Noranda
Kerr-Sulphurets Project

Tailings & Waste Rock Management

Conceptual Scoping Study

Agenda

1 Overview of Kerr Sulphurets Project – re cap

2 Location and Setting

3 Study parameters

4 Key project challenges

5 Alternatives evaluation criteria

6 Waste rock management alternatives

8 Tailings management alternatives

9 Pit walls drainage alternatives

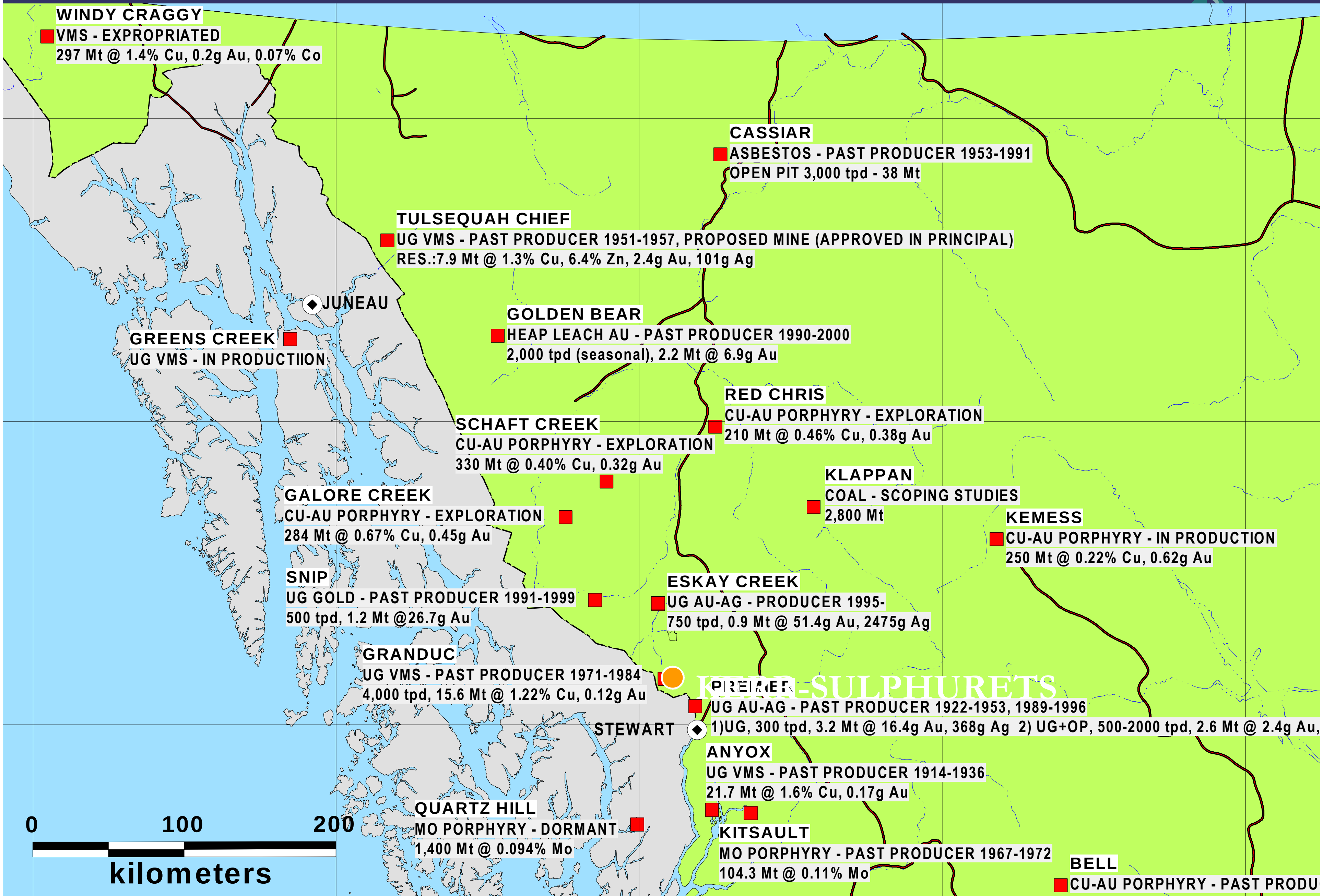
10 Technically viable schemes

Location and Setting

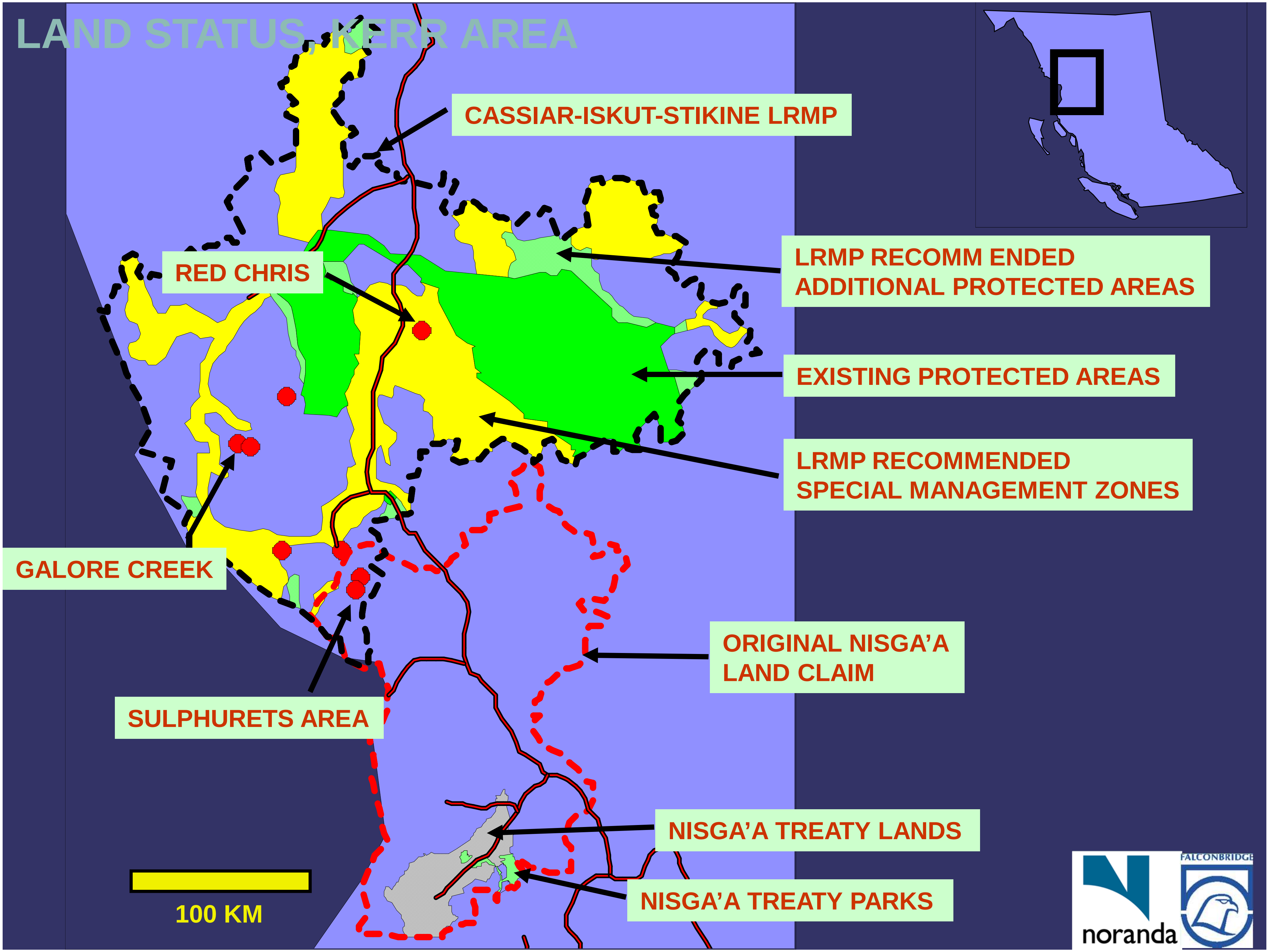
amec

- Iskut-Stikine River region
- 65 km northwest of Stewart, 35 km south of Eskay Creek Mine
- Nearest road is the Eskay Creek Mine Road, following Iskut River Valley from Bob Quinn Lake on HWY 37
- Other mines in the area:
  - Eskay
  - Granduc (closed)
  - Premier (closed)
  - Snip (closed)

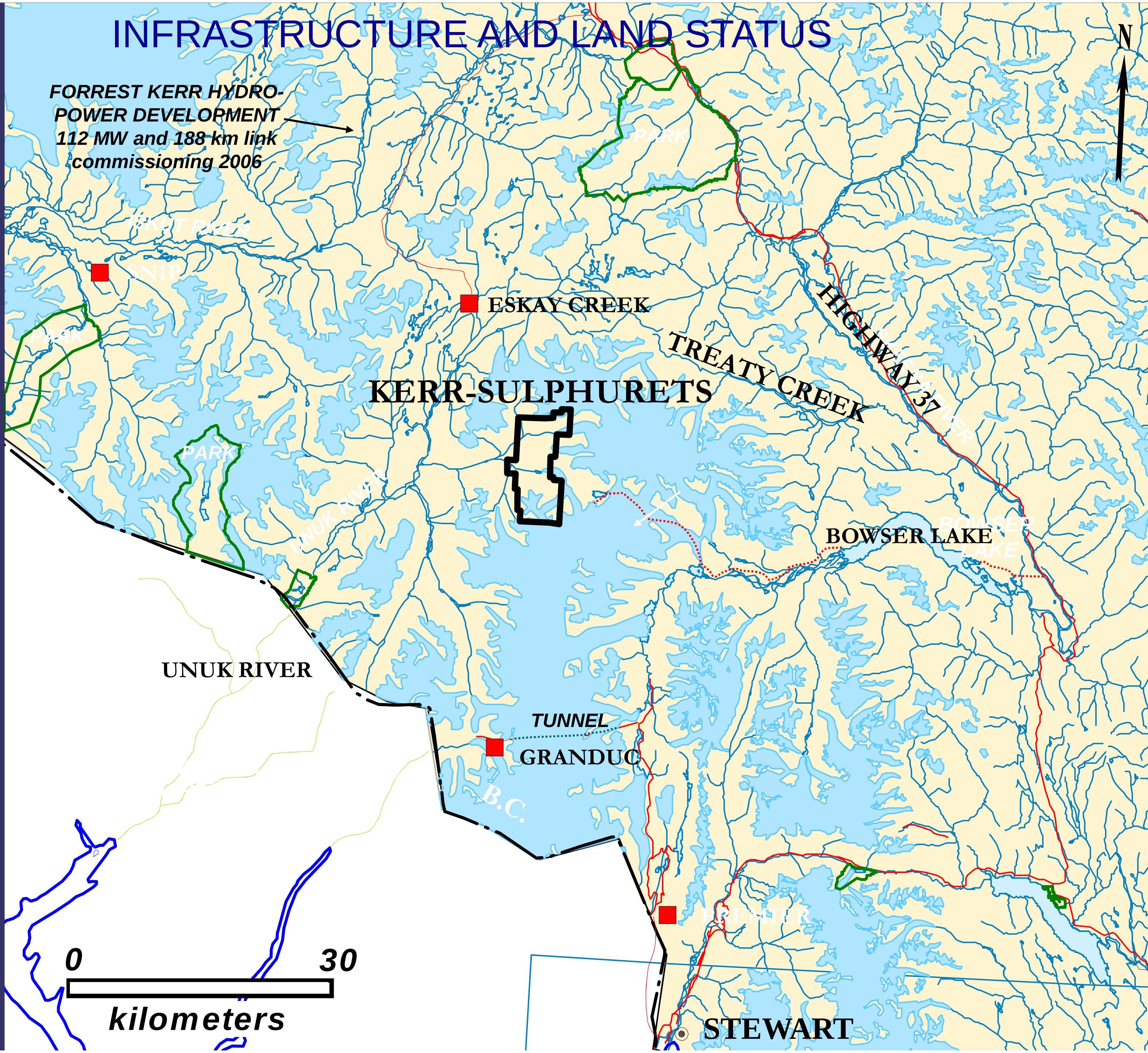
MINES AND EXPLORATION PROJECTS, NW B.C.

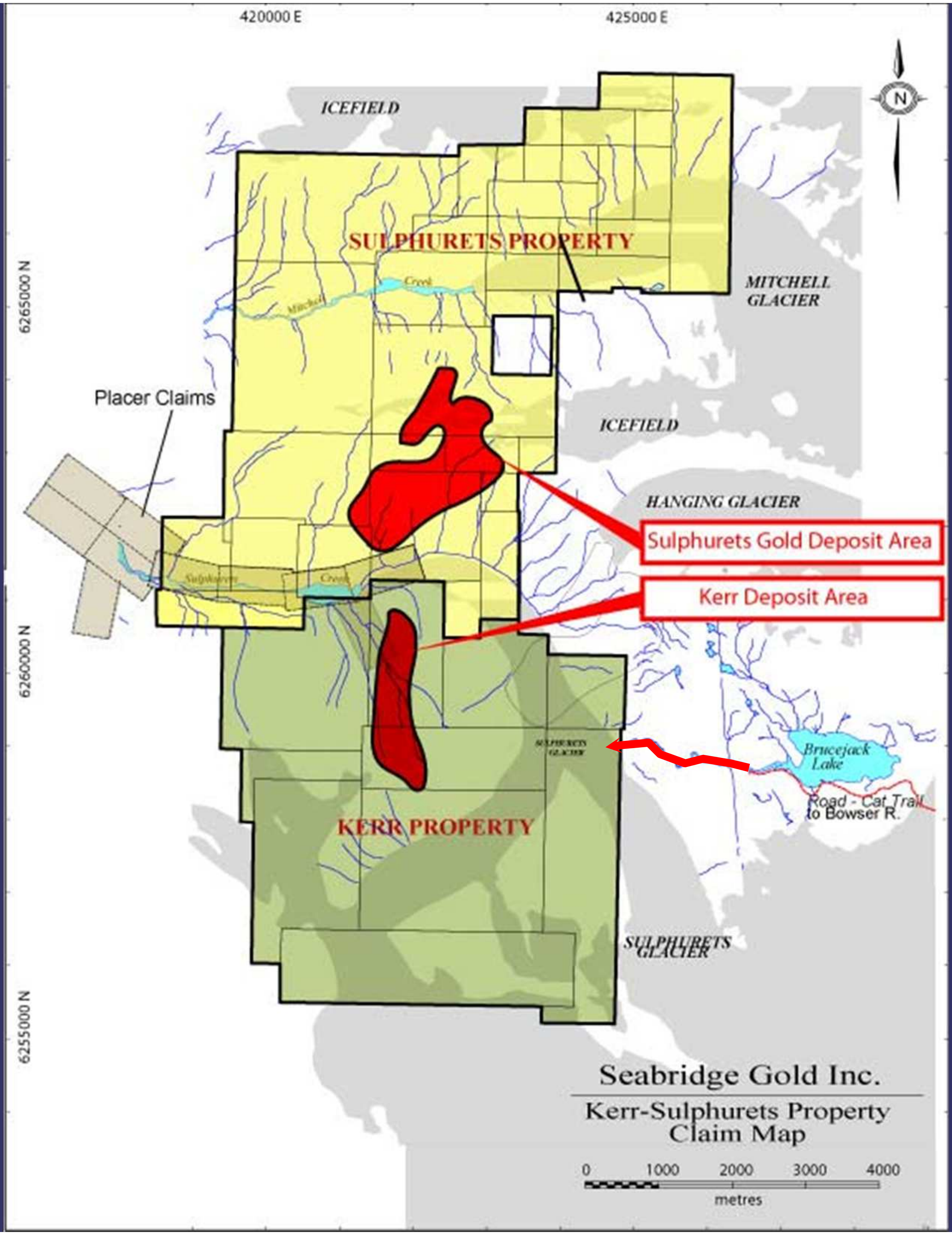


LAND STATUS, KERR AREA



INFRASTRUCTURE AND LAND STATUS





Note – Brucejack Lake drains to Sulphurets Creek.

Available Data/Studies

- Placer Dome "rough cut" evaluation
- Water quality data
- ABA Data
- Detailed geologic data
- Summary of baseline data to 1990 (Norecol)
- Preliminary evaluation of KS-Knipple Lake tunnel
- More recent Stantec environmental report for Noranda
- Meteorology data – Eskay Creek

Study 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 AG)
  - 800 MT waste rock (most likely AG)
  - April update from M. Savell:
    - 10% Kerr waste rock NAG
    - 30% Sulphurets waste rock NAG
    - Assume the NAG materials can be segregated in the pit

Waste 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

ABA Data

- Placer conducted ABA tests on Kerr deposit (223 samples)
- All samples were < 0.4% Cu (i.e. waste rock)
- Over 80% samples were PAG
- NP low to moderate, high sulphur content
- Short lag time to onset of ARD considered likely (Placer predicted mean of 32 weeks), 90% of samples suggested onset in < 1 year (but no kinetic tests to confirm any of this)
- Limited ABA data for Sulphurets

Key project challenges for tailings & waste rock management

- Rugged terrain
- AG/PAG materials
- Wet climate, high snowpack
- Frequent avalanches
- High seismicity
- Active glaciation
- Availability of construction materials for earthworks
- Risk associated with remote water-retaining dams required to function in perpetuity
- Runoff to west (Alaska, international waters issues e.g. Tulsequah Chief)
- Lake disposal a “challenge” to permit, although there are exceptions
- Natural ARD – how much more can receiving environment accommodate?
- Permitting, First Nations, NGO’s (e.g. Windy Craggy)

Key water management/ quality issues

- Big difference if have/do not have trans-boundary issues
- e.g. Alaska's limits tighter than BC's
- Projects go to joint US-Canada panel to determine what happens next, but BC government does not support that – "BC process good enough on its own"
- Kerr Sulphurets a fair ways up headwater from the border – likely no impact by the time Unuk gets to Alaska, but
- Unuk river supports sockeye salmon fishery – sockeye reported in Unuk upstream of confluence with Sulphurets Creek
- Have natural ARD and poor water quality - MOE's 1st position will be that system is already impacted, cannot tolerate more
- More work in BC to establish site-specific discharge criteria
- Eskay – site-specific WQ requirements
- Elevated cobalt, sulphate (from flowing boreholes), arsenic, Cadmium, aluminum, copper, iron, lead, zinc (Table 3 from Stantec report) at KS.
- Site hydrology is challenging

UNUK RIVER ESKAY CREEK
BRITISH COLUMBIA

Latitude: 56° 39' N **Longitude**: 130° 27' W **Elevation**: 887.00 m

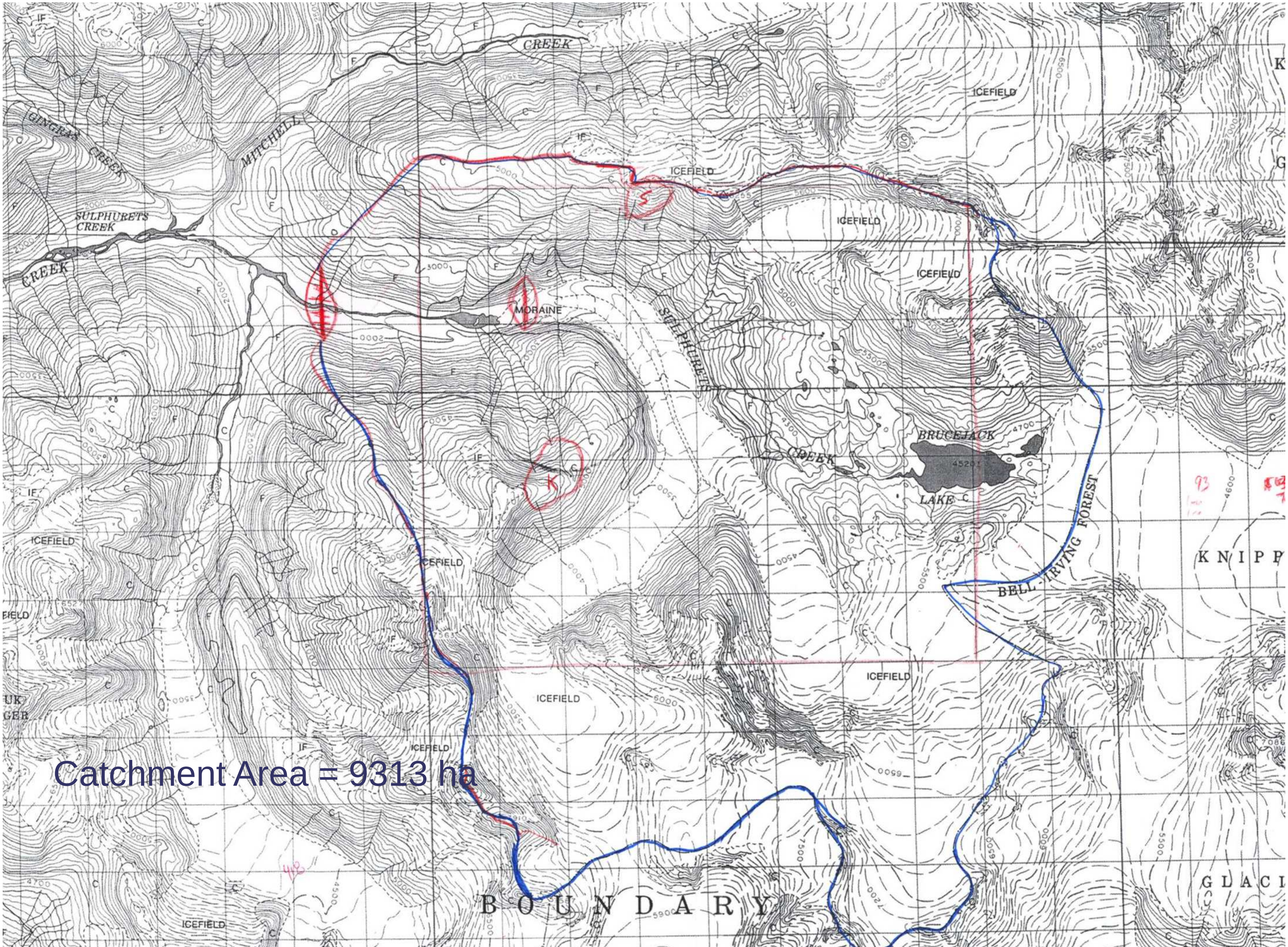
Climate ID: 1078L3D **WMO ID**: **TC ID**:

Previous Year | 1999 Go | Next Year

Monthly Data Report for 1999

Month	Mean Max Temp °C	Mean Temp °C	Mean Min Temp °C	Extr Max Temp °C	Extr Min Temp °C	Total Rain mm	Total Snow cm	Total Precip mm	Snow Grnd Last Day cm	Dir of Max Gust 10's Deg	Spd of Max Gust km/h
Jan	-5.4	-8.5	-11.5	2.0S	-23.0	0.0*	345.0	345.0*	180		
Feb	-2.0	-5.3	-8.5	2.0S	-14.0	0.0	175.0	175.0	190		
Mar	1.1	-2.9	-6.8	8.0	-12.5	0.0	102.0	102.0	168		
Apr	4.4	0.2	-4.0	14.5	-11.0	0.0	140.0	140.0	138		
May	6.5*	2.4*	-1.4	11.0*	-6.5S	144.0	20.4	164.4	0		
Jun	11.8*	7.7*	3.2	18.0*	-2.0	56.3	0.0	56.3	0		
Jul	15.7	11.1	6.5	24.0	3.0	81.7	0.0	81.7	0		
Aug	15.6	11.5	7.3	28.0S	3.0	160.7	0.0	160.7	0		
Sep	8.8	6.1	3.4	18.0	-4.0	182.1	1.0	183.1	0		
Oct	2.6	0.9	-0.8	6.0S	-6.0	167.4	276.0	443.4	96		
Nov	-0.3	-2.1	-4.0	6.0S	-10.0S	15.0E	262.7	277.7E	106		
Dec	-1.4	-3.5	-5.7	4.0S	-17.0	0.0	299.0	299.0	132		
Sum						807.2*	1621.1	2428.3*			
Avg	4.8*	1.5	-1.9								
Xtrm				28.0S	-23.0					M	M

Significant rainfall during the earthworks construction season.



