	42.5	29.2	24.9	21.1	19.8	18.7	intensities from Mayo Airport IDF curve (mm/hr)				
	3.2	2.3	1.7	1.1	1.0	0.8	0.8	0.7	in hr-1				
A =	3.0	10.0	30.0	100.0	200.0	300.0	400.0	500.0	ha				
	30,000	100,000	300,000	1,000,000	2,000,000	3,000,000	4,000,000	5,000,000	m2				
	1	1	1	1	1	1	1	1	segments				
	30,000	100,000	300,000	1,000,000	2,000,000	3,000,000	4,000,000	5,000,000	m2				
	7.41	24.71	74.13	247.10	494.20	741.30	988.40	1235.50	acre				
Qp =	21.49	50.34	111.63	255.66	436.02	554.22	693.44	118.25	acre - inches per hour	0.614	1.438	3.188	7.300
	21.5	50.3	111.6	255.7	436.0	554.2	693.4	118.2	ft3 s-1				
	0.608	1.426	3.162	7.240	12.348	15.696	19.639	3.349	m3 s-1				

Channel Sizing by Mannings Equatioı

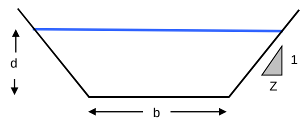
Flow velocity, V = 1/n * R^2/3 * S^1/2

Volumetric flowrate, Q = 1/n * A^5/3 P^-2/3 S^1/2

For trapezoidal cross-section:

Area of flow, A = bd+Zd^2

Wetted Perimeter, P = b+2d*sqrt(Z^2+1)



Slope 2% (i.e. on surfaces of dumps

Inputs										
Design flowrate	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	m3 s-1	
Mannings n	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040		**<-- Select from Table 1**
Slope	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02		
Design Variables										
Depth of flow	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	m	
Width	5	5	5	5	5	5	5	5	m	
Sideslope	5	5	5	5	5	5	5	5	H:1V	
Calculated Values										
Flow area	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	m2	
Wetted perimeter	15	15	15	15	15	15	15	15	m	
Hydraulic radius (A/P)	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Q = 1/n * A^5/3 P^-2/3 S^1/2	**28.00**	**28.00**	**28.00**	**28.00**	**28.00**	**28.00**	**28.00**	**28.00**	m3 s-1	**<-- Adjust design variables and depth of flow until this value matches the design flowra**
V = Q/A	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	m s-1	**<-- Then check this value against Table 2 to ensure that velocities do not cause erosic**

Table 1

Typical Values of Mannings n (from Haan & Barfield 1978

		Min	Design	Max.
	Earth Channels			
	Earth bottom, rubble sides	0.028	0.032	0.035
	Large drainage ditches with no vegetation:			
	A/P < 2.5	0.040		0.045
	2.5 < A/P < 4	0.035		0.040
	4 < A/P < 5	0.030		0.035
	5 < A/P	0.025		0.030
	Small drainage ditches	0.035	0.040	0.040
	Stony bed, weeds on bank	0.025	0.035	0.040
	Straight and uniform	0.017	0.0225	0.025
	Winding, sluggish	0.0225	0.025	0.030
	Lined Channels			
	Concrete	0.012		0.018
	Concrete rubble	0.016		0.029
	Metal, smooth	0.011		0.015
	Metal, corrugated	0.021	0.024	0.026
	Plastic	0.012		0.014
	Shotcrete	0.016		0.017
	Wood flume, planed	0.009	0.012	0.016
	Wood flume, unplaned	0.011	0.013	0.015
	Natural streams			
a	Clean, straight bank, full stage,	0.025		0.033
b	Same as a but some weeds anc	0.030		0.040
c	Winding, some pools and shoal	0.035		0.050
d	Same as c, lower stages, more	0.040		0.055
e	Same as c, some weeds and stı	0.033		0.045
f	Same as d, stony sections	0.045		0.060
g	Sluggish river reaches, rather w	0.050		0.080
h	Very weedy reaches	0.075		0.150

Table 2

Limiting Velocities for Erosion of Non-Vegetated Channels (from Lane 1955

Material	**Mannings n**	**Limiting Velocity (metres per second)**	
		Clear Water	**Silty Water**
Fine sand col	0.02	0.5	0.6
Sandy loam r	0.02	0.5	0.8
Silt loam non	0.02	0.6	0.9
Alluvial silts r	0.02	0.6	1.1
Ordinary firm	0.02	0.8	1.0
Volcanic ash	0.02	0.8	1.1
Stiff clay very	0.025	1.1	1.5
Alluvial silts c	0.025	1.1	1.5
Shales and h	0.025	1.8	1.8
Fine gravel	0.02	0.8	1.5
Graded loam	0.03	1.1	1.5
Graded loam	0.03	1.2	1.7
Coarse grave	0.025	1.2	1.8
Cobbles and	0.035	1.5	1.7

Original values (feet per second)

1.50	2.00
1.75	2.50
2.00	3.00
2.00	3.50
2.50	3.30
2.50	3.50
3.75	5.00
3.75	5.00
6.00	6.00
2.50	5.00
3.75	5.00
4.00	5.50
4.00	6.00
5.00	5.50

For vegetated channels, typical limiting velocities are 1-2 metres per second

Sizing of Stormwater Conveyance for Lower North Flat Creel

Design Flow by Rational Methoc

Qp = CIA

C =	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.13	Lawns, sandy soil, Average 2-7%					
I =	81.8	57.5	42.5	29.2	24.9	21.1	19.8	18.7	intensities from Mayo Airport IDF curve (mm/hr)					
	3.2	2.3	1.7	1.1	1.0	0.8	0.8	0.7	in hr-1					
A =	3.0	10.0	30.0	100.0	200.0	300.0	400.0	500.0	ha					
	30,000	100,000	300,000	1,000,000	2,000,000	3,000,000	4,000,000	5,000,000	m2					
	1	1	1	1	1	1	1	1	segments					
	30,000	100,000	300,000	1,000,000	2,000,000	3,000,000	4,000,000	5,000,000	m2					
	7.41	24.71	74.13	247.10	494.20	741.30	988.40	1235.50	acre					
Qp =	21.49	50.34	111.63	255.66	436.02	554.22	693.44	118.25	acre - inches per hour		0.614	1.438	3.188	7.300
	21.5	50.3	111.6	255.7	436.0	554.2	693.4	118.2	ft3 s-1					
	0.608	1.426	3.162	7.240	12.348	15.696	19.639	3.349	m3 s-1					

Channel Sizing by Mannings Equatioı

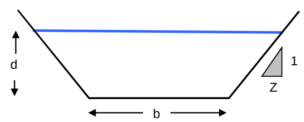
Flow velocity, V = 1/n * R^2/3 * S^1/2

Volumetric flowrate, Q = 1/n * A^5/3 P^-2/3 S^1/2

For trapezoidal cross-section:

Area of flow, A = bd+Zd^2

Wetted Perimeter, P = b+2d*sqrt(Z^2+1)



Slope 2% (i.e. on surfaces of dumps

Inputs										
Design flowrate	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	m3 s-1	
Mannings n	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040		**<-- Select from Table 1**
Slope	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02		
Design Variables										
Depth of flow	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	m	
Width	10	10	10	10	10	10	10	10	m	
Sideslope	3	3	3	3	3	3	3	3	H:1V	
Calculated Values										
Flow area	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	m2	
Wetted perimeter	15	15	15	15	15	15	15	15	m	
Hydraulic radius (A/P)	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68		
Q = 1/n * A^5/3 P^-2/3 S^1/2	**28.00**	**28.00**	**28.00**	**28.00**	**28.00**	**28.00**	**28.00**	**28.00**	m3 s-1	**<-- Adjust design variables and depth of flow until this value matches the design flowra**
V = Q/A	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	m s-1	**<-- Then check this value against Table 2 to ensure that velocities do not cause erosic**

Table 1

Typical Values of Mannings n (from Haan & Barfield 1978

		Min	Design	Max.
	Earth Channels			
	Earth bottom, rubble sides	0.028	0.032	0.035
	Large drainage ditches with no vegetation:			
	A/P < 2.5	0.040		0.045
	2.5 < A/P < 4	0.035		0.040
	4 < A/P < 5	0.030		0.035
	5 < A/P	0.025		0.030
	Small drainage ditches	0.035	0.040	0.040
	Stony bed, weeds on bank	0.025	0.035	0.040
	Straight and uniform	0.017	0.0225	0.025
	Winding, sluggish	0.0225	0.025	0.030
	Lined Channels			
	Concrete	0.012		0.018
	Concrete rubble	0.016		0.029
	Metal, smooth	0.011		0.015
	Metal, corrugated	0.021	0.024	0.026
	Plastic	0.012		0.014
	Shotcrete	0.016		0.017
	Wood flume, planed	0.009	0.012	0.016
	Wood flume, unplaned	0.011	0.013	0.015
	Natural streams			
a	Clean, straight bank, full stage,	0.025		0.033
b	Same as a but some weeds anc	0.030		0.040
c	Winding, some pools and shoal:	0.035		0.050
d	Same as c, lower stages, more	0.040		0.055
e	Same as c, some weeds and stı	0.033		0.045
f	Same as d, stony sections	0.045		0.060
g	Sluggish river reaches, rather w	0.050		0.080
h	Very weedy reaches	0.075		0.150

