Pony Creek Adit Bulkhead, Mt Nansen, Yukon

Prepared for:

Department of Energy, Mines and Resources
Assessment and Abandoned Mines Branch
Yukon Government

Prepared by:

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Pony Creek Adit Bulkhead, Mt Nansen, Yukon

Department of Energy, Mines and Resources
Assessment and Abandoned Mines Branch

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1 Introduction

The Yukon Government Department of Energy, Mines and Resources has determined that release of the water within the Mt. Nansen pit directly to Pony Creek will result in impacts to surface water quality. Consequently, means to prevent overflow from the pit via the Pony Adit to the creek are required. In recent years this has been achieved by periodically pumping out the pit water and treating it. A longer term solution is needed.

There are three general types of solutions which could be employed to prevent/reduce impacts to surface water:

- prevent or reduce inflow to the pit;
- modify conditions within the pit so that the water is of acceptable quality to discharge, and
- construct a barrier to outflow in the adit.

Option 3, a seepage barrier is the focus of this project. However, benefits may also be achieved with Options 1 or 2. It is recommended that these options be examined in conjunction with the measures described in this report.

2 Objectives

The objective of this project is to provide a design for a hydraulic bulkhead to prevent flow of pit water through the Pony Creek Adit. The scope of work included:

- Undertaking a site investigation;
- Providing a design, specifications, construction procedures and estimated material requirements such that the work can be carried out by local third-party contractors;
- Specifying what level of engineering supervision and inspection is required during the installation of the bulkhead; and
- Specifying any post-construction requirements or inspections that may be necessary.

After the site investigation and prior to the design work, alternative bulkhead designs were assessed. The results are also presented herein.

3 Background

Mining of the Mt. Nansen deposit was conducted between 1996 and early 1999 by open pit methods. The open pit mined through an exploration adit which had been developed in the 1960's. Since the end of mining, water accumulation in the pit has produced a small body of water which, if not managed, would discharge to Pony Creek via the adit. Figures 1 and 2 show the mine workings in plan view and cross-section.

Pit water quality has zinc levels in the order of 1 – 2 mg/l, which exceed the concentration of 0.5 mg/L that is licensed for direct discharge from the site.

A 2004 report by GLL suggests that there has been a gradual improvement in pit water quality. "Most metal concentrations appear to be highest in the pit lake water samples that were sampled immediately after closure (e.g. October 22, 1998 – September 29, 1999) after which they decrease in the pit lake water with time." (page 44, 3rd paragraph). These results suggest that a permanent bulkhead may not be necessary.

Recent studies by Gartner Lee have found that the pit water level cycles annually, increasing in the spring and summer followed by a decline over the winter. There is a net accumulation each year resulting in a gradual rise in water level, but there is also a loss of pit water to the environment via groundwater pathways. The escaping seepage appears to have no adverse effect on Pony Creek. These results suggest that slow seepage via groundwater, as opposed to un-attenuated flow out the adit, may be acceptable.

There is insufficient information to determine the equilibrium level of the pit water if there were no leakage via the adit. It is possible, although not likely, that this level is above the south rim of the pit (approximately 10 meters above the roof of the adit). A very low permeability bulkhead could result in a large body of contaminated water and unregulated discharge to surface once the pit fills.

4 Geotechnical Evaluation

An assessment of the underground conditions and rock quality was conducted by Bruce Murphy in the fall of 2005.

4.1 General Adit Conditions

4.1.1 Portal Condition

The current portal area has been loaded out until a relatively stable rock face was achieved and the overburden material stopped failing.

4.1.2 Adit Geometry and Ground Conditions

From the portal, to the point where the tunnel enters the pit, the approximate length of the adit is 165.0 m and the average size is 2.0 m high by 1.8 m wide.

The adit is within diorite rock types with the level of alteration increasing substantially in the area of the orebody within the Brown McDade pit. Pervasive propylitic and argillic alteration starts to take effect from a point 110.0 m into the adit and at 125.0 m the ground conditions deteriorate substantially. It is in this area where the frequency of rockfalls and signs of potential instability have increased.

4.1.3 Geology and Geotechnical Observations

General and geotechnical conditions of the adit were inspected and mapped on September 16th, 2005:

- The results of the mapping reveal that nearly all of the main fractures and faults are oriented parallel to sub-parallel to the ore zone. No major structures were observed which were sub-parallel to the adit. (The detailed evaluation of the ground conditions along the length of the adit is included in Appendix A, which indicates the location of the major structures, rockmass description and the suitability of the sections of the adit to a bulkhead installation.).
- The adit excavation is unsupported except for the first ± 5.0 m at the Pony Creek portal side, which is supported with rudimentary timber sets at a 1.5 – 2.0 m spacing.
- There was some seepage occurring in the first 15 m of the adit from the portal sides, water was also coming down from the overburden material, along the rock face. Conditions within the adit were damp and cold and there was some water on and around the ice on the floor, but no areas of high seepage were noted.
- At the time of the site visit there was in places about 15 – 20 cm of ice on the floor of the adit. This was not along the total section of the drift, but in lower isolated areas.

4.2 Bulkhead Location

The two best locations for construction of a bulkhead are identified in Table 1. The locations were selected based on the requirement of stable ground conditions for installation of a secure bulkhead.

Table 1: Recommended Bulkhead Location Areas

Distance from portal (m)l	Rock Condition	Comments
27 – 31	Competent in this interval only, strongly jointed d/s of location Uncertain extent/geometry of competent rock extending into walls, floor and roof of adit Low confining pressure – joints may be open	easier construction due to proximity to portal concern for ice infilling in fractures due to shallow rock cover very short interval of quality rock
95 - 110	rock is fractured and altered, alteration may reduce permeability of fractures	this location may be in alteration halo of ore zone, leading to a reduced risk of seepage by-pass as the fractures appear to have more infilling

Despite the low head to be resisted by the bulkhead and the apparently favourable geology, it is likely that both of the above will result in a leaky structure. This is due to the fractured nature of the rock and the low confining pressure, as the greatest thickness of overlying rock is only 30 m.

4.3 Rehabilitation Requirements

4.3.1 Portal Area

The overburden material above the portal will need to be scraped back to remove the currently overhanging soil/vegetation brow. This work could be undertaken with a backhoe.

Once the portal face area has been further cleaned by the backhoe, the face area will need to be inspected and barred by a competent person. Based on the assessment of the competent person, some limited spot bolting and mesh will be required to secure the rock face area. Additional timber sets will need to be installed in the immediate entrance of the portal.

If necessary, some mesh can be anchored on the road level and rolled down and anchored to protect the brow area.

4.3.2 Adit Tunnel

Within the immediate collar of the portal, over the distance 0.0 m – 15.0 m substantial additional support will be required. The recommended support is timber sets on a 2.0 m spacing with lagging on the top of the sets as required.

For the next section from 15.0 – 35.0 m the recommended support should consist of spot bolting as required. As part of the evaluation process, this section of the adit will need to be thoroughly barred down by a competent person, the material loaded out and the specific requirement for support assessed.

In the area of the bulkhead construction 27.0 – 31.0 m the level of bolting support should then be increased to a systematic pattern of 1.2 x 1.2 m on the tunnel back and upper sidewall. This requirement is based on the fact that this will be a high activity area and substantial drilling will be undertaken for the installation of shear pins, as part of the bulkhead design. In the immediate vicinity of the bulkhead (3 m upstream and downstream of the approximate location) only fully grouted rock bolts should be used so that connectivity between rock fractures is not increased.

4.3.3 Other Construction Requirements

To support work within the adit, it will also be necessary to provide for:

- Installation of ventilation; and
- Installation of piping for supply of air and water for drilling, with a compressor and water supply at the portal.

5 Bulkhead Design

5.1 Alternatives Considered

Historically, concrete slabs and massive plug-type bulkheads have been used in underground water control applications. Typically, the reinforced slab approach has been used for low head and/or short service life (duration of mining) applications. The massive plug approach is more common for high head and/or permanent (long-term post-mining) applications. In general, a reinforced slab bulkhead is the least costly approach to addressing the hydraulic thrust aspect of the design. However, it is difficult to effectively seal the rock/concrete contact in this type of bulkhead and for this reason, plugs are often constructed.