Catchment Area = 9313 ha

Eskay Creek – hydromet data

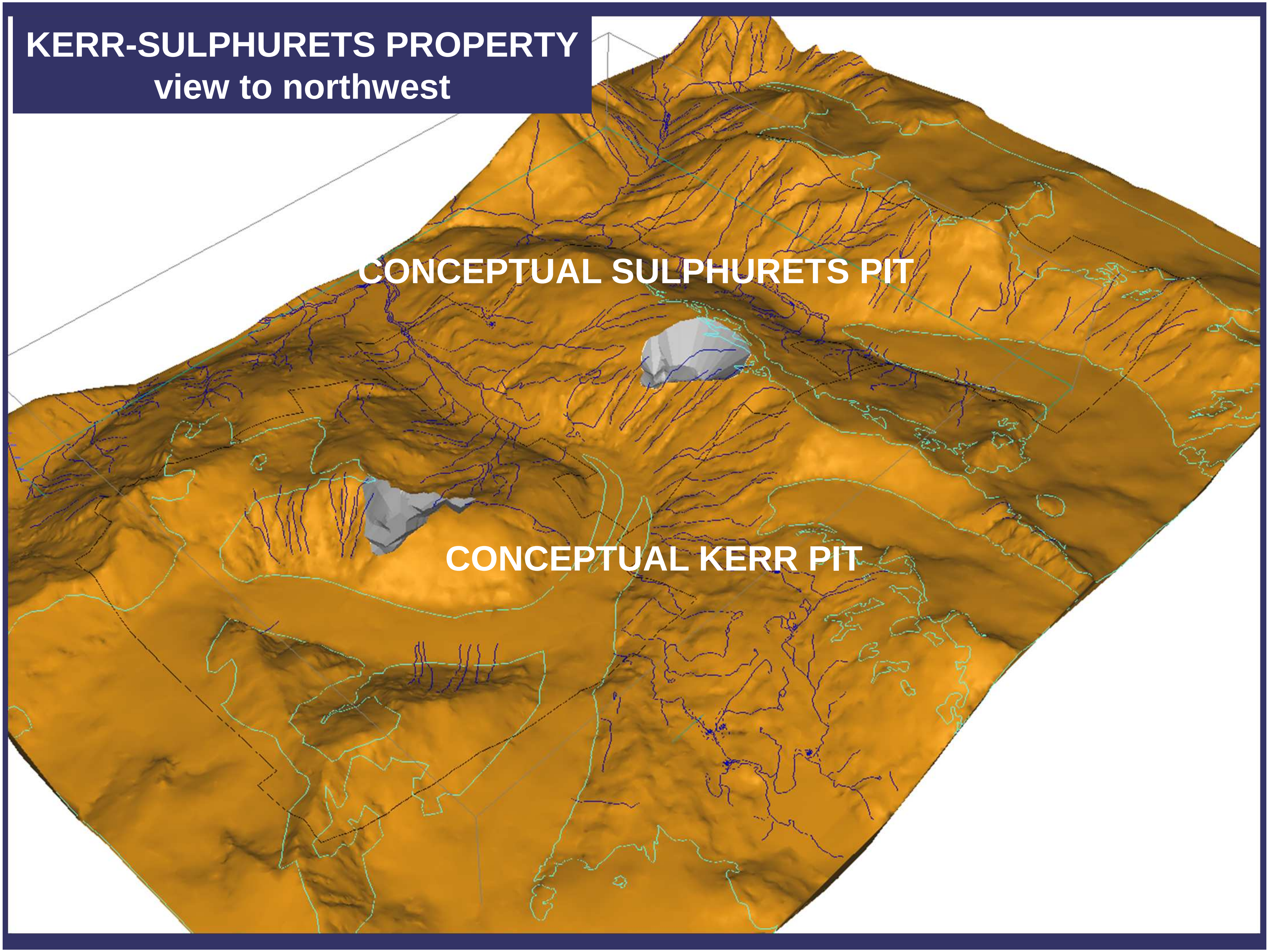
- Data since 1991
- Average 2.2 m annual precipitation
- About 1.5 m/year snowfall
- Snowmelt typically distributed as follows:
  - May: 60%
  - June: 30%
  - July: 10%
- Sulphurets Lake runoff catchment about 9,313 ha
- With runoff coeff. = 0.6, 2.2 m annual precipitation yields an annual average runoff of about 123 Mm^3
- With 60% of snowmelt in May, and 144 mm of rainfall, runoff in that month would average 35.4 m^3/sec (total runoff volume 92 Mm^3)
- Therefore, approximately 75% of annual runoff occurs in one month
- This is a significant challenge in terms of diversions – must be designed on the basis of handling 75% of annual runoff in a single month

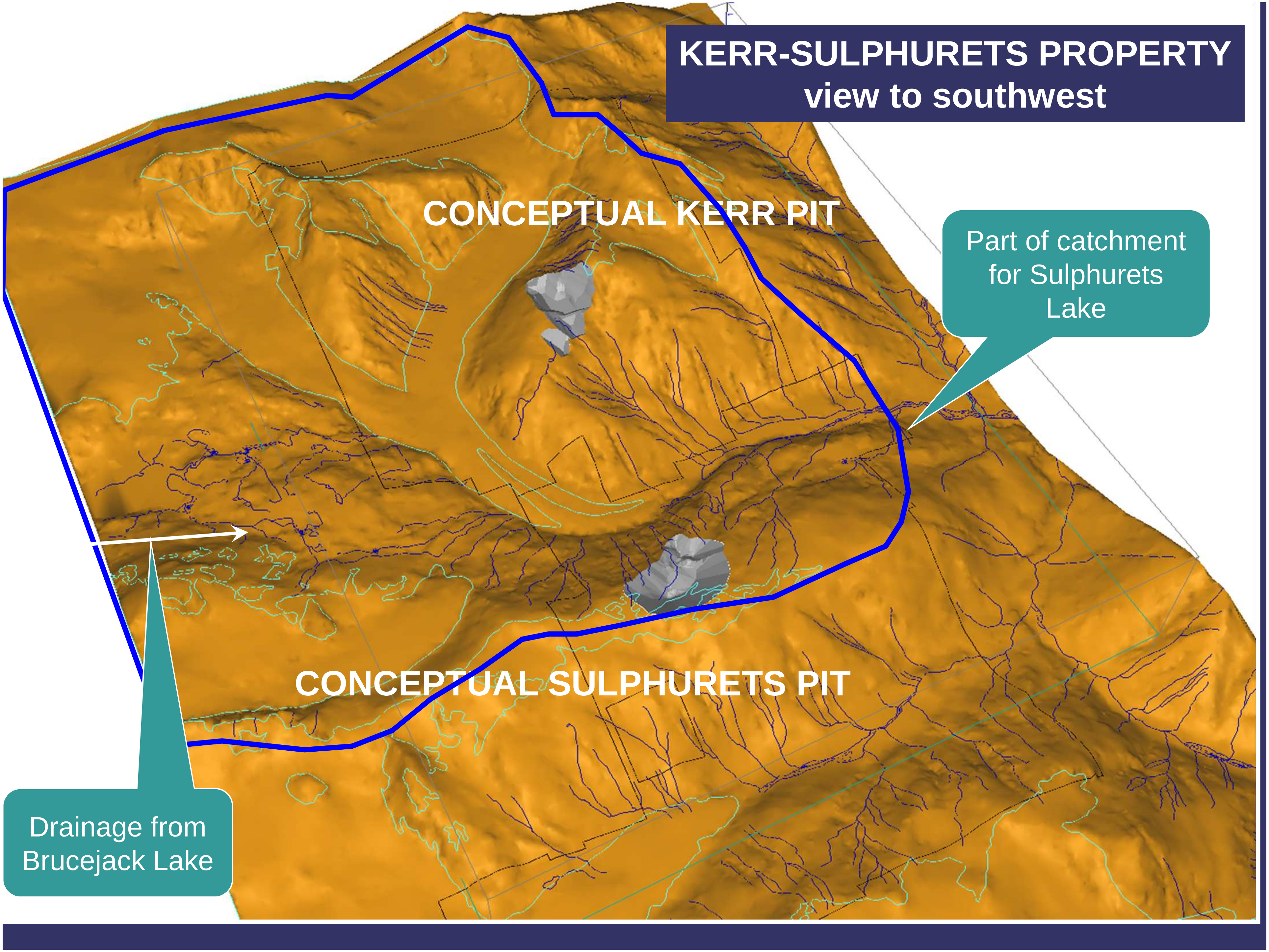
Eskay Creek Permit Discharge Quality Requirements

PARAMETERS		***Upper Portal Waste Rock Discharge (D3)***		***D3 Clean Water Bypass***	***Minewater & Mill Effluent Discharge (D7)***		***#5 Ramp Clean Water***		***Albino Lake Outlet Discharge (W20)***		***Sewage Plant Discharge***	
Parameter	***Units***	***Sample Freq.***	***Limits***	***Sample Freq***	***Sample Freq***	***Limits***	***Sample Freq***	***Limits***	***Sample Freq***	***Limits***	***Sample Freq***	***Limits***
Physical												
Flow	m^3/d	W	1250	W	D	3500	W	monitor	d	-	W	50
pH	pH units	W/1x	≥ 6.5 & ≤10.5	W	W/d	≥ 6.5 & ≤10	W	≥ 6.5 & ≤10	d	≥ 6.5 & ≤10	-	-
TSS/NFR	mg/l	W/1x	≤ 75	W	W/d	≤ 75	W	≤ 75	W/1x	≤ 50	M	≤60
Hardness	mg/l	W	monitor	W	W	monitor	W	monitor	W	monitor	-	-
Alkalinity	mg/L	-	-	-	-	-	-	-	W	monitor	-	-
TOC	mg/L	-	-	-	-	-	-	-	W	monitor	-	-
Conductivity	uS/cm	W	monitor	W	W	monitor	W	monitor	d	monitor	-	-
Oil/Grease	mg/l	-	-	-	W	10	-	10	W	monitor	-	-
BOD_5	mg/l	-	-	-	-	-	-	-	-	-	M	≤ 45
Fecal Coli.	mpn/100ml	-	-	-	-	-	-	-	-	-	M	≤200
Anions & Nutrients												
Sulphate	mg/l	W	monitor	W	W	monitor	W	monitor	W	monitor	-	-
Chlorine Residual	mg/l	-	-	-	-	-	-	-	-	-	M	monitor
Ammonia	mg/l	W	monitor	-	W	monitor	-	monitor	W	monitor	-	-
Total Metals												
Ag	mg/l	W	monitor	W	W	monitor	W	monitor	W	monitor	-	-
Al	mg/l	W	monitor	W	W	monitor	W	monitor	W	monitor	-	-
As	mg/l	W	monitor	W	W	monitor	W	monitor	W	monitor	-	-
Cd	mg/l	W	monitor	W	W	monitor	W	monitor	W	monitor	-	-
Cu	mg/l	W/1x	monitor	W	W/1x	monitor	W	monitor	W/1x	monitor	-	-
Fe	mg/l	W/1x	monitor	W	W/1x	monitor	W	monitor	W/1x	monitor	-	-
Ni	mg/l	W	monitor	W	W	monitor	W	monitor	W	monitor	-	-
Pb	mg/l	W/1x	monitor	W	W/1x	monitor	W	monitor	W/1x	monitor	-	-
Sb	mg/l	W/1x	monitor	W	W/1x	monitor	W	monitor	W/1x	monitor	-	-
Zn	mg/l	W/1x	monitor	W	W/1x	monitor	W	monitor	W/1x	monitor	-	-
Dissolved Metals												
Ag	mg/l	W	≤0.05	W	W	≤0.05	W	≤0.05	W	≤0.05	-	-
Al	mg/l	W	≤0.5	W	W	≤0.5	W	≤0.5	W	≤0.5	-	-
As	mg/l	W	≤0.1	W	W	≤0.1	W	≤0.1	W	≤0.1	-	-
Cd	mg/l	W	≤0.01	W	W	≤0.01	W	≤0.01	W	≤0.01	-	-
Cu	mg/l	W/1x	≤0.05	W	W/d	≤0.05	W	≤0.05	W/1x	≤0.05	-	-
Fe	mg/l	W/1x	≤1.0	W	W/d	≤1.0	W	≤2.0	W/1x	≤1.0	-	-
Ni	mg/l	W	≤0.2	W	W	≤0.2	W	≤0.2	W	≤0.2	-	-
Pb	mg/l	W/1x	**≤0.05** EXT	W	W/d	**≤0.05** EXT	W	**≤0.05** EXT	W/1x	**≤0.05** EXT	-	-
Sb	mg/l	W/1x	≤1.0	W	W/d	≤1.0	W	≤1.0	W/1x	monitor	-	-
Zn	mg/l	W/1x	≤0.2	W	W/d	≤0.2	W	≤0.2	W/1x	≤0.2	-	-
Toxicity												
Rainbow Trout 96hr LT 50		Q	P	-	Q	P		P	Q	P	-	-
Daphnia magna 48 hr LT50		-	-	-	-	-	I/M	P	-	-	-	-

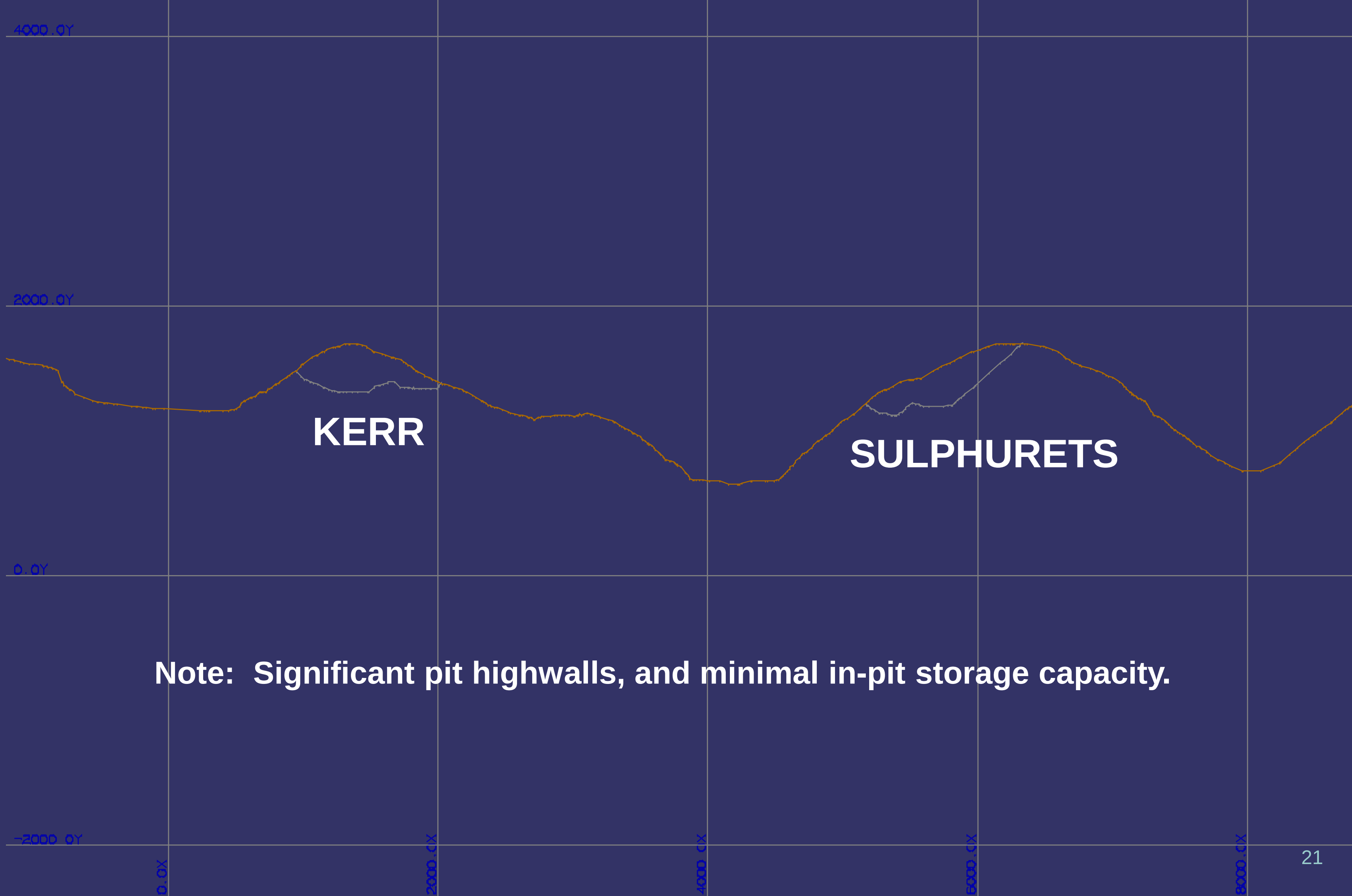
1989 Norecol Environmental Study

- Measured discharge of Sulphurets Creek at Sulphurets Lake outlet mid August 1989
- Snowmelt complete, but glaciers melting contributing to flow
- Measured discharge was 4.3 m^3/sec
- For August, based on 161 mm rainfall, runoff coefficient = 0.6 and 9,313 ha catchment, discharge from Sulphurets Lake would average about 3.5 m^3/sec
- Accounting for melt from glaciers during August, this is consistent with measured discharge of 4.3 m^3/sec
- Based on experience in the region, during peak weeks of snowmelt, flow rate could be about 10x higher (i.e. about 43 m^3/sec) than late summer, consistent with the 35 m^3/sec estimated for May (peak snowmelt month)


KERR-SULPHURETS PROPERTY
view to northwest
CONCEPTUAL SULPHURETS PIT
CONCEPTUAL KERR PIT


KERR-SULPHURETS PROPERTY
view to southwest
CONCEPTUAL KERR PIT
Part of catchment for Sulphurets Lake
CONCEPTUAL SULPHURETS PIT
Drainage from Brucejack Lake

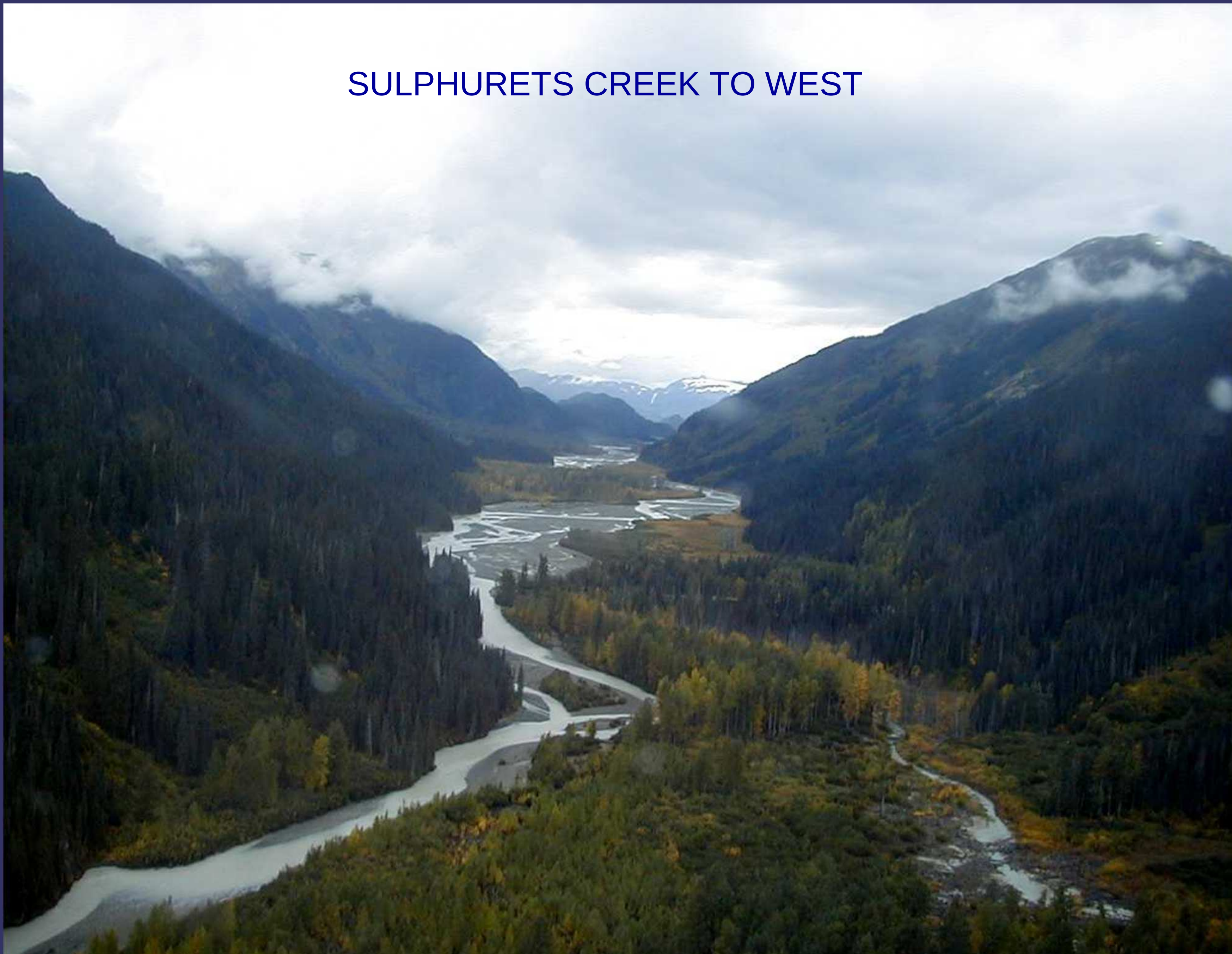
NORTH-SOUTH CROSS SECTION, VIEW TO WEST



Note: Significant pit highwalls, and minimal in-pit storage capacity.

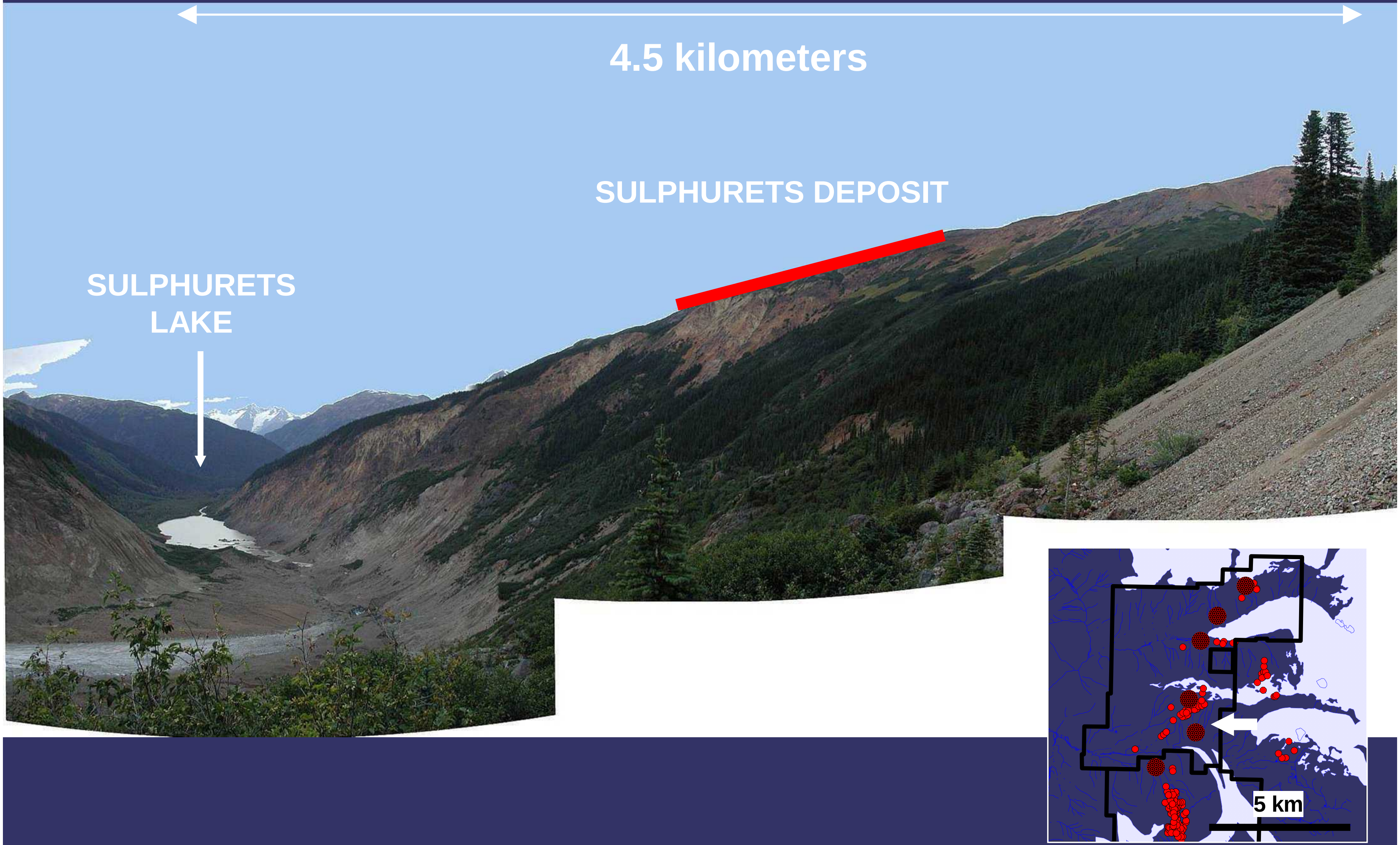
SULPHURETS CREEK TO EAST

SULPHURETS CREEK TO WEST



KERR DEPOSIT

SULPHURETS



VIEW TO WEST DOWN SULPHURETS VALLEY

noranda
FALCONBRIDGE

Noranda internal risk assessment

- Potential fatal flaws (high probability x high impact) identified with respect to waste management:
  - ***No suitable tailings disposal areas***
  - ***Waste rock pile closure costs prohibitive***
  - ***Tailings closure costs prohibitive***
  - ***Pit closure costs prohibitive***
- Steps to be taken next:
  - identify options, evaluate, and determine what option(s) are technically viable
  - Risk assessment of technically viable options – are there fatal flaws? Is cumulative risk profile excessively high?
  - Conceptual level costing for technically viable options that survive the "fatal flaws/cumulative risk" screening process

Project Components

- Waste rock management
- Tailings management
- Pit walls drainage

Alternatives evaluation criteria

- Technically viable, defensible, and successful precedent for tailings/waste rock/pit walls/water management - MUST
- Ability to permit - MUST
- Side benefits in terms of site access – "NICE TO HAVE"
- Cost to be dealt with separately – the 1st challenge is to find alternatives that satisfy the two "MUSTS" listed above.

Alternative A – Waste Rock

Side-hill dumps, cover, perpetual collection and treatment

The concept………..

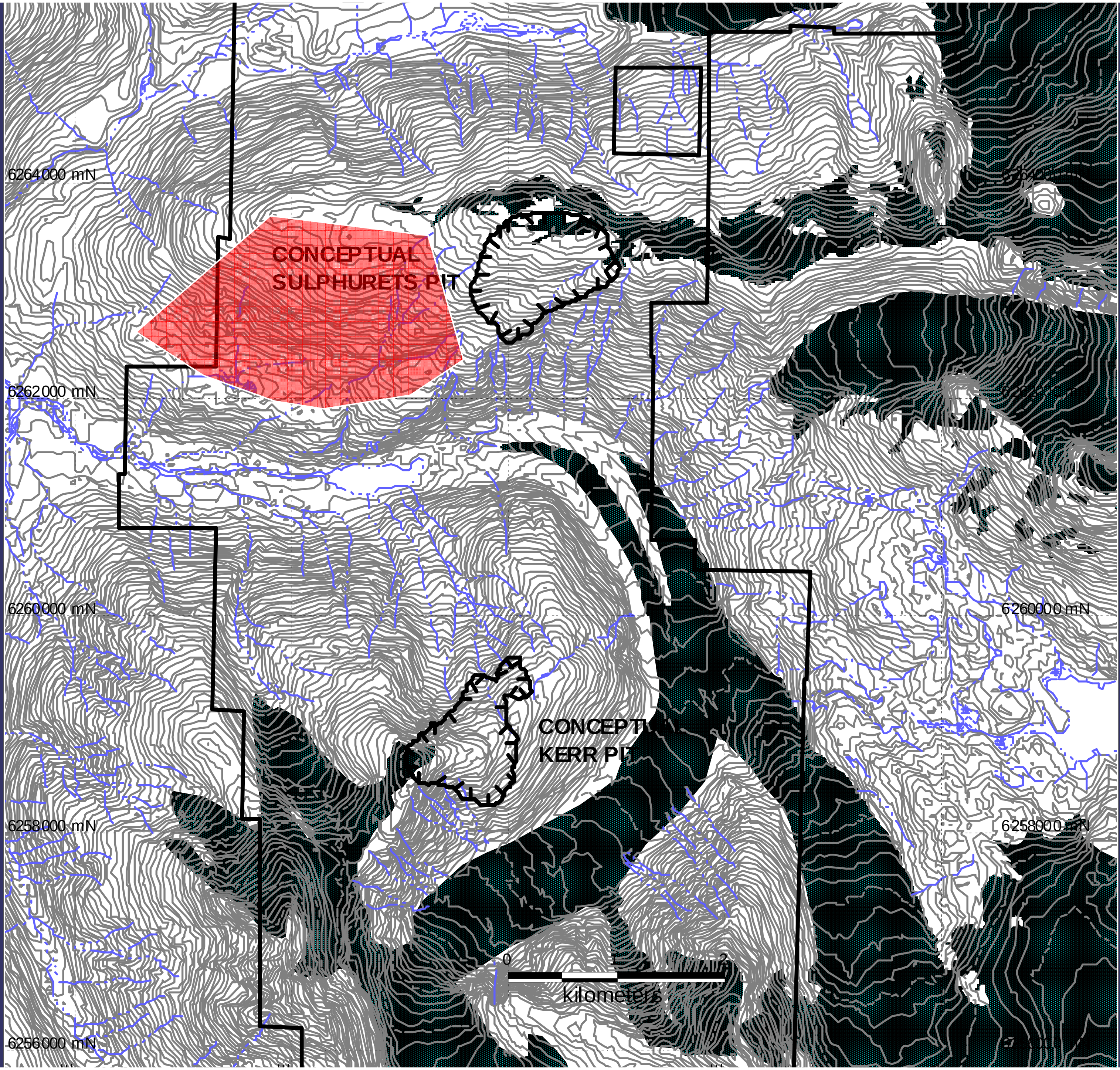
- Ex-pit dumps, cover, perpetual collection and treatment of waste rock and pit drainage
- Develop dumps and diversions as needed to minimize run on and required treatment volumes
- Require collection ditches/ponds for the runoff for storage prior to routing through water treatment plant
- Water treatment plant with permanent site access
- Discharge treated water to Sulphurets Creek (ultimately reports to Unuk/Alaska), or pump to Brucejack watershed (eventually into Bowser system)

Alternative A – Waste Rock

Ex-pit dumps, cover, perpetual collection and treatment

The reality…..