Table 2

Limiting Velocities for Erosion of Non-Vegetated Channels (from Lane 1955

Material	Mannings n	Limiting Velocity (metres per second) Clear Water	Silty Water		Original values (feet per second)	
Fine sand col	0.02	0.5	0.6		1.50	2.00
Sandy loam r	0.02	0.5	0.8		1.75	2.50
Silt loam non	0.02	0.6	0.9		2.00	3.00
Alluvial silts r	0.02	0.6	1.1		2.00	3.50
Ordinary firm	0.02	0.8	1.0		2.50	3.30
Volcanic ash	0.02	0.8	1.1		2.50	3.50
Stiff clay very	0.025	1.1	1.5		3.75	5.00
Alluvial silts c	0.025	1.1	1.5		3.75	5.00
Shales and h	0.025	1.8	1.8		6.00	6.00
Fine gravel	0.02	0.8	1.5		2.50	5.00
Graded loam	0.03	1.1	1.5		3.75	5.00
Graded loam	0.03	1.2	1.7		4.00	5.50
Coarse grave	0.025	1.2	1.8		4.00	6.00
Cobbles and	0.035	1.5	1.7		5.00	5.50

For vegetated channels, typical limiting velocities are 1-2 metres per second

Appendix C
Closure Options Cost Estimates

Appendix C1: Closure Option 1A Cost Estimate

UKHM VTF Closure Option 1A Cost Estimate

Contract Code	Work Area Code	Item	Task	Sub-task	Activity	Task	Quantity	Unit	Unit Cost	Activity Total	Subtotals	Source / Comments
CLOSURE COSTS - DIRECT CAPITAL												
Borrow Area Development											$473,096	
	1	1			Prepare Borrow Area	Clear and grub	217,448	m2	$2.18	$473,096		
Flatten profile of Dams #1, 2, 3											$10,981	
	1	2	1	1	Regrade dam crest	Dozer used to cut down dam crest	17,120	Bm3	$0.33	$5,697		
	1	2	2	1	Compact regraded material on downstream face	Compact relocated material	57,067	m2	$0.09	$5,284		
Relocation of South Valley Hillside Tailings											$118,704	
	1	3	1	1	Remove tailings from hillside	Dozer+Excavator to remove tailings from hillside	81,431	Bm3	$1.12	$91,608		
	1	3	2	1	Spread tailings within VTF	Dozer spreads material at base of hillside	81,431	Bm3	$0.33	$27,096		
Cover Placement											$5,257,546	
	1	4	1	1	Regrade tailings surface	Dozer regrades tailings surface	391,106	m2	$0.33	$130,142		
	1	4	2	1	Place vegetative cover from Borrow Site	Excavate, haul, dump and spread within VTF	391,106	Bm3	$12.21	$4,775,408		
	1	4	3	1	Revegetate	Seed and fertilize	782,213	m2	$0.45	$351,996		
North Fork Flat Creek											$1,155,680	
	1	5	1	1	Establish stable channel	Excavate and dump tailings to create channel	52,273	Bm3	$3.96	$207,054		
	1	5	2	1		Screen and Stockpile RipRap	44,251	Bm3	$8.78	$388,411		
	1	5	3	1		Load, Haul, Dump Channel Bed RipRap	44,251	Bm3	$12.21	$540,302		
	1	5	4	1		Seed and fertilize	44,251	m2	$0.45	$19,913		
Porcupine Creek Diversion											$584,635	
	1	6	1	1	Remove tailings from streambed	Excavate, haul and dump tailings from streambed	26,667	Bm3	$4.73	$126,026		
	1	6	2	1		Screen and Stockpile RipRap	21,393	Bm3	$8.78	$187,776		
	1	6	3	1		Load, Haul, Dump Channel Bed RipRap	21,393	Bm3	$12.21	$261,207		
	1	6	4	1		Seed and fertilize	21,393	m2	$0.45	$9,627		
Subtotal Direct Costs												
						Subtotal direct costs					**$7,600,642**	
CLOSURE COSTS - INDIRECT												
	100	100	1	1	Project Management	2.5% of direct costs	$ 7,600,642	x	2.5%		$190,016	
	100	100	2	1	Field Supervision	(included in major tasks)					$0	
	100	100	3	1	Contractor profit and home office overhead	10% of direct costs	$ 7,600,642	x	10.0%		$760,064	
	100	100	4	1	Insurance	0.5% of direct costs	$ 7,600,642	x	0.5%		$38,003	
	100	100	5	1	Bonding	0.5% of direct costs	$ 7,600,642	x	0.5%		$38,003	
	100	100	6	1	Field Engineering and QA	15% of direct costs	$ 7,600,642	x	15.0%		$1,140,096	
	100	100	7	1	Mob - Demob		1	lump	$356,722		$356,722	
	100	100	8	1	Living out allowances	Camp housing costs for a construction crew of 12	746	days	$77.00	17	$976,514	
	100	100	9	1	Taxes	7% of taxable direct and indirect costs	$ 8,603,419	x	7.0%		$602,239	
Subtotal Indirect Costs												
					Subtotal indirect costs						**$4,101,659**	
CLOSURE COSTS - CONTINGENCY												
					Contingency	20% of direct costs	$7,600,642	x	20.0%		**$1,520,128**	
CLOSURE COSTS - TOTAL												
					Total direct and indirect costs						**$13,222,429**	

Worksheet 1: Unit Costs

EQUIPMENT RATES

=Adjustable Factors

Equipment	BC Blue Book Rate 2008[1]	Adjustment Factor to UKHM Site	Fuel Adjustment Factor			All-Inclusive Rate ($/hr)
			HP	Incremental Fuel Cost ($/L)	Incremental Fuel Operating Cost ($/hr)[2]	
Excavator - CAT 325 C/D	$ 160.15	1.1	222	$ 0.20	$ 5.77	$ 181.94
Excavator - CAT 330	$ 174.80	1.1	222	$ 0.20	$ 5.77	$ 198.05
Excavator - CAT 350	$ 261.00	1.1	428	$ 0.20	$ 11.13	$ 298.23
Loader: Cat 966F	$ 155.30	1.1	235	$ 0.20	$ 6.11	$ 176.94
Loader: Cat 938G	$ 122.30	1.1	140	$ 0.20	$ 3.64	$ 138.17
Std 10 cyd truck (7.6 m3)	$ 72.15	1.1	222	$ 0.20	$ 5.77	$ 85.14
Trucks: Cat 769D	$ 186.75	1.1	518	$ 0.20	$ 13.47	$ 218.89
Trucks: Cat D350	$ 177.95	1.1	340	$ 0.20	$ 8.84	$ 204.59
Dozer: Cat D7	$ 187.90	1.1	240	$ 0.20	$ 6.24	$ 212.93
Dozer: Cat D8R/N	$ 219.55	1.1	310	$ 0.20	$ 8.06	$ 249.57
Dozer: Cat D10R/N	$ 365.05	1.1	570	$ 0.20	$ 14.82	$ 416.38
Dozer: Cat D11R	$ 415.60	1.1	850	$ 0.20	$ 22.10	$ 479.26
Roller: Cat CP553 / CP563	$ 102.15	1.1	130	$ 0.20	$ 3.38	$ 115.75
Roller: Walk-behind vibrating (30 in)	$ 13.30	1.1	12	$ 0.20	$ 0.31	$ 14.94
Grader: Cat 14G	$ 135.75	1.1	215	$ 0.20	$ 5.59	$ 154.92
Hydraulic Drill, 200cfm screw-type	$ 328.05	1.1	196	$ 0.20	$ 5.10	$ 365.95
Air track drill rig (900cfm)	$ 253.75	1.1	215	$ 0.20	$ 5.59	$ 284.72

1. Rate includes Ownership, Repair, Maintenance, Operator and Fuel (@ $0.50/L) costs

2. Fuel Operating Cost Formula from BC Blue Book

UNIT COSTS

Item	Unit Cost	Unit	Remark / Source
Earthworks			
Haul Road: Construct	$200.00	m	Colomac 2005 estimate
Access Road: Construct	$12.00	m	based on 3m wide by .5m high fill at $8.00/m3
Backfill/compact excavated ditches	$4.73	m3	see unit rate calcs
Clearing land	$1.51	m2	see unit rate calcs
Clearing and Grubbing	$2.18	m2	see unit rate calcs
Compaction: channel materials	$0.76	m2	see unit rate calcs
Compaction: Machine rolled	$0.09	m2	see unit rate calcs
Dozer: Regrading	$0.33	m3	see unit rate calcs
Drilling and Blasting	$20.00	Bm3	Costworks
Excavation: Channels (no haul)	$3.96	Lm3	see unit rate calcs
Grading: roads, ramps, etc.	$0.34	m2	see unit rate calcs
Lime Addition	$0.85	m3	see unit rate calcs
Rip-Rap: Drill, Blast and Stockpile	$24.16	m3	see unit rate calcs
Rip-Rap: Screen and Stockpile	$8.78	Lm3	see unit rate calcs
Rip-Rap rock placement	$4.55	Lm3	see unit rate calcs; excavator cost only
Scale Core Wall	$2.13	Bm3	see unit rate calcs
Scarify Roadways	$0.34	m	see unit rate calcs
Revegetation			
Native grass seeding	$0.40	m2	=revegetation - fertilization
Fertilization	$0.05	m2	D. Hockley - Red Dog cost estimate (pellets)
Revegetation	$0.45	m2	Min=Costworks, Max=assumption of $4500 per hectare (estimated from Faro FWSD work)
Relocations			
See Unit Cost Relocations Worksheet			
Personnel Rates			
Survey [GPS Crew - Surveyor, Assistant, Truck, Survey GPS]	$235.00	hr	Yukon Engineering Services (June, 2009)
Technician (Consultant)	$130.00	hr	SRK-Estimate (all inclusive)
Labourers General	$42.38	hr	Yukon Gov. Fair Wage Sched. Apr. 2008 (112% Loading Rate Added)*
Supervisor	$74.20	hr	Yukon Gov. Fair Wage Sched. Apr. 2008 (112% Loading Rate Added)*
Note: Loading Rate includes allowances for (EI, CPP, MSP/Benefits/Travel/OT)			
Materials			
Hydrated Lime [$Ca(OH)_2$]	$500.00	tonne	From Brad Thrall, February 2009
Geotextile (purchased/installed)	$4.55	m2	See unit rate calc; (cost of Geotextile= $3.50 from Yukon Pump quote, Aug. 2004)
Bitumen Liner	$24.60	m2	Quote: Kitsault Feb. 2006 (Coletanche ES1)
Geosynthetic Clay Liner (purchased/installed)	$25.90	m2	see unit rate calcs; material cost estimated
HDPE liner installed (for channels)	$22.67	m2	See unit rate calc; (cost of HDPE=$12.77 from Yukon Pump quote, Aug. 2004)

