Memo DRAFT FOR COMMENT

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Date	**03 May 2004**		
Subject	**Kerr-Sulphurets Project** **Scoping Study – Tailings & Waste Rock Management** **Status Update (Revision #1)**		

This memorandum summarizes AMEC's current status on the scoping study for tailings, waste rock, and pit walls drainage issues pertaining to the proposed Kerr-Sulphurets project, and updates and supercedes a previous version dated 24 April 2004.

This memorandum should be read in conjunction with viewing (in slide show mode) the powerpoint file "*KS study presentation April 23 2004.ppt*", which has been forwarded separately. This is an update of the file presented to Noranda during the teleconference of 13 April 2004. Following that teleconference, during which additional alternatives were identified, AMEC has assessed these additional alternatives, and obtained additional relevant information pertaining to the project area. The updated powerpoint file includes this additional work. Since issue of the 24 April 2004 memorandum, the following key changes have been made to update this memorandum:

- One additional alternative for tailings management, designated Alternative H, has been identified and scoped at a conceptual level.

- AMEC's cost estimator has reviewed the assumptions with regards to unit costs in the 24 April 24 memorandum, and those unit costs have been updated on the basis of that review.

- Three project base cases are identified, as opposed to the single base case provided in the 24 April 2004 memorandum.

- Conceptual level cost estimates for capital and sustaining capital costs (i.e. dam raising) for the two base cases are provided (see Section 5.0).

1.0 BACKGROUND BEHIND SCOPING STUDY

1.1 General

The scoping study was commissioned by Noranda for the project following an internal Noranda risk assessment of the project. That risk assessment identified four potential fatal flaws (high probability x high impact = high risk) for the project related to mine waste management, as follows:

- No suitable tailings disposal areas.
- Waste rock pile closure costs prohibitive.
- Tailings closure costs prohibitive.
- Pit closure costs prohibitive.

The scoping study was commissioned to examine these four potential flaws in more detail to assist Noranda in deciding whether or not to proceed with the Kerr Sulphurets project, which is still in the exploration phase.

1.2 Project Location

The Keer-Sulphurets project is in the Iskut-Stikine River area of northwest British Columbia. The site is 65 km northwest of Stewart, and 35 km south of the Eskay Creek Mine. The nearest road to the site is the Eskay Creek Mine road which follows the Iskut River, exiting Highway 37 near Bob Quinn Lake. A site location plan is shown on Figure 1.1.

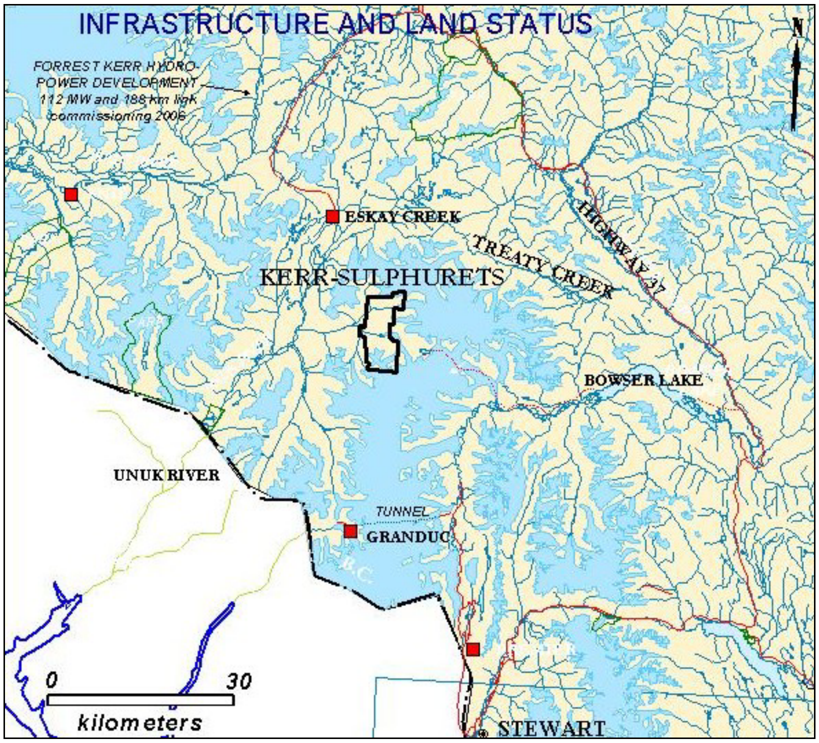

Figure 1.1 Project Location Plan

A plan of the Kerr-Sulphurets property is shown on Figure 1.2.

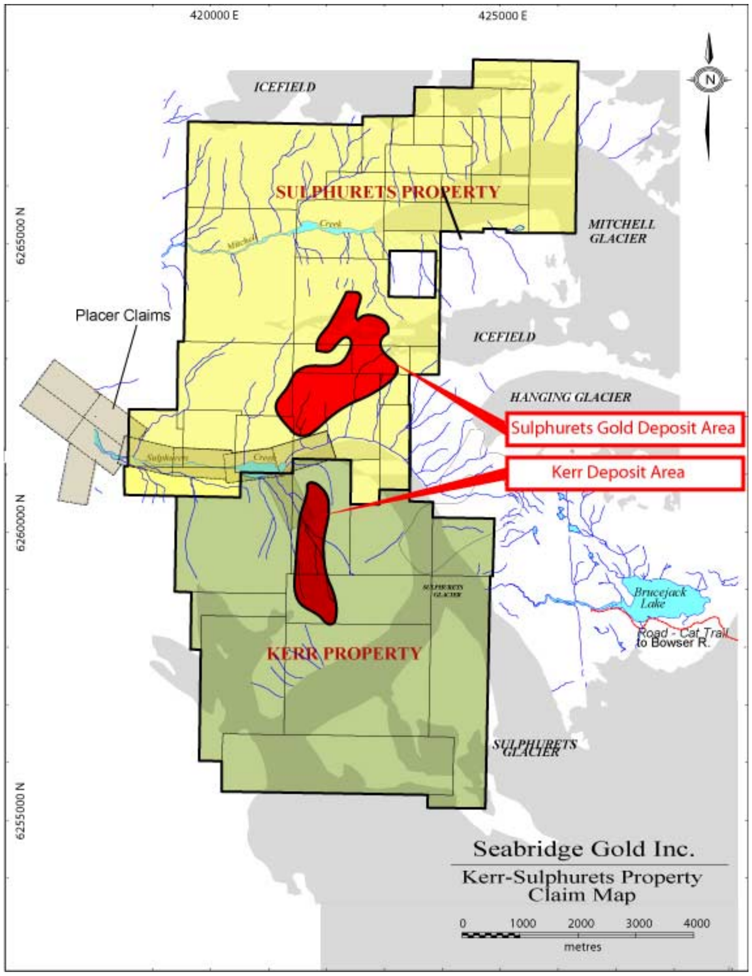

Figure 1.2 Kerr-Sulphurets Property

The Kerr-Sulphurets project area is bounded to the north, east and south by glaciers and ice-fields. Sulphurets Creek flows west, in the valley separating the Kerr and Sulphurets deposits, and drains into the Unuk River, which in turn flows west through Alaska.

1.3 Study Parameters

To provide a basis for the scoping study, Noranda provided the following project parameters:

- 2 open pits (Kerr & Sulphurets), 4 km apart
  - Sulphurets: 300 MT @0.75% Cu, 0.4 g/t Au
  - Kerr: 100 MT @ 0.75% Cu, 0.4 g/t Au
  - Recovery: 90% Cu, 70% Au
- 80,000 tpd (total from 2 pits, scheduling flexible)
- Mine life – 14 years
- Stripping ratio – 2:1

- 400 MT tailings (likely potentially acid generating - PAG)
- 800 MT waste rock
    - 10% Kerr waste rock non-acid generating (NAG), remainder PAG
    - 30% Sulphurets waste rock NAG, remainder PAG
- Assume the NAG materials can be segregated from PAG materials in the pits

Based on these assumptions, the quantities of tailings and waste rock to be managed for the project are as summarized in Table 1.1.

Table 1.1 Waste Rock and Tailings Quantities

Material	QUANTITY					
	Kerr Pit		Sulphurets Pit		Total	
	Mtonnes	Mm^3	Mtonnes	Mm^3	Mtonnes	Mm^3
Tailings (PAG)	100	77	300	231	400	307
Waste Rock (PAG)	180	95	420	221	600	316
Waste Rock (NAG)	20	11	180	95	200	106

Pit shell locations and geometries were provided by Noranda, as illustrated in Figure 1.3.