- Terrain is too steep for side-hill dumps that avoid the Sulphurets Creek Valley
- Runoff from dumps must be kept out of Sulphurets Creek, due to the large catchment and hence the large annual flows in that Creek
- Have a natural “bench” to the southwest of Sulphurets Pit, but of insufficient storage capacity for even 50% of Sulphurets waste rock, plus dump slope would be too steep for covering with till
- Even less potential for ex-pit dumps for the Kerr Pit, very steep ground all the way down to Sulphurets Creek valley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CONCEPTUAL
SULPHURETS PIT
CONCEPTUAL
KERR PIT
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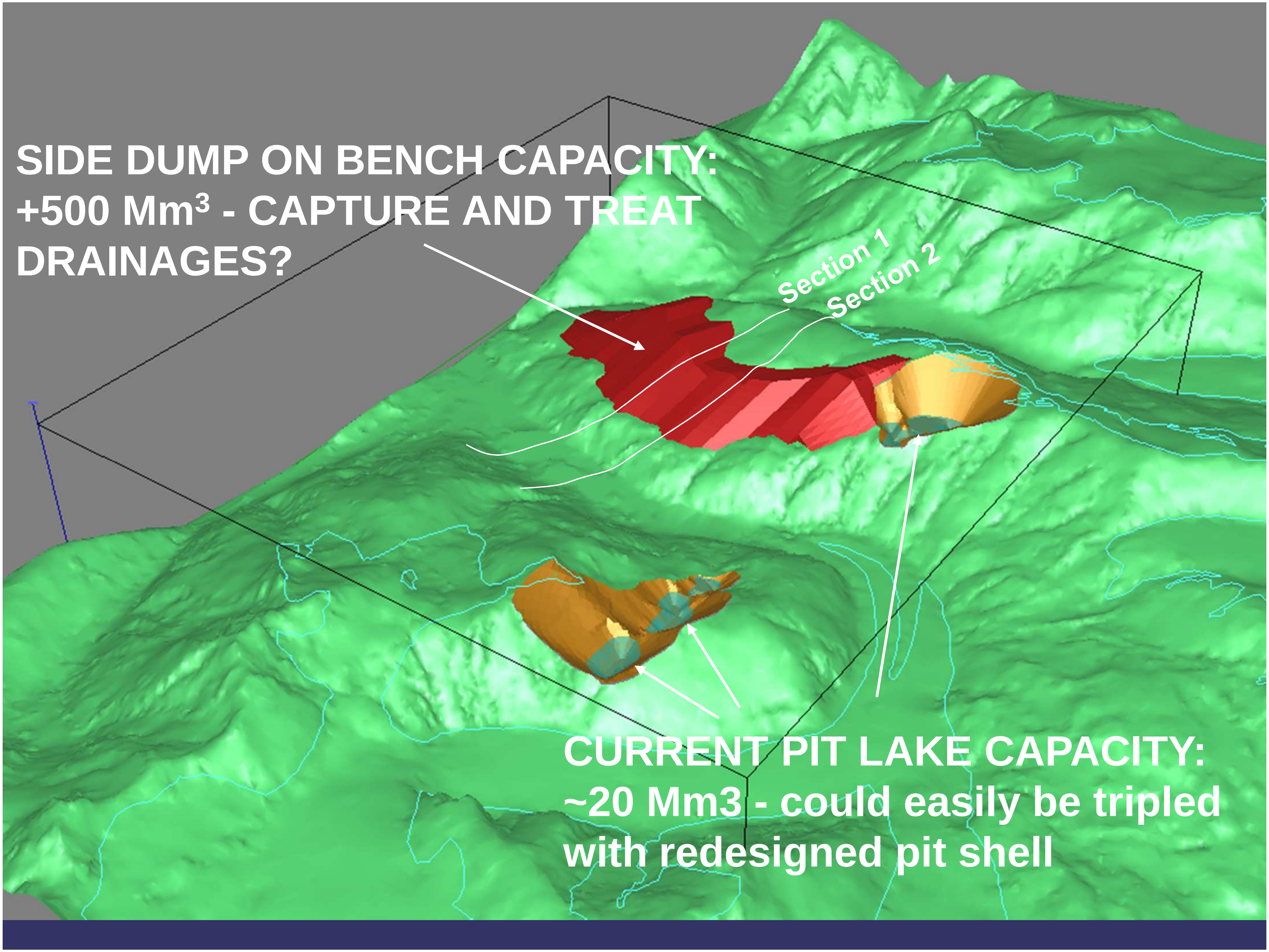
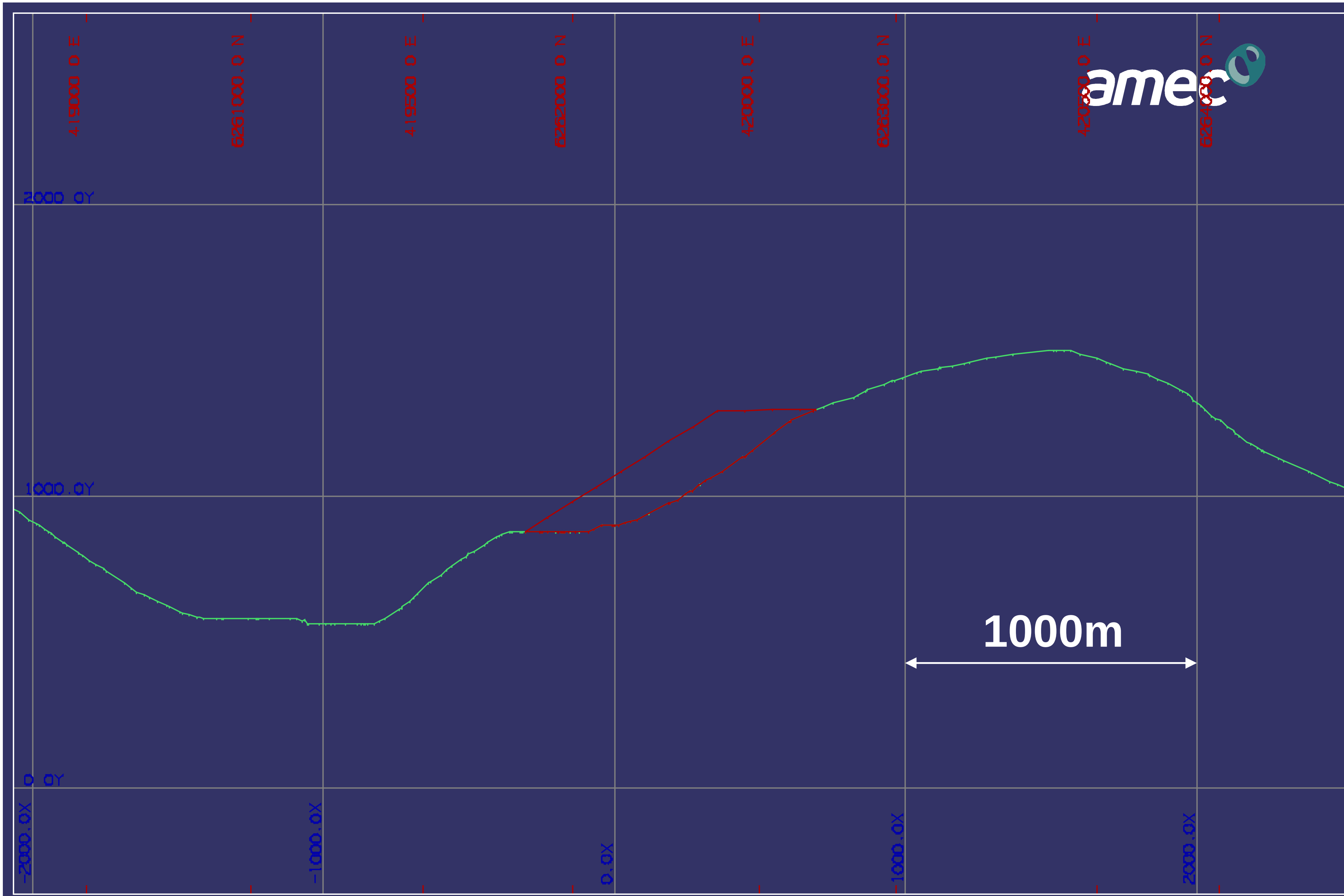
kilometers

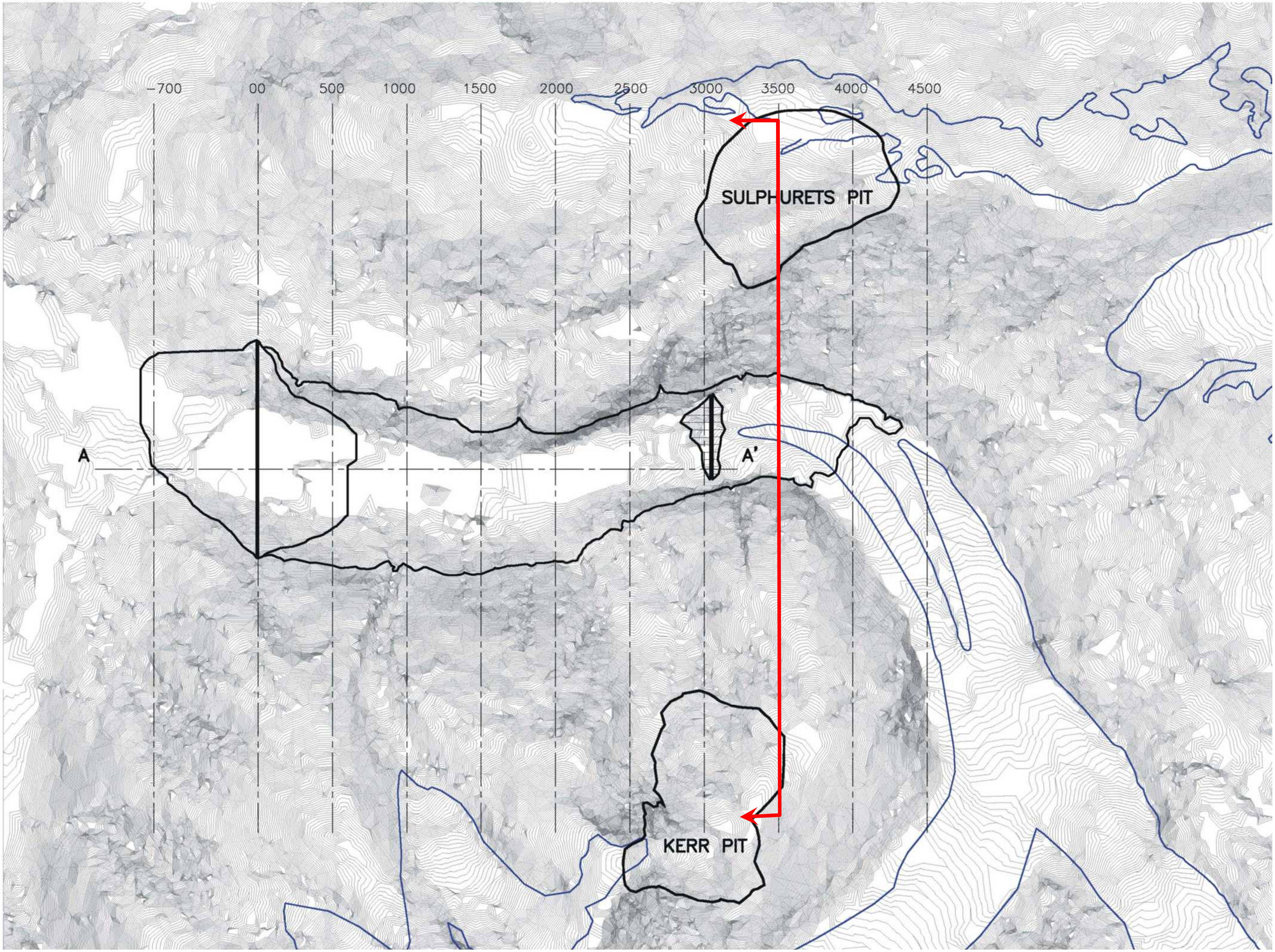

Sulphurets Pit – potential elevated dump area
Look at X-valley sections for additional perspective


SIDE DUMP ON BENCH CAPACITY:
+500 Mm3 - CAPTURE AND TREAT
DRAINAGES?
Section 1
Section 2
CURRENT PIT LAKE CAPACITY:
~20 Mm3 - could easily be tripled
with redesigned pit shell



Section 1 - Side Dump on Bench

Section 2 - Side Dump on Bench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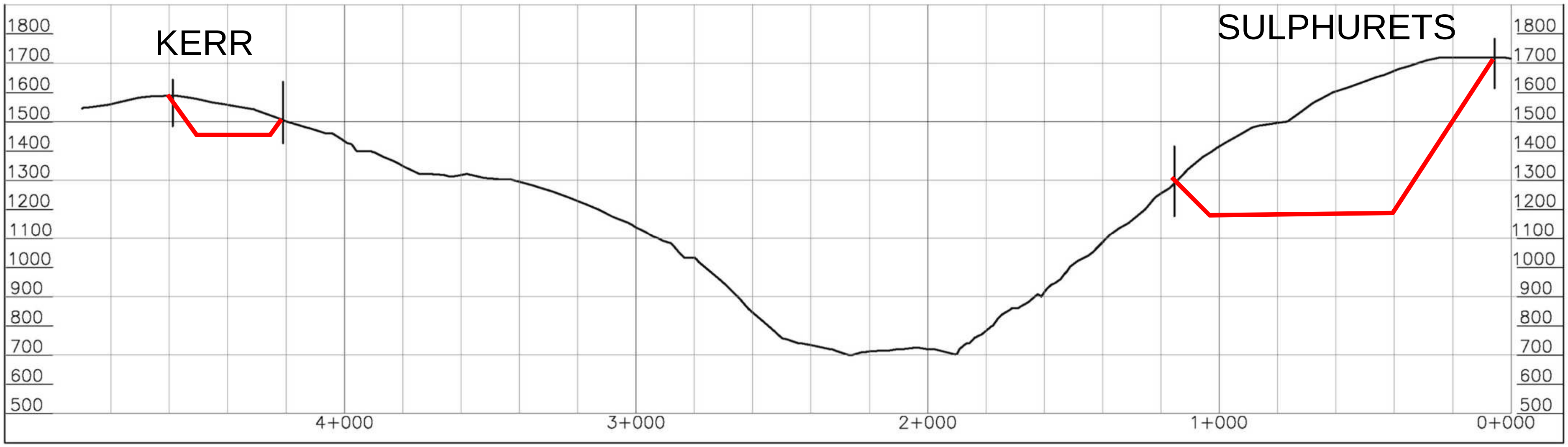
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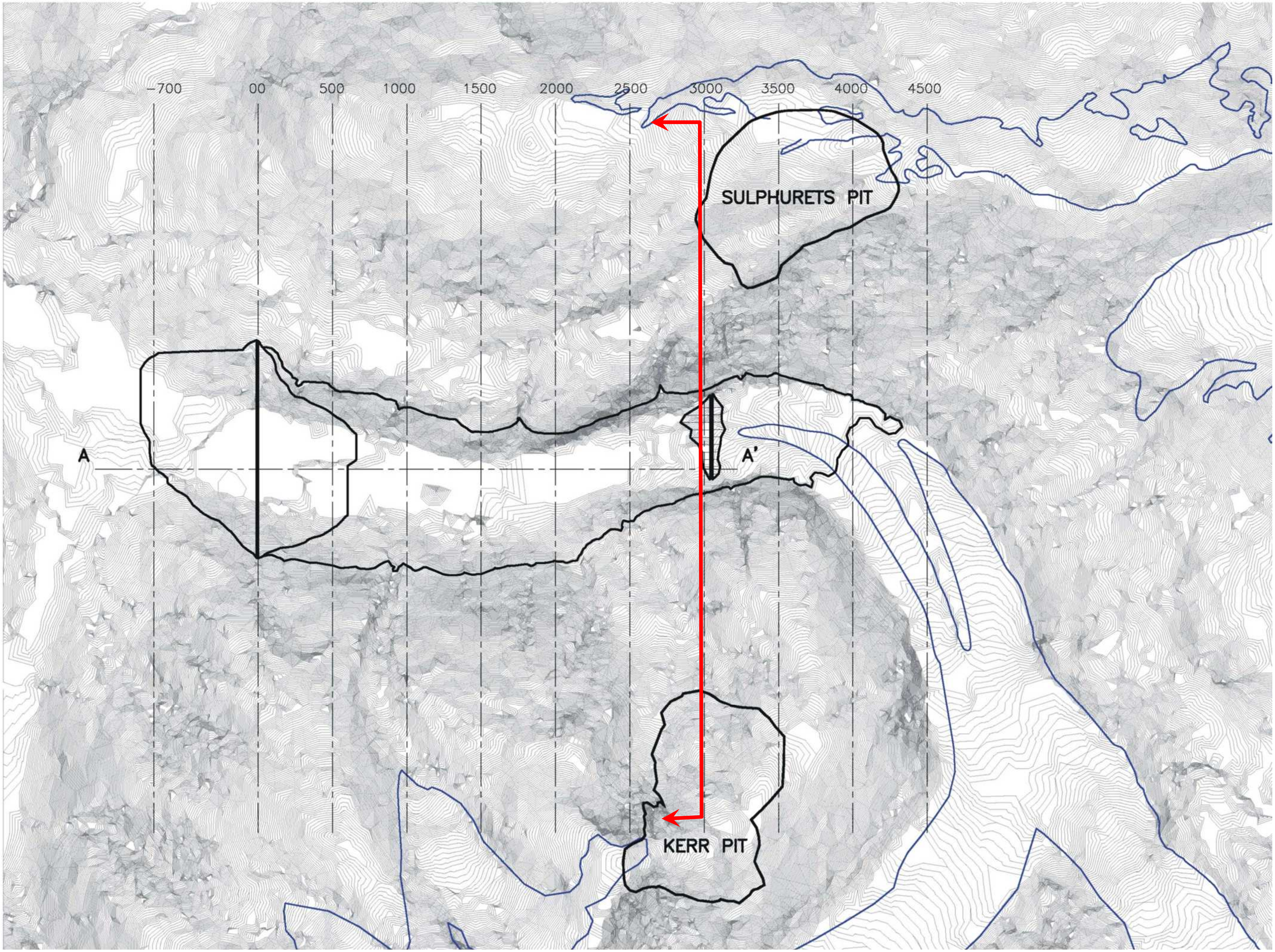
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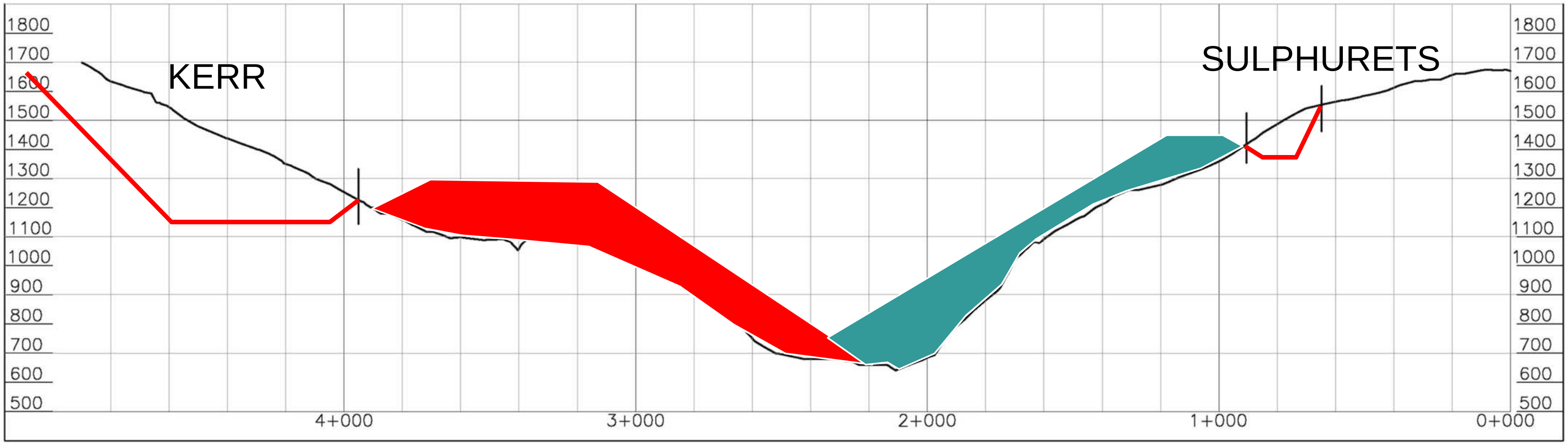

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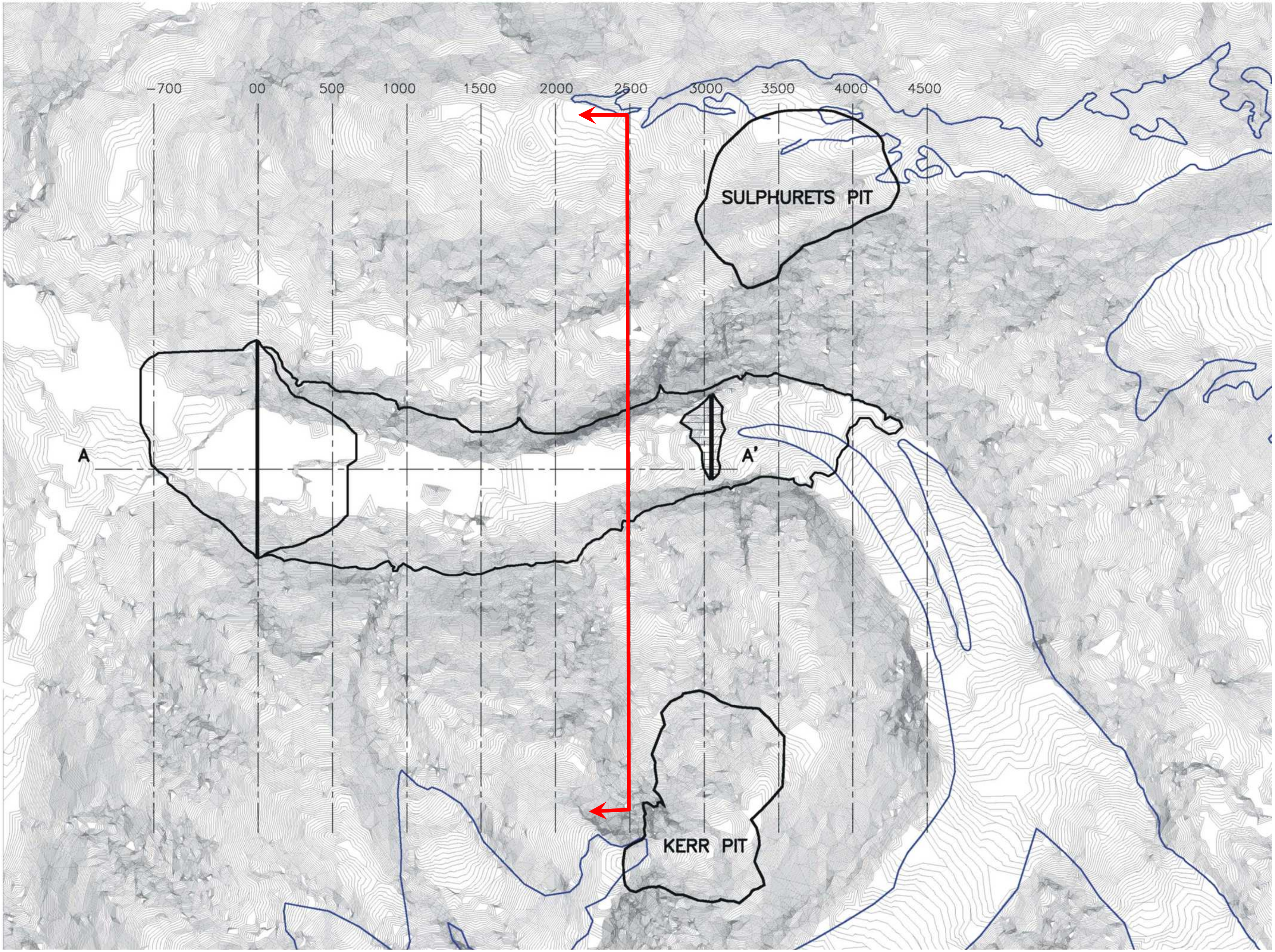