In 2004 a shotcrete bulkhead was constructed at the Giant Mine as means to get around the construction problems associated with massive plugs. Although the new bulkhead appears able to satisfy strength concerns relating to horizontal thrust, it does not appear to be suitable for control of seepage. This approach is not recommended for Mt. Nansen.

A soil plug was recently constructed in the Britannia Mine. The concept involves the use of earthen materials to address the longevity concerns associated with concrete. Select graded soils are placed and compacted in the adit to provide shear resistance and control of seepage and piping rather like the filter zones of an earth-fill dam. The so-called “millennium plug” at the Britannia Mine was the result of a research project focused on very long term performance with highly acidic water. The method has not been applied elsewhere and is probably over-designed for the Pony Creek application.

Natural ground freezing has caused the sealing of adits at several mines in the north. It is reasonable to conclude that engineered ground freezing would have a similar effect. Experience shows that simple ice plugs are not stable, and can blow out under high water pressure. Any engineered frozen plug would likely need to be combined with a structural plug, meaning that it is more appropriate as a contingency or backup method than as the primary bulkhead design.

The potentially viable options for construction of a seepage restricting bulkhead are summarized in Table 2.

Table 2: Potentially Viable Bulkhead Types

Type	Comments
Steel reinforced concrete slab	• low cost due to low concrete volume – approx. 0.4 m^3 • highest concern for leakage around bulkhead • concern for concrete curing against frozen rock • lower longevity
Massive plug	• High cost due to concrete volume – approx. 6 m^3 • Lower risk of seepage past bulkhead • Very slightly reduced concern for curing against frozen rock due to heat of hydration • Good longevity
Soil Plug	• A.K.A. "millennium plug" * • High cost • No industry standard for design or construction • Lower risk of seepage on plug/rock contact • Good longevity
Frozen plug - Thermosiphon assisted freezing of one of the above bulkhead types – freezing focused on rock contact to control seepage	• Variable cost depending upon material of construction • Best control of leakage • Variable durability • Concept proven for seepage control in dams (was used in the Mt. Nansen seepage collection dam) • Concept is novel for bulkhead construction

5.2 Design Considerations

In the case of either the slab or plug option, seepage loses could occur by one of three mechanisms, seepage through the concrete, seepage through the concrete – rock contact, and seepage through fractures in the rock around the bulkhead. Generally, the first mechanism is negligible, unless there are construction defects (cold-joints) or degradation of the concrete. Seepage through the concrete - rock contact may arise due to construction problems (filling tight to the roof) and shrinkage of the concrete on cooling. Seepage along the contact is directly related to the length of the barrier and is likely to be more severe for a slab type barrier than a plug. Seepage through the rock mass depends upon the degree and orientation of fractures. In most cases this can only be controlled by pre-grouting the rock.

The Mt. Nansen situation involves a low head and medium to possibly long-term problem. In addition, the local rock is moderately permeable as is evident by the seepage through the pit floor. Preliminary calculations using plug design criteria suggest a length of 0.13 m, which is essentially a slab type design. However, for seepage control, it is recommended (Auld, 1983) that ungrouted plugs should not be shorter than the minimum drift dimension, 2 m in this case.

Selection of the bulkhead design cannot be made without consideration of the construction issues. The key item here is that the nearest ready-mix concrete plant is in Whitehorse, which is 4 hours away in a passenger vehicle and probably over 5 hours in a concrete truck. Retarding agents can be added to concrete but there may be a reduction in strength.

Even if ready-mix concrete were available, it would be difficult to pour an entire massive plug type bulkhead without a cold joint. A massive bulkhead could be in the order of 20 m^3 (2.75 m x 2.35 m x 3 m).

The alternative to ready-mix concrete is using pre-mix bagged concrete and preparing it on-site. In the case of a reinforced slab, the pour could be completed in a single shift. Cold joints would almost certainly occur in a massive plug bulkhead, as the work would extend over 3 or more shifts.

A steel-reinforced concrete slab appears to be the most appropriate bulkhead design. That option is a proven method to prevent direct water outflow, and it has the minimum requirement for concrete and therefore the minimum risk of creating cold seams. The disadvantages are that it cannot be guaranteed to prevent water seepage through the rock around the bulkhead and it has a limited service life. However, given the likelihood that water currently seeps through the broader rock mass, and will continue to do so in future, limited seepage around the bulkhead is not expected to be a significant concern. Furthermore, the trend of improving water quality suggests that the high cost associated with a permanent plug is not justifiable at this time.

5.3 Recommended Design

Figure 3 shows the recommend design for the reinforced concrete bulkhead. The following specific recommendations provide further detail:

1. The bulkhead should be located approximately 30 m from the portal.
2. The bulkhead should be constructed of re-inforced concrete a minimum of approximately 50 cm thick, with shear pins to prevent movement.
3. Prior to forming the bulkhead, the rock surface would be treated with a penetrating grout to reduce the permeability of the rock in the vicinity of the bulkhead. In addition, an expansive waterproofing agent would be placed at the upstream edge of the concrete/rock contact; which will tend to reduce the permeability of the contact as water pressure rises.
4. The concrete should be sulphate-resisting low air-content Portland cement.
5. After pouring of the bulkhead, the concrete-rock contact at the roof would be treated with penetrating grout to seal any gap that may have opened due to settling of the concrete and to fill any high points which may have not been effectively sealed with concrete.
6. The bulkhead should include a pipe to facilitate drainage of water should that ever be necessary.

5.4 Contingency Measures

It is further recommended that two contingency measures be considered.

The first would involve a seepage collection dam (concrete wall), about 1 m high, located between the bulkhead and the portal. This structure would:

1. Impound any seepage such that it can be monitored for water quality and flow rate;

2. Provide potential to attenuate the discharge rate of any seepage which by-passes the main bulkhead; and
3. Provide a collection point should the seepage be excessive and it must pumped back to the pit.

Figure 4 presents a conceptual design for the concrete wall and V-notch weir.

The second contingency would be future installation of a thermosiphon freeze system in the event that additional seepage control is required. This would involve placement of a soil mass against the downstream side of the concrete bulkhead. Cooling pipes would be situated towards the corners of the adit so as to promote the advance of frozen conditions into the rock mass. If this contingency were required, it may be necessary to lower the water level in the pit so that there was no water against the bulkhead until frozen conditions were established because it is very difficult to freeze moving water.

The first contingency could be most economically constructed at the same time as the bulkhead. The second contingency is for future implementation only.

6 Cost Estimate

An order of magnitude cost estimate for the construction is presented in Table 3. This estimate has not been reviewed by a contractor. Unit costs are typical of northern contractor rates. Taxes, construction inspection and concrete testing are not included in the estimate.

Table 3: Construction Cost Estimate

Item		Unit	Quantity	Unit Rate	Total
Mob		each	1	$5,000	$5,000
Demob		each	1	$3,000	$3,000
Compressor & piping		day	5	$200	$1,000
Concrete mixer & pump		day	2	$500	$1,000
Pickup Truck		day	5	$150	$750
Backhoe		day	2	$1,200	$2,400
Scale, screen & bolt portal area	Foreman	hrs	8		$560
	Miner	hrs	16		$880
	Surf. Lab.	hrs	8		$360
Scale, bolt, stabilize adit	Foreman	hrs	8		$560
	Miner	hrs	16		$880
	Surf. Lab.	hrs	8		$360
Prepare bulkhead area	Foreman	hrs	8		$560
	Miner	hrs	16		$880
	Surf. Lab.	hrs	8		$360
Install shear pins & rebar, const. forms	Foreman	hrs	8		$560
	Miner	hrs	16		$880
	Surf. Lab.	hrs	8		$360
Pour concrete & clean-up for demob.	Foreman	hrs	8		$560
	Miner	hrs	16		$880
	Surf. Lab.	hrs	8		$360
Consumables					
Fuel		litre	300	$1.50	$450
Rockbolts		each	50	$25	$1,250
Concrete, bulkhead & dam		m^3	3.5	$200	$700
Concrete delivery		Est.			$1,000
Forming		Lump	1	$500	$500
Rebar		Lump			$400
Drainage pipe & valve		each	1	$400	$400
Drilling Consumables		Lump			$500
Vent fan & duct (rental)		Lump			$1,000
V-notch plate					$500
Accommodations assumed to be provided on site at no cost					
Meals		pd.			$1,160
Subtotal					**$30, 010**
Contingency			**30%**		**$9,000**
TOTAL					**$39,010**

7 References

Auld, F.A, (1983). Design of Underground Plugs, International Journal of Mining Engineering.