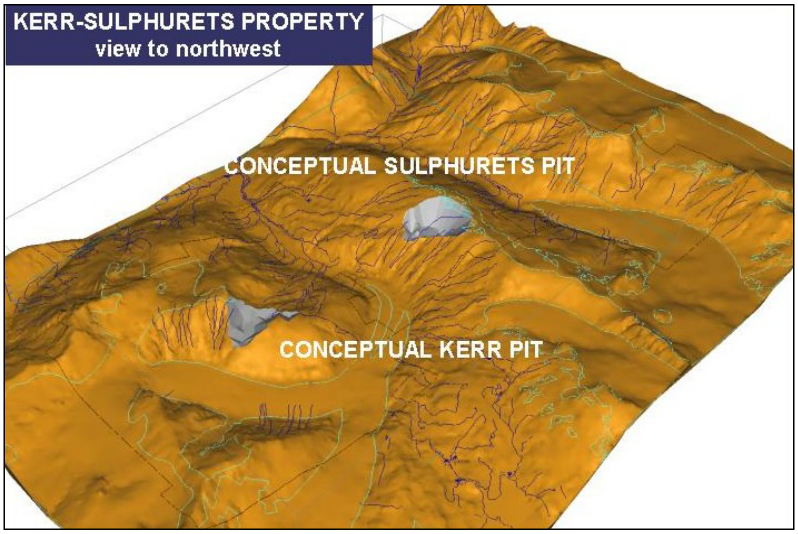

Figure 1.3 View of Conceptual Open Pits

The pit shell locations, geometries and stripping ratios used in this study are conceptual models only, and are not based on any reserve estimations, detailed economic modeling, mine planning or engineering studies. They are based on exploration drilling data and geological concepts in the Kerr and Sulphurets deposit area. The models were meant to provide some basic input for the scoping study in terms of potential scale of operations that would match the parameters of the extrapolated rough cut economic model. Only two targets were modeled, Kerr and Sulphurets, as they have the most drill data to draw from, however there are several other favorable exploration targets elsewhere on the property. A potential deposit developed from these could have altogether different characteristics.

It must also be borne in mind that:

- A lower stripping ratio (currently assumed to be 2:1) could significantly reduce the volume of waste rock
- Other exploration targets could have significantly different pit shell characteristics which may provide better storage and flooding capacity
- Storage of some PAG rock in a flooded pit could be viable if the pits are designed to maximize storage capacity by maintaining the elevation of the lower shell edge
- The location of the pit(s) could be optimized to address storage issues
- Current ABA work is based on the Kerr deposit, which has a higher degree of phyllic alteration (pyrite) and structural deformation (permeability) than other exploration targets; at other targets the volume of waste rock requiring treatment to prevent ARD could be significantly less
- A mine with a lower total production would obviously have a smaller waste rock volume to deal with; perhaps the model could be reduced from the current 80,000 tpd envisaged to address the maximum waste rock storage capacity.

2.0 KEY PROJECT CHALLENGES

In terms of mine waste management, from development through closure, the project is faced with a number of key technical and permitting challenges. Many of these were recognized at the outset of the study. Others became apparent as the study progressed. These issues are summarized in Table 2.1.

Table 2.1 Project challenges – summary of key issues

Issue	Challenges
Geochemistry of mine waste and pit wall rock	Tailings and an estimated 75% of waste rock are potentially acid generating. Work by Placer Dome suggests, once exposed, onset of oxidation and ARD generation by waste rock is within one year.
Pit shells geometry	No significant potential for pit lakes or in pit storage. The pit shells are analogous to bowls with one or more sides missing. Will have large highwalls generating ARD.
Rugged, glacially active terrain in KS area.	Steeply sloping ground with active glaciers except in Sulphurets Valley bottom, where creek with significant watershed exists. Very difficult terrain for dam construction. Deep glacial drift infills valley bottoms, likely pervious (requiring seepage cutoff works), and possibly with glacial lake sediments (low shear strength requiring flat dam slopes for adequate stability). Excessively steep terrain is not conducive to open channel diversions.
Wet climate and large snowpack.	About 2.4 m annual precipitation, 1.6 m (snow water equivalent) occurs as snow. High rainfall even during the summer months, rendering earthworks construction problematic. 60% of annual snowmelt typically occurs in May.
Avalanche concerns	Steep terrain and large snowpack creates avalanche concerns – many avalanche tracks clearly identified in immediate project area. Also an issue with regards to access/haul roads, and open channel diversions.
High seismicity	This is a significant challenge in terms of earthfill-rockfill dams design, particularly given that sediments forming valley bottom infill may include soils susceptible to seismic liquefaction. If so, dam construction only viable if ground improvement (specialized and expensive work) is undertaken.
Active glaciation	Glacial advance/retreat poses project risks. Advances could disrupt mine waste/containment facilities. Retreats could lead to slope instabilities (ice buttressing of slopes removed) and/or increased sediment loading in runoff that could fill up diversion dams/plug diversion tunnels etc.
Construction materials availability for earthworks	Earthfill materials available in valley bottoms, but much of the material likely inaccessible due to high water table (saturated materials cannot be used). For high dams, will have significant uphill haul. For dams, likely high reliance on rockfill – could use NAG open pit waste if it is confirmed that portion of open pit waste rock is NAG, <u>and</u> can be effectively segregated from PAG pit waste.
Natural ARD in the area	Due to extensive mineralization, there is natural ARD in the KS area. This could be a help and a hindrance to the project (e.g. regulators likely to take position that the system is already impacted so no additional impact can be accepted).
Trans-border drainage issues.	Sulphurets Creek (which drains the project area) flows into the Unuk River, which flows through Alaska.
Unuk fisheries	Unuk River has an “important commercial and sport fishery resource”, with sockeye salmon reported up-river from the conjunction of Sulphurets Creek with the Unuk.
Unuk River natural water quality	1991-1993 Environment Canada conducted 3 km upstream from Alaskan border indicates water quality periodically does not meet aquatic criteria for numerous parameters during freshet, and at all times for copper. With salmon present in the river, any incremental impact due to mining development would be strongly resisted by regulators.
Dam safety risk & liability	Long term risk and liability for water retaining dams in the KS area. Given the terrain, diversion issues, dam in Sulphurets valley is not “walk-away”, requires ongoing monitoring, maintenance and dam safety assessment. Also require long term access to the site.
Bowser Lake storage capacity	Based on published soundings data, placement of 400 million tonnes of tailings into Bowser Lake would occupy about 20% of its total volume.
Bowser river/lake fisheries	Bowser Lake & river accounts for about 10% of escapement for Nass River sockeye run. Sockeye reported in Bowser River upstream of Bowser Lake, but not as far upstream as Knipple Lake. These issues render use of Bowser Lake high risk in terms of permitting.
ARD issues in a KS-Knipple Lake tunnel scenario	Due to mineralization in KS area, will likely have ARD issues with a tunnel driven from Knipple Lake to the KS site.

3.0 SUMMARY OF ALTERNATIVES CONSIDERED

The alternatives considered in the study are summarized in the following tables:

Table 3.1 - waste rock management alternatives (2 pages)
Table 3.2 - tailings management alternatives (3 pages)
Table 3.3 - pit wall drainage alternatives (1 page)

These tables include, for each alternative, a ranking (relative to the other alternatives considered) for each of the following aspects:

- Capital cost
- Operating cost
- Ease of permitting
- Physical stability
- Closure liability
- Constructability

A ranking of "1" indicates the alternative that is considered the best in terms of that particular aspect. The relative rankings, including those based on capital and operating costs, are based on judgment.

The tables also indicate, for those alternatives deemed worthy of further consideration, the overall ranking (again relative to the other alternatives considered). These overall rankings are based on judgment, and do not reflect any preferential weighting given to the various project aspects.

The summary tables indicate the following:

- There are six waste rock management alternatives deemed worthy of further consideration on the basis of technical merit. Three of these (Alternatives A through C, ranked 1 through 3 respectively in terms of overall ranking) involve storage of waste rock in the KS area. Two others involve crushing and conveying waste rock, via a 19.4 km tunnel, from the KS area to the Bowser River drainage. The sixth involves crushing and conveying waste rock, via an approximately 23 km tunnel, from the KS area to the Treaty Creek drainage, for hauling (uphill) to storage within a flooded tailings impoundment in a tributary valley of Treaty Creek.

- The "conventional" solution for waste rock management at the KS site would be flooding behind a water-retaining dam, and this "conventional" solution would tend to be the most favored in terms of regulatory perception. However, to enact this solution in the Sulphurets valley, the downstream dam alone would be between 170 m and 190 m in height, which is almost without precedent for an earthfill-rockfill dam, particularly one founded on deep glacial drift. The upstream (diversion) dam would have to approach 80 m in height. These dams would be very challenging to design, construct, and maintain, and would likely require extensive (and specialized and expensive) foundation treatment measures including bedrock grouting, a seepage cutoff through the glacial drift (e.g. sheet-pile wall, plastic concrete cutoff wall, etc.), and filter, drainage, and riprap zones, with low permeability core zones (likely compacted clayey-silty glacial till). Concrete-faced rockfill dams are suitable only for bedrock foundations, and it is expected that the depth of glacial drift valley infill is excessive for excavation.

- There are only two tailings management alternatives deemed worthy of further consideration on the basis of technical merit. One of these involves crushing the ore at the mine site and conveying it, via a 19 km tunnel, from the KS area to a plantsite near Knipple Lake, in the Bowser River watershed. The other involves a similar concept, with a tunnel extending to the northwest into the Treaty Creek watershed, but rather than lake disposal, involves storage of the tailings in a valley impoundment formed by two 90-m high dams at either end. In this case, the plantsite would be in the Treaty Creek valley.

- Cost and tailings management methodology aside, a key difference between the two tailings management alternatives with technical merit is permitting risk. Due to the presence of sockeye salmon in Bowser Lake, which is recognized by the Department of Fisheries and Oceans (DFO) as a "significant sockeye salmon producer"[1], any mine waste management that involves use of Bowser Lake is considered to involve a high permitting risk (i.e. high probability x high impact). The alternative involving a plantsite and tailings impoundment in the Treaty Creek watershed is considered to be of much lower permitting risk because salmon are not reported as far upstream as the proposed plantsite and tailings impoundment locations.