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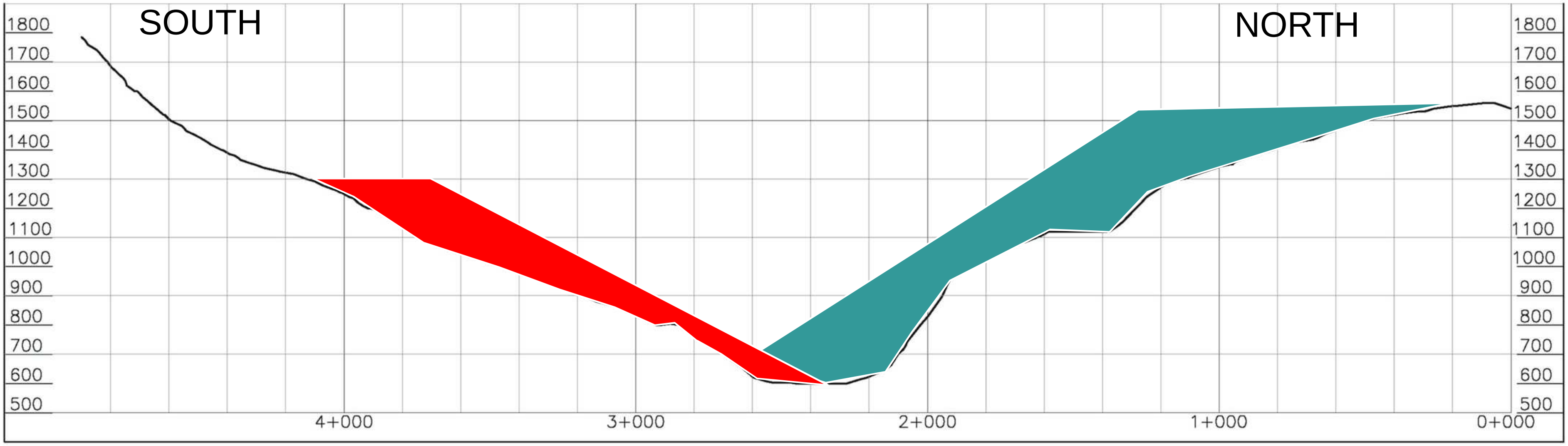
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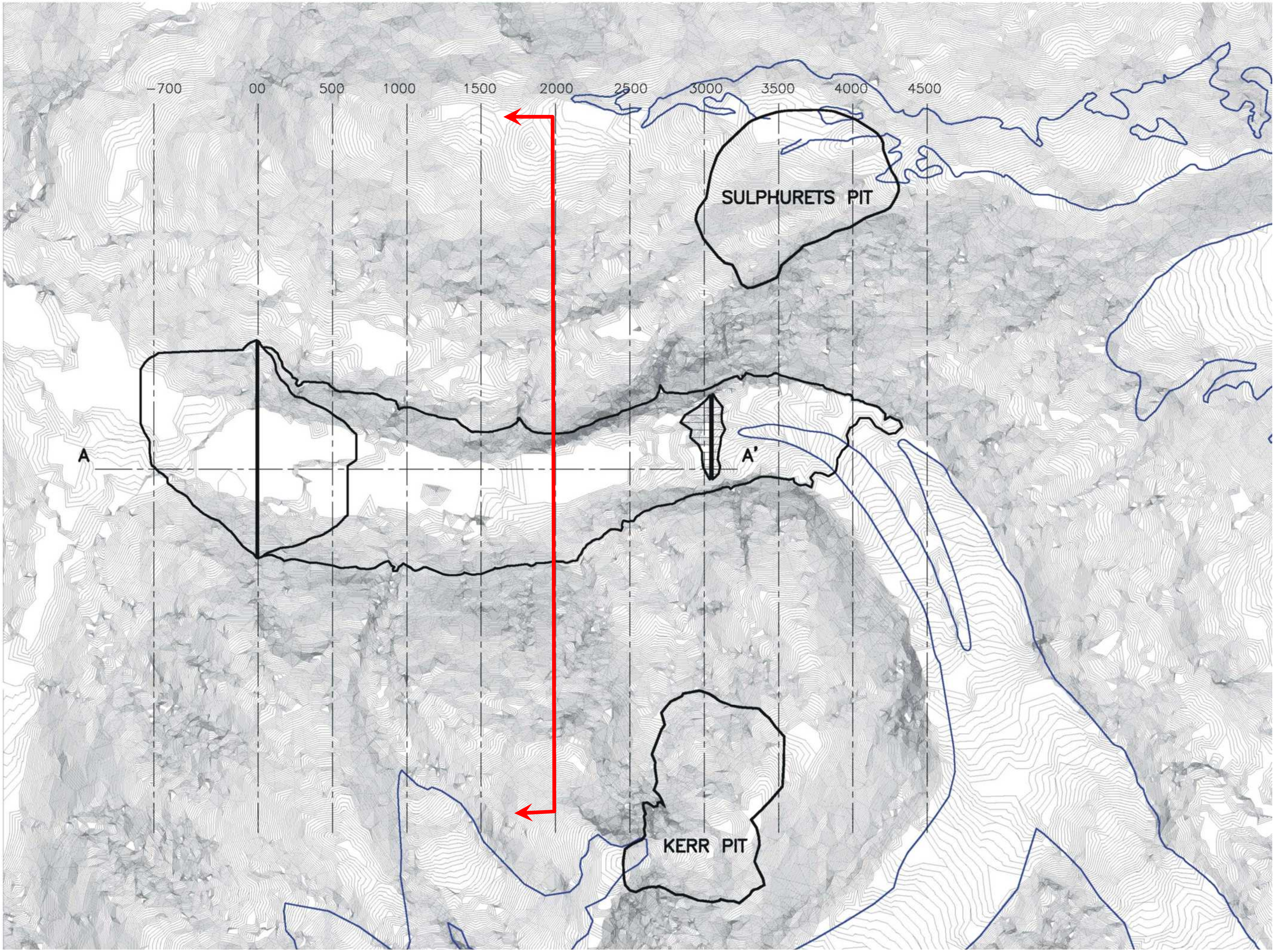
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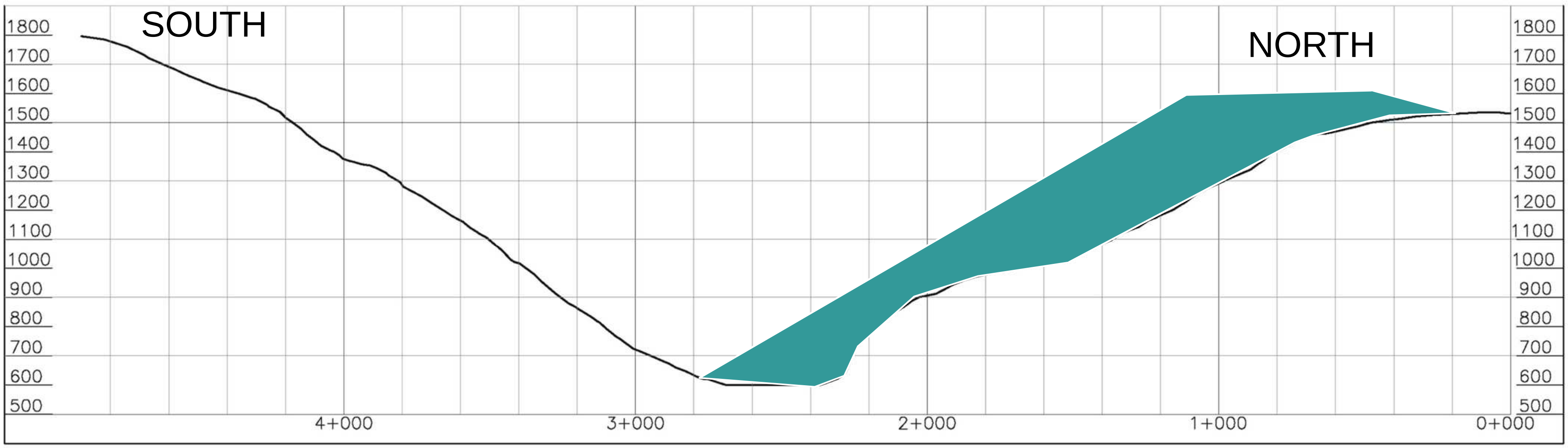
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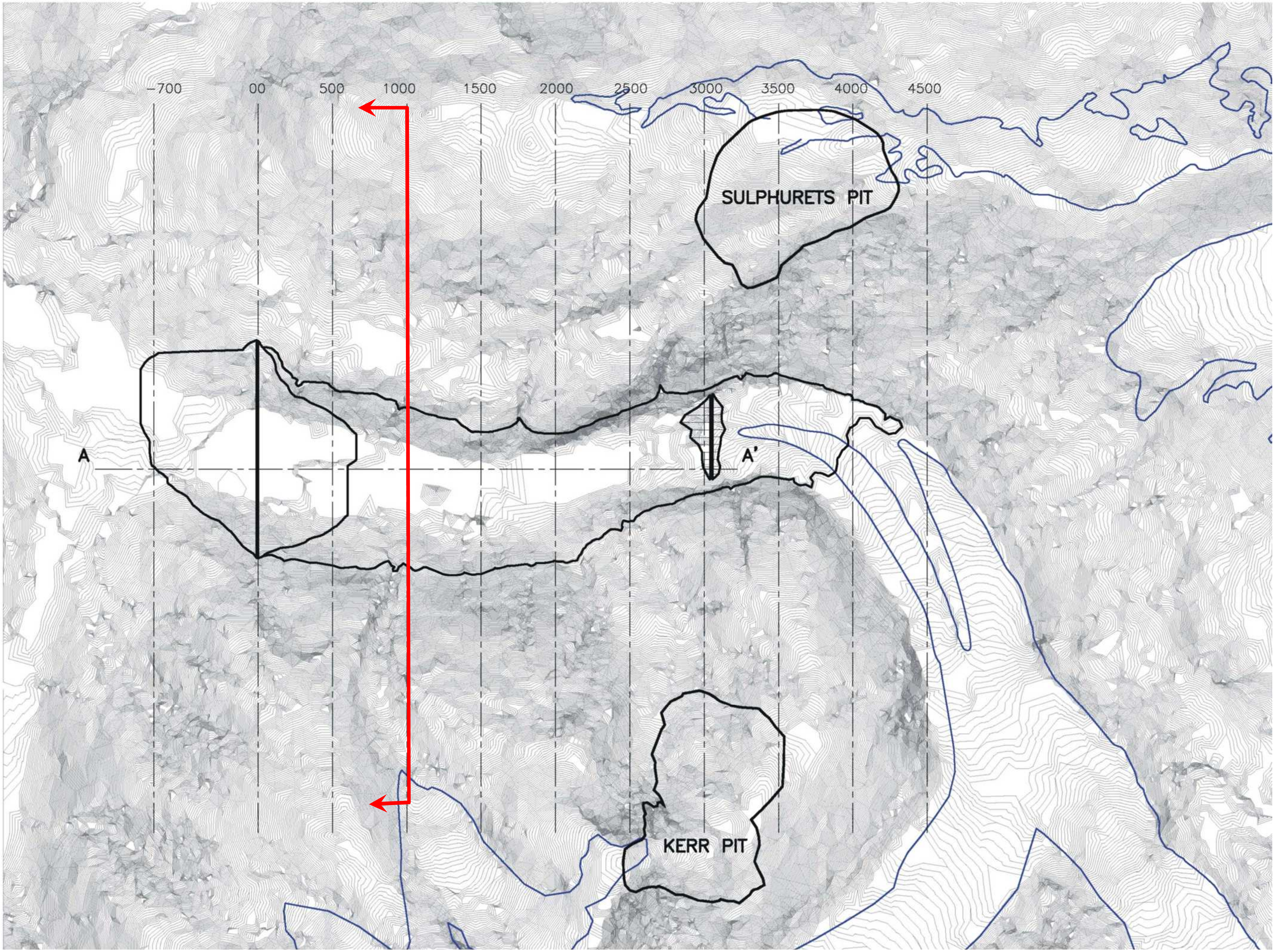

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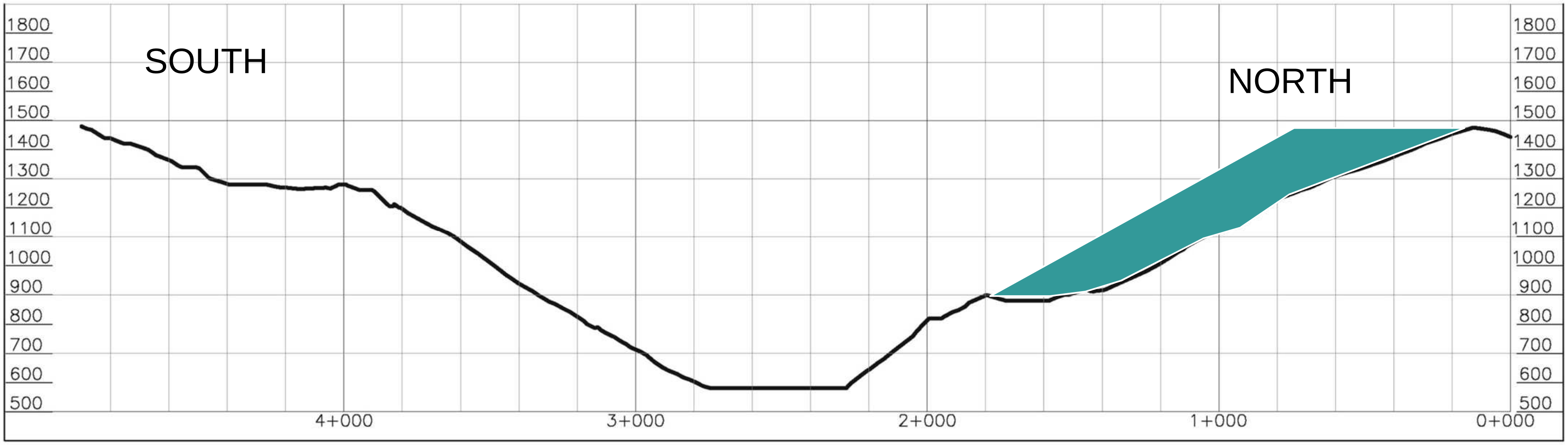
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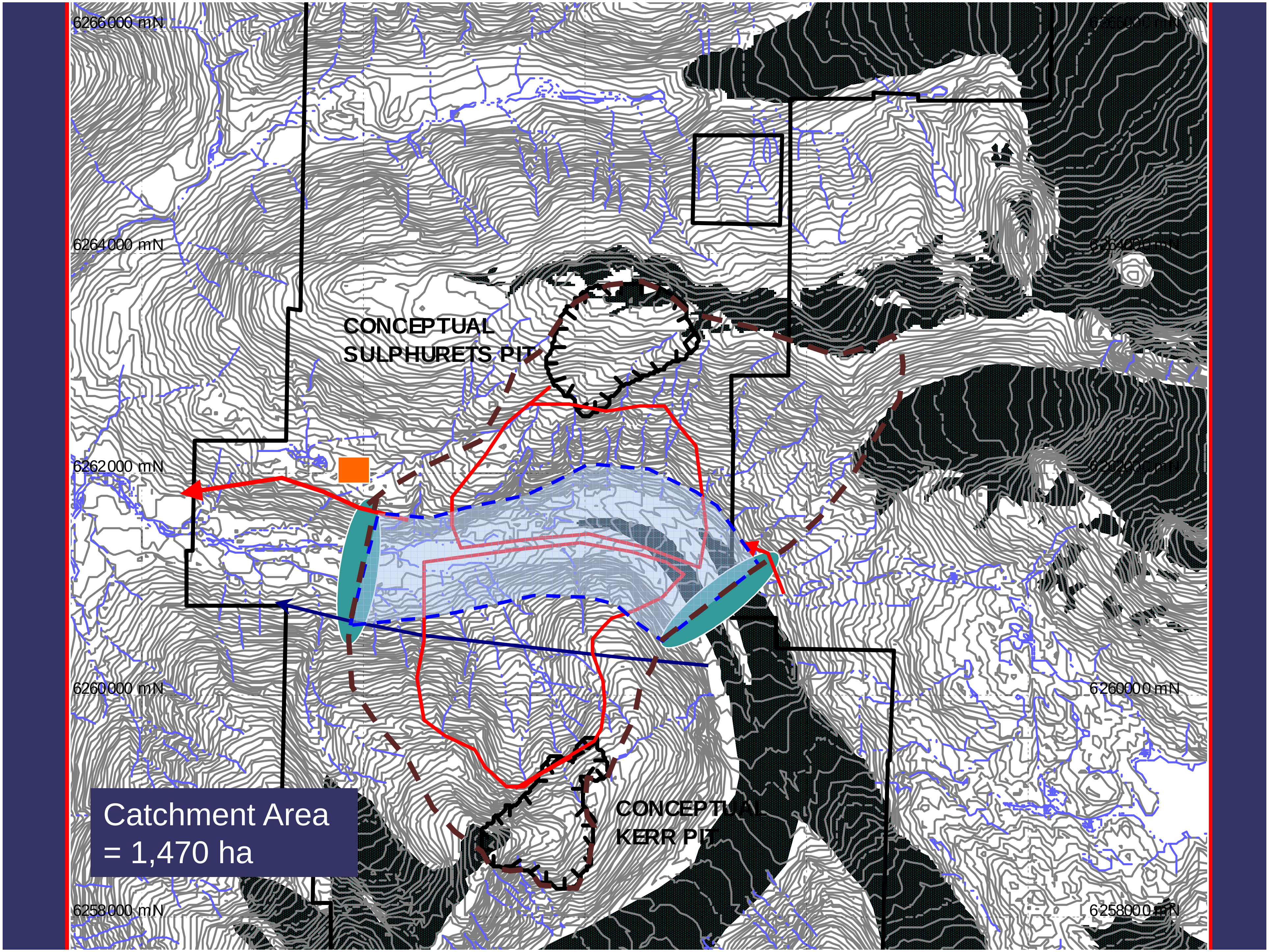
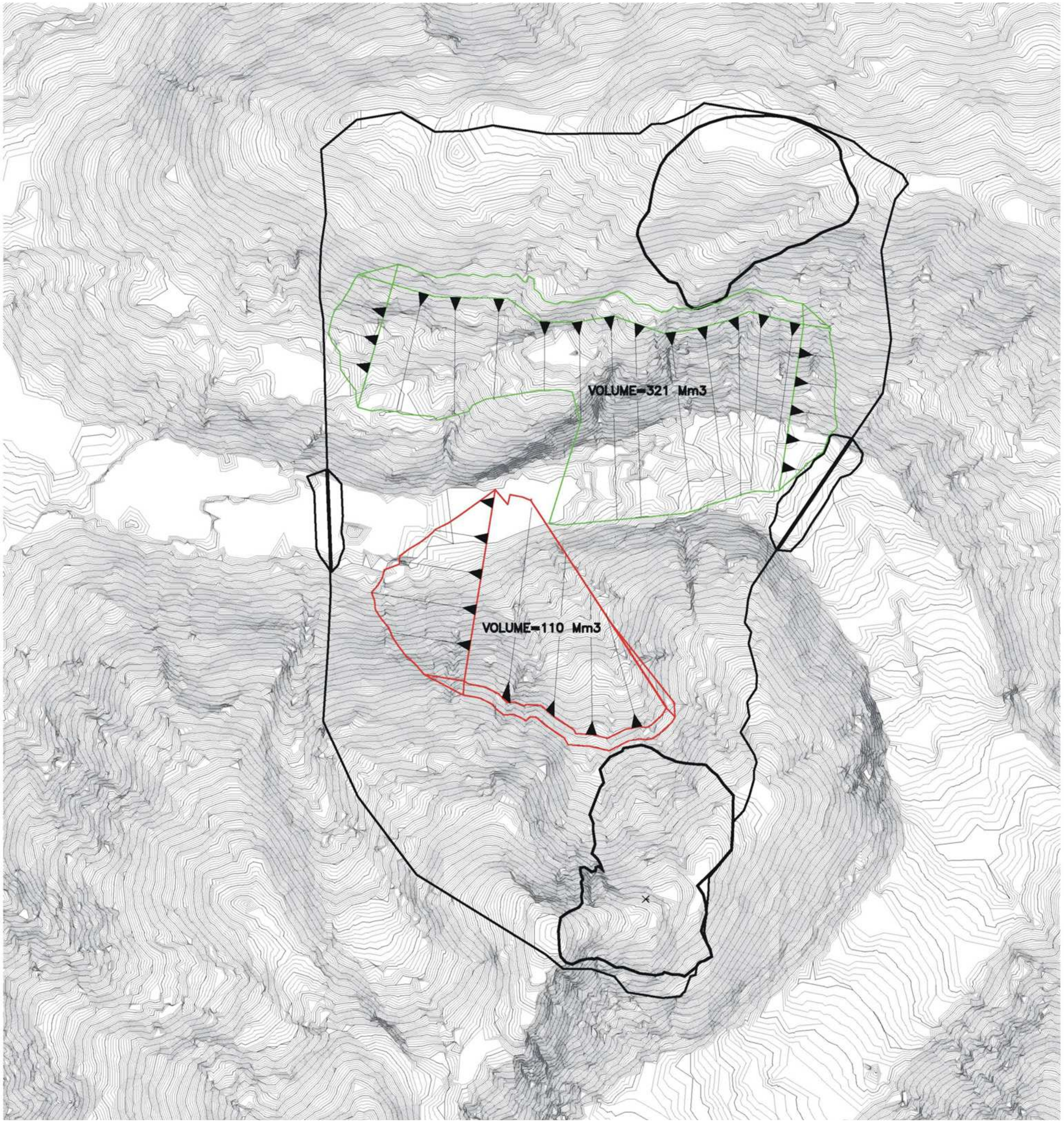
A more workable version of Alternative A?

- Construct water-retaining dams at two locations across Sulphurets Valley
- Diversion tunnel (about 4 km) from the upstream dam to discharge below the downstream dam (diversion channels not feasible). Tunnel would likely have to be lined to maximize hydraulic flow capacity.
- The two dams collect runoff from the waste rock dumps and the drainage from the open pits, for storage then treatment and discharge
- Treatment plant adjacent to the downstream of the two dams, will be in operation from the beginning of mining
- Diversion tunnel must be maintained in perpetuity together with collect/treat facilities
- Tunnel must be of sufficient flow capacity to pass significant floods from the reporting catchment without backing up pond level significantly (would flood toe of the glacier)
- Spillway allows bypass of the upstream dam in case of floods in excess of tunnel’s discharge capacity
- Another spillway protects the downstream dam against overtopping
- No known precedent for this scheme
- Till cover over dumps, separately pipe drainage from the pits to prevent if from flowing through the dumps (and mobilizing metals)


6266000 mN
6264000 mN
6262000 mN
6260000 mN
6258000 mN
6264000 mN
6260000 mN
6258000 mN
CONCEPTUAL
SULPHURETS PIT
CONCEPTUAL
KERR PIT
Catchment Area
= 1,470 ha



amec

Runoff volumes

- Catchment reporting to pond = 1,470 ha
- Includes open pits and waste rock dumps
- Runoff volumes estimated as follows:
  – Avg. annual runoff = 19.4 Mm^3 (annual avg. = 0.6 m^3/sec)
  – May runoff (60% of 1.5 m/year snowmelt, + 144 mm rainfall) = 9.2 Mm^3 (averaging, for the month, 3.6 m^3/sec).
- Based on these volumes, the dam heights required for the downstream dam and the upstream (diversion) dam will be very modest relative to those required for submergence of all PAG rock in Sulphurets

Scope of diversion dam/tunnel

- What combination of diversion dam reservoir capacity and tunnel diameter/length/grade is required to route 92 Mm^3 (avg. 35 m^3/sec) in a single month?
- Tunnel parameters:
  - Lined (to reduce friction coefficient that restricts flow)
  - Length – about 4 km
  - Gradient – 5% (200 m head drop portal to outlet)
  - Require energy dissipation measures at outlet to prevent erosion
- Tradeoff between tunnel diameter and height (i.e. reservoir capacity) of diversion dam
- Height of diversion dam is limited by the presence of the Sulphurets glacier – too high a dam results in transient flooding of the lower reaches of the glacier – is this a concern??

Preliminary tunnel calculations

Discharge	m^3/sec	35	40	45	50
Tunnel Diameter	m	1.8	1.9	2.0	2.1
Head loss	m	260	260	260	260

- Flow capacity is controlled by tunnel length, grade and head losses
- Tunnel flow capacity is therefore insensitive to driving head (height of water in diversion reservoir above the tunnel inlet)
- Therefore, sizing of diversion dam is primarily driven by:
  - Developing sufficient “dead” storage capacity so that portal is off the valley floor and suitably “clean” water (i.e. not heavily sediment laden) is discharged
  - Surcharge storage capacity for large storm events
  - Inlet sufficiently high above valley floor that risk of blockage is significantly reduced
- For margin of safety and preliminary costing purposes, probably best to assume a 3 m diameter tunnel

Alternative B – Waste Rock

Waste rock to flooded impoundment in Sulphurets Valley

The concept……..