Worksheet 2: Unit Costs Relocations

Relocation Productivities and truck #'s obtained from 'Master_Waste_Rock_Relocation' spreadsheet, using the equipment, route and other parameters listed below

Relocation Table

							Productivities				Equipment Used			
Area	Activity	Material	Bulking Factor	Source	Destination	Distance (1-way)	Unit Rate (Lm3/hr)	Productivity (Lm3/hr)	Unit Rate (Bm3/hr)	Productivity (Bm3/hr)	Equipment	Type	Quantity	Rate ($/hr)
South VTF Hillside	Tailings Relocation Excavate, spread	Tailings	1	VTF South Hillside	VTF	2	$ 1.12	351	$ 1.12	351	Excavator	CAT 325C/D	1	$ 181.94
											Truck	CAT D35	0	$ 204.59
											Dozer	CAT D7	1	$ 212.93
NFFC Channel	Load, Haul Dump Channel Bed	RipRap	1.30	Borrow Area	VTF	2	$ 6.57	209.2	$ 12.21	161	Loader	CAT 938	1	$ 138.17
											Truck	CAT D35	5	$ 204.59
											Dozer	CAT D7	1	$ 212.93
PCD Channel	Excavate, haul and dump tailings from streambed and sideslopes	Tailings	1	VTF West Side	VTF	2	$ 4.73	300	$ 4.73	300	Excavator	CAT 325C/D	1	$ 181.94
											Truck	CAT D35	5	$ 204.59
											Dozer	CAT D7	1	$ 212.93
PCD Channel	Load, Haul Dump Channel Bed	RipRap	1.30	Borrow Area	VTF	2	$ 6.78	209.2	$ 12.21	161	Excavator	CAT 325C/D	1	$ 181.94
											Truck	CAT D35	5	$ 204.59
											Dozer	CAT D7	1	$ 212.93
Vegetative Cover	Excavate, haul, dump, spread	Till	1.3	Borrow Area	VTF	2	$ 6.57	209.2	$ 12.21	161	Loader	CAT 938	1	$ 138.17
											Truck	CAT D35	5	$ 204.59
											Dozer	CAT D7	1	$ 212.93

		Haul Route Information														Other Hauling Parameters Used			
		Segment 1		Segment 2		Segment 3		Segment 4		Segment 5		Segment 6		Segment 7					
Area	Equipment	Grade (%)	Distance (km)	Grade (%)	Distance (km)	Grade (%)	Distance (km)	Grade (%)	Distance (km)	Grade (%)	Distance (km)	Grade (%)	Distance (km)	Grade (%)	Distance (km)	# of Supervisors	Supervisior Rate ($/hr)	Fuel ($/L)	Meal and Accomodation ($/person/day)
South VTF Hillside	Excavator	-5	0.7	-1	0.15											1	74.2	-	0
	Truck																		
	Dozer																		
NFFC Channel	Loader	0	0.2	0	0.6	0	0.4									1	74.2	-	0
	Truck																		
	Dozer																		
PCD Channel	Excavator	0	0.5													1	74.2	-	0
	Truck																		
	Dozer																		
PCD Channel	Excavator	0	0.2	0	0.6	0	0.4									1	74.2	-	0
	Truck																		
	Dozer																		
Vegetative Cover	Loader	0	0.2	0	0.6	0	0.4									1	74.2	-	0
	Truck																		
	Dozer																		

Worksheet 3: Unit Rate Calculations

Task	All-Inclusive Unit Rate	Unit	Equipment	# of Equipment	Productivity (unit/hour)	All Inclusive Unit Rate ($/hr)
Berm: Shape Berm Material	$ 4.55	lm	Excavator - CAT 235 C/D	1	40	$ 181.94
Clear	$ 1.51	sq. m.	Dozer: Cat D10	1	275	$ 416.38
Clear/Grub	$ 2.18	sq. m.	Dozer: Cat D10	1	275	$ 416.38
			Excavator - CAT 235 C/D	1	275	$ 181.94
Compaction: Wheeled-roller	$ 0.09	sq. m.	Compactor: CAT CP553	1	1250	$ 115.75
Compaction: Channel materials	$ 0.76	sq. m.	Labourers	2	125	$ 40.00
			Vibrator	1	125	$ 14.94
Excavation: channel (no haul)	$ 3.96	cu. m	Excavator - CAT 330	1	50	$ 198.05
Backfill excavated ditches	$ 4.73	cu. m	Excavator - CAT 235 C/D	1	125	$ 181.94
			Labourers	2	125	$ 204.59
Excavation: Rock	$ 26.86	cu. m	Air track drill rig	1	15	$ 284.72
			Excavator - CAT 235 C/D	0.2	15	$ 181.94
			Trucks: CAT 740	0.4	15	$ 204.59
GCL: Supply and Install	$ 25.90	sq. m.	Labourers	4	35	$ 42.38
(For Channels)			Loader: Cat 966F	1	35	$ 176.94
			Material: HDPE Liner (unit rate)			$ 16.00
Geotextile: Supply and Install	$ 4.55	sq. m.	Labourers	2	250	$ 42.38
			Loader: Cat 966F	1	250	$ 176.94
			Material: Geotextile			$ 3.50
HDPE Liner: Supply and Install	$ 22.67	sq. m.	Labourers	4	35	$ 42.38
(For Channels)			Loader: Cat 966F	1	35	$ 176.94
			Material: HDPE Liner (unit rate)			$ 12.77
Lime Addition	$ 0.85	cu. m	Dozer: Cat D8	1	500	$ 249.57
			Loader: Cat 966F	1	500	$ 176.94
Regrade	$ 0.33	cu.m.	Dozer: Cat D8	1	750	$ 249.57
Rip-Rap: Drill, Blast and Stockpile	$ 24.16	cu. m	Dozer: Cat D10R/N	1	100	$ 416.38
			Drill Blast (unit rate)			$ 20.00
Rip-Rap: Screen and stockpile	$ 8.78	cu. m	Dozer: Cat D7	1	40	$ 212.93
			Loader: Cat 938G	1	40	$ 138.17
Roads: Grade	$ 0.34	m2	Grader: Cat 14G	1	460	$ 154.92
Roads: Scarify	$ 0.34	m2	Grader: Cat 14G	1	460	$ 154.92
Scale West core wall	$ 2.13	cu. m	Dozer: Cat D8	1	200	$ 249.57
			Loader: Cat 966F	1	200	$ 176.94

Worksheet 4: Quantities

Option 1A

Cover Placement
Assume cover of 0.5 m thick

VTF Area	Area (m^2)
Pond 1	
Consolidated Tailings Area	296,691.2
Relocated Tailings Area	251,209.9
Pond 2	12,584.7
Pond 3	221,726.8
Total	**782,212.6**

Volume 391,106.3 m3

Flatten Dam Crests
Lower crest elevation by 2 m
Dam 1 Crest Dimensions

5	cm =	200	m Scaled from Figure 1
7	cm =	280	m Length
0.2	cm =	8	m Width
Volume to Flatten		4480	m3

Dam 2 Crest Dimensions

8.5	cm =	340	m Length
0.2	cm =	8	m Width
Volume to Flatten		5440	m3

Dam 3 Crest Dimensions

5	cm =	200	m Length
4	cm =	160	m Length
	Total =	360	m Length
0.25	cm =	10	m Width
Volume to Flatten		7200	m3

Total Volume to Flatten 17120 m3

VTF South Hillside Tailings Relocation
Area 162862 m2
Assume tailings 0.5 m thick
Volume to relocate 81431 m3

Regrade VTF Tailings Surface
Assume 0.5 m of tailings to be regraded on average
Area to regrade 782,212.6 m2
Volume to regrade 391106.3 m3

Construct Lower North Fork Flat Creek Channel
Length of Channel [Scaled From Figure 1]
20 cm = 800 m Length
Assume channel width 5 m Wide
Assume Channel Depth 2 m
Assume sideslopes 3 H: 1 V

Volume to Excavate 17600 m3

Liner Quantity 14119.29 m2

Channel Bedding layer
Assume 1 m of till to be placed
Channel Perimeter 14119.29 m2
Volume to place 14119.29 m3

Stabilize North Fork Flat Creek
Length of Channel
3.3 cm = 250 m Scaled from Figure 2
23 cm = 1742.424 m Length
Assume channel width 5 m Wide
Assume Channel Depth 2 m
Assume sideslopes 5 H: 1 V

Volume to Excavate 52272.73 m3

Liner Quantity 44250.74 m2

Channel Bedding layer
Assume 1 m of till to be placed
Channel Perimeter 44250.74 m2
Volume to place 44250.74 m3

Porcupine Creek Diversion
Assume channel sideslopes are left untouched as they are heavily vegitated and therefore stable
Remove tailings from streambed
Length of Channel [Scaled from Figure 2]
16 cm = 1212.121 m Length
Assume channel width 5 m Wide
Assume tailings depth 2 m
Assume sideslopes 3 H: 1 V

Volume to Excavate 26666.67 m3

Liner Quantity 21392.86 m2

Channel Bedding layer
Assume 1 m of till to be placed
Channel Perimeter 21392.86 m2
Volume to place 21392.86 m3