- Accepting that the project must, due to tailings management considerations, include a tunnel approximately 20 km in length, either to Knipple Lake in the Bowser River watershed, or to the Treaty Creek watershed, then the incremental operating cost associated with transporting PAG waste rock to either of these respective watersheds is reduced (in terms of capital cost, not operating costs). However, there is insufficient storage volume in Bowser Lake to accommodate PAG waste rock and tailings, along with the high permitting risk associated with use of that lake for mine waste management, and one potentially suitable dump location on the north bank of the Bowser River, with perpetual collection and treatment required (immediately upstream of a lake deemed a "significant sockeye salmon producer" by DFO). Given that requirement, there is little merit in incurring costs to transport waste rock from KS to a dump site in the Bowser watershed if it is not feasible to flood the waste rock in either location. In other words, given that perpetual collection and treatment of ARD runoff from the waste rock will be required, this may as well be done at the KS site rather than incurring the additional cost to transport it to the Bowser watershed. It is not worth avoidance of trans-border drainage issues to incur that additional hauling/conveying cost.

- By conveying crushed PAG waste rock to the Treaty Creek drainage, plus an approximately 8 km uphill haul to the tailings impoundment (in a tributary valley to the Treaty Creek valley), the PAG waste rock (it is assumed that the NAG waste rock would be left within the Sulphurets Creek valley) could be flooded within the tailings impoundment. So doing would approximately double the volume storage requirement of the impoundment to about 620 Mm^3. In turn, that would require the dams to be up to 140 m in height, versus 90 m in height

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[1] Bocking, R.C., Link, M.R., Baxter, B., Nass, B. and L. Jantz (2002). "Meziadin Lake biological escapement goa and considerations for increasing yield of sockeye salmon", Fisheries and Oceans Canada, Research Document 2002/124.

if only tailings storage were required. This would increase dam fill volume requirements by about 400% (from 20 Mm^3 to 80 Mm^3).

- Assuming that the dams required for flooding PAG rock in the Sulphurets valley can be constructed with upstream and downstream slopes of 2H:1V (which is probably optimistic given the dam heights and glacial drift foundation soils, there are many examples of lower earthfill dams on glacial drift in B.C. with significantly flatter slopes), the total dam volume required would be in the order of 110 Mm^3. About 50 Mm^3 of this volume could use PAG rock (the upstream shells of both dams, which has zero cost as it must be hauled to the valley bottom in any case), reducing dam fill volumes incurring costs to about 60 Mm^3. Assuming an average dam fill unit cost of $\$12/m^3$ (see Section 5.0), the dams could cost in the order of $720 million to construct just in terms of fill. Assuming that foundation treatment measures account for about $100 million (reasonable for difficult foundation conditions), then a total construction cost approaching $820 million (or significantly higher if flatter dam slopes than 2H:1V are required) is possible. The dams would be raised progressively over the mine life, but the starter dams (i.e. pre-production construction) could consume up to 1/3 of the total cost (most foundation treatment costs are borne with the starter dam), i.e. about $240 million. The 4 km diversion tunnel, assuming a diameter of 3 m and a cost per meter of $5,000 (see Section 5.0), would cost about $20 million (i.e. in the order of 10% of the starter dams construction cost).

- For waste rock management, the most attractive scenario, in terms of capital and operating costs, and in terms of practicality, involves side-hill dumps adjacent to the two open pits, toeing out in the Sulphurets Valley, in an area isolated to the upstream and downstream by two relatively modest water-retaining dams, in the order of 40 m to 50 m in height (compared to 170 m to 190 m high dam for flooding of all PAG rock in the Sulphurets valley). This option also entails construction, and maintenance in perpetuity, of a 3 m (approx.) diameter diversion tunnel, about 4 km in length, from the upstream dam to discharge beyond the downstream dam. During operation and at closure, a water treatment plant would be required to treat ARD from the waste rock, likely on the north abutment of the downstream of the two dams. In an average year, the water treatment plant would have to treat about 19.4 Mm^3 of runoff, about 50% of which would typically occur in the May freshet. An advantage of this option is that pit walls drainage would report to the same holding pond as contact water from the waste dumps, so the pit wall drainage issue is handled as a matter of course.

- The two dams required for the sidehill dumps option would combined require in the order of 10 Mm^3 of fill. At an assumed average fill cost of $\$12/m^3$, the two dams combined would cost about $120 million. Adding to this an allowance of $25 million for foundation treatment measures (these might have to be more involved for this option as the water quality of the runoff from the dumps will be poor, hence a greater need to minimize seepage losses), the total cost would be in the order of $145 million, about 17% of the dams construction cost required for the alternative of flooding all PAG rock within the Sulphurets Valley.

- The disadvantages of the side-hill dumps alternative is the closure liability involved, and the cost of water treatment plant operation, maintenance, and access in perpetuity. Provision for perpetual ARD collection and treatment at such a remote and challenging site is likely to involve substantial bonding. There is also likely to be strong resistance associated with exposed sulphidic waste rock in a drainage that flows into a salmon-bearing Alaskan river. In that sense, flooding of the PAG waste rock behind a dam that is 170 m to 190 m in height might be perceived more favorably by regulators, though this is a misconception as it replaces modest dam safety risk and high geochemical risk with a very high dam safety risk and still high geochemical risk.

- For pit wall drainage, the two viable alternatives are perpetual collection and treatment, and "doing nothing", implying that the water quality in Sulphurets Creek due to ARD from the open pits would be no worse than baseline conditions (ARD is occurring naturally in the area and affecting water quality). The latter alternative likely represents a project "opportunity" rather than a viable alternative as the permitting base case, as it would likely be very difficult to "sell" that alternative to regulators, it would have to be demonstrated. However, the preferred waste rock alternative, perpetual collection and treatment of runoff from the waste dumps, collects drainage from the open pits as a matter of course.

Table 3.1 Waste Rock Management Alternatives

Alternative	Description	Plantsite Location & Site Access Considerations	Risks/ Uncertainties	Preference/Ranking							Pursue Further?
				Capital Cost	Operating Cost	Ease of Permitting	Physical stability	Closure liability	Construct-ability	Successful Precedent	
A – side-hill dumps, cover, perpetual collection & treatment	Side hill dumps adjacent to the pits, extending to base of Sulphurets Valley. Require two dams, one diversion dam to upstream (with tunnel diversion, required in perpetuity), and another downstream to isolate the dump areas and contain runoff for treatment.	Plantsite location flexible, though constrained by the dumps and runoff collection pond. However, with this option tailings must go to Bowser Lake watershed, so plantsite likely near Knipple Lake. Require permanent site access and Water Treatment Plant.	Dependent on the diversion tunnel in perpetuity. Permitting difficulty? Maintain Knipple Lake tunnel as means of permanent site access for servicing/operation of Water Treatment Plant? Discharge is to the Unuk (trans-border issues).	1	1	3	2	3	1	Yes	Yes. This alternative is technically viable and entails relatively low capital/operating cost. Its main disadvantage is in closure liability, with need for perpetural collection and treatment. In this respect however, it does also allow for collection of drainage from the open pits. ***Overall ranking – 1***
B – PAG waste rock to flooded impoundment in Sulphurets Valley	Isolate section of Sulphurets Valley with a diversion dam upstream of Sulphurets Lake, and approx. 200 m high earthfill-rockfill dam at downstream end. Diversion tunnel from upstream dam required during operations, possibly in perpetuity unless flooding of area upstream of diversion dam is acceptable.	Plantsite located in Bowser Lake watershed as with this alternative no storage for tailings in immediate project area.	Diversion dam causes periodic flooding to 20 m higher in elevation than current terminus of Sulphurets glacier. Dam safety liability – water retaining dam in perpetuity. Discharge is to the Unuk (trans-border issues).	3	2	2	5	4	6	Yes	Yes, if in fact 25% of the waste rock is non potentially acid generating. If not, then dam construction costs likely prohibitive (138 Mm^3 of dam fill just for the downstream dam, assuming foundations will support 2H:1V slopes, which may well be optimistic. ***Overall ranking - 3***
C – Waste rock to Brucejack Lake	Haul or convey PAG waste rock to Brucejack Lake. Cover the dump (about 275 m high) with till, with perpetual collection and treatment. Not possible to flood the rock at this location. Approx. 40 m high dam to impound runoff for treatment.	Plantsite location flexible. Must maintain permanent access to Brucejack Lake area if that is where the water treatment plant is located. Treatment plant may however by located nearer the open pits, as pit wall drainage must be dealt with.	Ice field immediately to the east of Brucejack Lake. Very difficult terrain for access to Brucejack Lake via trucks or conveyors. Numerous avalanche tracks posing high safety hazard. Must cross icefield. Discharge is to the Unuk (trans-border issues).	2	3	4	3	3	5	Yes	Yes, but need to confirm viability of hauling/conveying waste rock across difficult terrain (including Sulphurets glacier). Only advantage of this alternative over Alternative 1 is reduced dam construction requirements, but at much higher operating costs and operating risks. ***Overall ranking - 4***