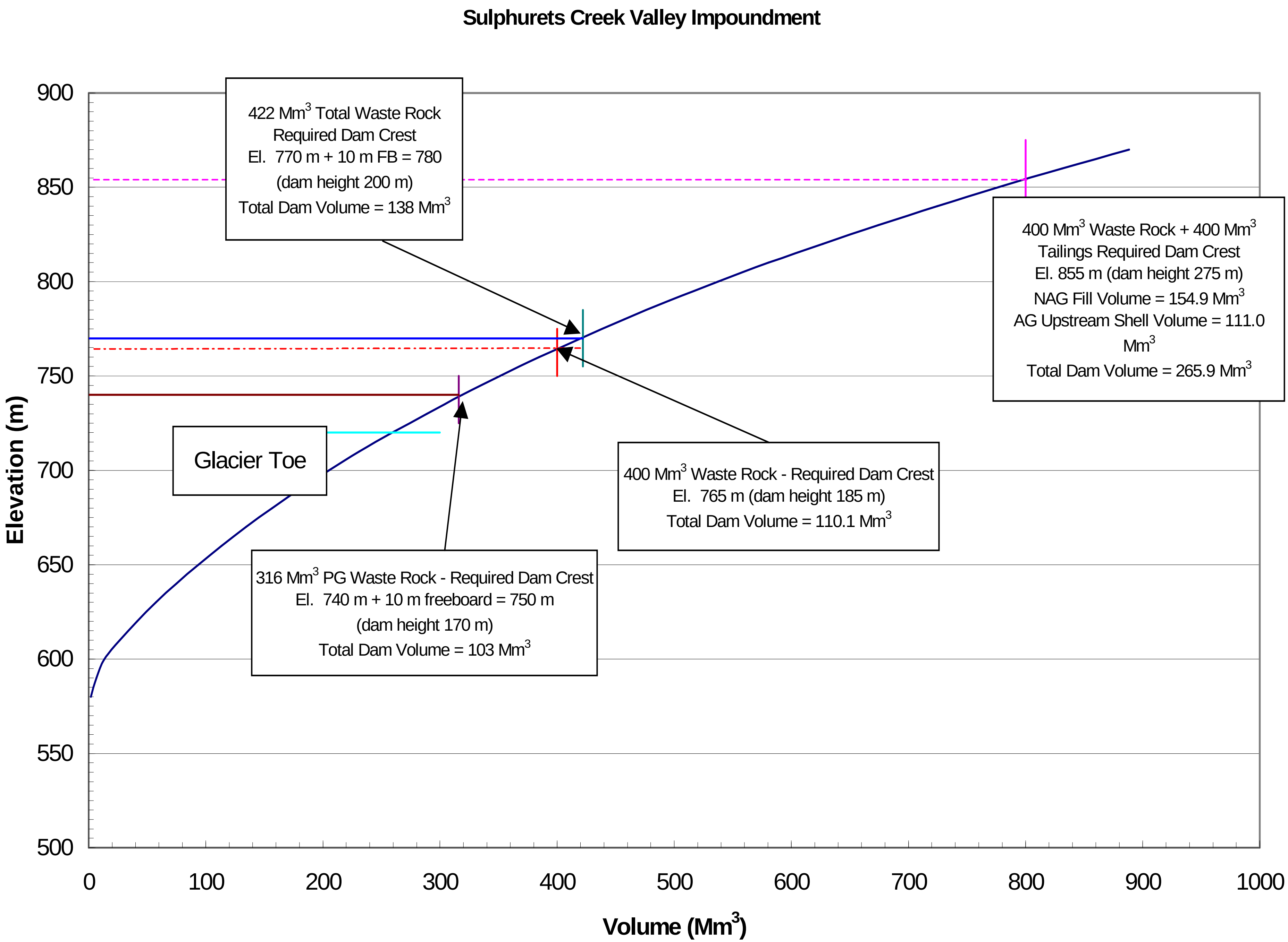
- Waste rock in Sulphurets Valley
- Water retaining dam to west
- Water retaining dam to east of Sulphurets Lake, with diversions (most likely tunnel) as required
- Convenient short downhill haul for rock
- Co-disposal with tailings is desirable with this alternative if sufficient storage capacity exists
- Flood waste rock at closure, with open channel spillway on north dam abutment
- Drainage to Sulphurets Ck./Unuk

Alternative B – Waste Rock

Waste rock to flooded impoundment in Sulphurets Valley

Some additional considerations…..

- Up to 200 million tonnes of NAG waste rock available for dams construction?
- How quickly must waste rock be flooded? Is there sufficient NP to delay the onset of ARD significantly?
- Placer studies suggested ARD onset likely within a year of exposure
- Steepness of terrain, and avalanche tracks, mean that diversion channels are not feasible (e.g. Kemess – buried diversion conduits)
- Three scenarios to assess:
  - PAG rock only to impoundment – 600 MT (portion of pit waste is NAG)
  - PAG rock only to impoundment – 800 MT (all is PAG)
  - PAG rock + tailings to impoundment



Sulphurets Creek Valley Impoundment
422 Mm3 Total Waste Rock
Required Dam Crest
El. 770 m + 10 m FB = 780
(dam height 200 m)
Total Dam Volume = 138 Mm3
400 Mm3 Waste Rock + 400 Mm3
Tailings Required Dam Crest
El. 855 m (dam height 275 m)
NAG Fill Volume = 154.9 Mm3
AG Upstream Shell Volume = 111.0 Mm3
Total Dam Volume = 265.9 Mm3
Glacier Toe
400 Mm3 Waste Rock - Required Dam Crest
El. 765 m (dam height 185 m)
Total Dam Volume = 110.1 Mm3
316 Mm3 PG Waste Rock - Required Dam Crest
El. 740 m + 10 m freeboard = 750 m
(dam height 170 m)
Total Dam Volume = 103 Mm3
Elevation (m)
900
850
800
750
700
650
600
550
500
0
100
200
300
400
500
600
700
800
900
1000
Volume (Mm3)

Storage of 316 Mm³ (600 MT) of PAG waste rock

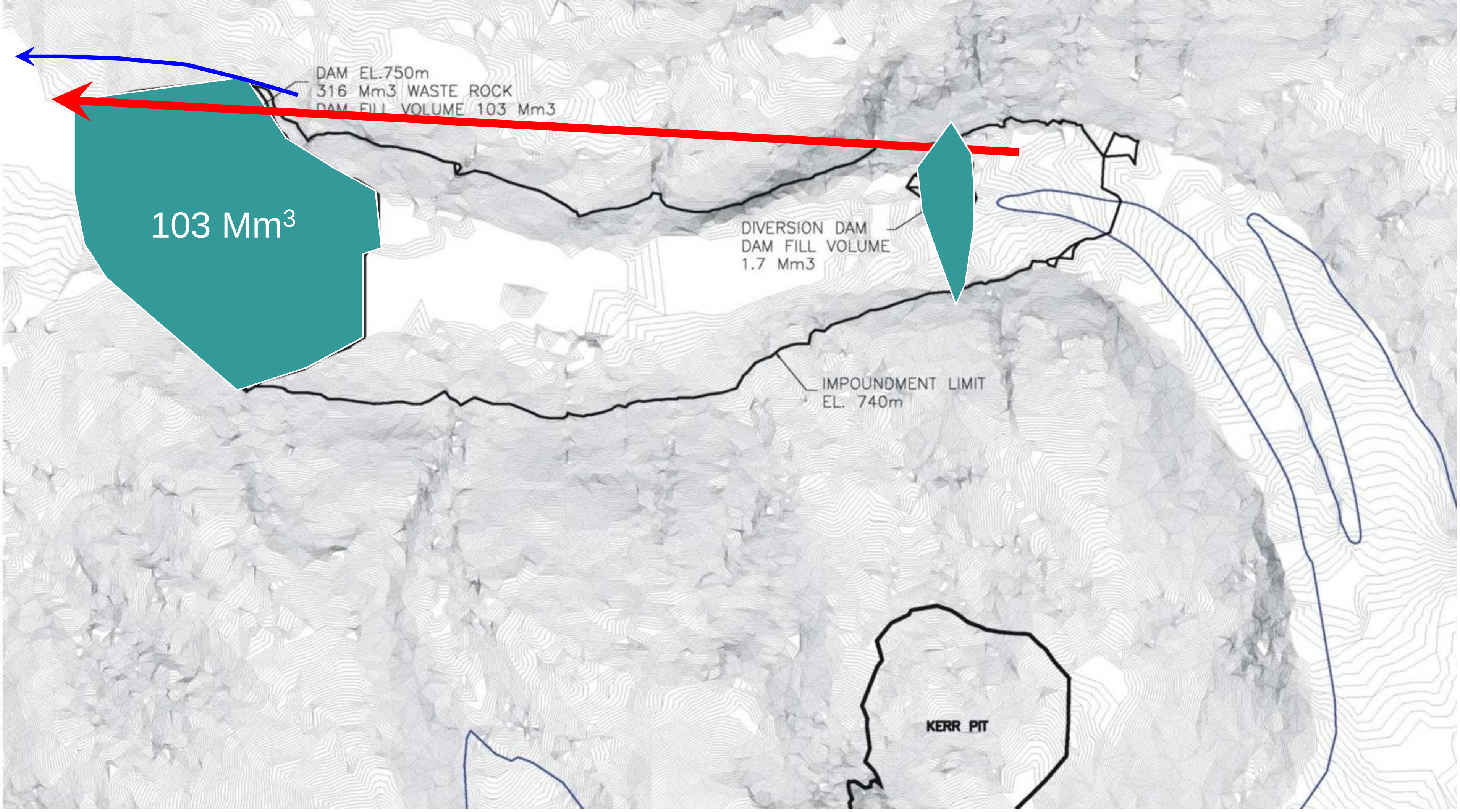
Main dam requires 103 Mm³ of fill (106 Mm³ of NAG rock estimated available from the open pits), Diversion Dam requires about 9 Mm³ of fill

Diversion dam of sufficient size to route peak runoff events through the diversion tunnel

Diversion tunnel plugged at closure, waste rock permitted to flood, flows passed via large open channel spillway (or tunnel) on the north abutment of the large dam

Main dam is about 190 m high

Cannot flood much of rock until closure – is there a significant lag between placement and onset of ARD?



Storage of 422 Mm^3 (800 MT) of PAG waste rock

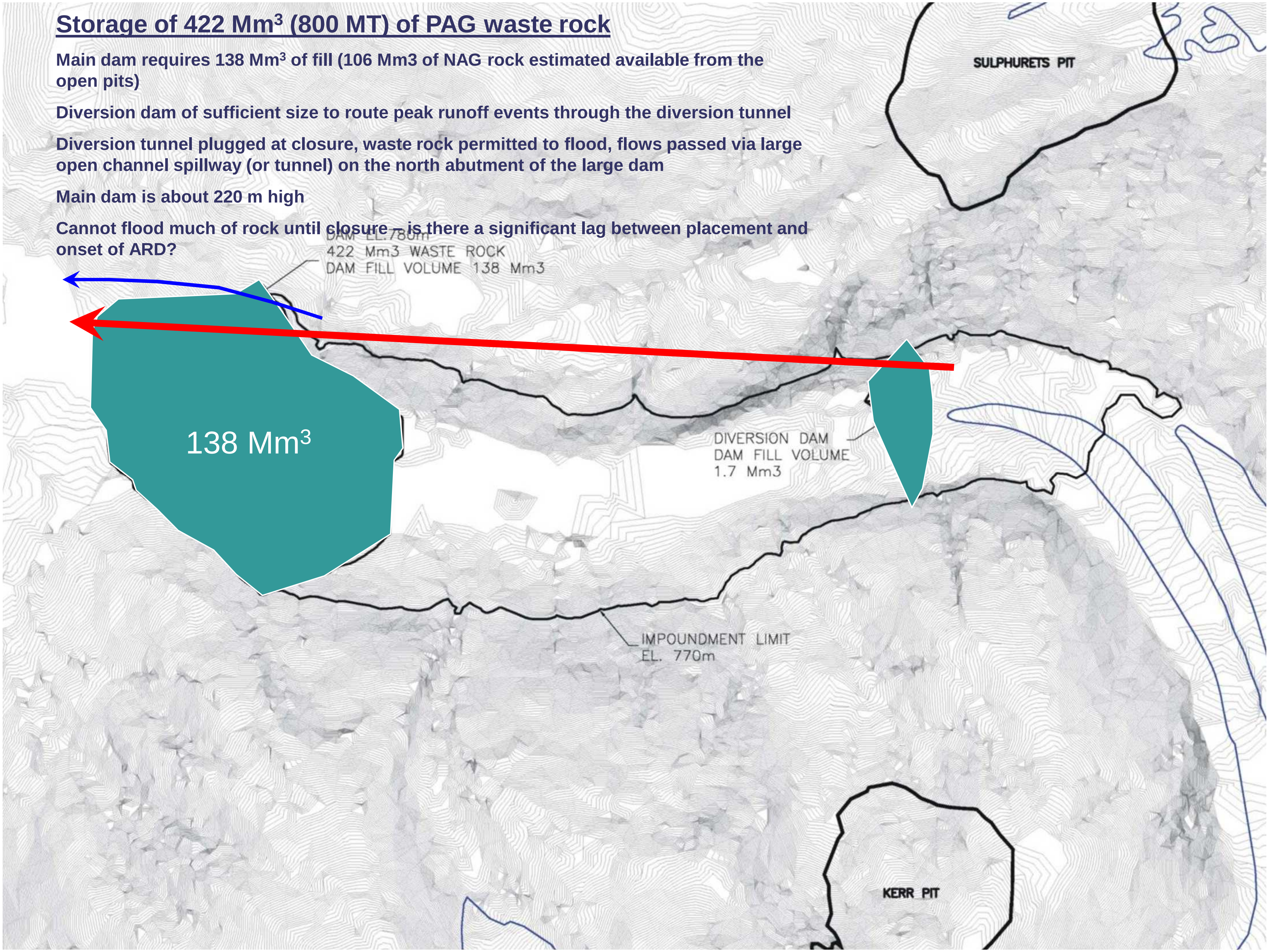
Main dam requires 138 Mm^3 of fill (106 Mm3 of NAG rock estimated available from the open pits)

Diversion dam of sufficient size to route peak runoff events through the diversion tunnel

Diversion tunnel plugged at closure, waste rock permitted to flood, flows passed via large open channel spillway (or tunnel) on the north abutment of the large dam

Main dam is about 220 m high

Cannot flood much of rock until closure – is there a significant lag between placement and onset of ARD?



Some issues associated with these concepts

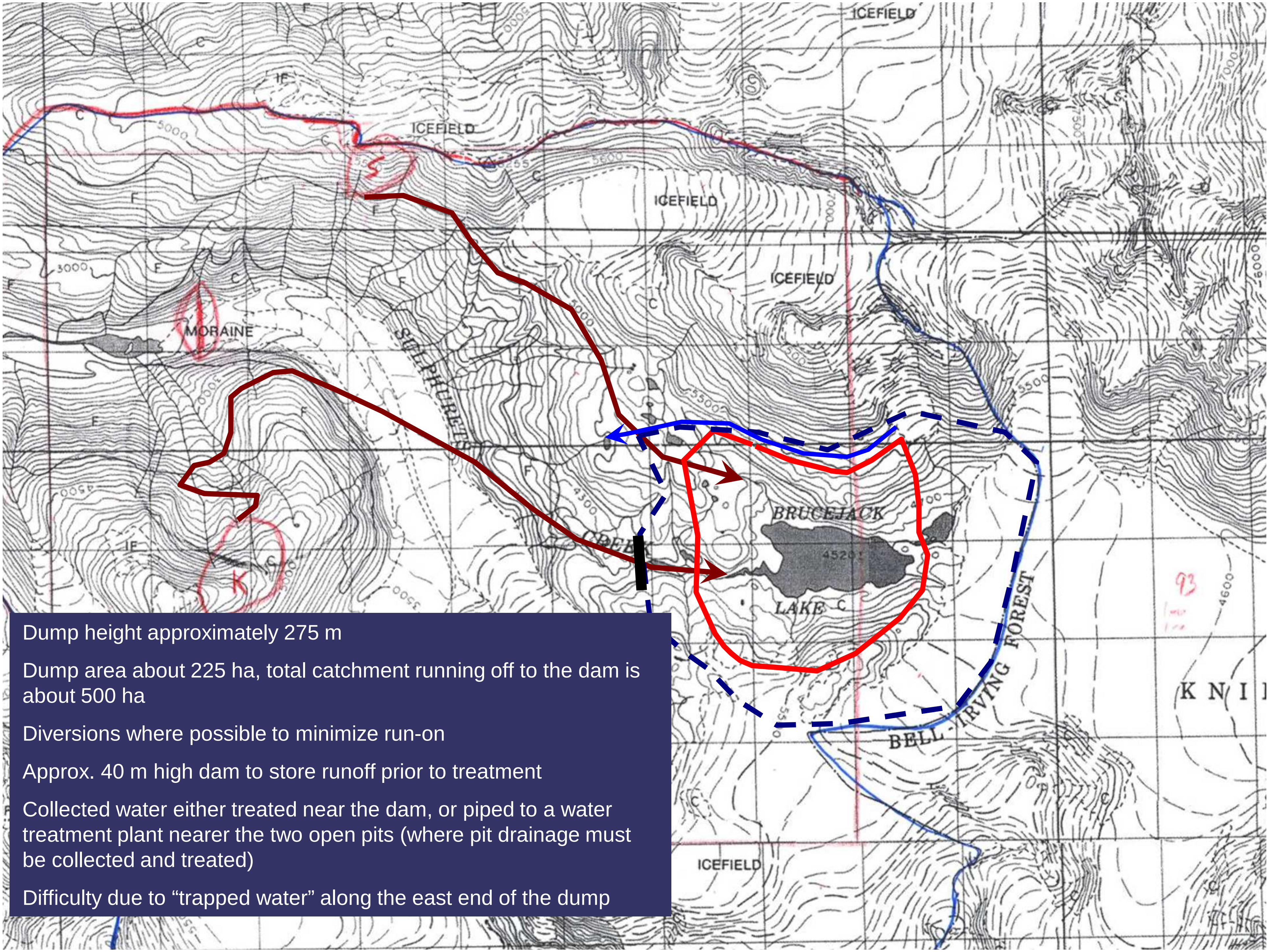
- Development of sufficient attenuation/routing capacity in diversion dam + tunnel to handle peak events
- May have to raise diversion dam to same crest elevation as Main Dam, possibly even higher if needed to create flood attenuation capacity (depends on design event selected – larger events would spill into the waste rock reservoir, then via the emergency spillway adjacent to the Main Dam, BUT
- This means that potentially poor quality water within the waste rock impoundment will be "flushed" out – what is the acceptable level of risk for this occurrence during operations? 1 in 500? 1 in 1,000?
- Dam design – 190 m – 220 m is "pushing the limits" for earth core rockfill dams, more typical for concrete faced rockfill dams (e.g. Antamina), BUT
- CFRD's are suitable for bedrock foundations – in Sulphurets Valley there are likely very thick glacial deposits infilling the valley, possibly with interbedded low strength glacial lake deposits (common in northern B.C.) as well
- Risk of debris blockage of tunnel? Recent moraine deposits due to glacial retreat likely marginally stable, could be mobilized in large runoff events
- Extent of flooding extends to 20 m above toe of Sulphurets glacier
- **What do we do with the drainage from the open pit walls???**
- **What do we do with the tailings? Sulphurets Valley is full just of PAG waste rock!**

Alternative C – Waste Rock

Waste rock to Brucejack Lake

The concept………..

- Haul/convey rock to Brucejack Lake area
  - Flood with impoundment/dams; or
  - Covered dumps with perpetual collect and treat
- Drainage avoids trans-border issues
- Could pump pit water to treatment plant at Brucejack as well, or else have a 2nd water treatment plant at minesite that treats pit water and discharges to Sulphurets/Unuk
- Either way, this is a perpetual care and maintenance scenario



Dump height approximately 275 m

Dump area about 225 ha, total catchment running off to the dam is about 500 ha

Diversions where possible to minimize run-on

Approx. 40 m high dam to store runoff prior to treatment

Collected water either treated near the dam, or piped to a water treatment plant nearer the two open pits (where pit drainage must be collected and treated)

Difficulty due to “trapped water” along the east end of the dump

Alternative C – Waste Rock

Waste rock to Brucejack Lake

The reality……

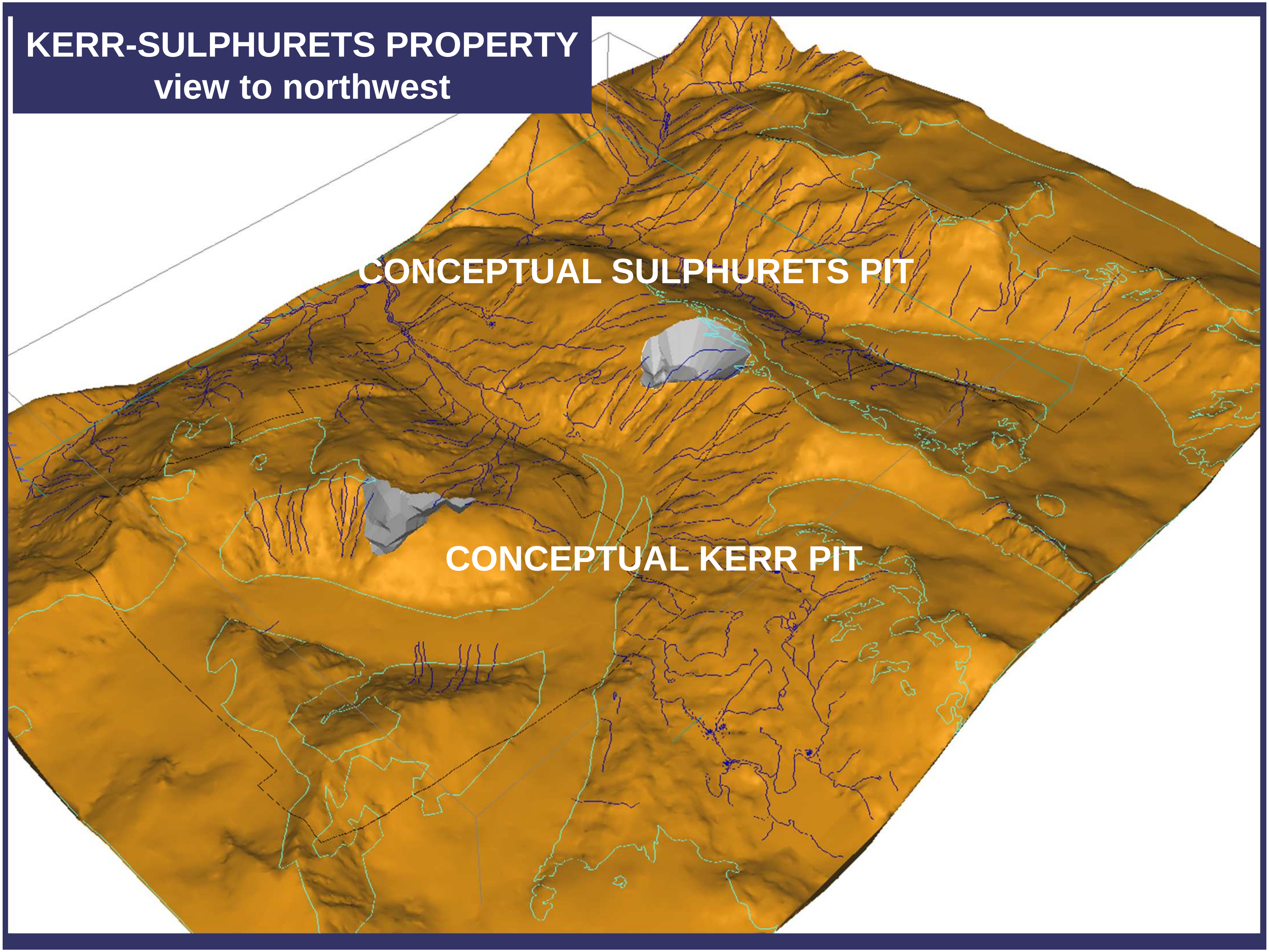
- Brucejack Lake drains to the Sulphurets valley – trans-border issues are not avoided
- To route drainage to the east, have to go across an icefield
- Can void excessive uphill hauls of waste rock if:
  - High elevation road (on steep terrain with avalanche risk from Sulphurets
  - High elevation road across the Sulphurets glacier from Kerr
  - Conveyors an alternative? Will need access roads in any case
- Capping the rock will till is a very long and difficult uphill haul
- This scheme advantageous in terms of limited catchment area
- At 500 ha, the May runoff = 4.9 Mm^3 (average 1.9 m^3/sec) – this is quite manageable in terms of water treatment.
- This modest inflow rate limits the extent of containment dam construction at the outlet

Alternative D – Waste Rock

Side hill dumps, backfill the first mined-out pit, remainder of rock to down-sized flooded impoundment

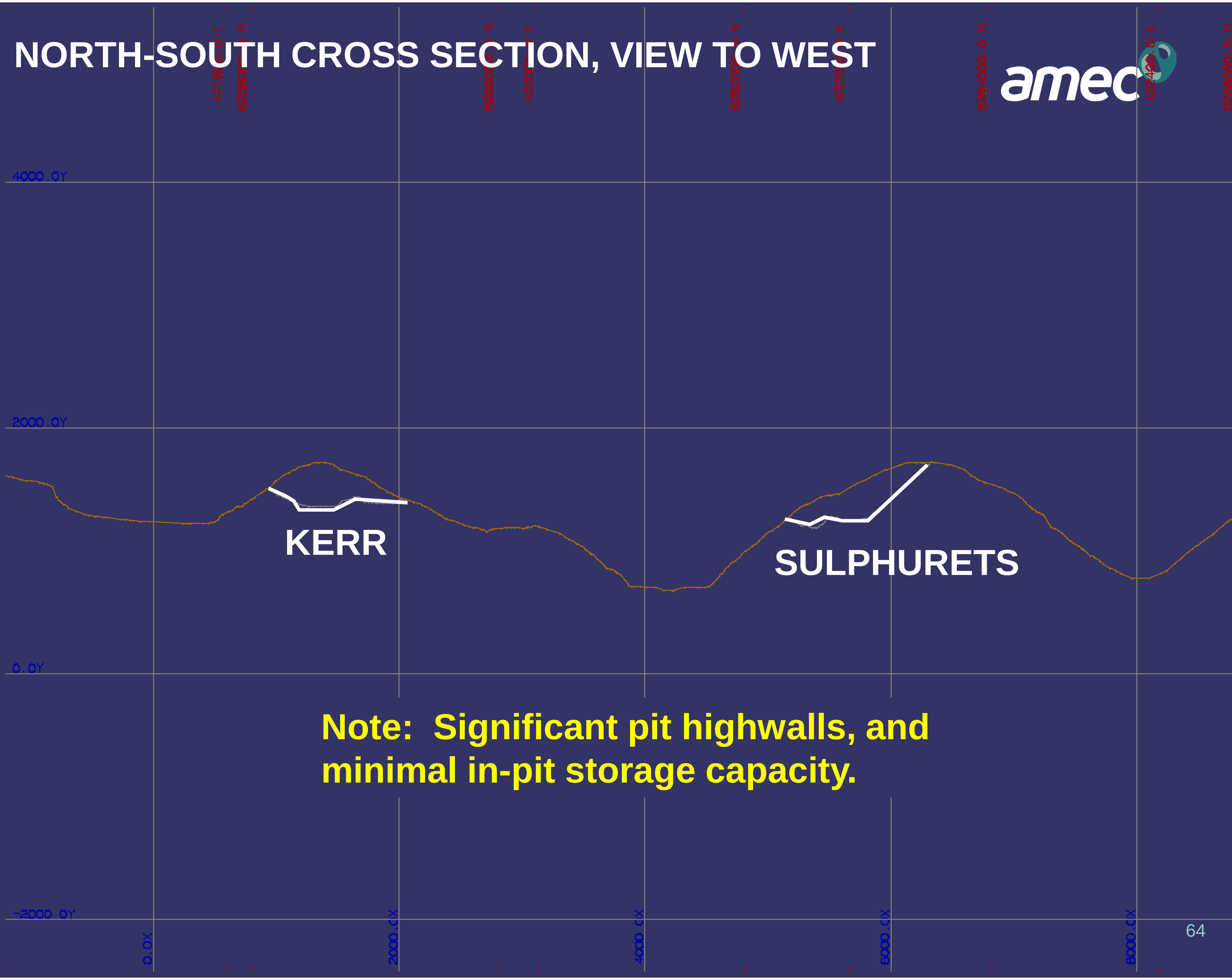
The concept………

- Side hill dumps during operation with collection and treatment
- Backfill pit that is mined out first
- Remainder of waste rock to flooded impoundment in Sulphurets valley
- This is essentially a variant on Alternative B, except that the size of the flooded valley impoundment is reduced due to some rock being flooded within the pit mined out first


KERR-SULPHURETS PROPERTY
view to northwest
CONCEPTUAL SULPHURETS PIT
CONCEPTUAL KERR PIT

NORTH-SOUTH CROSS SECTION, VIEW TO WEST

amec



Note: Significant pit highwalls, and minimal in-pit storage capacity.