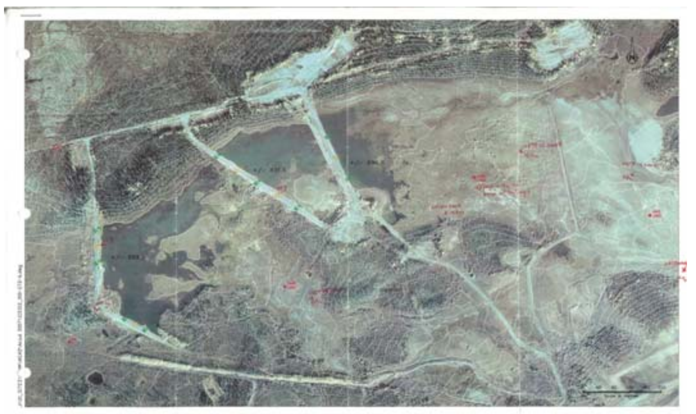


Figure 1

Figure 2

Appendix C2: Closure Option 1B Cost Estimate

UKHM VTF Closure Option 1B Cost Estimate

Contract Code	Work Area Code	Item	Task	Sub-task	Activity	Task	Quantity	Unit	Unit Cost	Activity Total	Subtotals	Source / Comments
CLOSURE COSTS - DIRECT CAPITAL												
Borrow Area Development											$473,096	
	1	1			Prepare Borrow Area	Clear and grub	217,448	m2	$2.18	$473,096		
Flatten profile of Dams #1, 2, 3											$10,981	
	1	2	1	1	Regrade dam crest	Dozer used to cut down dam crest	17,120	Bm3	$0.33	$5,697		
	1	2	2	1	Compact regraded material on downstream face	Compact relocated material	57,067	m2	$0.09	$5,284		
Relocation of South Valley Hillside Tailings											$177,334	
	1	3	1	1	Remove tailings from hillside	Dozer+Excavator to remove tailings from hillside	81,431	Bm3	$1.84	$150,237		
	1	3	2	1	Spread tailings within VTF	Dozer spreads material at base of hillside	81,431	Bm3	$0.33	$27,096		
Cover Placement											$5,257,546	
	1	4	1	1	Regrade tailings surface	Dozer regrades tailings surface	391,106	m2	$0.33	$130,142		
	1	4	2	1	Place vegetative cover from Borrow Site	Excavate, haul, dump and spread within VTF	391,106	Bm3	$12.21	$4,775,408		
	1	4	3	1	Revegetate	Seed and fertilize	782,213	m2	$0.45	$351,996		
North Fork Flat Creek											$1,411,464	
	1	5	1	1	Establish stable channel through VTF	Excavate and dump tailings to create channel	69,697	Bm3	$3.96	$276,072		
	1	5	2	1		Screen and Stockpile RipRap	52,963	Bm3	$8.78	$464,882		
	1	5	4	1		Load, Haul, Dump Channel Bed RipRap	52,963	Bm3	$12.21	$646,677		
	1	5	5	1		Seed and fertilize	52,963	m2	$0.45	$23,833		
Brefalt and Porcupine Creek											$1,012,572	
	1	6	1	1	Establish stable channel through VTF	Excavate and dump tailings to create channel	50,000	Bm3	$3.96	$198,052		
	1	6	2	1		Screen and Stockpile RipRap	37,995	Bm3	$8.78	$333,502		
	1	6	3	1		Load, Haul, Dump Channel Bed RipRap	37,995	Bm3	$12.21	$463,920		
	1	6	4	1		Seed and fertilize	37,995	m2	$0.45	$17,098		
Porcupine Creek Diversion											$889,163	
	1	7	1	1	Remove tailings from streambed	Excavate, haul and dump tailings from streambed	38,788	Bm3	$7.75	$300,629		
	1	7	2	1		Screen and Stockpile RipRap	27,453	Bm3	$8.78	$240,973		
	1	7	3	1		Load, Haul, Dump Channel Bed RipRap	27,453	Bm3	$12.21	$335,207		
	1	7	4	1		Seed and fertilize	27,453	m2	$0.45	$12,354		
Lower North Fork Flat Creek											$594,230	
	1	8	1	1	Establish stable channel through Borrow Area	Excavate till to create channel	25,600	Bm3	$8.04	$205,797		
	1	8	2	1		Screen and Stockpile RipRap	18,119	Bm3	$8.78	$159,042		
	1	8	3	1		Load, Haul, Dump Channel Bed RipRap	18,119	Bm3	$12.21	$221,237		
	1	8	4	1		Seed and fertilize	18,119	m2	$0.45	$8,154		
Subtotal Direct Costs												
						Subtotal direct costs					**$9,826,385**	
CLOSURE COSTS - INDIRECT												
	100	100	1	1	Project Management	2.5% of direct costs	$ 9,826,385	x	2.5%		$245,660	
	100	100	2	1	Field Supervision	(included in major tasks)					$0	
	100	100	3	1	Contractor profit and home office overhead	10% of direct costs	$ 9,826,385	x	10.0%		$982,638	
	100	100	4	1	Insurance	0.5% of direct costs	$ 9,826,385	x	0.5%		$49,132	
	100	100	5	1	Bonding	0.5% of direct costs	$ 9,826,385	x	0.5%		$49,132	
	100	100	6	1	Field Engineering and QA	15% of direct costs	$ 9,826,385	x	15.0%		$1,473,958	
	100	100	7	1	Mob - Demob		1	lump	$356,722		$356,722	
	100	100	8	1	Living out allowances	Camp housing costs for a construction crew of 12	778	days	$77.00	17	$1,018,402	
	100	100	9	1	Taxes	7% of taxable direct and indirect costs	$ 11,018,350	x	7.0%		$771,284	
Subtotal Indirect Costs												
					Subtotal indirect costs						**$4,946,928**	
CLOSURE COSTS - CONTINGENCY												
					Contingency	20% of direct costs	$9,826,385	x	20.0%		**$1,965,277**	
CLOSURE COSTS - TOTAL												
					Total direct and indirect costs						**$16,738,590**	

Worksheet 1: Unit Costs

EQUIPMENT RATES

=Adjustable Factors

Equipment	BC Blue Book Rate 2008[1]	Adjustment Factor to Kitsault Site	Fuel Adjustment Factor HP	Incremental Fuel Cost ($/L)	Incremental Fuel Operating Cost ($/hr)[2]	All-Inclusive Rate ($/hr)
Excavator - CAT 325 C/D	$ 160.15	1.1	222	$ 0.20	$ 5.77	$ 181.94
Excavator - CAT 330	$ 174.80	1.1	222	$ 0.20	$ 5.77	$ 198.05
Excavator - CAT 350	$ 261.00	1.1	428	$ 0.20	$ 11.13	$ 298.23
Loader: Cat 966F	$ 155.30	1.1	235	$ 0.20	$ 6.11	$ 176.94
Loader: Cat 938G	$ 122.30	1.1	140	$ 0.20	$ 3.64	$ 138.17
Std 10 cyd truck (7.6 m3)	$ 72.15	1.1	222	$ 0.20	$ 5.77	$ 85.14
Trucks: Cat 769D	$ 186.75	1.1	518	$ 0.20	$ 13.47	$ 218.89
Trucks: Cat D350	$ 177.95	1.1	340	$ 0.20	$ 8.84	$ 204.59
Dozer: Cat D7	$ 187.90	1.1	240	$ 0.20	$ 6.24	$ 212.93
Dozer: Cat D8R/N	$ 219.55	1.1	310	$ 0.20	$ 8.06	$ 249.57
Dozer: Cat D10R/N	$ 365.05	1.1	570	$ 0.20	$ 14.82	$ 416.38
Dozer: Cat D11R	$ 415.60	1.1	850	$ 0.20	$ 22.10	$ 479.26
Roller: Cat CP553 / CP563	$ 102.15	1.1	130	$ 0.20	$ 3.38	$ 115.75
Roller: Walk-behind vibrating (30 in)	$ 13.30	1.1	12	$ 0.20	$ 0.31	$ 14.94
Grader: Cat 14G	$ 135.75	1.1	215	$ 0.20	$ 5.59	$ 154.92
Hydraulic Drill, 200cfm screw-type	$ 328.05	1.1	196	$ 0.20	$ 5.10	$ 365.95
Air track drill rig (900cfm)	$ 253.75	1.1	215	$ 0.20	$ 5.59	$ 284.72