Table 3.1 (continued) – Waste Rock Management Alternatives

Alternative	Description	Plantsite Location & Site Access Considerations	Risks/ Uncertainties	Preference/Ranking							Pursue Further?
				Capital Cost	Operating Cost	Ease of Permitting	Physical stability	Closure liability	Construct-ability	Successful Precedent	
D – PAG waste rock to flooded impoundment and to backfill (& flood) in 1st mined-out pit	*Fatal Flaw – there is no significant storage capacity within the pits for flooding (i.e. minimal pit lake will form) due to pit geometry. This alternative is therefore non-viable.*			Not worth further consideration.							No.
E1 – crush and haul/convey PAG waste via tunnel for placement in Bowser Lake	Waste rock and tailings to Bowser Lake watershed. Crush ore and waste rock and transport to plant via conveyor. Consider campaigning of ore and waste so that a single conveyor could be used. Tailings to subaqueous disposal in Bowser Lake via pipeline. Waste rock hauled/conveyed to Bowser Lake.	Plantsite is at Knipple Lake, via 19 km tunnel from KS. Tunnel provides access for servicing of conveyor. Require year-round road for accessing the site (5-m dia. tunnel with conveyor (belt width 2 m for 80,000 tpd) too small for regular traffic access, or else a larger tunnel	Tailings would occupy about 20% of estimated Bowser Lake volume. Waste rock (assuming 600 Mt of PAG) would consume another 20% of the lake volume. Dumping waste rock in lake is more “disruptive” to fish than pipeline discharge of tailings at depth.	4	6	5	1	1	4	Yes	Yes. However, placing tailings and waste rock into Bowser Lake would occupy approx. 40% of its total volume. High operating cost involved in hauling waste rock 20 km to Bowser Lake from Knipple Lake. Waste rock does allow “segmenting” of the lake which might make combined tailings & waste rock storage more palatable to regulators. ***Overall ranking - 6***
E2 – crush and haul/convey PAG waste via 19.5 km tunnel for placement in dump in Bowser watershed.	Waste rock and tailings to Bowser Lake watershed. Crush ore and waste rock and transport to plantsite via conveyor. Consider campaigning of ore and waste so a single conveyor will suffice. Tailings to subaqueous disposal in Bowser Lake via pipeline. Waste rock hauled to dump near plantsite, covered, with perpetual collection and treatment.		No apparent dump sites available. Terrain is either very steep valley slopes, or else floodplain of the Bowser River. Dump within floodplain will require erosion protection and measures for interception and recovery of groundwater (unless base of dump can be lined, or is naturally lined, by low permeability material).	4	5	5	2	3	2	Yes	Yes. However, based on currently available information there are no clearly advantageous dump sites. This is still a perpetual collect and treat alternative, hence the only advantage over Alternative 1 is that trans-border drainage issue is avoided. ***Overall ranking - 5***
F – crush and haul/convey PAG via 23 km tunnel for placement in flooded tailings impoundment in Treaty Creek watershed.	Waste rock and tailings to Treaty Creek watershed. Ore and waste rock crushed at KS and conveyed to Treaty Creek. Waste rock then hauled uphill (about 8 km) for placement and permanent submergence within tailings impoundment (see tailings management Alternative H).	Plantsite is in Treaty Creek drainage. Tunnel provides conveyor route and servicing access to conveyor, but 5-m diameter too small for regular site access. Require year-round access road to site, or larger diameter tunnel.	Tunnel alignment has not been studied, in terms of likely ground conditions, groundwater inflows, and potential mineralization (i.e. ARD). Dam safety risk associated with two 135-m high dams.	5	4	1	4	2	3	Yes	Yes. This alternative ranks poorly in terms of capital and operating costs, but is worth pursuing because it represents a means of achieving flooded waste rock storage in more favorable terrain than at KS, and no salmon issues/ trans-border drainage issues. ***Overall ranking - 2***

Table 3.2 Tailings Management Alternatives

Alternative	**Description**	**Plantsite Location & Site Access Considerations**	**Risks/ Uncertainties**	Preference/Ranking							Pursue Further*?*
				Capital Cost	Operating Cost	Ease of Permitting	Physical stability	Closure liability	Construct-ability	Successful Precedent	
A – co-disposal with waste rock in flooded impoundment in Sulphurets Valley	Two water retaining dams in Sulphurets Valley. The most downstream of which would have height of 275 m (266 Mm^3 of fill at 2H:1V upstream and downstream slopes). Upstream dam would be about 140 m high. Diversion tunnel (4 km) from upstream dam to discharge downstream of impoundment.	Plantsite in KS area, likely on the bench adjacent to the Sulphurets Pit.	275 m high earthfill-rockfill water-retaining dam on deep glacial drift is without precedent. Very high dam safety risk. If diversion tunnel not maintained in perpetuity (i.e. plugged in favour of spillway release from the downstream dam), then extent of flooding of the Sulphurets glacier would be 120 m in elevation.	Not worth further consideration.						NO	No. Water-retaining earthfill-rockfill dam of this scope, and in active glacial environment, founded on deep and likely compressible glacial drift valley infill, is without precedent
B – Create NAG/PAG tailings streams, two separate impoundments.	Sulphide tailings (assume 10% of total tailings stream, say 40 million tonnes) to a separate flooded impoundment or to co-disposal with flooded PAG rock in Sulphurets Valley. Then a separate impoundment, further downstream for NAG tailings.	Fatal flaw – no incentive for removal of sulphides, apart from allowing disposal and flooding of PAG rock and PAG tailings in Sulphurets Valley. Still require impoundment storage for 90% of tailings assumed NAG, hence more dams and diversions. This option not worth further consideration.									No.
C – Tailings to 1st mined-out pit, with down-sized flooded impoundment in Sulphurets Valley	Fatal flaw – the pit geometries are such that there is no significant storage in the pits for flooding of tailings. This alternative is therefore non-viable.										No.
D1 – Tailings to subaqueous storage in Bowser Lake.	19 km tunnel from KS to Knipple Lake area. Crush ore and convey through tunnel to plantsite. Tailings sent via approximately 20 km pipeline, through the Bowser River floodplain, to subaqueous disposal in the deepest portion of Bowser Lake, requiring frequent relocation of tailings pipeline. Discharge to deepest portion of the lake avoids areas used by salmon. The tailings will occupy roughly 20% of the lake volume by end of mine life. Tunnel excavation creates 1 million tonnes (about 0.53 Mm^3) of rock.	Knipple Lake area. Routine site access via the tunnel. Summer road to site for heavy equipment etc. that is not passable via the tunnel.	5 m dia. tunnel creates about 1 million tonnes of rock requiring disposal, some of which might be PAG. Bowser Lake accounts for 10% of sockeye escapement for the Nass River – therefore is viewed by DFO as very important habitat for spawning/rearing…permitting risk is therefore very high. Discharge of slurry tailings into lake may not be permittable, depending on water quality of process water – Eskay Creek places filtered (dewatered) tailings into a non-salmon lake. Slurry water inflow rate, for 80,000 tpd and assuming slurry density of 30% is 2.2 m3/sec, which is 30% of estimated natural lake discharge during low flow (winter) periods. Hence “flushing” and water quality concerns amplified.	1	1	3	1	1	1	1	Yes. Costs aside, however, the permitting risk for this alternative is sufficiently high that it might represent a fatal flaw. ***Overall ranking - 2***

Table 3.2 (continued) – Tailings Management Alternatives

Alternative	Description	**Plantsite Location & Site Access Considerations**	**Risks/ Uncertainties**	Preference/Ranking							Pursue Further?
				Capital Cost	Operating Cost	Ease of Permitting	Physical stability	Closure liability	Construct-ability	Successful Precedent	
D2 – Tailings to subaqueous storage in segmented portion of Bowser Lake.	19 km tunnel from KS to Knipple Lake area. Crush ore and convey through tunnel to plantsite. Tailings sent via approximately 20 km pipeline, through the Bowser River floodplain, to subaqueous disposal in Bowser Lake. Portion of lake used for tailings storage is segmented, via rockfill causeways, to reduce disturbance to salmon spawning/rearing. Require about 125 Mm^3 of rockfill for causeways to segment portion of lake. Construction of 19 km, 6 m dia. tunnel produces about 0.53 Mm^3 of rockfill. Might be some means of providing fisheries habitat compensation in conjunction with this alternative?	Knipple Lake area. Routine site access via the tunnel. Summer road to site for heavy equipment etc. that is not passable via the tunnel.	Same issues as listed above for Alternative D2, plus several more, as follows: 1. Is this option any more palatable to DFO than deposition to deepest portion of lake? 2. Cut off access to shore (shoal) areas and tributaries that may be spawning habitat. 3. Turbidity caused by rockfill causeway placement may be unacceptable. 4. Soft lakebottom sediments (varved silts and clays, typically of very low shear strength) will create unstable foundations for rockfill causeways of substantial depth.	2	2	4	2	2	2	2	Yes, if only to explore what might be a more permitable alternative than Alternative D1. ***Overall ranking - 3***
D3 – Tailings to flooded storage in Knipple Lake	19 km tunnel from KS to Knipple Lake area. Crush ore and convey through tunnel to plantsite. Tailings discharged to Knipple Lake for permanent subaqueous storage.		Knipple Lake has insufficient storage capacity – would have to have depth in excess of 300 m to store all the tailings (i.e. be 3X deeper than Bowser Lake). This is not credible. Dam construction would be required to provide adequate storage – this would mean damming the Bowser – not credible given the enormous upstream watershed and the floodplain environment. Sockeye confirmed to get into the headwaters of Bowser Lake, but not confirmed as far upstream as Knipple Lake. Still, there is some risk that fisheries issues exist even that far upstream.	*This alternative is not technically credible and does not warrant further consideration.*							No.
E1 – Float out sulphides, filter the NAG tailings for placement in a dry stack.	Via flotation, remove sulphide-bearing portion of the tailings (assume 10%) to produce a NAG tailings stream. NAG tailings stream is filtered and then hauled/conveyed to placement in a dry stack on suitable terrain, progressibly covered with NAG waste rock for erosion protection. Sulphide tailings to flooded impoundment storage with PAG waste rock in Sulphurets Valley.	KS area.	Fatal flaw – terrain in the KS area is such that a stable tailings dry stack is not possible. Only relatively gently sloping land is in the Sulphurets Creek Valley bottom, where stack cannot be protected against erosion.	*This alternative is not technically credible and does not warrant further consideration.*							No .