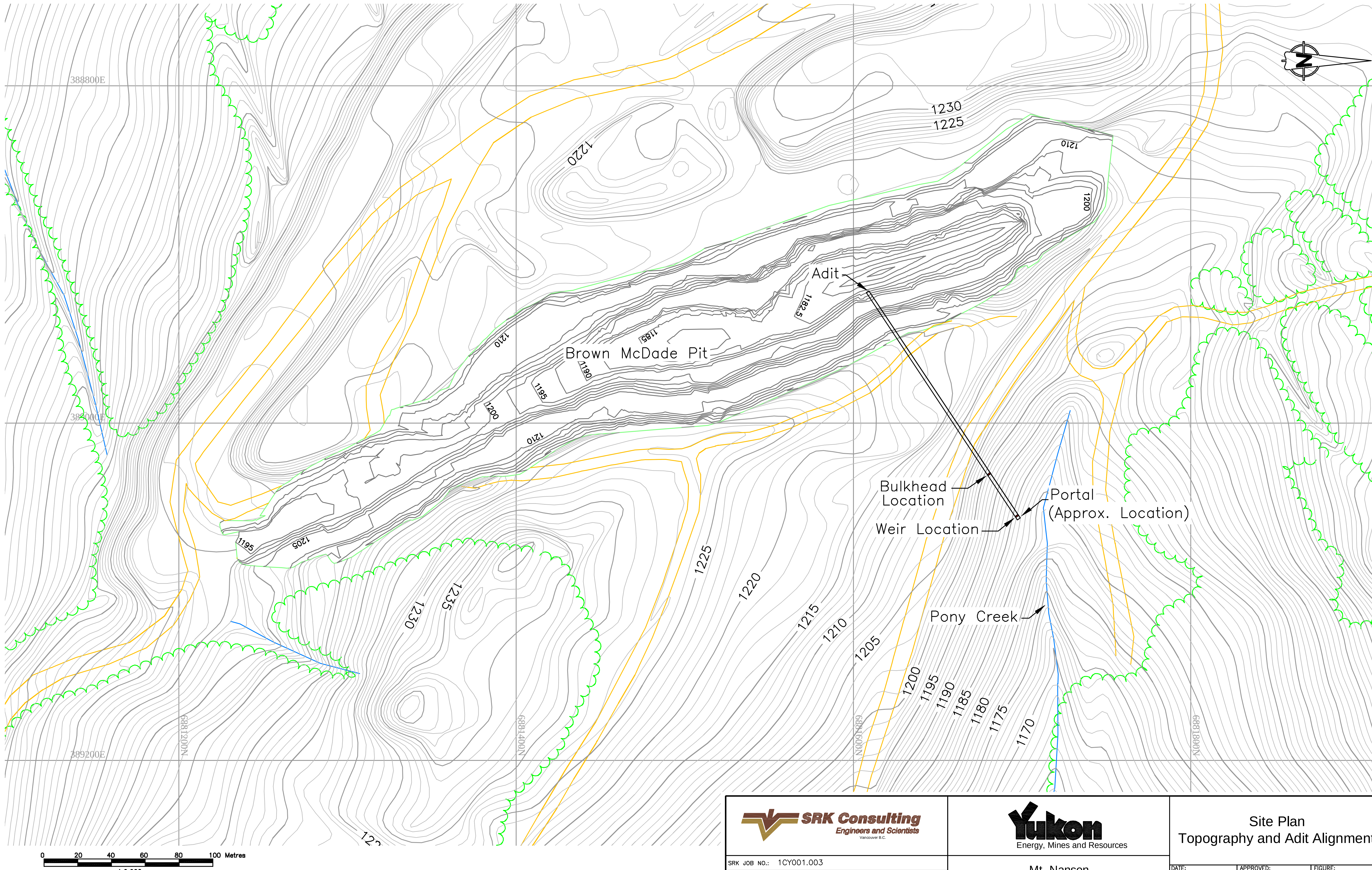
Gartner Lee Ltd., (2004). Mt. Nansen Mine Site, Brown McDade Pit Hydrogeological and Geochemical Investigation - Draft Report.

8 Professional Certification

This report, **"Pony Creek Adit Bulkhead, Mt Nansen, Yukon"**, has been prepared by SRK Consulting (Canada) Inc. under the supervision of the undersigned.

Daryl Hockley, P. Eng.
Principal

Figures



SRK Consulting Engineers and Scientists Vancouver B.C.	Yukon Energy, Mines and Resources	Site Plan Topography and Adit Alignment
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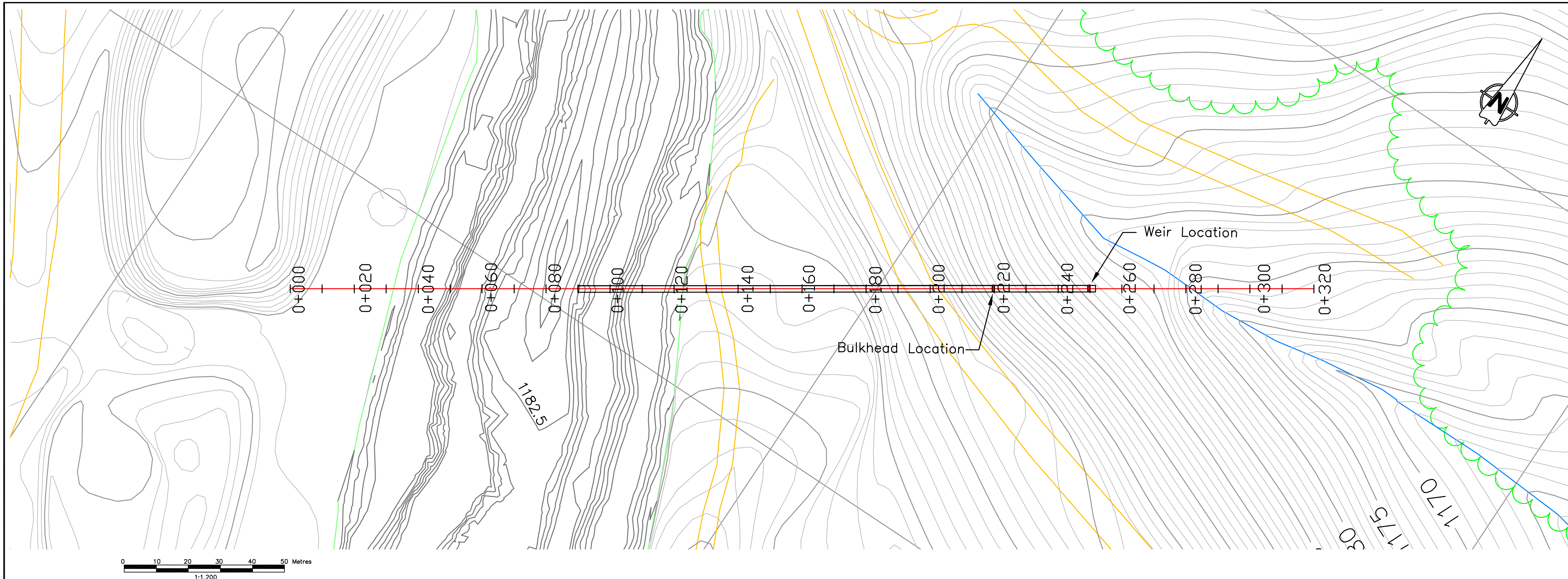
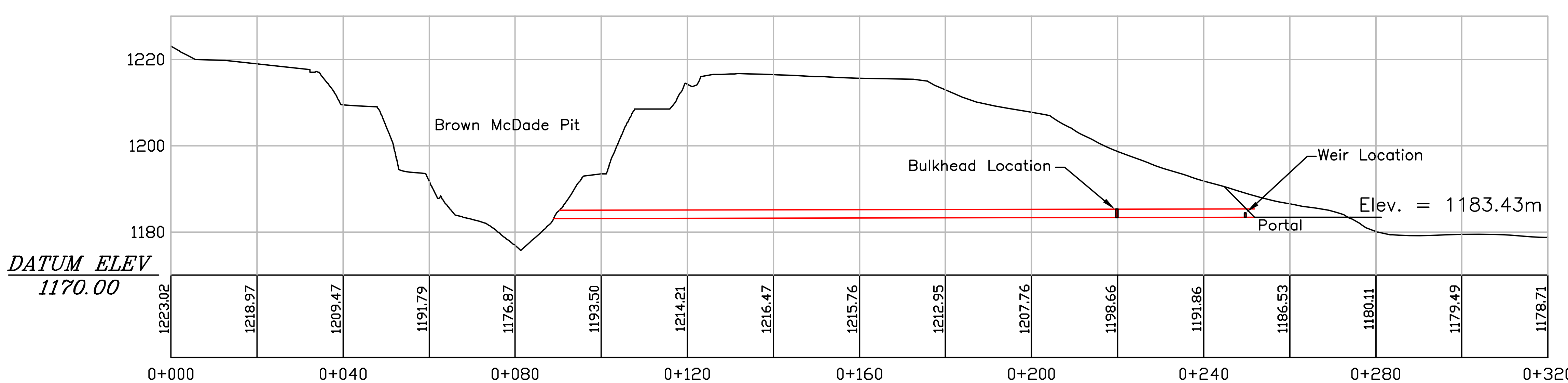
		FIGURE: 1