1. Rate includes Ownership, Repair, Maintenance, Operator and Fuel (@ $0.50/L) costs

2. Fuel Operating Cost Formula from BC Blue Book

UNIT COSTS

Item	Unit Cost	Unit	Remark / Source
Earthworks			
Haul Road: Construct	$200.00	m	Colomac 2005 estimate
Access Road: Construct	$12.00	m	based on 3m wide by .5m high fill at $8.00/m3
Backfill/compact excavated ditches	$4.73	m3	see unit rate calcs
Clearing land	$1.51	m2	see unit rate calcs
Clearing and Grubbing	$2.18	m2	see unit rate calcs
Compaction: channel materials	$0.76	m2	see unit rate calcs
Compaction: Machine rolled	$0.09	m2	see unit rate calcs
Dozer: Regrading	$0.33	m3	see unit rate calcs
Drilling and Blasting	$20.00	Bm3	Costworks
Excavation: Channels (no haul)	$3.96	Lm3	see unit rate calcs
Grading: roads, ramps, etc.	$0.34	m2	see unit rate calcs
Lime Addition	$0.85	m3	see unit rate calcs
Rip-Rap: Drill, Blast and Stockpile	$24.16	m3	see unit rate calcs
Rip-Rap: Screen and Stockpile	$8.78	Lm3	see unit rate calcs
Rip-Rap rock placement	$4.55	Lm3	see unit rate calcs; excavator cost only
Scale Core Wall	$2.13	Bm3	see unit rate calcs
Scarify Roadways	$0.34	m	see unit rate calcs
Revegetation			
Native grass seeding	$0.40	m2	=revegetation - fertilization
Fertilization	$0.05	m2	D. Hockley - Red Dog cost estimate (pellets)
Revegetation	$0.45	m2	Min=Costworks, Max=assumption of $4500 per hectare (estimated from Faro FWSD work)
Relocations			
See Unit Cost Relocations Worksheet			
Personnel Rates			
Survey [GPS Crew - Surveyor, Assistant, Truck, Survey GPS]	$235.00	hr	Yukon Engineering Services (June, 2009)
Technician (Consultant)	$130.00	hr	SRK-Estimate (all inclusive)
Labourers General	$42.38	hr	Yukon Gov. Fair Wage Sched. Apr. 2008 (112% Loading Rate Added)*
Supervisor	$74.20	hr	Yukon Gov. Fair Wage Sched. Apr. 2008 (112% Loading Rate Added)*
Note: Loading Rate includes allowances for (EI, CPP, MSP/Benefits/Travel/OT)			
Materials			
Hydrated Lime [$Ca(OH)_2$]	$120.00	tonne	$88/tonne material cost, shipping estimated
Geotextile (purchased/installed)	$4.55	m2	See unit rate calc; (cost of Geotextile= $3.50 from Yukon Pump quote, Aug. 2004)
Bitumen Liner	$24.60	m2	Quote: Kitsault Feb. 2006 (Coletanche ES1)
Geosynthetic Clay Liner (purchased/installed)	$25.90	m2	see unit rate calcs; material cost estimated
HDPE liner installed (for channels)	$22.67	m2	See unit rate calc; (cost of HDPE=$12.77 from Yukon Pump quote, Aug. 2004)

Worksheet 2: Unit Costs Relocations

Relocation Productivities and truck #'s obtained from 'Master_Waste_Rock_Relocation' spreadsheet, using the equipment, route and other parameters listed below

Relocation Table

							Productivities				Equipment Used			
Area	Activity	Material	Bulking Factor	Source	Destination	Distance (1-way)	Unit Rate (Lm3/hr)	Productivity (Lm3/hr)	Unit Rate (Bm3/hr)	Productivity (Bm3/hr)	Equipment	Type	Quantity	Rate ($/hr)
South VTF Hillside	Tailings Relocation Excavate, spread	Tailings	1.64	VTF South Hillside	VTF	0.85	**$ 1.12**	351	**$ 1.84**	214	Excavator	CAT 325C/D	1	$ 181.94
											Truck	CAT D35	0	$ 204.59
											Dozer	CAT D7	1	$ 212.93
NFFC Channel Procupine & Brefalt Creek Channel	Load, Haul Dump Channel Bed	RipRap	1.64	Borrow Area	VTF	1.2	**$ 6.57**	209.2	**$ 12.21**	128	Loader	CAT 938	1	$ 138.17
											Truck	CAT D35	5	$ 204.59
											Dozer	CAT D7	1	$ 212.93
PCD Channel	Excavate, haul and dump tailings from streambed and sideslopes	Tailings	1.64	VTF West Side	VTF	0.5	**$ 4.73**	300	**$ 7.75**	183	Excavator	CAT 325C/D	1	$ 181.94
											Truck	CAT D35	5	$ 204.59
											Dozer	CAT D7	1	$ 212.93
PCD Channel	Load, Haul Dump Channel Bed	RipRap	1.64	Borrow Area	VTF	1.2	**$ 6.57**	209.2	**$ 12.21**	128	Loader	CAT 938	1	$ 138.17
											Truck	CAT D35	5	$ 204.59
											Dozer	CAT D7	1	$ 212.93
Lower NFFC Channel	Excavate, haul and dump till to create channel	Till	1.64	Borrow Area	Borrow Area	0.7	**$ 4.90**	300	**$ 8.04**	183	Excavator	CAT 330	1	$ 198.05
											Truck	CAT D35	5	$ 204.59
											Dozer	CAT D8	1	$ 249.57
Lower NFFC Channel	Load, Haul Dump Channel Bed	RipRap	1.64	Borrow Area	Borrow Area	0.7	**$ 6.57**	209.2	**$ 12.21**	128	Loader	CAT 938	1	$ 138.17
											Truck	CAT D35	5	$ 204.59
											Dozer	CAT D7	1	$ 212.93
Vegetative Cover	Excavate, haul, dump, spread	Till	1.64	Borrow Area	VTF	1.2	**$ 6.57**	209.2	**$ 12.21**	128	Loader	CAT 938	1	$ 138.17
											Truck	CAT D35	5	$ 204.59
											Dozer	CAT D7	1	$ 212.93

		Haul Route Information														Other Hauling Parameters Used			
		Segment 1		Segment 2		Segment 3		Segment 4		Segment 5		Segment 6		Segment 7					
Area	Equipment	Grade (%)	Distance (km)	Grade (%)	Distance (km)	Grade (%)	Distance (km)	Grade (%)	Distance (km)	Grade (%)	Distance (km)	Grade (%)	Distance (km)	Grade (%)	Distance (km)	# of Supervisors	Supervisior Rate ($/hr)	Fuel ($/L)	Meal and Accomodation ($/person/day)
South VTF Hillside	Excavator	-5	0.7	-1	0.15											1	74.2	-	0
	Truck																		
	Dozer																		
NFFC Channel Procupine & Brefalt Creek Channel	Loader	0	0.2	0	0.6	0	0.4									1	74.2	-	0
	Truck																		
	Dozer																		
PCD Channel	Excavator	0	0.5													1	74.2	-	0
	Truck																		
	Dozer																		
PCD Channel	Loader	0	0.2	0	0.6	0	0.4									1	74.2	-	0
	Truck																		
	Dozer																		
Lower NFFC Channel	Excavator	0	0.2	0	0.6	0	0.4												
	Truck																		
	Dozer																		
Lower NFFC Channel	Loader	0	0.2	0	0.6	0	0.4												
	Truck																		
	Dozer																		
Vegetative Cover	Loader	0	0.2	0	0.6	0	0.4									1	74.2	-	0
	Truck																		
	Dozer																		

Worksheet 3: Unit Rate Calculations

Task	All-Inclusive Unit Rate	Unit	Equipment	# of Equipment	Productivity (unit/hour)	All Inclusive Unit Rate ($/hr)
Berm: Shape Berm Material	$ 4.55	lm	Excavator - CAT 235 C/D	1	40	$ 181.94
Clear	$ 1.51	sq. m.	Dozer: Cat D10	1	275	$ 416.38
Clear/Grub	$ 2.18	sq. m.	Dozer: Cat D10	1	275	$ 416.38
			Excavator - CAT 235 C/D	1	275	$ 181.94
Compaction: Wheeled-roller	$ 0.09	sq. m.	Compactor: CAT CP553	1	1250	$ 115.75
Compaction: Channel materials	$ 0.76	sq. m.	Labourers	2	125	$ 40.00
			Vibrator	1	125	$ 14.94
Excavation: channel (no haul)	$ 3.96	cu. m	Excavator - CAT 330	1	50	$ 198.05
Backfill excavated ditches	$ 4.73	cu. m	Excavator - CAT 235 C/D	1	125	$ 181.94
			Labourers	2	125	$ 204.59
Excavation: Rock	$ 26.86	cu. m	Air track drill rig	1	15	$ 284.72
			Excavator - CAT 235 C/D	0.2	15	$ 181.94
			Trucks: CAT 740	0.4	15	$ 204.59
GCL: Supply and Install (For Channels)	$ 25.90	sq. m.	Labourers	4	35	$ 42.38
			Loader: Cat 966F	1	35	$ 176.94
			Material: HDPE Liner (unit rate)			$ 16.00
Geotextile: Supply and Install	$ 4.55	sq. m.	Labourers	2	250	$ 42.38
			Loader: Cat 966F	1	250	$ 176.94
			Material: Geotextile			$ 3.50
HDPE Liner: Supply and Install (For Channels)	$ 22.67	sq. m.	Labourers	4	35	$ 42.38
			Loader: Cat 966F	1	35	$ 176.94
			Material: HDPE Liner (unit rate)			$ 12.77
Lime Addition	$ 0.85	cu. m	Dozer: Cat D8	1	500	$ 249.57
			Loader: Cat 966F	1	500	$ 176.94
Regrade	$ 0.33	cu.m.	Dozer: Cat D8	1	750	$ 249.57
Rip-Rap: Drill, Blast and Stockpile	$ 24.16	cu. m	Dozer: Cat D10R/N	1	100	$ 416.38
			Drill Blast (unit rate)			$ 20.00
Rip-Rap: Screen and stockpile	$ 8.78	cu. m	Dozer: Cat D7	1	40	$ 212.93
			Loader: Cat 938G	1	40	$ 138.17
Roads: Grade	$ 0.34	m2	Grader: Cat 14G	1	460	$ 154.92
Roads: Scarify	$ 0.34	m2	Grader: Cat 14G	1	460	$ 154.92
Scale West core wall	$ 2.13	cu. m	Dozer: Cat D8	1	200	$ 249.57
			Loader: Cat 966F	1	200	$ 176.94

Worksheet 4: Quantities

Option 1B


Figure 1

Cover Placement

Assume cover of 0.5 m thick

VTF Area	Area (m^2)
Pond 1	
Consolidated Tailings Area	296,691.2
Relocated Tailings Area	251,209.9
Pond 2	12,584.7
Pond 3	221,726.8
Total	**782,212.6**