Table 3.2 (continued) – Tailings Management Alternatives

Alternative	**Description**	**Plantsite Location & Site Access Considerations**	**Risks/ Uncertainties**	Preference/Ranking							Pursue Further?
				Capital Cost	Operating Cost	Ease of Permitting	Physical stability	Closure liability	Construct-ability	Successful Precedent	
E2 – float out sulphides, filter the NAG tailings for dry stack placement in Bowser watershed, sulphide tailings to subaqueous deposition in Bowser Lake	19 km tunnel from KS to Knipple Lake area. Crush ore and convey through tunnel to plantsite. Remove the sulphide-bearing tailings via flotation (assume 10% of tailings is sulphidic). The sulphide tailings stream is piped about 20 km for deep subaqueous deposition in the deepest part of Bowser Lake. The NAG tailings is filtered and conveyed/hauled to a dry stack, likely the area indicated in slides 108/109 of the powerpoint file. Require roughly 250 Mm^3 dry stack storage capacity, thus the stack, with a base area of about 600 m x 2 km, would be about 200 m in height. Dry stack would have to be progressively covered with NAG rock (use rock stockpiled from the tunnel construction, if NAG).	Plantsite in Knipple Lake area. Routine site access via the tunnel. Summer road to site for heavy equipment etc. that is not passable via the tunnel.	Same issues as per Alternatives D1 and D2 w.r.t. discharge of tailings into Bowser Lake, however, the scope of discharge contemplated is reduced by 90% (i.e. only 10% of the tailings stream going to Bowser Lake). This might make this more palatable for permitting. Runoff diversions not possible on the steep terrain. Placement of 72,000 tpd of filtered tailings in a dry stack in a wet climate in such steep terrain is unprecedented. Given geometry of stack, tailings will have to be effectively compacted. This cannot be achieved in wet weather/very cold conditions. Mid range operating cost/tonne of filtered tailings is $5/tonne, giving daily cost of $400,000/day (for 80,000 tpd operation).	4	4	2	4	3	4	NO	No. This option has the highest capital and operating costs. It is without precedent at this scale and in similar terrain/climatic conditions.
F – Ocean disposal via the Unuk, into Alaskan Fjord	Pipeline approximately 70 km to tidewater in fjord fed by the Unuk River.	Plantsite in KS area.	Fatal flaw – given trans-border issues and the "important" salmon fishery associated with the Unuk, this option has no chance of being permitted and is therefore not worthy of further consideration.								No.
G – Tailings to flooded impoundment, separate from PAG waste rock, further downstream in Sulphurets Creek Valley	Construct a total of 5 dams. Two of the dams provided flooded storage for the PAG waste rock. One of these two dams separates the waste rock and the tailings impoundments. Two of the other three dams serve as diversion dams. Require 3 diversion tunnels, of total length of about 13 km. Total catchment area about 22,500 ha, about 80% of which must be diverted by permanent diversion tunnels. Highest of the dams about 170 m in height. Water balance in tailings impoundment, even with diversions, in large surplus requiring treatment and discharge (to Unuk system) even during operations.	Plantsite in KS area.	A large and complex undertaking that is unprecedented in terms of tailings management. Very high dam safety risk, 5 substantial dams on deep glacial drift, and probably neither permittable nor constructable.	Not worthy of further consideration.							No.
H – Tailings to flooded impoundment in tributary valley to Treaty Creek	Two dams, about 90 m in height, required. No up-river catchments to be diverted, and side-hill open channel diversions relatively easy to achieve due to more favorable terrain than at KS. Do require one diversion dam (about 60 m high) and conduit. Assume flotation removal of sulphides to create two tailings streams, allowing above water NAG beaches in front of dams for closure.	Plantsite in Treaty Creek watershed.	Long term dam safety risk associated with two 90-m high dams, though this is alleviated somewhat if NAG tailings above-water beaches in front of dams at closure. Foundation conditions at dam sites unknown.	3	3	1	3	4	3	YES	Yes. This alternative is judged to be the most readily permittable of those considered technically viable. ***Overall ranking - 1***

Table 3.3 Pit Wall Drainage Management Alternatives

Alternative	**Description**	**Plantsite Location & Site Access Considerations**	**Risks/ Uncertainties**	Preference/Ranking							Pursue Further?
				Capital Cost	Operating Cost	Ease of Permitting	Physical stability	Closure liability	Construct-ability	Successful Precedent	
A – Perpetual collection and treatment, discharging to Sulphurets (and Unuk)	Drainage from the open pits is collected, contained, and routed to a water treatment plant for metals removal prior to discharge to the Sulphurets-Unuk drainage systems. Average annual pit runoff requiring treatment estimated at 2.2 Mm^3. Likely require minor saddle dams in pits to provide enough storage to handle freshet flows without spillage.	Plantsite location flexible (KS or Knipple Lake), but require a water treatment plant at site, location of which depends on fate of the waste rock. Require permanent access and power to site.	Pit drainage must be collected and piped to a holding pond adjacent to the Water Treatment Plant, unless saddle dams construction can create some in-pit storage. Pits on opposite sides of valley, so some risk associated with pumping/piping of drainage from pits to the plant.	2	2	1	2	1	2	Yes	Yes. ***Overall ranking - 1***
B – Perpetual in-pit biologically assisted treatment	Collect high wall runoff and put in anoxic zone at bottom of pit lake, use biologically assisted treatment in anoxic zone to improve water quality.	Fatal flaw – pit shells do not provide any pit lake volumes of consequence, rendering this alternative non-viable and unworthy of further of consideration.									No.
C – Backfill the pits to approximate pre-mining form, cover, and treat reduced runoff/seepage	Backfill the pits with waste rock, then cover with compacted low permeability soil (glacial till). Reduce infiltration to pits, but still have some infiltration, and seepage through pit walls, requiring collection and treatment.	Fatal flaw – A large volume of waste rock to be rehandled, and only a portion of the waste rock can be used to backfill the pits, so will still have PAG waste rock to deal with on site. All that is achieved is a marginal reduction in volume of ARD to be treated, but at exorbitant cost. Not worthy of further consideration.									No
D – extend pit walls beyond pit shell required to access ore so that final walls are NAG	Extend pit excavation beyond geometry required to access ore, so that all PAG rock is removed to waste rock dumps. Final pit walls in NAG rock, so no issue re: pit walls drainage.	Fatal flaw – there is a significant pyritic halo around the pits. As such, the volume of rock required to achieve this alternative is prohibitive. Not worthy of further consideration.									No
E – Do nothing, accept acid drainage from pit walls	Allow pit drainage to flow un-treated to Sulphurets and Unuk, on basis that conditions would be no worse than natural (baseline) conditions, or allow drainage to flow into same collection pond used to contain runoff from non-flooded PAG rock dumps (Waste Rock Alternative A), in which case pit wall drainage is collected and treated as a matter of course.	Plantsite location flexible (KS or Knipple Lake). No water treatment plant specifically required at KS for this alternative for handling pit walls drainage.	How likely is it that pit walls drainage will result in conditions no worse than baseline conditions? Unlikely this would be accepted as the base case by regulators without exhaustive water quality/ARD predictive studies, and even then seems likely provision for water treatment plant would be required.	1	1	2	1	2	1	No	Yes, though it may represent more of an upside than a truly permitable alternative. ***Overall ranking - 2***

4.0 MOST REASONABLE PROJECT CASES

4.1 General

On the basis of the alternatives considered and the preceding discussions, two project cases are considered reasonable combinations of technically viable waste rock, tailings, and pit wall drainage alternatives. Both cases involve access tunnels, in the order of 20 km in length, to allow conveying crushed ore to plantsites outside of the KS area.