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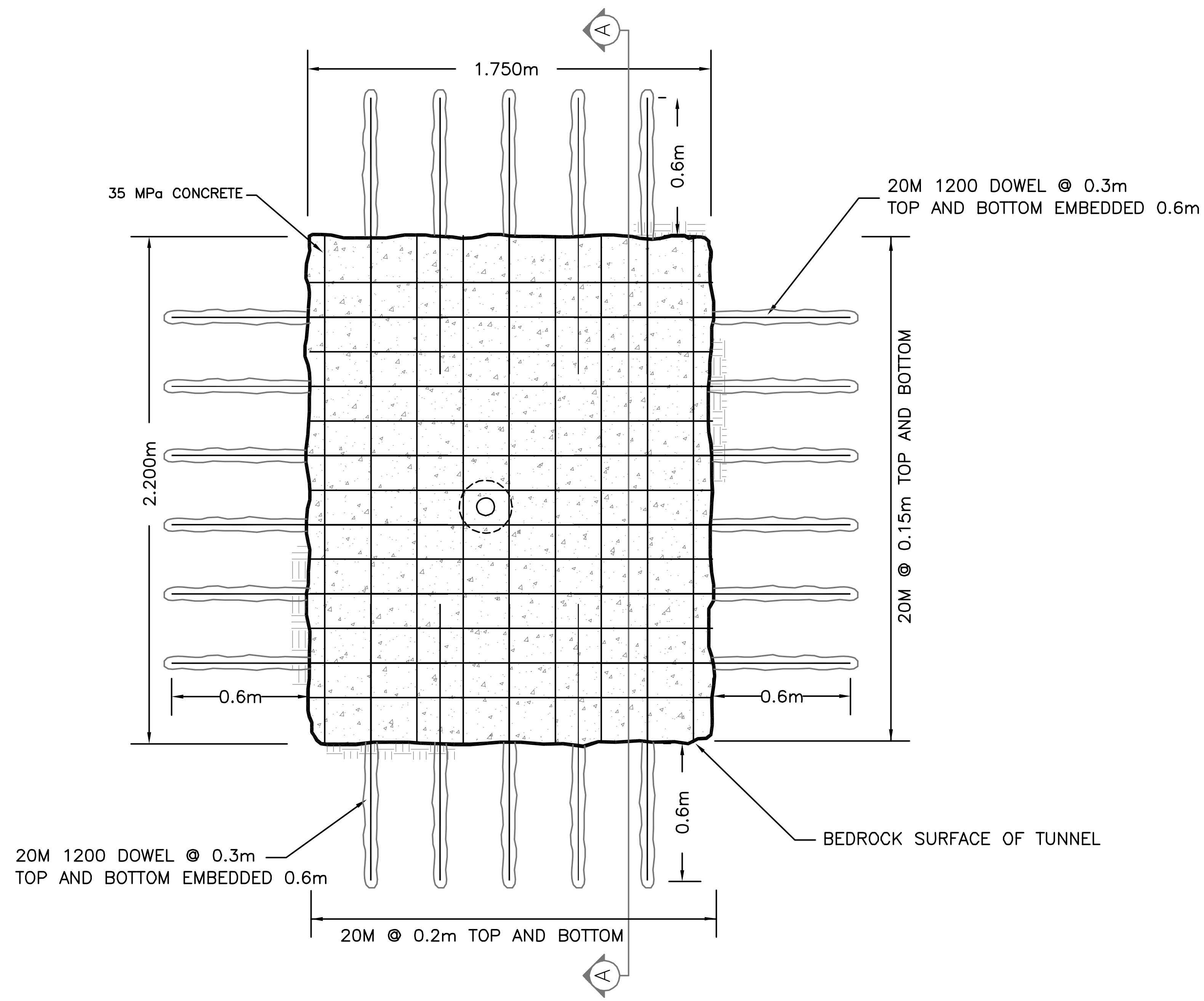

ELEVATION
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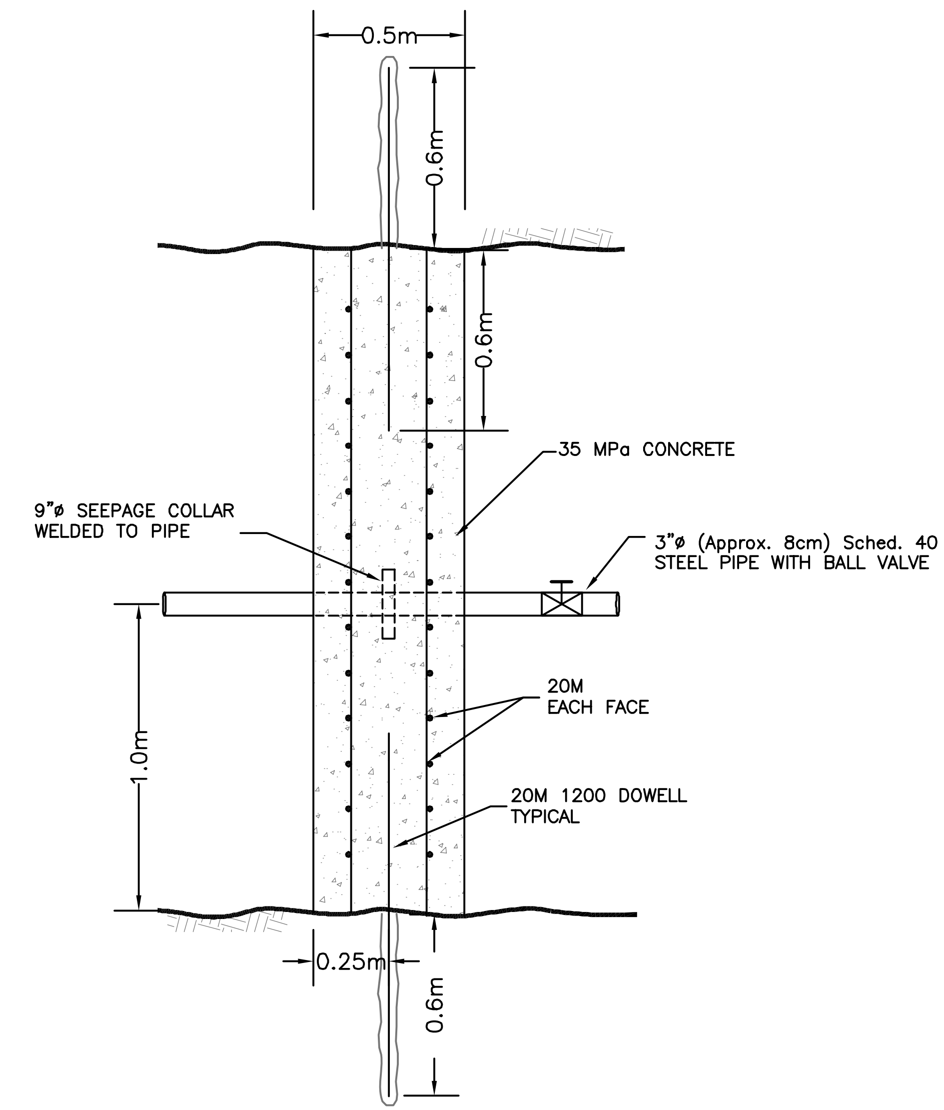