Volume 391106.3 m3

Flatten Dam Crests

Lower crest elevation by	2 m			
Dam 1 Crest Dimensions				
	5	cm =	200	m Scaled from Figure 1
	7	cm =	280	m Length
	0.2	cm =	8	m Width
	Volume to Flatten		4480	m3
Dam 2 Crest Dimensions				
	8.5	cm =	340	m Length
	0.2	cm =	8	m Width
	Volume to Flatten		5440	m3
Dam 3 Crest Dimensions				
	5	cm =	200	m Length
	4	cm =	160	m Length
		Total =	360	m Length
	0.25	cm =	10	m Width
	Volume to Flatten		7200	m3
Total Volume to Flatten			17120	m3

VTF South Hillside Tailings Relocation

Area	162862	m2
Assume tailings	0.5	m thick
Volume to relocate	81431	m3

Regrade VTF Tailings Surface

Assume	0.5	m of tailings to be regraded on average
Area to regrade	782,212.6	m2
Volume to regrade	391106.3	m3

Construct Lower North Fork Flat Creek Channel

Length of Channel [Scaled From Figure 1]						
	20	cm =			800	m Length
Assume channel width					10	m Wide
Assume Channel Depth					2	m
Assume sideslopes			3	H:	1	V
Volume to Excavate					25600	m3
	Liner Quantity				18119.29	m2
Channel Bedding layer						
	Assume				1	m of till to be placed
	Channel Perimeter				18119.29	m2
	Volume to place				18119.29	m3

Stabilize North Fork Flat Creek

Length of Channel						
	3.3	cm =			250	m Scaled from Figure 2
	23	cm =			1742.424	m Length
Assume channel width					10	m Wide
Assume Channel Depth					2	m
Assume sideslopes			5	H:	1	V
Volume to Excavate					69696.97	m3
Liner Quantity					52962.86	m2
Channel Bed Layer						
	Assume				1	m of till to be placed
	Channel Perimeter				52962.9	m2
	Volume to place				52962.86	m3

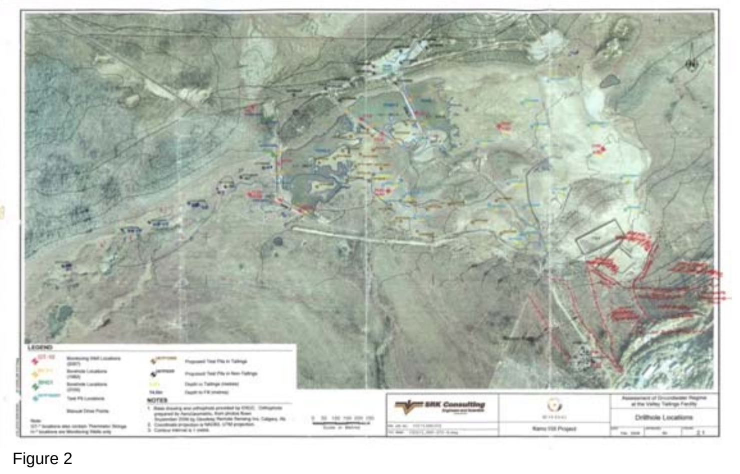


Figure 2

Porcupine Creek Diversion

Assume channel sideslopes are left untouched as they are heavily vegitated and therefore stable
Remove tailings from streambed

Length of Channel [Scaled from Figure 2]						
	16	cm =			1212.1	m Length
Assume channel width					10	m Wide
Assume tailings depth					2	m
Assume sideslopes			3	H:	1	V
Volume to Excavate					38787.88	m3
Liner Quantity					27453.47	m2
Channel Bedding layer						
	Assume				1	m of till to be placed
	Channel Perimeter				27453.47	m2
	Volume to place				27453.47	m3

Develop Brefalt and Porcupine Channel through VTF

Length of Channel [Scaled from Figure 2]						
	16.5	cm =			1250	m Length
Assume channel width					10	m Wide
Assume Channel Depth					2	m
Assume sideslopes			5	H:	1	V
Volume to Excavate					50000	m3
	Liner Quantity				37995.1	m2
Channel Bedding layer						
	Assume				1	m of till to be placed
	Channel Perimeter				37995.1	m2
	Volume to place				37995.1	m3

Appendix C3: Closure Option 2 Cost Esimate

UKHM VTF Closure Option 2 Cost Estimate

Contract Code	Work Area Code	Item	Task	Sub-task	Activity	Task	Quantity	Unit	Unit Cost	Activity Total	Subtotals	Source / Comments
CLOSURE COSTS - DIRECT CAPITAL												
Borrow Area Development											$473,096	
	1	1	1	1	Prepare Borrow Area	Clear and grub	217,448	m2	$2.18	$473,096		
Flatten profile of Dams #1, 2, 3											$10,981	
	1	2	1	1	Regrade dam crest	Dozer used to cut down dam crest	17,120	Bm3	$0.33	$5,697		
	1	2	2	1	Compact regraded material on downstream face	Compact relocated material	57,067	m2	$0.09	$5,284		
Relocate of South Valley Hillside Tailings											$91,608	
	1	3	1	1	Remove tailings from hillside	Strip tailings from hillside and place at base of hill	81,431	Bm3	$1.12	$91,608		
Relocate VTF Tailings											$31,713,245	
	1	4	1	1	Relocate candidate tailings	Excavate, haul, dump and spread within the NE Quadrant of VTF	1,739,073	Bm3	$11.48	$19,964,556		
	1	4	2	1	Procure lime	Purchase lime to amend tailings	20,530	tonnes	$500.00	$10,265,242		
	1	4	3	1	Add lime to relocated tailings	Lime addition	1,739,073	Bm3	$0.85	$1,483,446		
Cover Placement											$1,836,519	
	1	5	2	1	Place vegetative cover from Borrow Site	Excavate, haul, dump and spread within VTF	148,346	Bm3	$11.48	$1,703,007		
	1	5	3	1	Revegetate	Seed and fertilize	296,691	m2	$0.45	$133,511		
North Fork Flat Creek											$302,541	
	1	6	1	1	Establish stable channel over tailings cover	Excavate and dump tailings to create channel	15,360	Bm3	$3.96	$60,842		
	1	6	2	1		Screen and Stockpile RipRap	11,672	Bm3	$8.78	$102,452		
	1	6	3	1		Load, Haul, Dump Channel Bed RipRap	11,672	Bm3	$11.48	$133,996		
	1	6	4	1		Seed and fertilize	11,672	m2	$0.45	$5,252		
North Fork Flat Creek											$484,183	
	1	7	1	1	Establish stable channel through VTF in original ground	Excavate and dump mineral soil to create channel	28,160	Bm3	$1.46	$41,066		
	1	7	2	1		Screen and Stockpile RipRap	21,399	Bm3	$8.78	$187,828		
	1	7	3	1		Load, Haul, Dump Channel Bed RipRap	21,399	Bm3	$11.48	$245,659		
	1	7	4	1		Seed and fertilize	21,399	m2	$0.45	$9,629		
Brefalt and Porcupine Creek											$880,332	
	1	8	1	1	Establish stable channel through VTF in original ground	Excavate and dump mineral soil to create channel	51,200	Bm3	$1.46	$74,666		
	1	8	2	1		Screen and Stockpile RipRap	38,907	Bm3	$8.78	$341,506		
	1	8	3	1		Load, Haul, Dump Channel Bed RipRap	38,907	Bm3	$11.48	$446,652		
	1	8	4	1		Seed and fertilize	38,907	m2	$0.45	$17,508		
Porcupine Creek Diversion											$751,803	
	1	9	1	1	Remove tailings for streambed	Excavate, haul and dump tailings from streambed and sideslopes	38,788	Bm3	$4.73	$183,310		
	1	9	2	1		Screen and Stockpile RipRap	27,453	Bm3	$8.78	$240,973		
	1	9	3	1		Load, Haul, Dump Channel Bed RipRap	27,453	Bm3	$11.48	$315,166		
	1	9	4	1		Seed and fertilize	27,453	m2	$0.45	$12,354		
Lower North Fork Flat Creek											$532,486	
	1	10	1	1	Establish stable channel through Borrow Area	Excavate, haul and dump till to create channel	25,600	Bm3	$6.14	$157,280		
	1	10	2	1		Screen and Stockpile RipRap	18,119	Bm3	$8.78	$159,042		
	1	10	3	1		Load, Haul, Dump Channel Bed RipRap	18,119	Bm3	$11.48	$208,009		
	1	10	4	1		Seed and fertilize	18,119	m2	$0.45	$8,154		
Subtotal Direct Costs												
						Subtotal direct costs					**$37,076,793**	
CLOSURE COSTS - INDIRECT												
	100	100	1	1	Project Management	2.5% of direct costs	$ 37,076,793	x	2.5%		$926,920	
	100	100	2	1	Field Supervision	(included in major tasks)					$0	
	100	100	3	1	Contractor profit and home office overhead	10% of direct costs	$ 37,076,793	x	10.0%		$3,707,679	
	100	100	4	1	Insurance	0.5% of direct costs	$ 37,076,793	x	0.5%		$185,384	
	100	100	5	1	Bonding	0.5% of direct costs	$ 37,076,793	x	0.5%		$185,384	
	100	100	6	1	Field Engineering and QA	15% of direct costs	$ 37,076,793	x	15.0%		$5,561,519	
	100	100	7	1	Mob - Demob		1	lump	$356,722		$356,722	
	100	100	8	1	Living out allowances	Camp housing costs for a construction crew of 12	1,931	days	$77.00	17	$2,527,679	
	100	100	9	1	Taxes	7% of taxable direct and indirect costs	$ 40,585,043	x	7.0%		$2,840,953	
Subtotal Indirect Costs												
					Subtotal indirect costs						**$16,292,240**	
CLOSURE COSTS - CONTINGENCY												
					Contingency	20% of direct costs	$37,076,793	x	20.0%		**$7,415,359**	
CLOSURE COSTS - TOTAL												
					Total direct and indirect costs						**$60,784,392**	