4.2 Case 1 – Tailings to Bowser River watershed

Case 1 is described as follows:

- Plantsite located in the Bowser River Valley, near Knipple Lake.
- 5 m diameter tunnel, about 19.4 km in length, driven from Knipple Lake area to the Kerr-Sulphurets site. The tunnel fits a conveyor (hung from the crown). The tunnel is suitable only for service vehicle access to the conveyor, not for regular use as site access.
- A year-round access road (likely an extension of the Eskay Creek road) to the Kerr-Sulphurets site, suitable for transport of heavy equipment.
- Two dams (40 to 50 m in height) constructed to dam off a section of the Sulphurets valley, below the pit locations. Both are earthfill-rockfill water retaining dams with seepage cutoff works and foundation treatment as required given the geologic conditions at the dam sites. These water retaining dams will require monitoring and maintenance, and periodic dam safety assessments, in perpetuity.
- 3 m diameter tunnel, about 4 km in length, grading about 5% to downstream, with portal near the upstream dam, and outlet beyond the toe of the downstream dam. This diversion tunnel will be maintained in perpetuity.
- Water treatment plant adjacent to the downstream of the two dams, likely on the north abutment of the dam. Required during operation and closure.
- Ore is crushed near the pits, and conveyed, via the tunnel, to the plantsite in the Bowser drainage.
- Waste rock (potentially acid generating) is placed in side-hill dumps adjacent to the two open pits. The dumps extend to the floor of the Sulphurets valley, but are not extended to the point of effectively raising the valley floor in order to reduce the height of containment dams required to contain the dumps runoff.
- The waste rock dumps will be re-sloped and covered, to the extent practical (and cost-effective), with locally available compacted low permeability soils (likely clayey-silty glacial till), to reduce infiltration through the dumps.
- The catchment area encompassing the waste rock dumps and the open pits is about 1,470 ha. Annual average runoff from this area would be in the order of 19.4 Mm^3 (about 50% of which would typically occur in May). This runoff will be contained between the two dams, treated for ARD, and discharged into the Sulphurets Creek (eventually reporting to the Unuk River). Water treatment will be ongoing through mine life and in perpetuity for closure.
- Plant tailings will be directed via pipeline (about 20 km in length) for subaqueous disposal in Bowser Lake. This will be achieved either by deep discharge into the deepest section (about 100 m deep) of the lake, or into a portion of the lake segmented off from the remainder in order to limit disturbance to fisheries.

- During low flow (winter) periods, when the rate of tailings slurry water inflow is comparable to estimated Bowser River flows, reclaim water will be drawn from Bowser Lake (20 km uphill pumping) to reduce "flushing" of the lake due to slurry water inflow. During high flow periods, process water can likely be drawn from the Bowser River near the plantsite.

4.3 Case 2 – Tailings to Treaty Creek Watershed

Case 2 is identical to Case 1 in terms of waste rock and pit walls drainage management. The difference between the two cases is in terms of tailings management (and plantsite location), with the Case 2 parameters being as follows:

- An approximately 23 km long, 5-m diameter tunnel is constructed between the KS site and the Treaty Creek watershed. The tunnel fits a conveyor (hung from the crown). The tunnel is suitable only for service vehicle access to the conveyor, not for regular use as site access.
- A year-round access road (likely an extension of the Eskay Creek road) to the Kerr-Sulphurets site, suitable for transport of heavy equipment.
- For conveyance of 80,000 tpd of ore, conveyor width would be about 2 m, leaving at most 4 m for an access road, hence dictating one-way, small vehicle traffic.
- A year-round access road (likely an extension of the Eskay Creek road) to the Kerr-Sulphurets site, suitable for transport of heavy equipment.
- Ore would be hauled about 1.5 km from the tunnel portal to the plantsite, at about El. 640 m.
- Two dams (ultimate height about 90 m) would be constructed within a tributary valley to Treaty Creek. The dams would be constructed in stages to a final crest elevation of about El. 945 m. The dams would be about 9 km apart.
- The tailings dams would initially be constructed with a low permeability glacial till core, with granular fill (likely spoil from the tunnel excavation, about 925,000 m^3, assuming the spoil is non acid generating – this would be a haul distance, from the Treaty Creek tunnel portal, of between 3 and 12 km for the southern and northern dams respectively). For subsequent raising, the non acid generating portion of the tailings (created by flotation removal of sulphides from the total tailings stream) would be cycloned to produce a NAG cycloned sand for use in raising and extending the downstream shell of the dam, using hydraulic fill placement methods. Drainage from the cycloned sand placement would be collected behind small seepage dams for return to the tailings impoundment (or direct to the process water recycle system). The till core of the dam would be raised, using the centerline raising method. The sulphide-bearing portion of the tailings stream would be discharged into the central portion of the impoundment for permanent submergence.
- The total tailings stream would be pumped 300 m uphill to a cyclone/flotation station on the abutment of the southern of the two dams. In this station, sulphides would be removed via flotation, to create the NAG tailings used for cycloned sand production. This is the same process currently employed at the Kemess Mine.
- To produce the required volume of sand fill for extension and raising of the downstream shells of the two tailings dams, the cyclone plant would have to be in operation about 4 months per year, based on the following assumptions:
    - Sulphides split = 10% of total tailings = 8,000 tpd
    - Double cycloning of 72,000 tpd of NAG tailings
    - 25% sand recovery after double cycloning (= 18,000 tpd of NAG sand)
    - In place compacted sand density = 1.65 t/m^3

  - 85% plant operating factor
  - Total volume required for construction of the two dams, assuming centerline raising above starter dam configuration, is about 12 Mm^3, based on 3H:1V downstream slopes.
  - Sand shell volume required for raising/extension = 1 Mm^3/year
- When not required for downstream shell extension, the NAG cycloned sand will be discharged from the upstream of both dams to create above water beaches of NAG tailings. This will result in exposed beaches acceptable for closure, greatly enhancing the safety of the dams relative to a closure configuration where water is in direct contact with the upstream face of the dam.
- Open channel runoff diversions would be constructed along the west perimeter of the tailings impoundment, and along most of the east perimeter (the exception being a portion near the southern dam where terrain is too steep). An approximately 60-m high diversion dam (fill volume about 1.5 Mm^3) would be constructed at the outlet of a significant sub-drainage along the eastern side of the impoundment valley, with the collected water routed either via the open channel ditches or possibly via a conduit. An emergency overflow spillway from the diversion dam will protect it against overtopping in the event of runoff events greater than the ditches/conduit discharge capacity.
- At closure, an open channel spillway would be constructed likely on the west abutment of the northern dam (more gentle terrain there). Above-water NAG tailings beaches, likely 200 m or so in minimum width, would be maintained in front of the dams. All sulphide-bearing tailings would be submerged within the impoundment. The downstream slopes of the two dams would be appropriately reclaimed.
- A water treatment plant, and permanent site access, will be required at the KS site to manage ARD from the pit walls, in perpetuity.

4.4 Case 3 – Tailings & PAG Waste Rock to Treaty Creek Watershed

The elements of Case 3 are as follows:

- All PAG waste rock (600 million tonnes) and ore (400 million tonnes) would be crushed at the KS site, and conveyed via the 23 km, 6-m diameter tunnel to the plantsite in the Treaty Creek watershed.
- For conveyance of 80,000 tpd of ore plus 120,000 tpd of waste rock = 200,000 tpd total, conveyor belt width would be about 2.5 m. The conveyor would be hung from the crown, with an access road beneath suitable only for vehicles servicing the conveyor.
- A year-round access road (likely an extension of the Eskay Creek road) to the Kerr-Sulphurets site, suitable for transport of heavy equipment.
- From the tunnel portal, the crushed waste rock would be hauled approximately 9 km uphill to the tailings impoundment on the north side of the Treaty Creek valley, which would therefore be used for storage of tailings and for permanent flooding of the PAG waste rock. The rock would be placed at elevations such that submergence would be achieved within one year.
- The total fill volume required for the two tailings dams would be about 80 Mm^3 (with 3H:1V upstream and downstream slopes), reducing to about 48 Mm^3 if centerline raising above the starter dams configuration is used. This is an increase of about 400% relative to the dam raise volumes required for Case 2 (tailings only, no waste rock in the impoundment).

- With an annual shell extension/raise requirement of about 4 Mm^3, cycloned sand production is insufficient to meet the full requirement. As such, the unit cost for dam fill for Case 3 will be significantly higher than that for Case 2 (cost for cycloned sand = \$2.50/m^3, cost for imported fill = \$12/m^3, see Section 5.0). It is assumed that cycloned sand will make up 25% of the annual shell extension/raise fill volumes, yielding an average unit cost of \$9.63/m^3.
- The final crest elevation of the dams would be about 995 m, 50 m higher than for Case 2. As such, tailings will have to be pumped 350 m uphill (compared to 300 m for Case 2).
- Open channel runoff diversions would be constructed along the west perimeter of the tailings impoundment, and along most of the east perimeter (the exception being a portion near the southern dam where terrain is too steep). An approximately 60-m high diversion dam (fill volume about 1.5 Mm^3) would be constructed at the outlet of a significant sub-drainage along the eastern side of the impoundment valley, with the collected water routed either via the open channel ditches or possibly via a conduit. An emergency overflow spillway from the diversion dam will protect it against overtopping in the event of runoff events greater than the ditches/conduit discharge capacity.
- At closure, an open channel spillway would be constructed likely on the west abutment of the northern dam (more gentle terrain there). Above-water NAG tailings beaches, likely 200 m or so in minimum width, would be maintained in front of the dams. All sulphide-bearing tailings would be submerged within the impoundment. The downstream slopes of the two dams would be appropriately reclaimed.
- A water treatment plant, and permanent site access, will be required at the KS site to manage ARD from the pit walls, in perpetuity.

4.5 Ranking of Cases

The three cases are ranked in terms of capital cost, operating cost, ease of permitting, physical stability, trans-border drainage issues and closure liability in Table 4.1 below.

Table 4.1 Ranking of Cases 1 through 3

Case		Relative Ranking					
		Capital Cost	Operating Cost	East of Permitting	Physical Stability	Trans-border drainage	Closure Liability
1	Tailings to Bowser Lake, waste rock to sidehill dumps in Sulphurets Valley.	1	1	3	1	2	2
2	Tailings to impoundment in Treaty Creek watershed, waste rock to sidehill dumps in Sulphurets Valley.	2	2	2	2	2	3
3	Tailings and PAG waste rock to impoundment in Treaty Creek watershed.	2	3	1	3	1	1

The justification for the relative rankings of each case are as given below.