SECTION A
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SRK Consulting Engineers and Scientists Vancouver B.C.	Yukon Energy, Mines and Resources	Bulkhead Details
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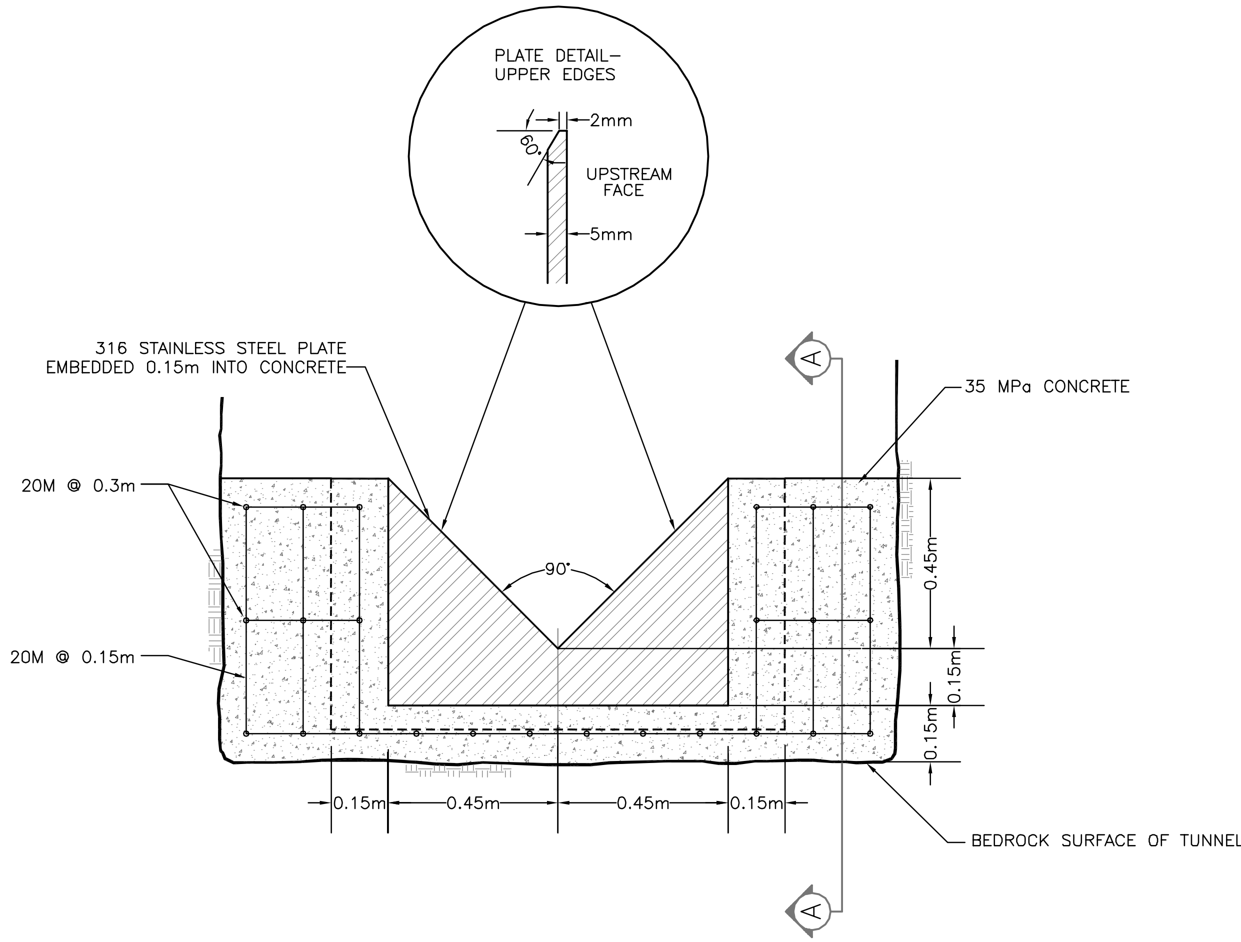

ELEVATION
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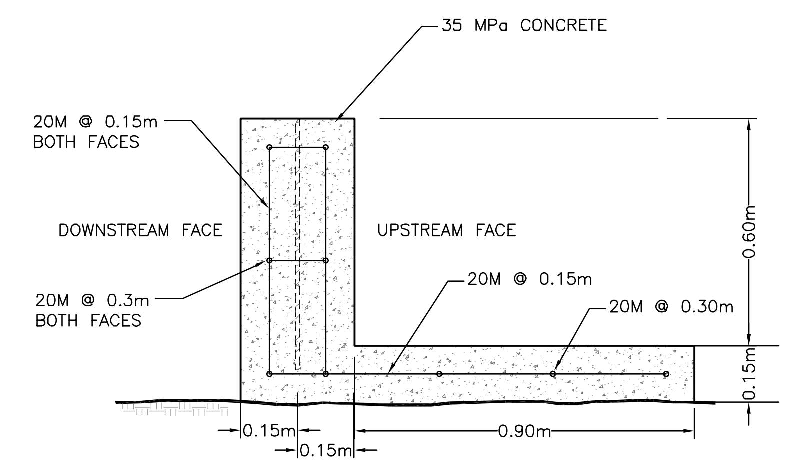

SECTION A
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V-Notch Weir Details