Worksheet 1: Unit Costs

EQUIPMENT RATES

=Adjustable Factors

Equipment	BC Blue Book Rate 2008[1]	Adjustment Factor to Kitsault Site	Fuel Adjustment Factor: HP	Incremental Fuel Cost ($/L)	Incremental Fuel Operating Cost ($/hr)[2]	All-Inclusive Rate ($/hr)
Excavator - CAT 325 C/D	$ 160.15	1.1	222	$ 0.20	$ 5.77	$ 181.94
Excavator - CAT 330	$ 174.80	1.1	222	$ 0.20	$ 5.77	$ 198.05
Excavator - CAT 350	$ 261.00	1.1	428	$ 0.20	$ 11.13	$ 298.23
Loader: Cat 966F	$ 155.30	1.1	235	$ 0.20	$ 6.11	$ 176.94
Loader: Cat 938G	$ 122.30	1.1	140	$ 0.20	$ 3.64	$ 138.17
Std 10 cyd truck (7.6 m3)	$ 72.15	1.1	222	$ 0.20	$ 5.77	$ 85.14
Trucks: Cat 769D	$ 186.75	1.1	518	$ 0.20	$ 13.47	$ 218.89
Trucks: Cat D350	$ 177.95	1.1	340	$ 0.20	$ 8.84	$ 204.59
Dozer: Cat D7	$ 187.90	1.1	240	$ 0.20	$ 6.24	$ 212.93
Dozer: Cat D8R/N	$ 219.55	1.1	310	$ 0.20	$ 8.06	$ 249.57
Dozer: Cat D10R/N	$ 365.05	1.1	570	$ 0.20	$ 14.82	$ 416.38
Dozer: Cat D11R	$ 415.60	1.1	850	$ 0.20	$ 22.10	$ 479.26
Roller: Cat CP553 / CP563	$ 102.15	1.1	130	$ 0.20	$ 3.38	$ 115.75
Roller: Walk-behind vibrating (30 in)	$ 13.30	1.1	12	$ 0.20	$ 0.31	$ 14.94
Grader: Cat 14G	$ 135.75	1.1	215	$ 0.20	$ 5.59	$ 154.92
Hydraulic Drill, 200cfm screw-type	$ 328.05	1.1	196	$ 0.20	$ 5.10	$ 365.95
Air track drill rig (900cfm)	$ 253.75	1.1	215	$ 0.20	$ 5.59	$ 284.72

1. Rate includes Ownership, Repair, Maintenance, Operator and Fuel (@ $0.50/L) costs
2. Fuel Operating Cost Formula from BC Blue Book

UNIT COSTS

Item	Unit Cost	Unit	Remark / Source
Earthworks			
Haul Road: Construct	$200.00	m	Colomac 2005 estimate
Access Road: Construct	$12.00	m	based on 3m wide by .5m high fill at $8.00/m3
Backfill/compact excavated ditches	$4.73	m3	see unit rate calcs
Clearing land	$1.51	m2	see unit rate calcs
Clearing and Grubbing	$2.18	m2	see unit rate calcs
Compaction: channel materials	$0.76	m2	see unit rate calcs
Compaction: Machine rolled	$0.09	m2	see unit rate calcs
Dozer: Regrading	$0.33	m3	see unit rate calcs
Drilling and Blasting	$20.00	Bm3	Costworks
Excavation: Channels (no haul)	$3.96	Lm3	see unit rate calcs
Grading: roads, ramps, etc.	$0.34	m2	see unit rate calcs
Lime Addition	$0.85	m3	see unit rate calcs
Rip-Rap: Drill, Blast and Stockpile	$24.16	m3	see unit rate calcs
Rip-Rap: Screen and Stockpile	$8.78	Lm3	see unit rate calcs
Rip-Rap rock placement	$4.55	Lm3	see unit rate calcs; excavator cost only
Scale Core Wall	$2.13	Bm3	see unit rate calcs
Scarify Roadways	$0.34	m	see unit rate calcs
Revegetation			
Native grass seeding	$0.40	m2	=revegetation - fertilization
Fertilization	$0.05	m2	D. Hockley - Red Dog cost estimate (pellets)
Revegetation	$0.45	m2	Min=Costworks, Max=assumption of $4500 per hectare (estimated from Faro FWSD work)
Relocations			
See Unit Cost Relocations Worksheet			
Personnel Rates			
Survey [GPS Crew - Surveyor, Assistant, Truck, Survey GPS]	$235.00	hr	Yukon Engineering Services (June, 2009)
Technician (Consultant)	$130.00	hr	SRK-Estimate (all inclusive)
Labourers General	$42.38	hr	Yukon Gov. Fair Wage Sched. Apr. 2008 (112% Loading Rate Added)*
Supervisor	$74.20	hr	Yukon Gov. Fair Wage Sched. Apr. 2008 (112% Loading Rate Added)*
Note: Loading Rate includes allowances for (EI, CPP, MSP/Benefits/Travel/OT)			
Materials			
Hydrated Lime [$Ca(OH)_2$]	$500.00	tonne	From Brad Thrall, February 2009
Geotextile (purchased/installed)	$4.55	m2	See unit rate calc; (cost of Geotextile= $3.50 from Yukon Pump quote, Aug. 2004)
Bitumen Liner	$24.60	m2	Quote: Kitsault Feb. 2006 (Coletanche ES1)
Geosynthetic Clay Liner (purchased/installed)	$25.90	m2	see unit rate calcs; material cost estimated
HDPE liner installed (for channels)	$22.67	m2	See unit rate calc; (cost of HDPE=$12.77 from Yukon Pump quote, Aug. 2004)

Worksheet 2: Unit Costs Relocations

Relocation Productivities and truck #'s obtained from 'Master_Waste_Rock_Relocation' spreadsheet, using the equipment, route and other parameters listed below

Relocation Table

							Productivities				Equipment Used				Haul Route Information														Other Hauling Parameters Used			
															Segment 1		Segment 2		Segment 3		Segment 4		Segment 5		Segment 6		Segment 7					
Area	Activity	Material	Bulking Factor	Source	Destination	Distance (1-way)	Unit Rate (Lm3/hr)	Productivity (Lm3/hr)	Unit Rate (Bm3/hr)	Productivity (Bm3/hr)	Equipment	Type	Quantity	Rate ($/hr)	Grade (%)	Distance (km)	Grade (%)	Distance (km)	Grade (%)	Distance (km)	Grade (%)	Distance (km)	Grade (%)	Distance (km)	Grade (%)	Distance (km)	Grade (%)	Distance (km)	# of Supervisors	Supervisior Rate ($/hr)	Fuel ($/L)	Meal and Accomodation ($/person/day)
South VTF Hillside	Tailings Relocation	Tailings	1	VTF South Hillside	NE Quadrant of VTF	0.85	$ 1.12	351	$ 1.12	351	Excavator	CAT 325C/D	1	$ 181.94	-5	0.7	-1	0.15											1	74.2	-	0
	Excavate, spread										Truck	CAT D35	0	$ 204.59																		
											Dozer	CAT D7	1	$ 212.93																		
Tailings Relocation	Excavate, haul, dump, spread	Tailings	1	VTF West Side	NE Quadrant of VTF	2	$ 6.78	209.2	$ 11.48	209	Excavator	CAT 325C/D	1	$ 181.94	0	0.5	0	0.6	0	0.4									1	74.2	-	0
											Truck	CAT D35	5	$ 204.59																		
											Dozer	CAT D7	1	$ 212.93																		
NFFC Channel	Load, Haul Dump Channel Bed	RipRap	1.00	Borrow Area	VTF	1.2	$ 6.57	209.2	$ 11.48	209	Loader	CAT 938	1	$ 138.17	0	0.2	0	0.6	0	0.4									1	74.2	-	0
											Truck	CAT D35	5	$ 204.59																		
											Dozer	CAT D7	1	$ 212.93																		
BC & PC Channel	Develop Channel	Mineral Soil	1.30	VTF West Side	VTF	0.5	$ 1.12	352	$ 1.46	271	Excavator	CAT 325C/D	1	$ 181.94	0	0.5													1	74.2	-	0
NFFC Channel	Excavate, spread										Truck	CAT D35	0	$ 204.59																		
											Dozer	CAT D7	1	$ 212.93																		
BC & PC Channel	Load, Haul Dump Channel Bed	RipRap	1.00	Borrow Area	VTF	1.2	$ 6.57	209.2	$ 11.48	209	Loader	CAT 938	1	$ 138.17	0	0.2	0	0.6	0	0.4									1	74.2	-	0
NFFC Channel											Truck	CAT D35	5	$ 204.59																		
											Dozer	CAT D7	1	$ 212.93																		
PCD Channel	Excavate, haul and dump tailings from streambed and sideslopes	Tailings	1.00	VTF West Side	VTF	0.5	$ 4.73	300	$ 4.73	300	Excavator	CAT 325C/D	1	$ 181.94	0	0.5													1	125	-	0
											Truck	CAT D35	5	$ 204.59																		
											Dozer	CAT D7	1	$ 212.93																		
PCD Channel	Load, Haul Dump Channel Bed	RipRap	1.00	Borrow Area	VTF	1.2	$ 6.57	209.2	$ 11.48	209	Loader	CAT 938	1	$ 138.17	0	0.2	0	0.6	0	0.4									1	125	-	0
											Truck	CAT D35	5	$ 204.59																		
											Dozer	CAT D7	1	$ 212.93																		
Lower NFFC Channel	Excavate, haul and dump till to create channel	Till	1.30	Borrow Area	Borrow Area	0.7	$ 4.73	300	$ 6.14	231	Excavator	CAT 325C/D	1	$ 181.94	0	0.2	0	0.6	0	0.4												
											Truck	CAT D35	5	$ 204.59																		
											Dozer	CAT D7	1	$ 212.93																		
Lower NFFC Channel	Load, Haul Dump Channel Bed	RipRap	1.00	Borrow Area	Borrow Area	0.7	$ 6.57	209.2	$ 11.48	209	Loader	CAT 938	1	$ 138.17	0	0.2	0	0.6	0	0.4												
											Truck	CAT D35	5	$ 204.59																		
											Dozer	CAT D7	1	$ 212.93																		
Vegetative Cover	Excavate, haul, dump, spread	Till	1.30	Borrow Area	VTF	1.2	$ 6.57	209.2	$ 11.48	161	Loader	CAT 938	1	$ 138.17	0	0.2	0	0.6	0	0.4									1	74.2	-	0
											Truck	CAT D35	5	$ 204.59																		
											Dozer	CAT D7	1	$ 212.93																		