<u>Capital Cost.</u> Pre-production capital costs (exclusive of any contingency factors) pertaining to tailings and waste rock management only, as detailed in Section 5.0, are as summarized below:

Case 1 – $577 million
Case 2 – $709 million
Case 3 – $711 million

It should be noted that these costs do not include other development costs such as plantsite, mill facilities, access roads, mining fleet, power facilities, camp, etc., and indirects (engineering, construction management, owner's costs). The costs only account for those items specifically indicated in Section 5.0, and are considered suitable only for input to a "rough cut" economic analysis of the project.

Operating Cost. Case 1 is clearly the most favorable in terms of operating costs, with subaqueous tailings disposal to Bowser Lake (no tailings dams required), and sidehill waste rock dumps in the Sulphurets valley. Case 3 is the least favorable in terms of operating costs due to the larger conveyor required, the 9 km uphill haul for crushed waste rock from the Treaty Creek tunnel portal to the tailings impoundment, and the increased dam raising costs relative to Case 2.

Ease of Permitting. Case 1 is clearly strongly disadvantaged in terms of permitting. Bowser Lake is a significant sockeye salmon producer and provides about 10% of the escapement making up the Nass River salmon run, the fourth largest in B.C. As such, any development within the Bowser watershed in general (e.g. tunnel driving, plantsite construction near Knipple Lake) is likely to draw close scrutiny from DFO. In particular, the proposed storage of process tailings (and discharge of process water) in Bowser Lake will meet with very strong resistance. Storage of tailings in Bowser Lake could only be permitted if it could be demonstrated that such storage created no disturbance to fisheries activities. This would be very difficult to demonstrate, even if it were possible.

Another permitting hurdle common to both Cases 1 and 2 is that, acid generating waste rock will be left exposed in the headwaters of the Unuk River, which hosts an "important" (Environment Canada) commercial and sport salmon fishery, and which flows through Alaska, hence creating trans-border drainage issues, and the associated permitting risk.

No salmon are reported into the proposed tailings impoundment site for Cases 2 and 3, and none are reported as far upstream in Treaty Creek as the proposed tunnel portal and plantsite. In terms of permitting, Case 3 is more favorable than Case 2 as waste rock is permanently submerged in the tailings impoundment, rather than representing a perpetual collection and treatment scenario. Case 3 is therefore judged the most favorable in terms of ease of permitting.

Physical Stability. Case 1 is the most favorable in terms of physical stability as the tailings are stored at depth within Bowser Lake, and the dams in the Sulphurets Valley are relatively modest. Case 2 is second in preference as the tailings dam in the tributary to Treaty Creek would be 90 m in height, whereas the dam required in that same tributary for Case 3 would be about 140 m in height.

Trans-border Drainage. Case 3 is the most favorable in this regard, with only pit walls drainage (following treatment) reporting to the Unuk watershed. Cases 1 and 2 are equivalent in terms of ranking on this issue. If however it could be demonstrated that the water quality where Sulphurets Creek flows into the Unuk River would be no worse than baseline conditions without any treatment of pit walls drainage (assuming the terminus of Sulphurets Creek were accepted by regulators as the point of compliance), then trans-border drainage issues would be essentially eliminated by Case 3.

Closure Liability. Case 3, which provides for submergence of all PAG materials (waste rock and tailings) within the impoundment in the tributary of Treaty Creek, leaving only ARD issues from the pit walls to be contended with, is judged the most favorable in terms of closure liability. In this judgment, the benefit of submergence of all PAG materials is considered to outweigh the increased dam safety risk associated with the two 140 m high dams required to achieve this submergence. Case 1 is ranked second in preference as there is no tailings dam, making it superior to Case 2.

5.0 CONCEPTUAL COST ESTIMATES

5.1 Tunnel Unit Costs

Because it is such a significant component of the project's capital cost for all three cases considered, the unit pricing for the tunnel requires consideration.

The unit rates used for the tunneling work in the Placer Dome rough cut study (1992) are, in AMEC's judgment, unrealistic and are understated by a very large amount. A unit rate of approximately $2,000 per meter for a 6 m diameter tunnel is much too low, particularly when so little is known of the ground and groundwater conditions along the alignment, not to mention the more than 4000 feet of overburden over long segments of the tunnel. For example, on the Kemano Completion project, where a 16 km long 6-m diameter power tunnel (the ground was so good that the tunnel required practically no ground support at all over it's full length) with an access adit and a surge shaft, the contract was awarded to a low bidder for about $95 million in 1989 (give or take a year). Discounting the bid price by say 15% for the access adit and surge shaft (this is a conservative assumption - they were not big components of the overall work), the unit tunneling rate with a TBM was over $5,000 per lineal meter. With that project occurring more than a decade ago, one would expect tunneling costs to now be even higher.

More appropriate unit tunneling costs for this scoping study are as follows:

- 5-m diameter (Cases 1 and 2) - $7 million per km
- 6-m diameter (Case 3) - $8 million per km

These costs could be low if ground conditions prove to be very difficult and steel sets, bolts, shotcrete, or even concrete lined sections are required. To this, it might also be necessary to add an intermediate access adit along the route (for better emergency egress, shorter muck disposal routes, and to also open up two more potential work faces for schedule acceleration), access roads, ventilation shafts, refuge stations, and invert upgrades - to level it for vehicular traffic if the tunnel is driven round-shaped with a TBM. Additional requirements would include permanent power supplies, ventilation fans, tunnel lighting, and portal structures, Muck disposal would represent another cost item, along with tunnel drainage (ARD a potential issue towards Kerr-Sulphurets side) collection & treatment costs.

5.2 Conveyor Costs

The capital cost per meter of a conveyor capable of transporting 80,000 tpd (Cases 1 and 2) is estimated to be in the order of $7,000 per meter length. Such a conveyor would have a width (including hangers) of about 2 m, and would be in operation 65% of each day to convey 80,000 tpd. It is assumed that the conveyor would be hung from the tunnel crown (example: AMEC design for Freeport, where the tunnel diameter was about 5 m). A road below the conveyor would be suitable for servicing of the conveyor, but not appropriate (due to safety concerns) for regular site access below an operating conveyor. As such, an alternative means of site access to the Kerr-Sulphurets site would be required, which could take the form of:

- A year-round access road (cost in the order of $300,000 per km as a conceptual estimate)

- A larger diameter tunnel (likely cost prohibitive relative to a year-round access road)
- A summer road and an airstrip at/near the site

The capital cost per meter of a conveyor capable of transporting 200,000 tpd (80,000 tpd of crushed ore, 120,000 tpd of crushed PAG waste rock), is estimated in the order of $8,000 per meter length. The width of this conveyor would likely be in the order of 2.5 m, which it is assumed would require a 6-m diameter tunnel. As such, for Case 3, a 6-m diameter tunnel has been assumed.

5.3 Dam Fill Costs

A unit rate of $12/m^3 of fill has been assumed for the study. This is deemed to represent a reasonable “all-in” cost accounting for borrow development and reclamation, foundation and abutment preparation (in addition to seepage cutoff), crushing/screening operations, haul/access roads around the site, and placement and compaction costs. This cost is deemed reasonable on the basis of a review of several large civil dam construction projects in the United States, determined by the total bid price divided by total embankment fill volumes.

For cycloned sand construction (Cases 2 and 3), a unit rate of $2.50/m^3 is assumed. This is based on data from Kemess, and includes cyclone plant operating costs and sand transport/placement/compaction costs.

5.4 Pre-Production Capital Costs – Tailings & Waste Rock Management Aspects

Conceptual level, pre-production capital cost estimates for those aspects of the three cases pertaining to tailings and waste rock management are given in Table 5.1 through Table 5.3 for Cases 1 through 3 respectively. These tables also provide estimates of sustaining capital costs (for tailings dam raising, Cases 2 and 3, not applicable for Case 1) and closure/reclamation costs for tailings dams (again, only applicable for Cases 2 and 3). The estimates do not include operating costs, and exclude many other capital costs required for an economic analysis of the project. They are therefore meant only to provide input, on selected items, to Noranda’s economic evaluation of the project. Also not included are the long term closure costs for Water Treatment Plant operation.