Alternative D – Waste Rock

Side hill dumps, backfill the first mined-out pit, remainder of rock to down-sized flooded impoundment

The reality…….

- There is no flooding capacity within the pits, therefore no payback for back-hauling the rock uphill
- This option is not worth pursuing further

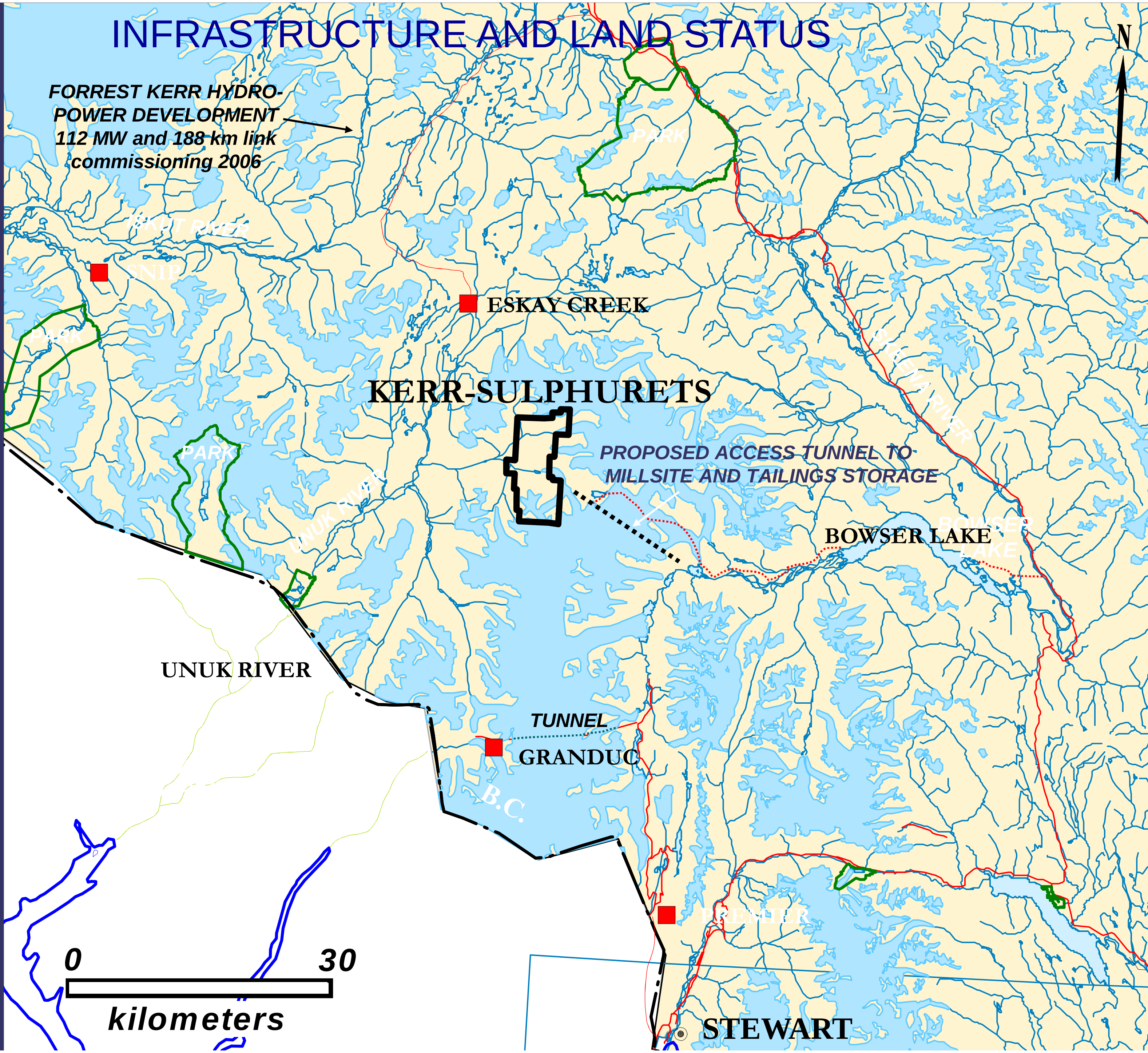
Alternative E – Waste Rock

Crush and haul/convey PAG waste rock, via tunnel, for submergence within Bowser Lake

The concept…..

- 19.4 km access tunnel from site to Bowser River (Knipple Lake)
- 6 m diameter tunnel, conveyor hung from crown, access road only for vehicles servicing the conveyor, not adequate for regular mine access
- Approximately 18 km haul from portal on Bowser River side (likely plantsite location under this alternative) to Bowser Lake
- All PAG waste rock to secure, sub-aqueous storage in Bowser Lake
- This assumes that tailings likewise is being directed to Bowser Lake
- Obvious capital cost implications in terms of access tunnel(s) sizes, and operating cost implications in terms of haulage/conveyance of waste rock
- Campaign waste rock and ore via the conveyor, eliminating need for separate conveyors for ore and waste? Reduces required tunnel capacity, hence cost.
- Side benefit in terms of concentrate haul costs, but still need year-round road and/or summer road + airstrip to access site

INFRASTRUCTURE AND LAND STATUS



ROUTE OF PROPOSED ACCESS TUNNEL

BOWSER RIVER VALLEY, POSSIBLE MILL SITE


BOWSER LAKE


WASTE STORAGE IN LAKE, ESKAY CREEK MINE

Excerpt from Eskay Creek's permit for lake disposal of waste rock

amec

1.1. Waste Rock Discharge to Albino Lake

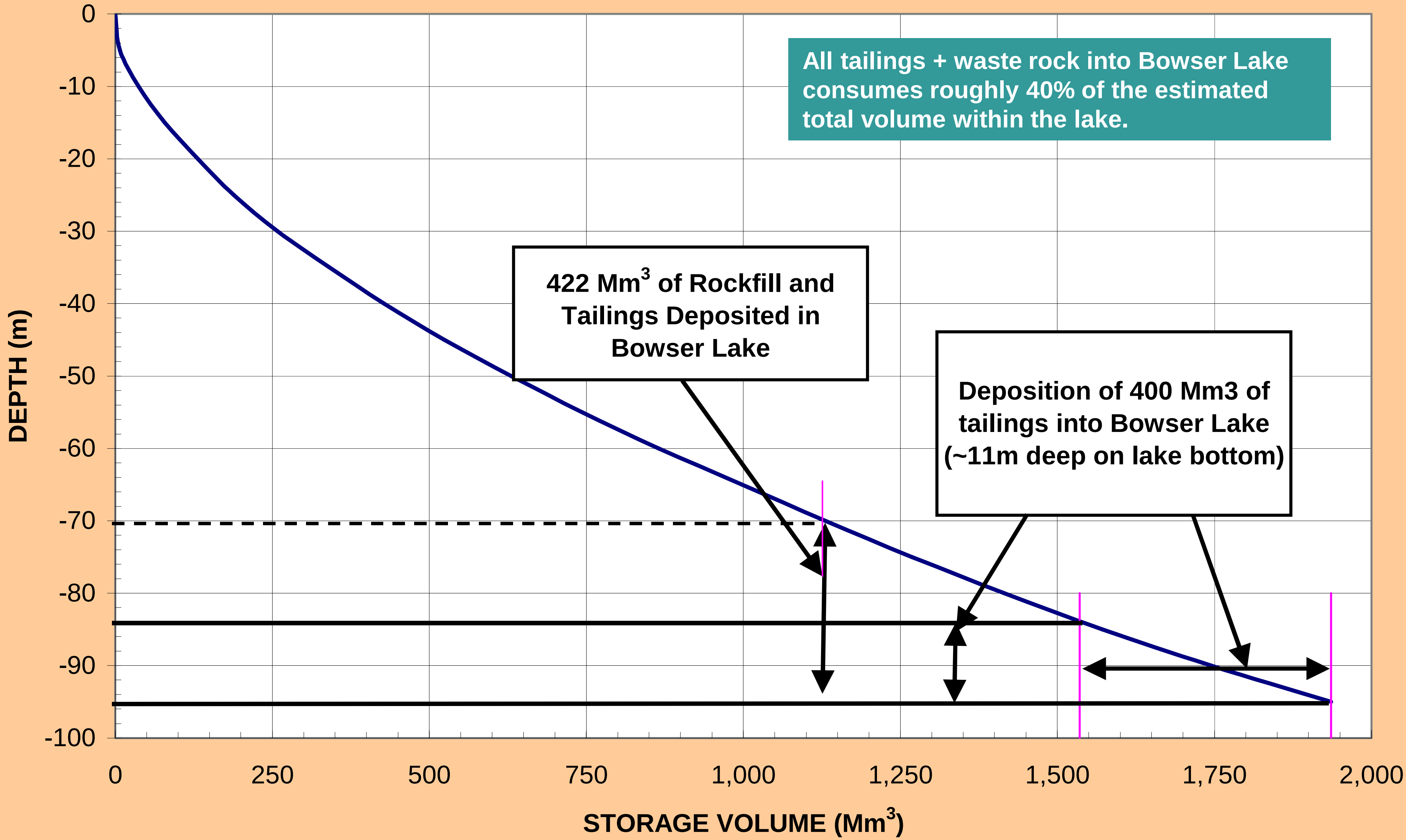
1.1.1. Waste rock from the development of the Eskay Ck. underground mine is authorized to be discharged to Albino Lake such that it is submerged a minimum of one metre below the surface. The site identification number is E224385.

1.1.2. The maximum quantity of waste rock to be discharged is 500,000 tonnes, (300,000 m^3) over the projected life of the mine.

1.1.3. The characteristics of the discharge shall be typical of waste rock from the development of the Eskay Ck. underground mine.

1.1.4. The works authorized are a contained ore/waste storage facility at the minesite, discharge causeway(s) with a non-acid generating surface, three sediment curtains, log booms around the discharge causeway and related appurtenances located approximately as shown on attached Site Plan A.

BOWSER LAKE STORAGE



Alternative E – Waste Rock

Crush and haul/convey PAG waste rock, via tunnel, for submergence within Bowser Lake

The reality…..

- This assumes that tailings likewise is being directed to Bowser Lake
- Obvious cost implications in terms of access tunnel(s) sizes, and haulage/conveying costs
- Can reduce tunnel cost by "campaigning" ore and waste rock on a single conveyor
- Tailings and waste rock into Bowser Lake consumes between 40% and 60% (based on 75% and 100% respectively of waste rock being PAG) of total lake volume.
- Permitting risk excessively high?
- More discussion of Bowser Lake use under assessment of tailings management alternatives

Alternative F – Waste Rock

Crush and haul/convey PAG waste rock, via tunnel, for co-disposal with tailings in impoundment to north of Treaty Creek

The concept…..

- 23 km access tunnel from site to Treaty Creek
- 6 m diameter tunnel, conveyor hung from crown, access road only for vehicles servicing the conveyor, not adequate for regular mine access
- Crushed ore and PAG waste rock campaigned via the conveyor on a daily basis (assume 65% conveyor availability per day)
- Approximately 8 km uphill haul from portal to tailings impoundment
- All PAG waste rock to eventual submergence within impoundment
- Obvious capital cost implications in terms of access tunnel and conveyor, and operating cost implications in terms of haulage/conveyance of waste rock
- Tunnel not sufficiently large for regular site access, so still need year-round road and/or summer road + airstrip to access site
- Discussion of this alternative in Tailings Management Alternative H.
- This is technically viable and worth further consideration.

Waste Rock Alternatives

Where do we stand?

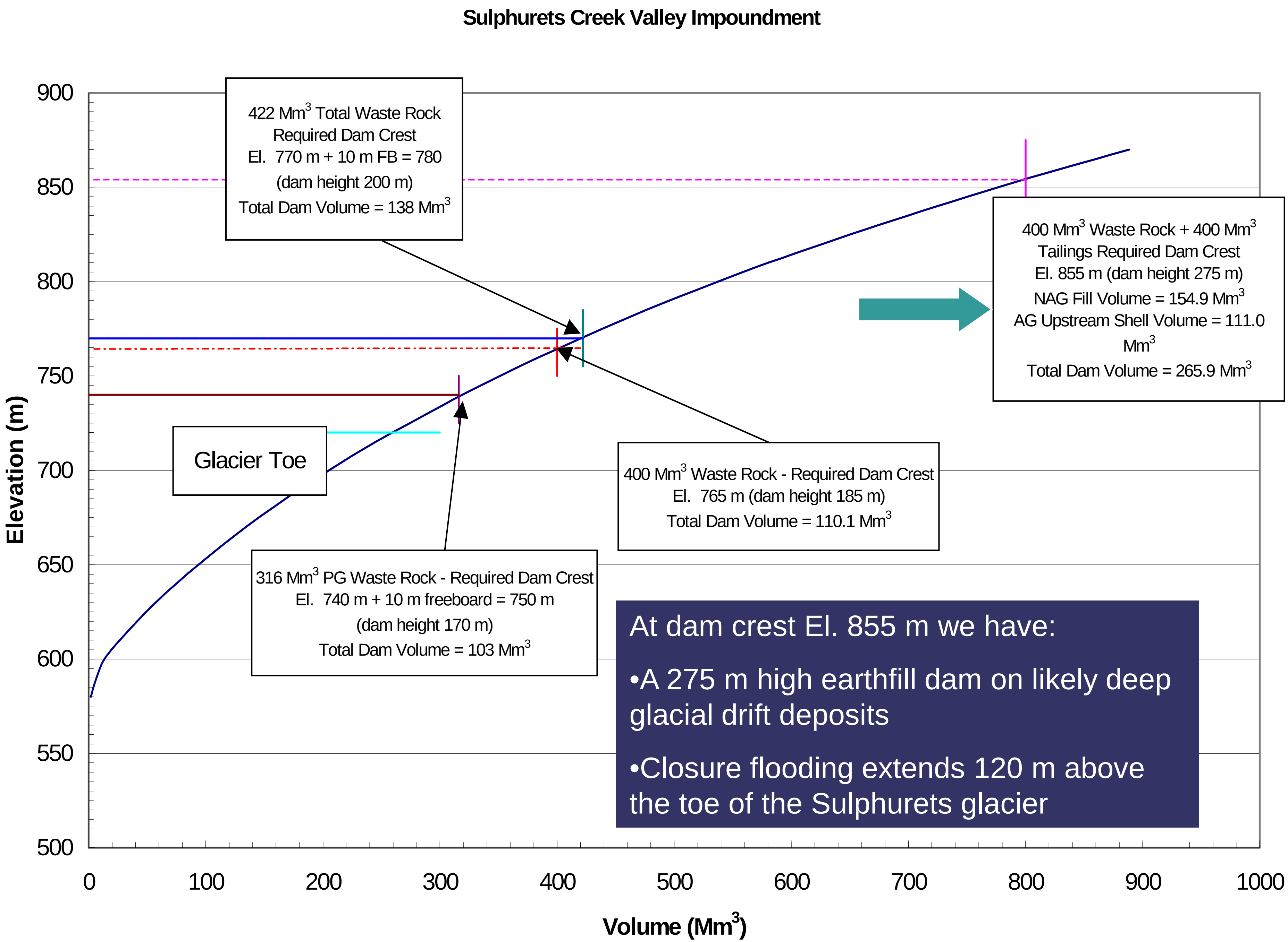
Alternative		Technically Feasible?	Worthy of Further Consideration?
A	Side hill dumps, cover, perpetual collection and treatment	Yes	YES
B	Waste rock to flooded impoundment in Sulphurets Valley	Yes	YES
C	Waste rock to Brucejack Lake Dump, cover, diversions as possible, perpetual collection and treatment	Yes	YES
D	Ex-pit dumps, collect and treat, back-haul rock for flooding to 1st mined-out pit	No	NO
E	Crush PAG waste rock and haul/convey, via tunnel, to Bowser Lake	Yes	YES
F	Crush PAG waste rock and haul/convey, via tunnel, to co-disposal with tailings in impoundment north of Treaty Creek	Yes	YES

Alternative A – Tailings

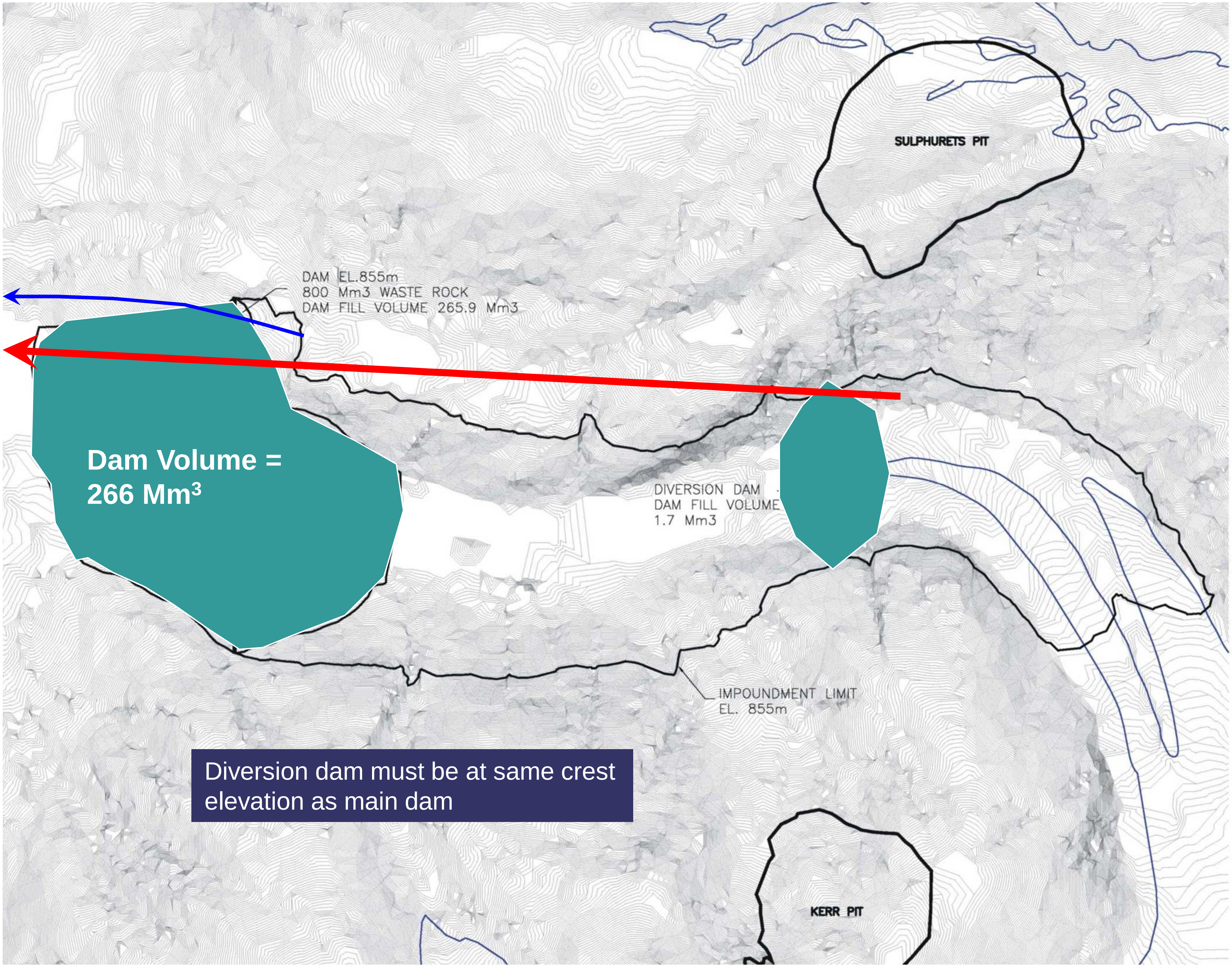
Co-disposal with waste rock in flooded impoundment in Sulphurets Valley

The concept……..

- Co-disposal with waste rock in Sulphurets Valley impoundment
- Upstream diversion dam + tunnel
- For closure, either:
  - Maintain a water cover
  - Float out the sulphides, create 2 tailings streams, place above water NAG tailings beach in front of dam
  - Plug diversion tunnel and route flows through impoundment via large open channel spillway in relative gently sloping ground on north dam abutment



Sulphurets Creek Valley Impoundment
422 Mm3 Total Waste Rock
Required Dam Crest
El. 770 m + 10 m FB = 780
(dam height 200 m)
Total Dam Volume = 138 Mm3
400 Mm3 Waste Rock + 400 Mm3
Tailings Required Dam Crest
El. 855 m (dam height 275 m)
NAG Fill Volume = 154.9 Mm3
AG Upstream Shell Volume = 111.0 Mm3
Total Dam Volume = 265.9 Mm3
Glacier Toe
400 Mm3 Waste Rock - Required Dam Crest
El. 765 m (dam height 185 m)
Total Dam Volume = 110.1 Mm3
316 Mm3 PG Waste Rock - Required Dam Crest
El. 740 m + 10 m freeboard = 750 m
(dam height 170 m)
Total Dam Volume = 103 Mm3
At dam crest El. 855 m we have:
•A 275 m high earthfill dam on likely deep glacial drift deposits
•Closure flooding extends 120 m above the toe of the Sulphurets glacier
Elevation (m)
Volume (Mm3)
900
850
800
750
700
650
600
550
500
0
100
200
300
400
500
600
700
800
900
1000



Diversion dam must be at same crest elevation as main dam

Alternative A – Tailings

Co-disposal with waste rock in flooded impoundment in Sulphurets Valley

The reality……..

- Require a 275 m high earthfill-rockfill dam (unprecedented) on deep glacial drift foundation
- Volume of Main Dam alone about 266 Mm^3
- Diversion Dam volume not yet estimated, but likely in order of 50 Mm^3
- Plugging of diversion tunnel at closure floods 120 m (vertical) of Sulphurets glacier
- Risk and cost of this alternative, on inspection, render it non-feasible and can therefore be discarded
- Lack sufficient useable storage capacity in Sulphurets Valley to flood waste rock and tailings
- Moving further downstream adds other drainages to the catchment that must be diverted (via tunnels), therefore yet more large dams (see Alternative G)

Alternative B – Tailings

Float sulphides to create NAG/PAG streams, separate disposal in Sulphurets Valley, co-disposal with waste rock

The concept…..

- Float sulphides to create NAG and AG tailings streams
- NAG impoundment in Sulphurets Valley, co-dispose with waste rock (NAG cover), or create a separate, completely "NAG" facility
- AG tails to separate flooded impoundment (Brucejack? Others? Put in same impoundment but at deep end to keep flooded during operations?)

Alternative B – Tailings

Float sulphides to create NAG/PAG streams, separate disposal in Sulphurets Valley, co-disposal with waste rock

What is the incentive for floating the sulphides out of the tailings for separate disposal?