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		FIGURE: 4

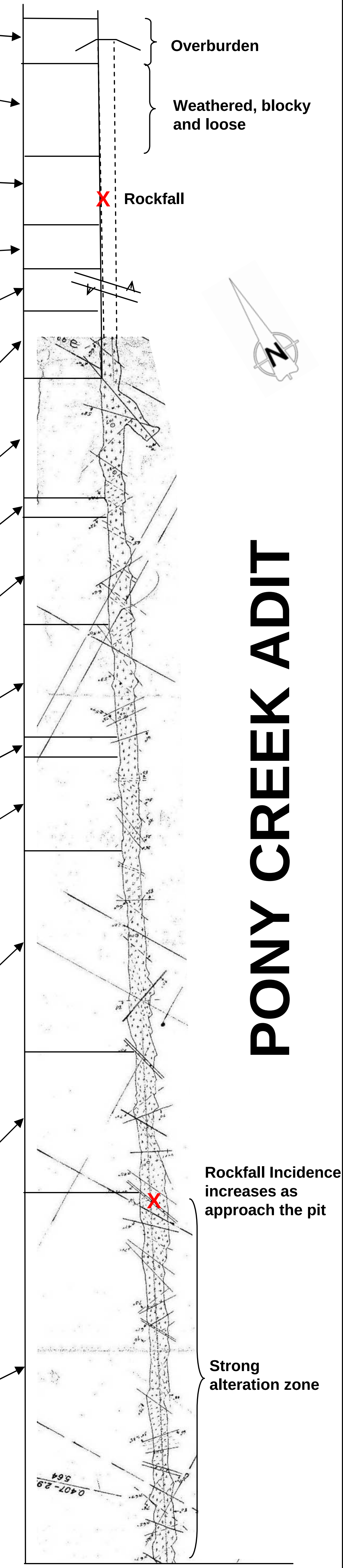
Appendix A

Geotechnical Inspection
SRK, September 16, 2005

From	To	Detail Location	Rockmass Description	Comments
0.0	5.0		Overburden, weathered rock, soil and sand. Required additional timber support in the form of timber sets and lagging before any access to get in and do any work.	Re-support work required to stabilise the portal area.
5.0	15.0		Weathered, blocky, loose, overburden area was dripping water.	
15.0	23.0		Heavily jointed, weak structures dipping towards the pit, sub-parallel to the pit (50º/245º) and other features to the northwest (60º/280º) The rock strength is higher as the material is less weathered, but there are still some large weak areas as indicated by the sidewall failure at approximately 20.0m. Some of the large structural features have altered walls of 2 - 15 cm.	Resupport work will be required before contartors can access this area.
23.0	27.0		This area is slightly more jointed and the sidewalls are more damaged by the same larger structures as in the previous zone.	Resupport work will be required before contartors can access this area.
27.0	31.0		This appears to be a good area to place a potential bulkhead, though this area still has some sheared/altered features but these are narrow. IRS:R4/R5, 3 joint sets, 1 prominent and 2 discontinuous, the third set being discontinuous: Prominent set J1 (65º/280º), planar, undulating stepped, fine non-softening. Spacing 0.5m within two swarms comining through. J2 (33º/100º):planar, planar/undulating, fine non-softening/limited fill, spacing 1.1m At 26m (W=1.76m, H=2.05m); at 27m (W=1.65m, H=2.29m). In both cases there was 0.15 - 0.2m ice on the floor	These are considered to be the most favorable rockmasss conditions within the adit, and the proximity to the portal implies the least level of difficulty. In terms of rockmass and ease of installation this is the recommended plug location.
31.0	39.0		More discontinuity features, but the ground conditions are still reasonable. Structural features are more altered. At 39m a strong structural feature is coming through (50º/285º); 0.15m commutated shear zone, some quartz fill, weak altered rock adjacent to this.	
39.0	51.0		The rockmass becomes more altered(slightly, 10 - 20%) and disturbed over this length.	
51.0	53.0		A more mafic band 25º/250º - adit direction at 245º. Reasonable ground conditions with RMR's of approximately 55 - 65 and a fracture frequency of 1.0 - 2.0/m	
53.0	65.0		Ground conditions are Fair with prominent structures being intersected by the adit excavation.	
		62.2	Weathered regional joint or fault coming through, can see that fluids have moved through this feature. 80º/286º	
65.0	77.0	75.0	Ground conditions are generally Fair with some weak zones related to the more prominent structural features. Very strong feature coming through	65.0 - 70.0m the rockmass conditions are reasonable, a possible bulkhead location position. Increased support and remediation requirements.
77.0	79.0	79.0	Strong altered zone with three mineralized shear features (58º/225º) these are 0.15 - 0.2m thick. Really is a prominent shear zone.	At 80.0 m the rockmass conditions are fairly reasonable, a possible location for a bulkhead. Increased support and remediation requirements.
79.0	85.0		The rockmass is still fair, but it is starting to show a higher level of alteration and the weaker zones around structures are becoming more prominent.	
		84.0	Strong joint which is not very altered 68º/290º	
		90.0	Strong altered shear feature: 65º/288º	
85.0	110.0	90.0	The rockmass is starting to get progressively weaker as the orebody zone is approached, more weak zones, higher levels of alteration. The estimates visual RMR is 45 - 50.	95.0 - 110m possible location for a bulkhead. Increased support and remediation requirements, Long traveling distances for material to be used in bulkhead construction. This is the closest recommended location to the pit excavation
		94.0	Strong altered shear feature: 80-110º/288º - strong fluid alteration, definitely undulating	
		95.0	Altered Joint 64º/295º and ice on the floor of the adit	
		102.0	Joint structures with some alteration, these show weaker zones that are 2. 0 - 15.0cm thick. Some clay on the structures. These features are anastomizing with variable dip. One measurement taken was 63º/290º.	
		107.5	Strong structure coming through. The rock is becoming progressively weaker and more altered as the main orebody is approached.	
		110.0	The rockmass continues to get weaker as the alteration levels increase.	
110.0	125.0		The rockmass is still, in general, Fair, but there are more Poor zones occurring related to the alteration of the intact rockmass. The rock around the major structural features coming through show a wider halo of alteration.	
		111.0	Well developed strong structures intersect the adit excavation. 80º/260º	
125.0	165.0		Level of alteration increases substantially. Oxidation levels are intense. The weak zones are up to 0.5 m thick. The number of falls of ground noted, from the back increases.	
		132.0	A large altered structure crosses through the drift, which is very weak and weathered, 58º/293º.	
		154.5	A strong structure is intersected by the adit. The rockmass condition after this point are weak and loose, with multiple falls on the ground. These poor ground conditions are related to the increased levels of alteration and shake-up due to blasting as a result of the close proximity to the pit.	
		165 m	End of adit	

Not Recommended Area

Recommended Area



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Pony Creek Adit
MT. Nansen Mine Site

Geotechnical Conditions Within the Pony Creek Adit

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Photos 1: Pony Creek portal overview

Photo 2: Portal close-up ground conditions

Photo 3: Rockmass conditions for the first 25m – View back to the portal (Note sidewall failure)

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Pony Creek Adit
MT. Nansen Mine Site

Ground Condition Photographs
Photos 1- 3

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Photo 4: Weak rockmass detail at 20m – View towards the pit

Photo 5: Rockmass conditions of North sidewall at 27 to 31m area

Photo 6: Adit back rockmass conditions at 27 to 31m area

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Pony Creek Adit
MT. Nansen Mine Site

Ground Condition Photographs
Photos 4 - 6

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Photo 7: South sidewall rockmass conditions at 27m

Photo 8: Rockmass conditions at 75m – View towards the pit

Photo 9: Rockmass conditions at 75m – View towards the adit

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Pony Creek Adit MT. Nansen Mine Site			
Ground Condition Photographs Photos 7 - 9			
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Photo 10: Strong geological feature at 75m – North wall

Photo 11: Geological structures at 102m – North wall

Photo 11: Detail of strong feature at 102m

SRK Consulting Engineers and Scientists	**Pony Creek Adit** **MT. Nansen Mine Site**
Yukon Energy, Mines and Resources	**Ground Condition Photographs** **Photos 10 - 12**

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Photo 13: Detail of feature at 111m – North wall

Photo 14: Rockmass conditions at 115m

Photo 15: Rockmass conditions at 125m – View towards the pit

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	Ground Condition Photographs **Photos 13 - 15**			
Yukon Energy, Mines and Resources	PROJECT: 1CY001.003	DATE: March 2006	APPROVED:	FIGURE:: 6

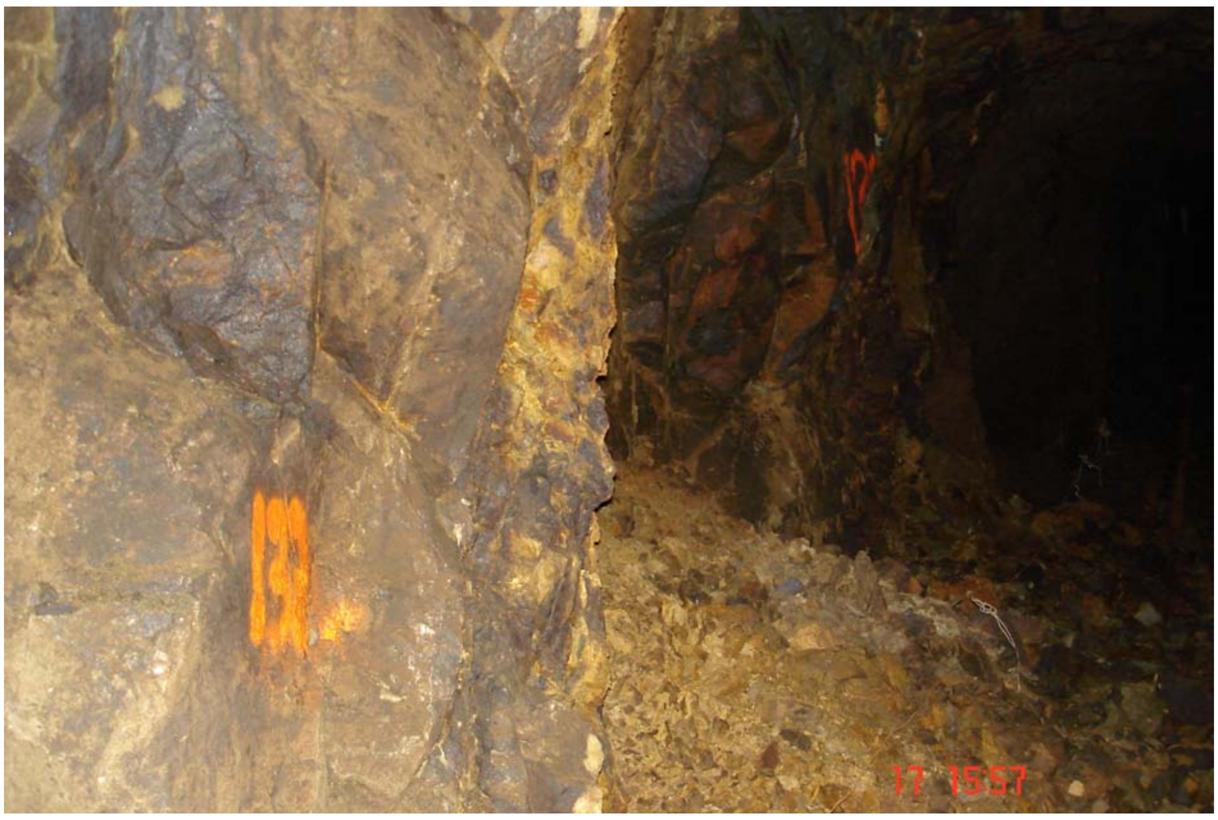

Photo 16: Rockmass poor at 132m

Photo 17: Rockmass poor at 145m – View towards the portal

Photo 18: Rockmass conditions detail at 155m – North wall

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Photos 16 - 18

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Photo 19: Weak altered rockmass at 160m – View to pit