Table 5.1 Conceptual cost estimate (partial) for Case 1

Case 1 - Tailings to Bowser Lake, Waste Rock in Side Hill Dumps in Sulphurets Valley

Item No.	Description of Work	Unit	Qty.	Unit Cost	Total Cost ($ Cdn)
Tunnel & conveyor for ore transport					
1	5 m dia tunnel from Knipple Lake to KS Area (not including rock support)	km	19.4	7,000,000	$135,800,000
2	Allowance for rock support in tunnel (steel sets, bolts, shotcrete, liners)	km	19.4	2,500,000	$48,500,000
3	Allowance for access adits, ventilation shafts, portal structures, level invert	ls	1.0	15,000,000	$15,000,000
4	Conveyor for crushed ore transport	m	19,400	7,000	$135,800,000
	Tunnel & conveyor for ore transport - total				***$335,100,000***
Dams & Plants for Waste Rock at KS Site					
5	Dams in Sulphurets Valley (at 2:1 side slopes)	m^3	10,000,000	12.00	$120,000,000
6	Allowance for flatter side slopes	m^3	4,000,000	12.00	$48,000,000
7	Allowance for foundation treatment (grout curtains, etc)	ls	2	5,000,000	$10,000,000
8	3 m dia diversion tunnel around two dams	km	4.0	4,000,000	$16,000,000
9	Allowance for rock support in diversion tunnel (steel sets, bolts, shotcrete)	km	4.0	1,000,000	$4,000,000
10	Inlet and outlet channels & structures for diversion tunnel	ls	1	500,000	$500,000
11	Water treatment plant (initial construction)	ls	1	15,000,000	$15,000,000
12	Low-permeability (glacial till) cover over the waste dumps - borrow, haul, place and compact.	ls	1	10,000,000	$10,000,000
	Dam & Plants for Waste Rock - Total				***$223,500,000***
Tailings Transport from Mill to Bowser Lake					
13	Pipeline from mill to Bowser Lake (for sub-aqueous disposal)	km	20	500,000	$10,000,000
14	Twinning of the pipeline for maintenance and repairs ?? Return water line??	km	20	250,000	$5,000,000
15	Allowance for deep submergence of pipeline at Bowser Lake	ls	1	1,000,000	$1,000,000
16	Water return line from Bowser Lake	km	20	100,000	$2,000,000
	Tailings transport from plantsite to Bowser Lake - Total				***$18,000,000***
				Total	***$576,600,000***

Note - The following items are NOT included in the above costs:

1. Detail design and project/construction management costs.
2. Plantsite, power, and other infrastructure.
3. Mining costs (including waste rock crushing, conveying and hauling).
4. Operating costs, including long term closure & operation of WTP.
5. Summer road (extension of the Eskay Creek Road).

Table 5.2 Conceptual cost estimate (partial) for Case 2

Case 2 - Tailings to Treaty Creek Watershed, Waste Rock in Side Hill Dumps in Sulphurets Valley

Item No.	Description of Work	Unit	Qty.	Unit Cost	Total Cost ($ Cdn)
Tunnel & conveyor for ore transport					
1	5 m dia tunnel from Treaty Creek to KS Area (not including rock support)	km	23.0	7,000,000	$161,000,000
2	Allowance for rock support in tunnel (steel sets, bolts, shotcrete, liners)	km	23.0	2,500,000	$57,500,000
3	Allowance for access adits, ventilation shafts, portal structures, level invert	ls	1.0	15,000,000	$15,000,000
4	Conveyor for crushed ore transport	m	23,000	7,000	$161,000,000
	Tunnel & conveyor for ore transport - total				*$394,500,000*
Dams & Plants for Waste Rock at KS Site					
5	Dams in Sulphurets Valley (at 2:1 side slopes)	m^3	10,000,000	12.00	$120,000,000
6	Allowance for flatter side slopes	m^3	4,000,000	12.00	$48,000,000
7	Allowance for foundation treatment (grout curtains, etc)	ls	2	5,000,000	$10,000,000
8	3 m dia diversion tunnel around two dams	km	4.0	4,000,000	$16,000,000
9	Allowance for rock support in diversion tunnel (steel sets, bolts, shotcrete)	km	4.0	1,000,000	$4,000,000
10	Inlet and outlet channels & structures for diversion tunnel	ls	1	500,000	$500,000
11	Water treatment plant (initial construction)	ls	1	15,000,000	$15,000,000
12	Low-permeability (glacial till) cover over the waste dumps - borrow, haul, place and compact.	ls	1	10,000,000	$10,000,000
	Dam & Plants for Waste Rock - Total				*$223,500,000*
Tailings Impoundment - Treaty Creek Tributary (Pre-Production Capital Costs)					
13	Fill for two starter dams	m^3	4,000,000	12	$48,000,000
14	Allowance for foundation treatment (grout curtains, etc)	ls	2	1,000,000	$2,000,000
15	Allowance for two seepage collection dams downstream of each of the two main tailings dams	ls	2	400,000	$800,000
16	Diversion Dam	m^3	1,500,000	12	$18,000,000
17	Cyclone Station with flotation cells - south abutment of the southernmost dam	ls	1	12,000,000	$12,000,000
18	Diversion Ditches	m	15,000	150	$2,250,000
19	Diversion conduit outlet from diversion dam	m	5,000	150	$750,000
20	Tailings pipelines & access roads	km	15	500,000	$7,500,000
	Tailings impoundment pre-production capital costs - total				*$91,300,000*
	Total pre-production capital costs				*$709,300,000*
Tailings Impoundment - Treaty Creek Tributary (sustaining capital costs for dam raising)					
21	Core and drainage blanket fill	m^3	1,500,000	12	$18,000,000
22	Cycloned NAG tailings sand for downstream shell extension/raising	m^3	8,000,000	2.50	$20,000,000
23	Annual allowance for clean out/maintenance of downstream decant/settling ponds	years	12	150,000.00	$1,800,000
24	Allowance for foundation treatment (grout curtains, etc)	ls	2	1,000,000	$2,000,000
	Sustaining capital costs for dam raising - total				*$41,800,000*
Tailings Impoundment - Treaty Creek Tributary (closure/reclamation costs)					
25	Closure spillway channel	ls	1	500,000	$500,000
26	Cover/erosion protection and reclamation of dam slopes	ls	2	1,000,000	$2,000,000
	Tailings impoundment closure costs - total				*$2,500,000*

Note - The following items are NOT included in the above costs:

1. Detail design and project/construction management costs.
2. Plantsite, power, and other infrastructure.
3. Mining costs (including waste rock crushing, conveying and hauling).
4. Operating costs, including long term closure & operation of WTP.
5. Summer road (extension of the Eskay Creek Road).

Table 5.3 Conceptual cost estimate (partial) for Case 3

Case 3 - Tailings and PAG Waste Rock to Treaty Creek Watershed Impoundment

Item No.	Description of Work	Unit	Qty.	Unit Cost	Total Cost ($ Cdn)
Tunnel & conveyor for ore & PAG waste rock transport					
1	6 m dia tunnel from Treaty Creek to KS Area (not including rock support)	km	23.0	8,000,000	$184,000,000
2	Allowance for rock support in tunnel (steel sets, bolts, shotcrete, liners)	km	23.0	3,000,000	$69,000,000
3	Allowance for access adits, ventilation shafts, portal structures, level invert	ls	1.0	20,000,000	$20,000,000
4	Conveyor for crushed ore transport	m	23,000	8,000	$184,000,000
				Tunnel & conveyor for ore transport - total	***$457,000,000***
ARD Management at KS Site (pre-production capital costs)					
11	Water treatment plant (initial construction)	ls	1	15,000,000	$15,000,000
12	Allowance for collection ponds, pumping, piping for management of site runoff	ls	1	3,000,000	$3,000,000
				ARD Management at KS Site - total pre-production cost	***$18,000,000***
Tailings Impoundment - Treaty Creek Tributary (Pre-Production Capital Costs)					
13	Fill for two starter dams	m^3	16,000,000	12	$192,000,000
14	Allowance for foundation treatment (grout curtains, etc)	ls	2	1,500,000	$3,000,000
15	Allowance for two seepage collection dams downstream of each of the two main tailings dams	ls	2	400,000	$800,000
16	Diversion Dam	m^3	1,500,000	12	$18,000,000
17	Cyclone Station with flotation cells - south abutment of the southernmost dam	ls	1	12,000,000	$12,000,000
18	Diversion Ditches	m	15,000	150	$2,250,000
19	Diversion conduit outlet from diversion dam	m	5,000	150	$750,000
20	Tailings pipelines & access roads	km	15	500,000	$7,500,000
				Tailings impoundment pre-production capital costs - total	***$236,300,000***
				Total pre-production capital costs	***$711,300,000***
Tailings Impoundment - Treaty Creek Tributary (sustaining capital costs for dam raising)					
21	Imported fill (including core material)	m^3	36,000,000	12	$432,000,000
22	Cycloned NAG tailings sand for downstream shell extension/raising	m^3	12,000,000	2.50	$30,000,000
23	Annual allowance for clean out/maintenance of downstream decant/settling ponds	years	12	150,000.00	$1,800,000
24	Allowance for foundation treatment (grout curtains, etc)	ls	2	1,500,000	$3,000,000
				Sustaining capital costs for dam raising - total	***$466,800,000***
Tailings Impoundment - Treaty Creek Tributary (closure/reclamation costs)					
25	Closure spillway channel	ls	1	500,000	$500,000
26	Cover/erosion protection and reclamation of dam slopes	ls	2	2,000,000	$4,000,000
				Tailings impoundment closure costs - total	***$4,500,000***

Note - The following items are NOT included in the above costs:

1. Detail design and project/construction management costs.
2. Plantsite, power, and other infrastructure.
3. Mining costs (including waste rock crushing, conveying and hauling).
4. Operating costs, including long term closure & operation of WTP.
5. Summer road (extension of the Eskay Creek Road).

6.0 CLOSURE

The next step foreseen in this study is a qualitative risk assessment of the three cases presented herein. This will be conducted in our offices in Burnaby, with the objective of is to gain an understanding of the technical and permitting risks associated with the mine waste management aspects of the Kerr-Sulphurets project. This will be achieved by thoroughly interrogating each of the three cases by addressing the following questions:

- What can go wrong?
- How likely is it to occur?
- If it happens, how serious are the consequences?
- What measures are in place now to limit the likelihood and/or consequence?
- What additional measures can be adopted to limit the likelihood and/or consequence?
- What are the key uncertainties in the assessments of likelihood and consequence?

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