- Given the wet climate, it is not possible to keep any impoundment from flooding in any case
- NAG tailings cover of no benefit because water cover so easily achievable
- Co-disposal of NAG tailings with waste rock in Sulphurets Valley allows no reduction in dam size relative to Alternative A, and ADDS additional dam(s) for the sulphide tailings confinement
- Only benefit to be gained is placement of tailings against the main dam, which decreases the “geotechnical” stress on the dam (simplifying design somewhat), but we are still looking at a dam of unprecedented height and complexity
- Still have the same insufficient storage capacity in Sulphurets Valley for both tailings and waste rock
- **Conclusion – there is no merit to this alternative, not worthy of further consideration, the problems associated with Alternative A are still there.**

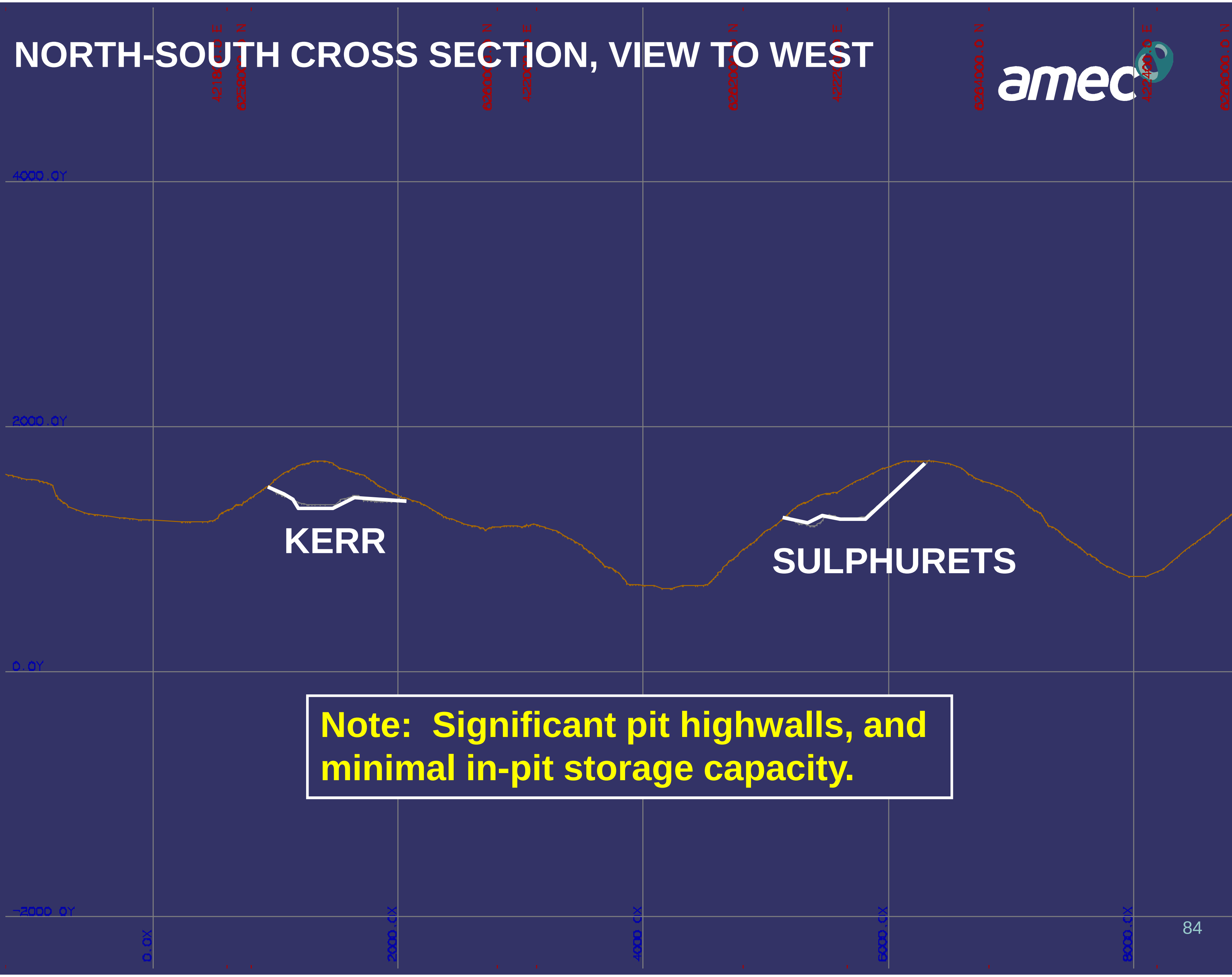
Alternative C – Tailings

Tailings to flooded impoundment in Sulphurets Valley until first pit mined out, then to in-pit storage for remainder of mine life

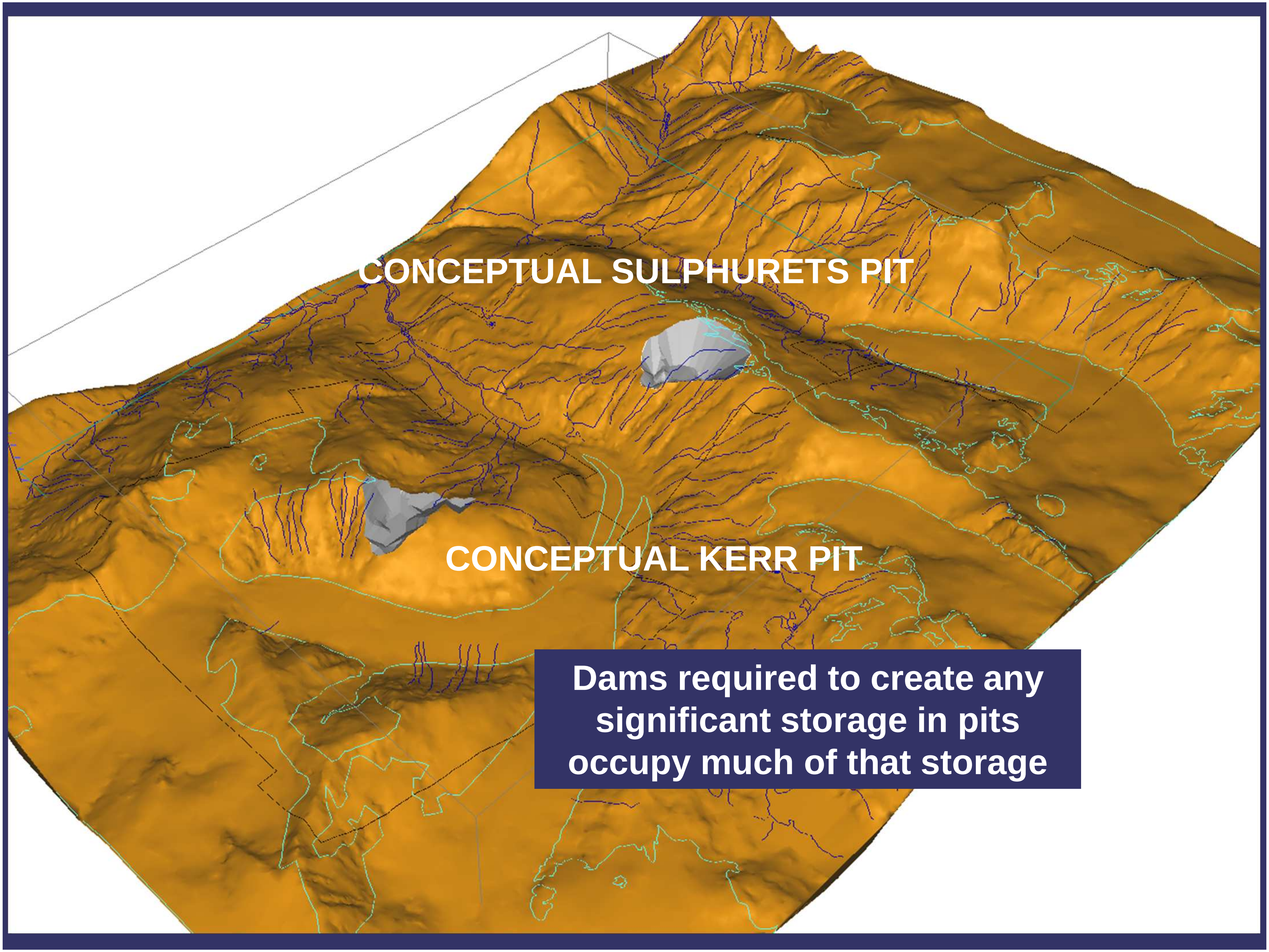
The concept……

- Sequence pits so one mined out early to store remainder of tailings
- Consider a dam on lower wall to increase storage capacity if possible

NORTH-SOUTH CROSS SECTION, VIEW TO WEST



Note: Significant pit highwalls, and minimal in-pit storage capacity.


CONCEPTUAL SULPHURETS PIT
CONCEPTUAL KERR PIT
Dams required to create any significant storage in pits occupy much of that storage

Alternative C – Tailings

Tailings to flooded impoundment in Sulphurets Valley until first pit mined out, then to in-pit storage for remainder of mine life

The reality……

- There is no readily available storage capacity in the pits – the pit shells are “bowls with one or more sides missing”
- Based on current conceptual pit designs, have combined 20 Mm^3 storage capacity – need 300 Mm^3 in total for tailings, so would require radically different pit designs to make a significant difference
- Ratio of storage volume to dam volume in pits likely no better than, and probably worse, than for main dam in Sulphurets Valley
- Conclusion – based on currently projected pit shells, this option is not feasible

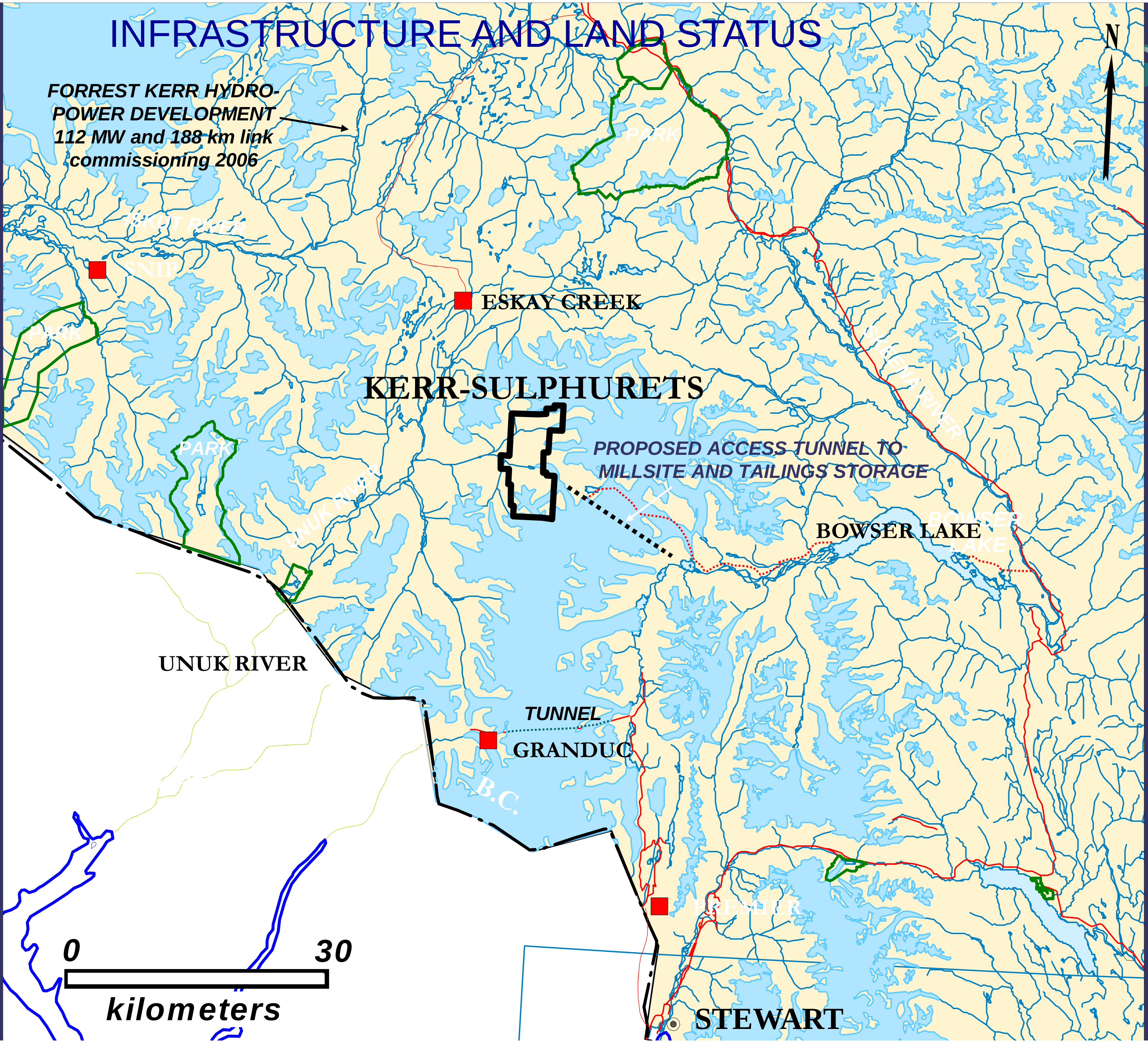
Alternative D1 – Tailings

Crush ore at minesite, tunnel to plantsite near Knipple Lake, truck/convey ore to plant, pipe tailings for submarine disposal into Bowser Lake

The concept……..

- Access tunnel to site from near Knipple Lake (about 19 km), at 0.3% grade, 5 m diameter
- Crush ore at mine area and convey via tunnel to plantsite near Knipple Lake
- Pipe tailings about 20 km from plantsite to Bowser Lake for subaqueous discharge and secure, permanent flooding
- Tunnel insufficient for regular site access, suitable only for access for vehicles servicing conveyor
- Precedent for this at Eskay Creek and, earlier, at Granduc (tailings went into Bowser River, eventually reporting to the lake)
- “Son of Granduc”

INFRASTRUCTURE AND LAND STATUS



BOWSER RIVER VALLEY, POSSIBLE MILL SITE


BOWSER LAKE


WASTE STORAGE IN LAKE, ESKAY CREEK MINE

Excerpt from Eskay permit re: lake disposal of tailings

Tailings Disposal to Albino Lake

Filter pressed tailings from a 200 tonnes per day gravity and flotation concentrator mill at the Eskay Creek mine is authorized to be discharged to Albino Lake. The site identification number is E224385.

The maximum quantity of tailings to be discharged is 160 tonnes per day, with a maximum total discharge volume of 400,000 m3 .

The characteristics of the discharge shall be typical of filter pressed tailings containing approximately 12 - 20 % moisture content produced from a gravity and flotation concentrator plant using no cyanide.

The works authorized include, but are not limited to, a 200 tonne per day gravity and flotation concentrator mill, a ferric sulphate High Density Sludge water treatment plant and related appurtenances.

Eskay Creek – water quality requirements for discharge from Albino Lake

Lake Water Discharge from Albino Lake

Lake water which has come into contact with waste rock is authorized to be discharged to Albino Ck. The site identification number or this discharge is E221177.

The maximum rate of discharge is equivalent to the natural hydrologic discharge per annum from the southern outlet of Albino Lake. The discharge frequency is continuous.

The characteristics of the discharge shall be equal to or better than the quality as detailed in Table 1.0 attached.

The works authorized are three sediment curtains, a sampling station and related appurtenances located approximately as shown on Site Plan A attached.

The location of the point of discharge is the main outlet at the southern end of Albino Lake at approximately 408395.7E, 6279029.5N at elevation 1040m., as illustrated on Site Plan A attached.

What happens if Albino lake discharge water quality criteria in permit are not met??

This is what the permit says….

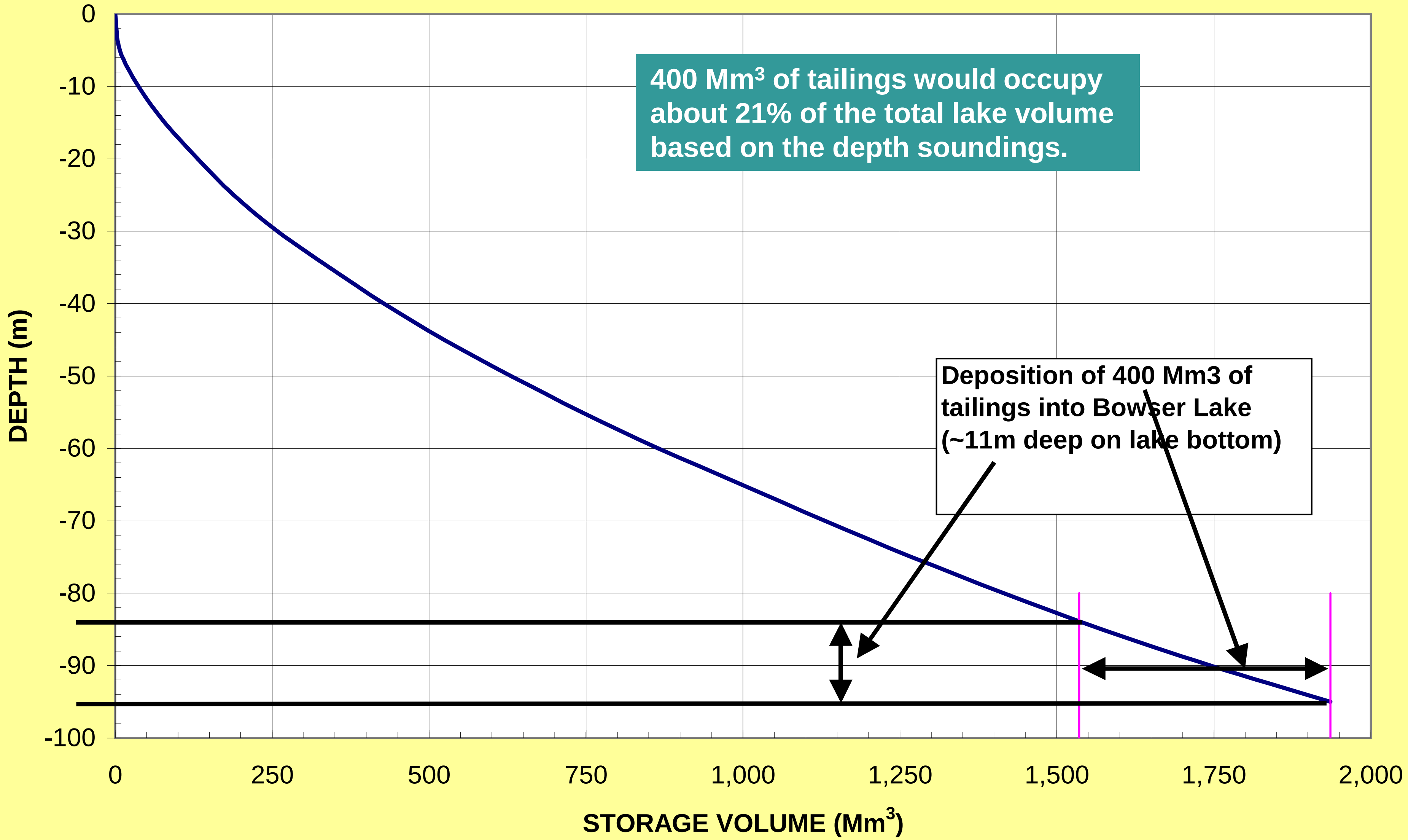
amec

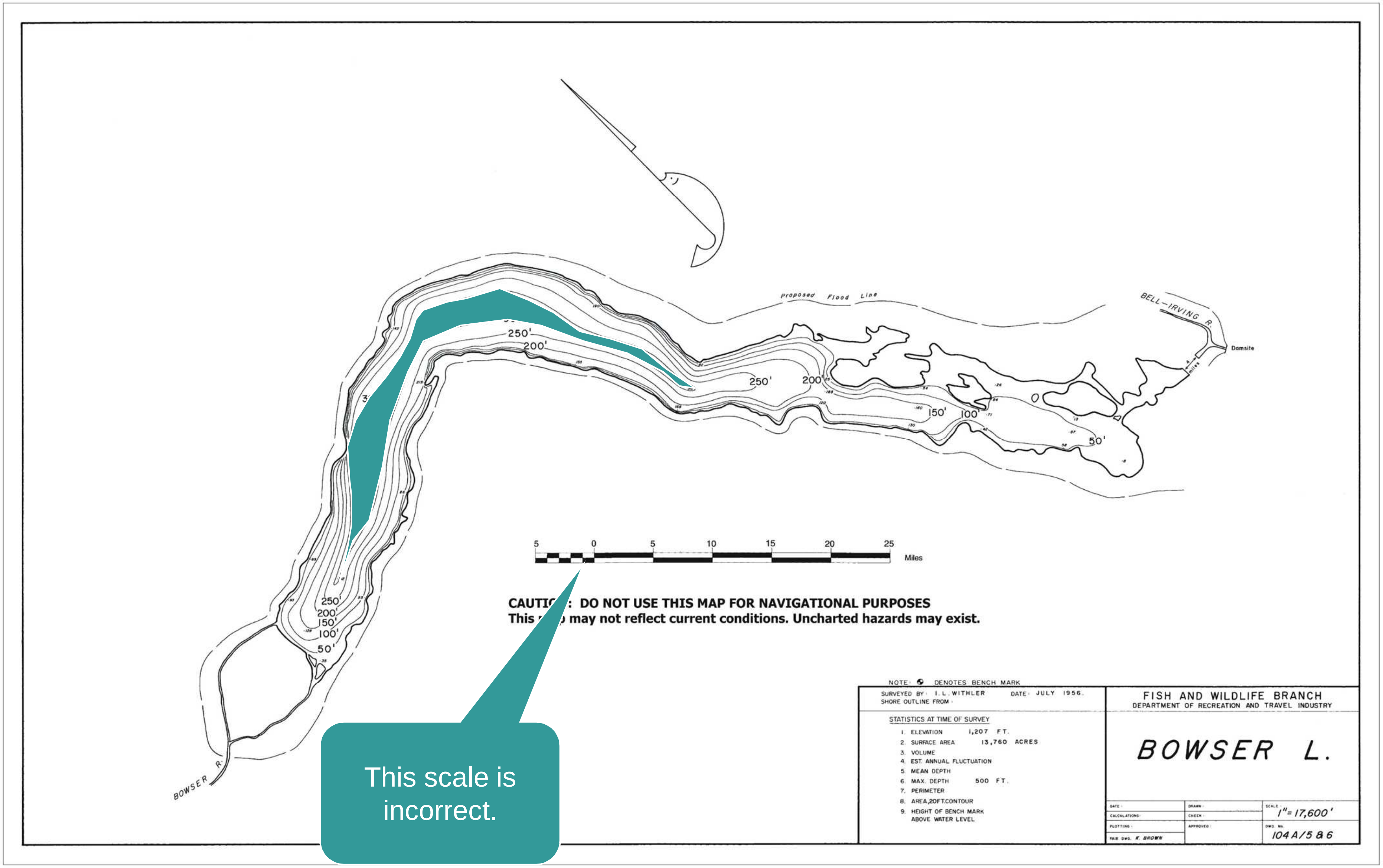
Dissolved metals> Limits described in Table 1.0 Albino Lake Discharge

Collect samples daily for on-site analysis. If three consecutive daily samples exceed the limits detailed in Table 1.0 attached, the Permittee is required to cease discharging waste rock and tailings to Albino Lake until dissolved metals levels are less than the permitted limit for three consecutive days or until approval for the resumption of waste rock and tailings disposal is received from the Regional Waste Manager.

Collect samples daily for on-site analysis. If three consecutive daily samples exceed the limits detail

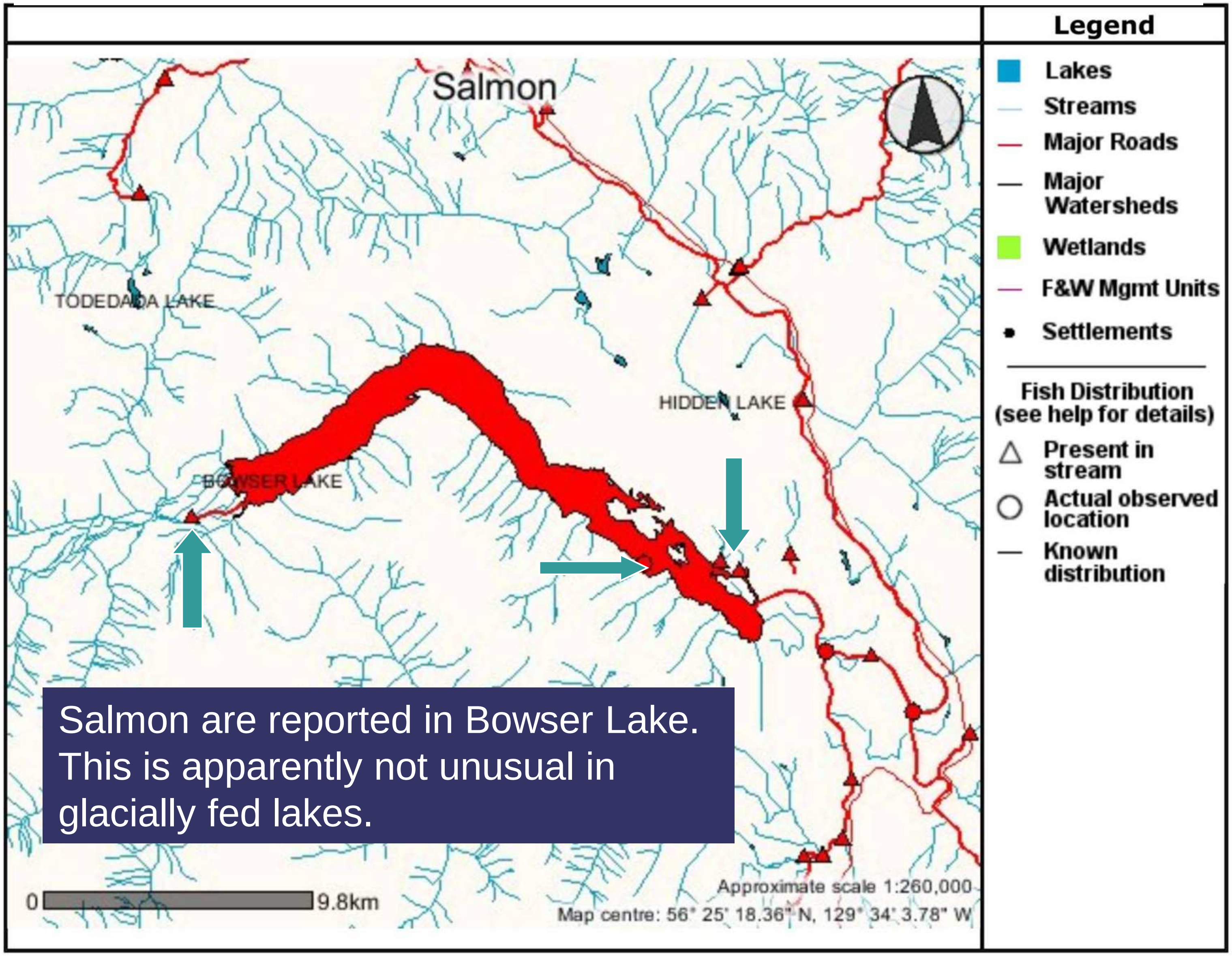
BOWSER LAKE STORAGE




Proposed Flood Line
BELL-IRVING R.
Damsite
BOWSER R.
250'
200'
150'
100'
50'
5 0 5 10 15 20 25
Miles
CAUTION: DO NOT USE THIS MAP FOR NAVIGATIONAL PURPOSES
This map may not reflect current conditions. Uncharted hazards may exist.
NOTE: DENOTES BENCH MARK
SURVEYED BY: I. L. WITHLER DATE: JULY 1956.
SHORE OUTLINE FROM:
STATISTICS AT TIME OF SURVEY
1. ELEVATION 1,207 FT.
2. SURFACE AREA 13,760 ACRES
3. VOLUME
4. EST. ANNUAL FLUCTUATION
5. MEAN DEPTH
6. MAX. DEPTH 500 FT.
7. PERIMETER
8. AREA,20FT.CONTOUR
9. HEIGHT OF BENCH MARK ABOVE WATER LEVEL
FISH AND WILDLIFE BRANCH
DEPARTMENT OF RECREATION AND TRAVEL INDUSTRY
BOWSER L.
DATE:
DRAWN:
SCALE: 1" = 17,600'
CALCULATIONS:
CHECK:
PLOTTING:
APPROVED:
DWG. No. 104 A/5 & 6
FAIR DWG. K. BROWN
This scale is incorrect.

FishWizard Map

FishWizard is a co-operative presentation of
BC Fisheries and Fisheries and Oceans Canada.