Worksheet 3: Unit Rate Calculations

Task	All-Inclusive Unit Rate	Unit	Equipment	# of Equipment	Productivity (unit/hour)	All Inclusive Unit Rate ($/hr)
Berm: Shape Berm Material	$ 4.55	lm	Excavator - CAT 235 C/D	1	40	$ 181.94
Clear	$ 1.51	sq. m.	Dozer: Cat D10	1	275	$ 416.38
Clear/Grub	$ 2.18	sq. m.	Dozer: Cat D10	1	275	$ 416.38
			Excavator - CAT 235 C/D	1	275	$ 181.94
Compaction: Wheeled-roller	$ 0.09	sq. m.	Compactor: CAT CP553	1	1250	$ 115.75
Compaction: Channel materials	$ 0.76	sq. m.	Labourers	2	125	$ 40.00
			Vibrator	1	125	$ 14.94
Excavation: channel (no haul)	$ 3.96	cu. m	Excavator - CAT 330	1	50	$ 198.05
Backfill excavated ditches	$ 4.73	cu. m	Excavator - CAT 235 C/D	1	125	$ 181.94
			Labourers	2	125	$ 204.59
Excavation: Rock	$ 26.86	cu. m	Air track drill rig	1	15	$ 284.72
			Excavator - CAT 235 C/D	0.2	15	$ 181.94
			Trucks: CAT 740	0.4	15	$ 204.59
GCL: Supply and Install (For Channels)	$ 25.90	sq. m.	Labourers	4	35	$ 42.38
			Loader: Cat 966F	1	35	$ 176.94
			Material: HDPE Liner (unit rate)			$ 16.00
Geotextile: Supply and Install	$ 4.55	sq. m.	Labourers	2	250	$ 42.38
			Loader: Cat 966F	1	250	$ 176.94
			Material: Geotextile			$ 3.50
HDPE Liner: Supply and Install (For Channels)	$ 22.67	sq. m.	Labourers	4	35	$ 42.38
			Loader: Cat 966F	1	35	$ 176.94
			Material: HDPE Liner (unit rate)			$ 12.77
Lime Addition	$ 0.85	cu. m	Dozer: Cat D8	1	500	$ 249.57
			Loader: Cat 966F	1	500	$ 176.94
Regrade	$ 0.33	cu.m.	Dozer: Cat D8	1	750	$ 249.57
Rip-Rap: Drill, Blast and Stockpile	$ 24.16	cu. m	Dozer: Cat D10R/N	1	100	$ 416.38
			Drill Blast (unit rate)			$ 20.00
Rip-Rap: Screen and stockpile	$ 8.78	cu. m	Dozer: Cat D7	1	40	$ 212.93
			Loader: Cat 938G	1	40	$ 138.17
Roads: Grade	$ 0.34	m2	Grader: Cat 14G	1	460	$ 154.92
Roads: Scarify	$ 0.34	m2	Grader: Cat 14G	1	460	$ 154.92
Scale West core wall	$ 2.13	cu. m	Dozer: Cat D8	1	200	$ 249.57
			Loader: Cat 966F	1	200	$ 176.94

Worksheet 4: Quantities

Option 1

Cover Placement

Assume cover of 0.5 m thick

VTF Area	Area (m^2)
Pond 1	
Consolidated Tailings Area	296,691.2
Relocated Tailings Area	251,209.9
Pond 2	12,584.7
Pond 3	221,726.8
Total	296,691.2

Volume 148345.6 m3

Flatten Dam Crests

Lower Crest elevation 2 m

Dam 1 Crest Dimensions

5	cm =	200 m	Scaled from Figure 1
7	cm =	280 m	Length
0.2	cm =	8 m	Width
Volume to Flatten		4480 m3	

Dam 2 Crest Dimensions

8.5	cm =	340 m	Length
0.2	cm =	8 m	Width
Volume to Flatten		5440 m3	

Dam 3 Crest Dimensions

5	cm =	200 m	Length
4	cm =	160 m	Length
	Total =	360 m	Length
0.25	cm =	10 m	Width
Volume to Flatten		7200 m3	

Volume to Flatten 17120 m3

Tailings to be Relocated - With 0.5 m Over Excavation

VTF Area	Volume (m^3)
Pond 1	
Consolidated Tailings Area	
Relocated Tailings Area	1,147,670.6
Pond 2	42,431.0
Pond 3	467,540.2
Total	1,657,641.8

VTF South Hillside Tailings Relocation

Area	162862 m2
Assume tailings	0.5 m thick
Volume to relocate	81431 m3

Total Volume of Tailings and Overexcavation to relocate 1,739,072.8 m3

Lime Addition to Relocated Tailings

Assume average Field Bulk Density of tailings	1.97	
Mass of tailings and overexcavation	3,421,747.5	tonnes
Assume lime addition rate of	6	kg $Ca(OH_2)$/tonne of tailings
Lime required	20,530.5	tonnes $Ca(OH_2)$

Regrade VTF Tailings Surface

Assume	0.5 m of tailings to be regraded on average
Area to regrade	296,691.2 m2
Volume to regrade	148345.6 m3

Construct Lower North Fork Flat Creek Channel

Total Length of Channel - Scaled From Figure 1

	20	cm =	800 m	Length
Assume channel width			10 m	Wide
Assume Channel Depth			2 m	
Assume sideslopes	3	H:	1	V
Volume to Excavate			25600 m3	
Liner Quantity			18119.28851 m2	

Channel Bedding layer

Assume	1 m of till to be placed
Channel Perimeter	18119.28851 m2
Volume to place	18119.28851 m3

Stabilize North Fork Flat Creek over Tailings Cover

Length of Channel

	2.5	cm =	320 m	Scaled from Figure 2
	3	cm =	384 m	Length
Assume channel width			10 m	Wide
Assume Channel Depth			2 m	
Assume sideslopes	5	H:	1	V
Volume to Excavate			15360 m3	
Liner Quantity			11672.09397 m2	

Channel Bedding layer

Assume	1 m of till to be placed
Channel Perimeter	11672.09397 m2
Volume to place	11672.09397 m3

Develop North Fork Flat Creek through VTF Original Ground

Length of Channel [Scaled from Figure 2]

	5.5	cm =	704 m	Length
Assume channel width			10 m	Wide
Assume Channel Depth			2 m	
Assume sideslopes	5	H:	1	V
Volume to Excavate			28160 m3	
Liner Quantity			21398.83895 m2	

Channel Bedding layer

Assume	1 m of till to be placed
Channel Perimeter	21398.83895 m2
Volume to place	21398.83895 m3

Develop Brefalt and Porcupine Channel through VTF Original Ground

Length of Channel [Scaled from Figure 2]

	10	cm =	1280 m	Length
Assume channel width			10 m	Wide
Assume Channel Depth			2 m	
Assume sideslopes	5	H:	1	V
Volume to Excavate			51200 m3	
Liner Quantity			38906.97991 m2	

Channel Bedding layer

Assume	1 m of till to be placed
Channel Perimeter	38906.97991 m2
Volume to place	38906.97991 m3

Porcupine Creek Diversion

Assume channel sideslopes are left untouched as they are heavily vegitated and therefore stable

Remove tailings from streambed

Length of Channel [Scaled from Figure 3]

	3.3	cm =	250 m	Scaled from Figure 3
	16	cm =	1212.1 m	Length
Assume channel width			10 m	Wide
Assume tailings depth			2 m	
Assume sideslopes	3	H:	1	V
Volume to Excavate			38787.87879 m3	
Liner Quantity			27453.46744 m2	

Channel Bedding layer

Assume	1 m of till to be placed
Channel Perimeter	27453.46744 m2
Volume to place	27453.46744 m3

Figure 1

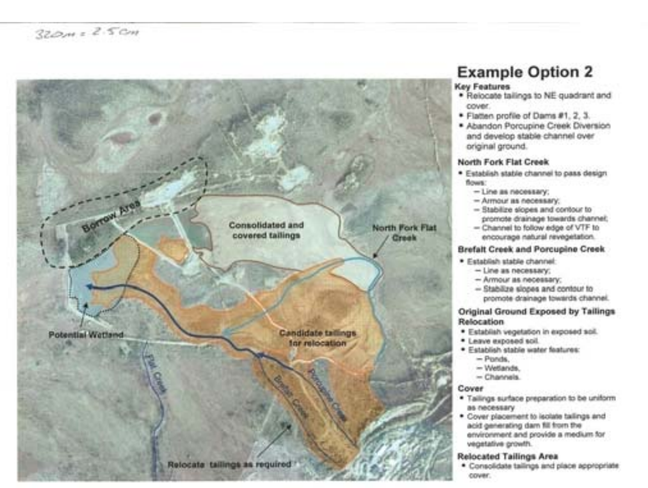


Figure 2

Figure 3