Photo 20: NNE view indicating adit location

Photo 21: SE view of North wall

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Ground Condition Photographs
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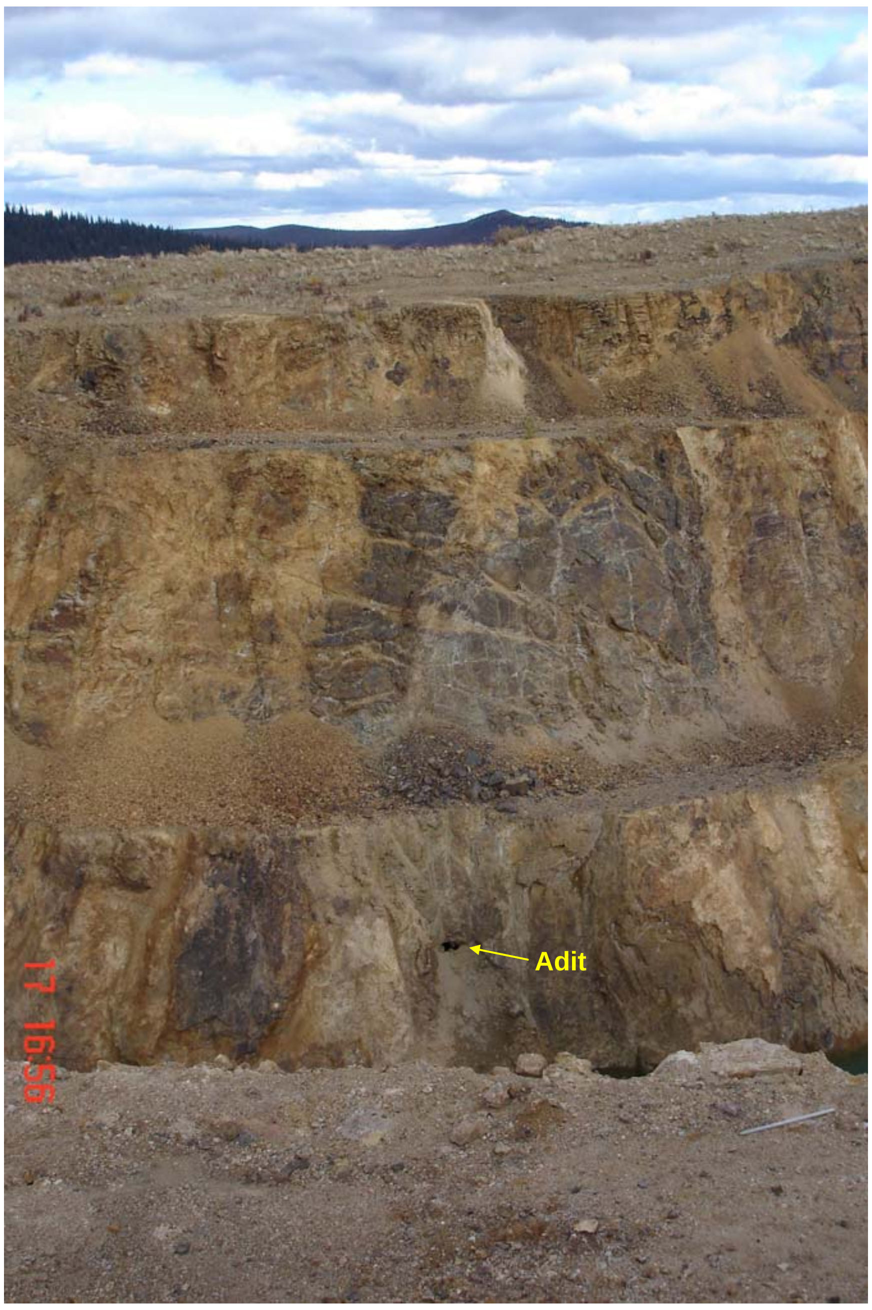

Photo 22: NE view of adit location

Photo 23: Pit adit collar close up

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Ground Condition Photographs
Photos 22 - 23

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Appendix B

Bulkhead Design

Westmar Consultants Inc., February 2006

Design Criteria

1. Bulkhead design is in accordance with the following standards:
   - CSA-A23.1-04 – Concrete Materials and Methods of Concrete Construction
   - CSA-A23.3-04 – Design of Concrete Structures

2. Design loading for the bulkhead is a uniform pressure corresponding to 35 metres of water head.

3. The design of the bulkhead is based on anchorage in to sound competent rock. An assessment of the surrounding rock shall be completed by a qualified engineer prior to the start of the work. Findings shall be reported to the Owner.

General Notes

1. General

   1.1 Materials and testing have been specified to conform to the current editions of relevant standards published by the following organizations:
   - Canadian Standards Association (CSA)
   - American Society for Testing and Materials (ASTM)

   1.2 Bulkhead dimensions shown are based on field measurements. The Contractor shall verify the dimensions of the bulkhead following preparation work and removal of any fractured rock, and advise the Engineer of actual dimensions prior to the installation of reinforcement and dowels.

   1.3 Dispose of any waste material or debris as directed by the Owner.

2. Concrete Reinforcement

   2.1 Reinforcing steel shall be hot rolled deformed billet bars to CAN/CSA-G30.18M, Grade 400R

   2.2 Welding of reinforcement is not permitted.

   2.3 Reinforcing bars shall be supplied in full lengths between bulkhead sides. Splicing of reinforcement is not permitted without approval from the Engineer.

   2.4 Reinforcing dowels in to rock shall be anchored using Hilti HIT HY150 adhesive. Alternate products will be considered. Follow the manufacture’s recommendations for drill hole sizes and working time.

3. Cast in Place Concrete

3.1 Cast in place concrete materials and methods of construction shall conform to CSA A23.1.

3.2 Select cast in place concrete mix proportions in accordance with CSA-A23.1 Alternative 1 to give the following properties:

3.2.1 Cement: Portland Cement Type HS (50)
3.2.2 Minimum Compressive Strength at 28 days: 35MPa
3.2.3 Maximum Water/Cementing Materials Ratio: 0.40
3.2.4 Exposure Class: S-1
3.2.5 Nominal Maximum Size of Coarse Aggregate: 20 mm
3.2.6 Slump at Time and Point of Discharge: 80 +/- 20 mm
3.2.7 Air Content: 4 to 7%. Spacing factor shall comply with CAN/CSA-A23.1 Clauses 4.3.3.2 and 4.3.3.3.
3.2.8 Super Plasticizing Admixture: to ASTM C1017

3.3 Clear concrete cover to the reinforcing steel shall be 75 mm

3.4 Apply a bonding agent to the rock surface prior to pouring of concrete. The proposed bonding agent shall be submitted to the Engineer for review and approval. In place of a bonding agent, the Contractor is permitted to use a cement paste in accordance with CSA A23.1.

3.5 Curing and protection

3.5.1 Cure and protect concrete in accordance with CSA-A23.1 Clause 7.4.
3.5.2 Conform to hot and cold weather requirements of ACI 305R and ACI 306R.
3.5.3 Formwork shall be left in place for a period of not less than five days.

4 Preparation

4.1 Remove all loose and fractured rock along all sides of the new bulkhead to expose only rock that is sound.

4.2 Roughen rock to a minimum 5 mm amplitude over entire surface that shall receive concrete. Ensure surface is clean and dry prior to pouring concrete.

5 Field Quality Control

5.1 Perform all concrete work in accordance with the requirements of CSA-A23.1

5.2 Inspection and testing of concrete and concrete materials shall be in accordance with CSA-A23.1 and carried out by an independent testing laboratory approved by the Owner.

5.3 Minimum concrete testing (not withstanding CSA-A23.1) shall be completed as follows:

- One “test” per batch
- One “test” per day of placement regardless of the total quantity placed that day.

A “test” shall consist of a slump test, an air-entrainment test, and samples collected for compression testing.

5.4 The Contractor shall submit a procedure for casting concrete over the full height of the bulkhead and ensuring a strong bond between the concrete and the rock. Particular attention should be paid to pouring concrete against the ceiling.

5.5 Any gaps around the perimeter that remain after concreting of the bulkhead shall be filled with an epoxy grout mixed with sand to ensure that bulkhead is water-tight.

6 Submittals

6.1 Submit certification to the Owner from the supplier that the concrete to be supplied conforms to the requirements.

6.2 Submit copies of all test results directly to the Engineer from the testing agency for review.

6.3 Submit a statement from the concrete supplier identifying the proposed source of aggregate and certifying that the proposed aggregate/cement combination will not produce deleterious expansion due to alkali-aggregate reaction.

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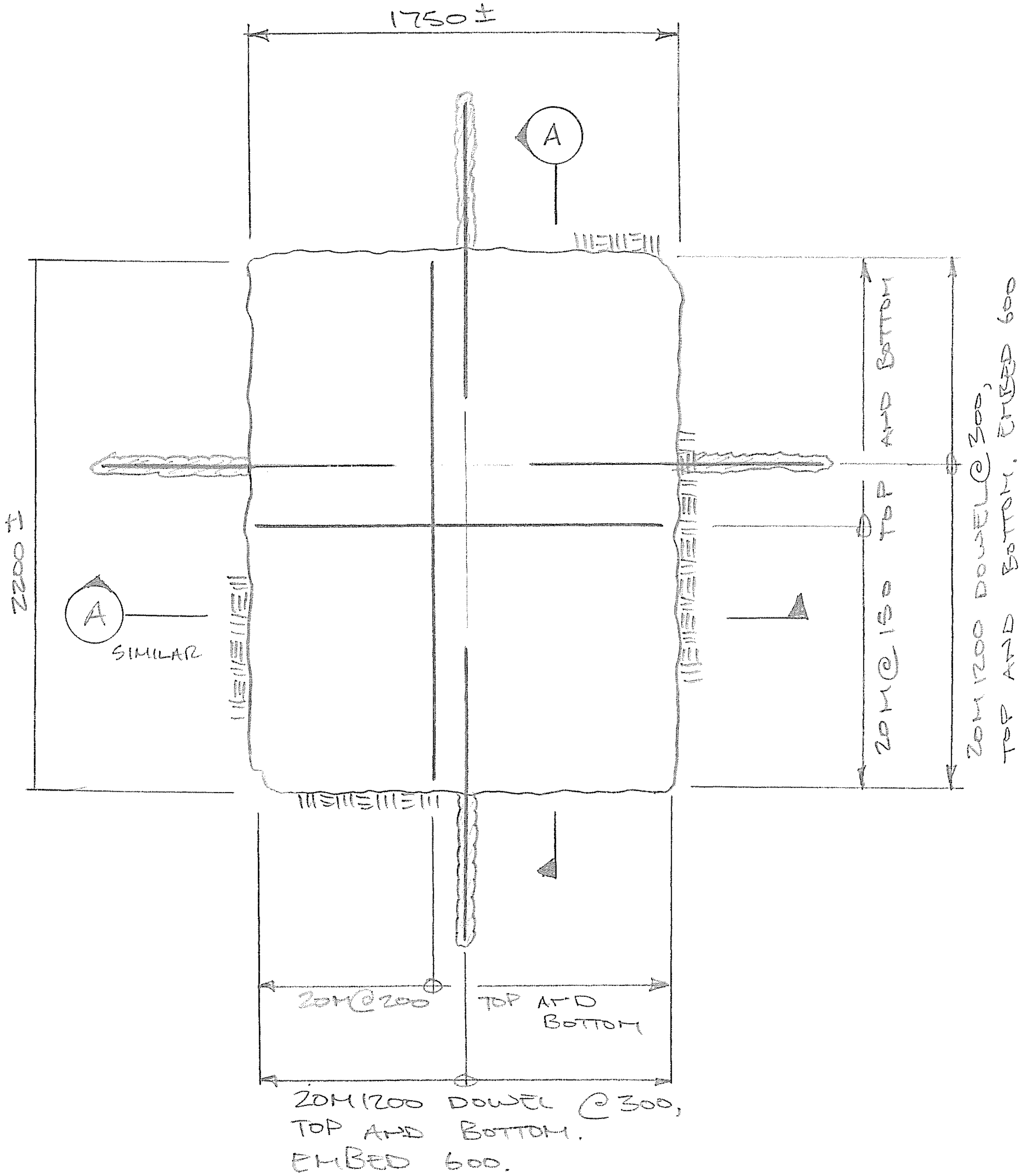
Subject BULKHEAD SK1	Ckd	Date	Job No. 06029



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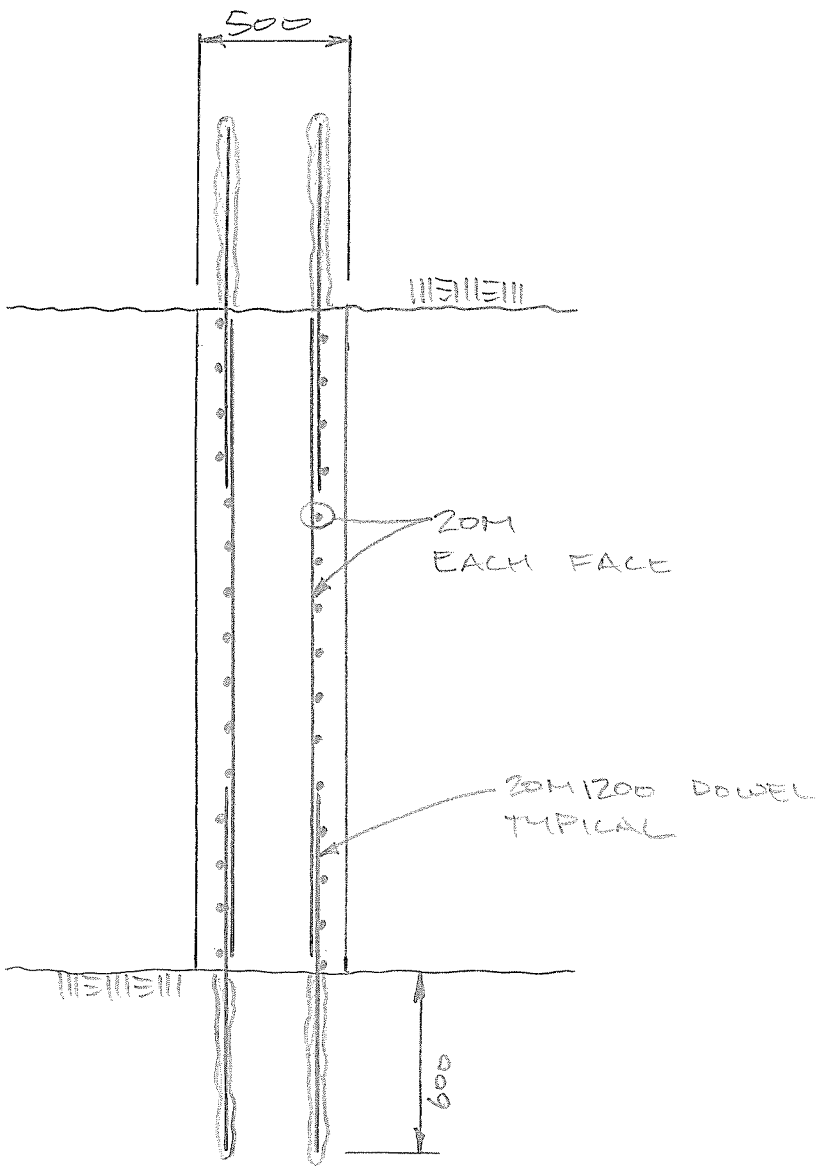
Subject BULKHEAD SK2	Ckd	Date	Job No. 06029



SECTION A

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