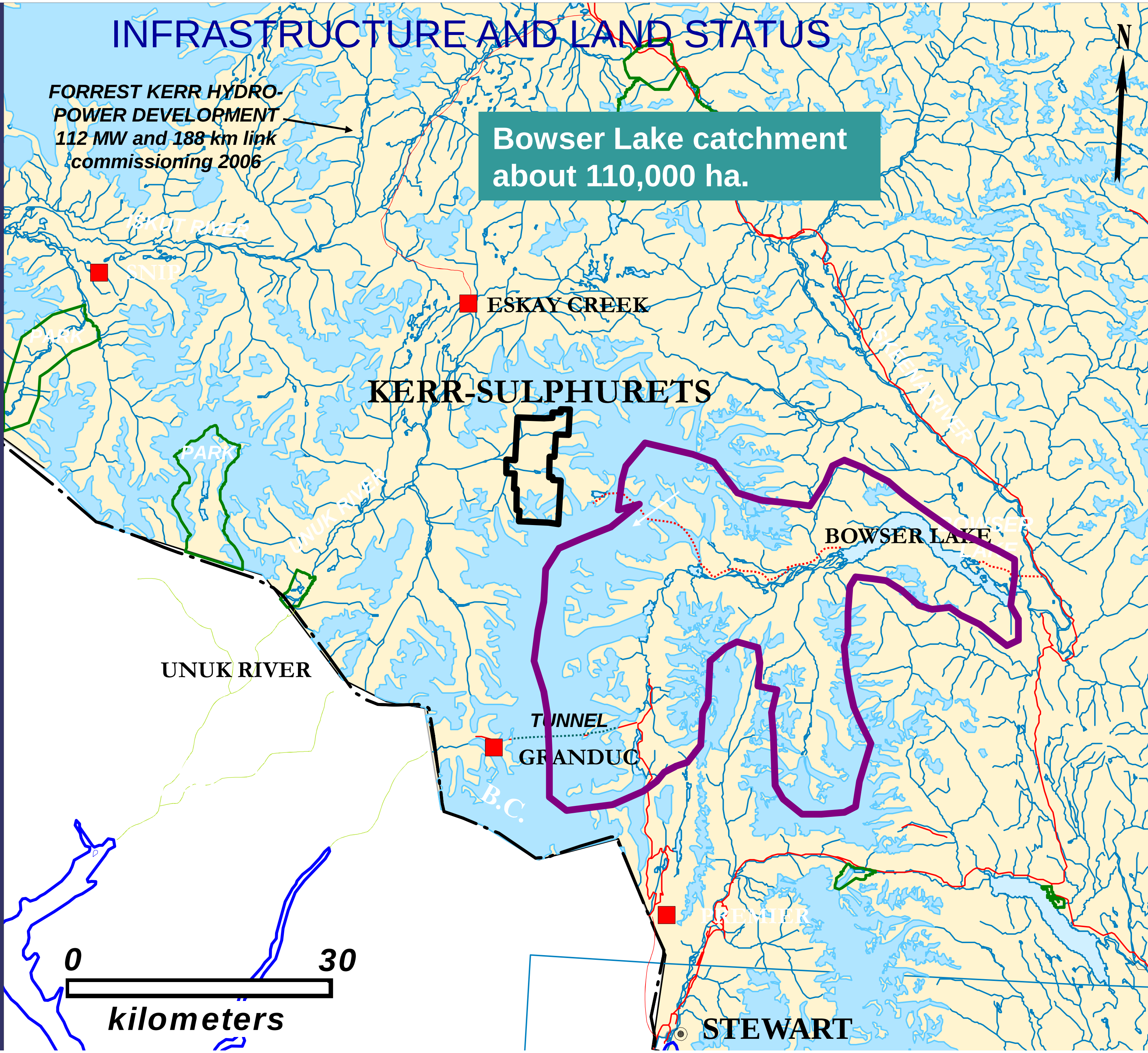
Salmon are reported in Bowser Lake. This is apparently not unusual in glacially fed lakes.

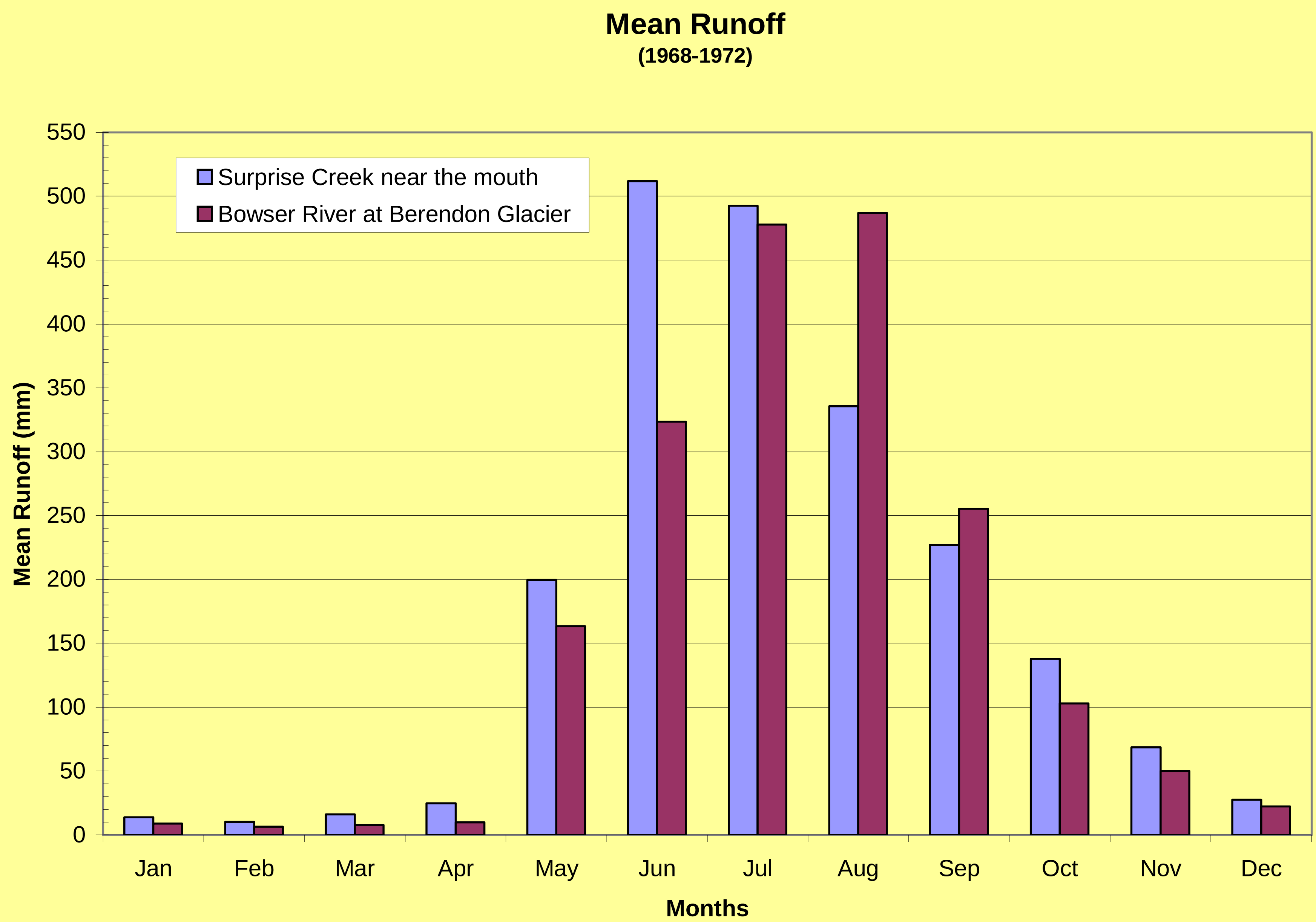
Looking into Bowser Lake fisheries a bit further…..

amec

- Bowser Lake is a "significant sockeye salmon producer" (Bocking et al., 2002)
- Highest sockeye escapement on the Nass system next to Meziadin Lake/River (slightly over 10% of Nass system total, 1980-1999)
- Salmon use the lake for access to tributary streams for spawning
- Salmon reported in Bowser Lake headwaters, but unsure how far upstream they go
- Approval for lake disposal is unlikely unless it can be demonstrated that there would be no disturbance to salmon spawning/rearing
- Would this be a case of trying to "prove the un-provable"?
- What about the water quality of the process water discharged in the tailings slurry?
  - @ 80,000 tpd and 30% solids by weight, then water discharge into lake is about 187,000 m^3/day (2.2 m^3/sec)
  - To assess effects of process water on lake water quality, consider 2.2 m^3/sec inflow against the base inflow (assume = outflow) to lake during low flow periods (winter)

INFRASTRUCTURE AND LAND STATUS





Mean Runoff
(1968-1972)
Surprise Creek near the mouth
Bowser River at Berendon Glacier
Mean Runoff (mm)
550
500
450
400
350
300
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Months

2.2 m^3/sec slurry inflow volume is significant portion of low-flow-periods Bowser Lake discharge

Estimate of Runoff for Bowser River below Bowser Lake

Month	No. of Days	Evaporation (mm)	Runoff (mm)		% of Total Runoff		Mean Monthly Discharge (m3/s)
			Surprise (05DA005)	Bowser R	Bowser R	Nass (08DB001)	
Jan	31		16	16	1.0%	1.5%	6.48
Feb	28.25		13	13	0.8%	1.2%	5.65
Mar	31		15	15	0.9%	1.3%	6.05
Apr	30		53	53	3.3%	3.1%	22.43
May	31	50	278	228	14.1%	13.1%	93.82
Jun	30	175	512	337	20.8%	22.4%	142.90
Jul	31	175	492	317	19.6%	19.2%	130.37
Aug	31	100	336	236	14.6%	12.9%	96.74
Sep	30	50	212	162	10.0%	9.1%	68.75
Oct	31		158	158	9.8%	9.6%	64.85
Nov	30		58	58	3.6%	4.5%	24.53
Dec	31		25	25	1.5%	2.1%	10.14
Total		550	2166	1616	100.0%	100.0%	

Note 1: Evaporation taken from the Hydrologic Atlas of Canada
Note 2: Drainage Area below Bowser Lake assumed to be 1100 km2.

Depending on quality of process water, could be significant impact on water quality within Bowser Lake and in discharge during low flow periods.

Alternative D1 – Tailings

Crush ore at minesite, tunnel to plantsite near Knipple Lake, truck/convey ore to plant, pipe tailings for submarine disposal into Bowser Lake

The reality……..

- Though expensive, this is the first of the tailings management options to be technically viable
- Tailings in deep lake are "secure" and present minimum closure liability
- Permitting risk is high because of:
  - Salmon in tributaries and lake itself (this requires further looking into)
  - NGO/emotional reaction to tailings into a lake (Granduc experience may be a liability in this regard, not an asset)
  - Slurry water inflow rate versus lake discharge during winter (low flow) periods has implications in terms of water quality in the lake
- Conclusion – this is technically viable and worthy of further consideration, but entails high permitting risk.

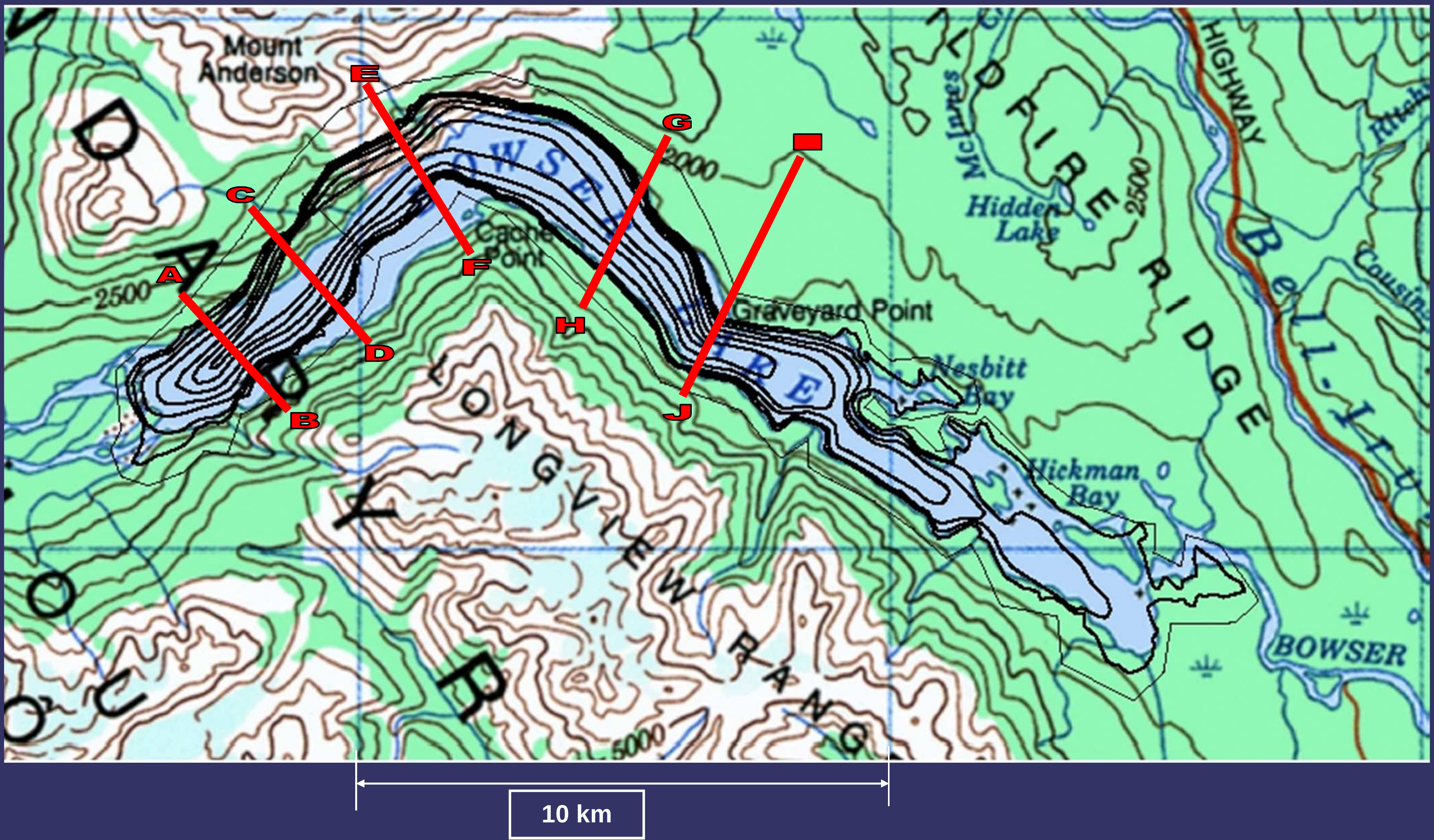
Alternative D2 – Tailings

Crush ore at minesite, tunnel to plantsite near Knipple Lake, truck/convey ore to plant, pipe tailings for submarine disposal into segmented portion of Bowser Lake

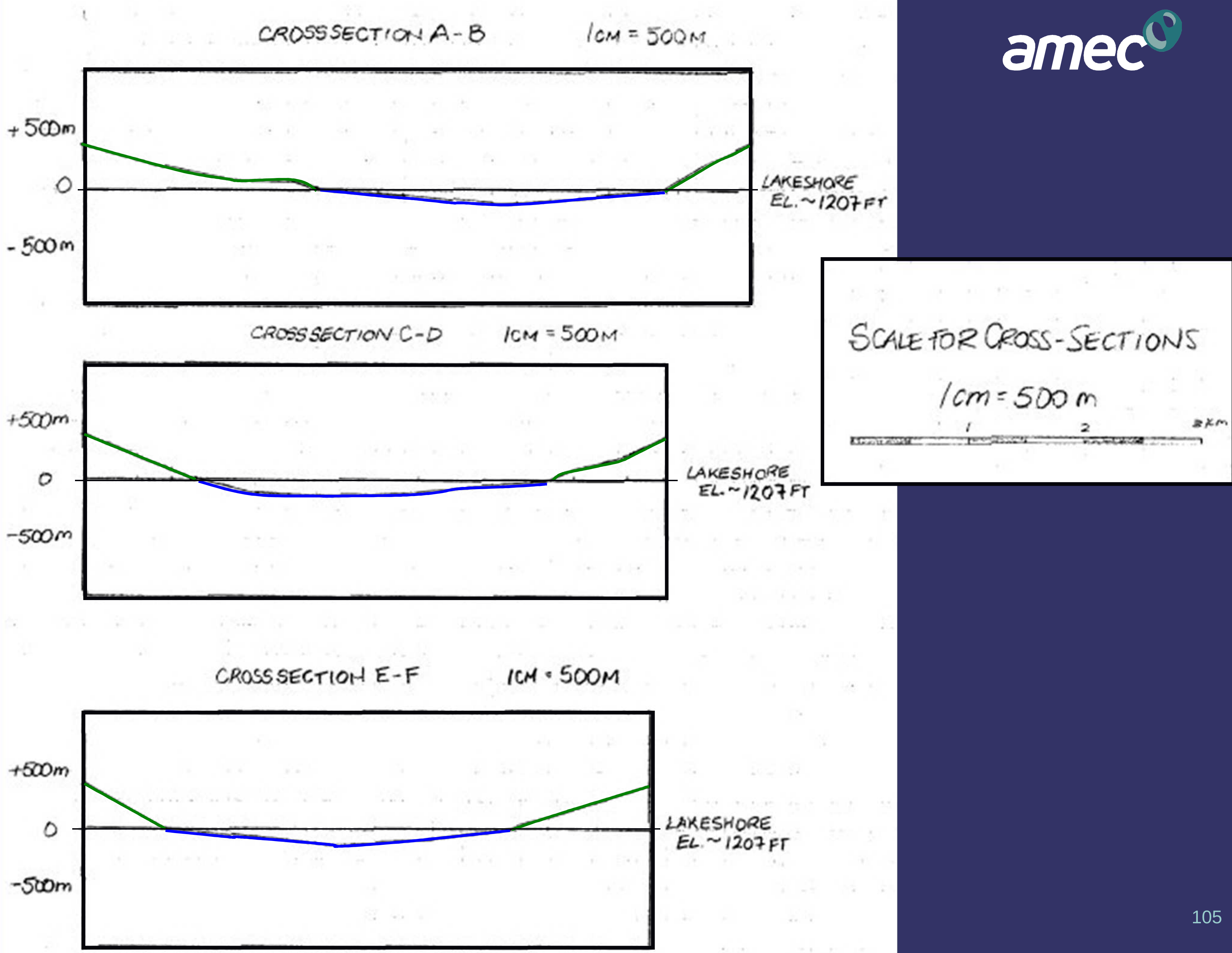
The concept……..

- Access tunnel to site from near Knipple Lake (about 19 km), at 0.3% grade, 5 m diameter
- Crush ore at mine area and convey via tunnel to plantsite near Knipple Lake
- Pipe tailings for subaqueous discharge and secure, permanent flooding within Knipple Lake, with dams as needed to increase storage capacity
- This option represents, conceptually, a possible means of achieving "no disturbance" to fish, but…
- Does not appear practical to construct

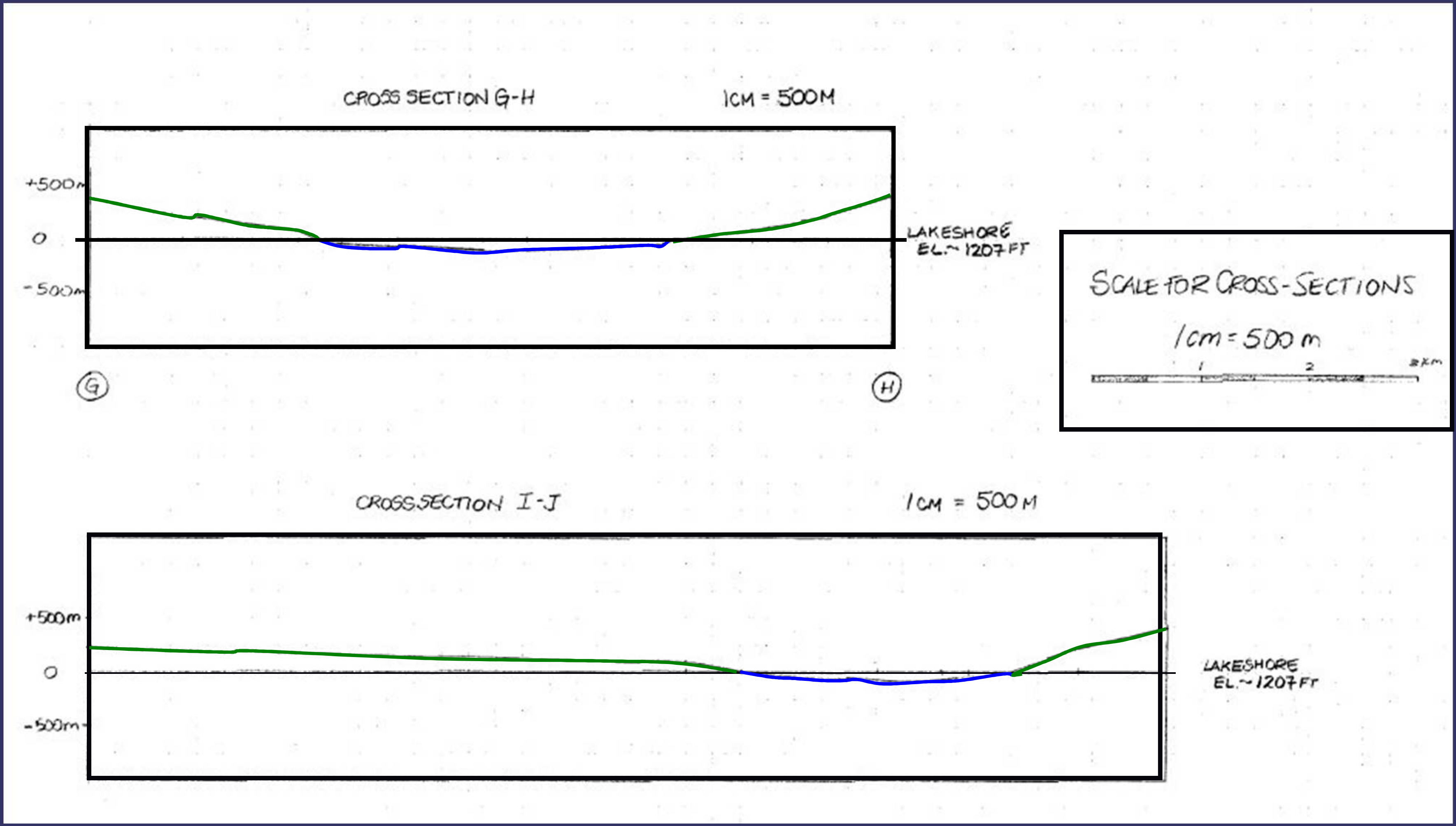
Bowser Lake Plan with Section Lines



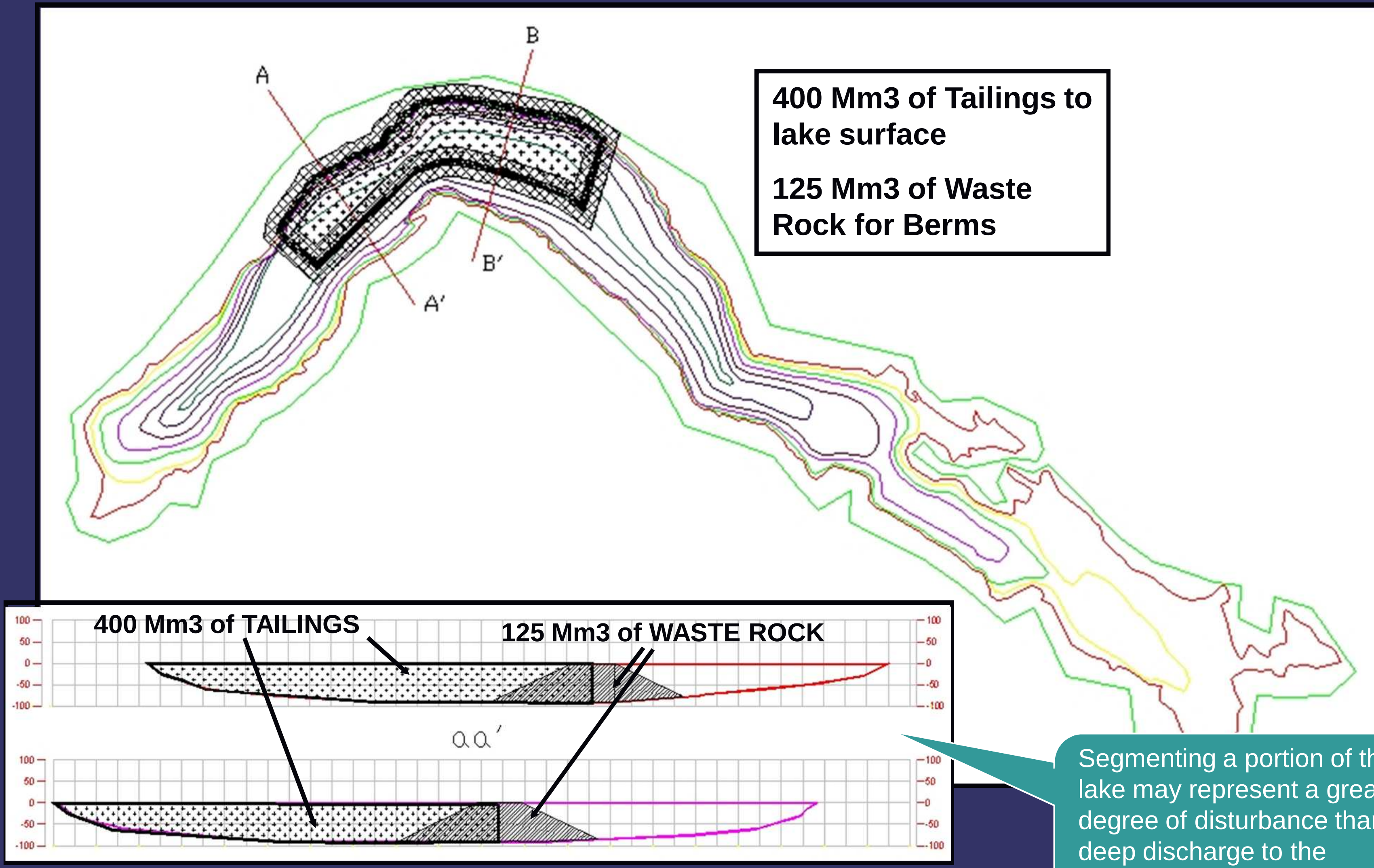
10 km


CROSSSECTION A-B
1CM = 500M
+500m
0
-500m
LAKESHORE
EL.~1207FT
CROSSSECTION C-D
1CM = 500M
+500m
0
-500m
LAKESHORE
EL.~1207FT
CROSSSECTION E-F
1CM = 500M
+500m
0
-500m
LAKESHORE
EL.~1207FT
SCALE FOR CROSS-SECTIONS
1cm = 500 m
1
2
3km

amec


CROSS SECTION G-H
1CM = 500M
+500m
0
-500m
LAKESHORE
EL.~ 1207 FT
G
H
SCALE FOR CROSS-SECTIONS
1cm = 500 m
1
2
3 km
CROSS SECTION I-J
1CM = 500M
+500m
0
-500m
LAKESHORE
EL.~ 1207 FT

Bowser Lake Underwater Tailings Deposition



Segmenting a portion of the lake may represent a greater degree of disturbance than deep discharge to the deepest portion of the lake

Alternative D2 – Tailings

Crush ore at minesite, tunnel to plantsite near Knipple Lake, truck/convey ore to plant, pipe tailings for submarine disposal into segmented portion of Bowser Lake

The reality……..

- Require 125 Mm^3 (about 250 tonnes) of rock (assumed 50 m crest width to accommodate truck turn-arounds) to segment a portion of the lake, before tailings placement can commence
- 19.4 km tunnel at 5 m diameter would produce 0.54 Mm^3, but this has to be hauled 20+ km from the Knipple Lake portal
- A significant area of Bowser Lake is rendered inaccessible to fish
- Does the rockfill/tailings provide fisheries compensation of any value?
- Is this any more “fish-friendly” than piping tailings to depth within the lake, or less so?
- Turbidity/mud waves generated by rockfill causeway construction – silt curtains required? Practical?

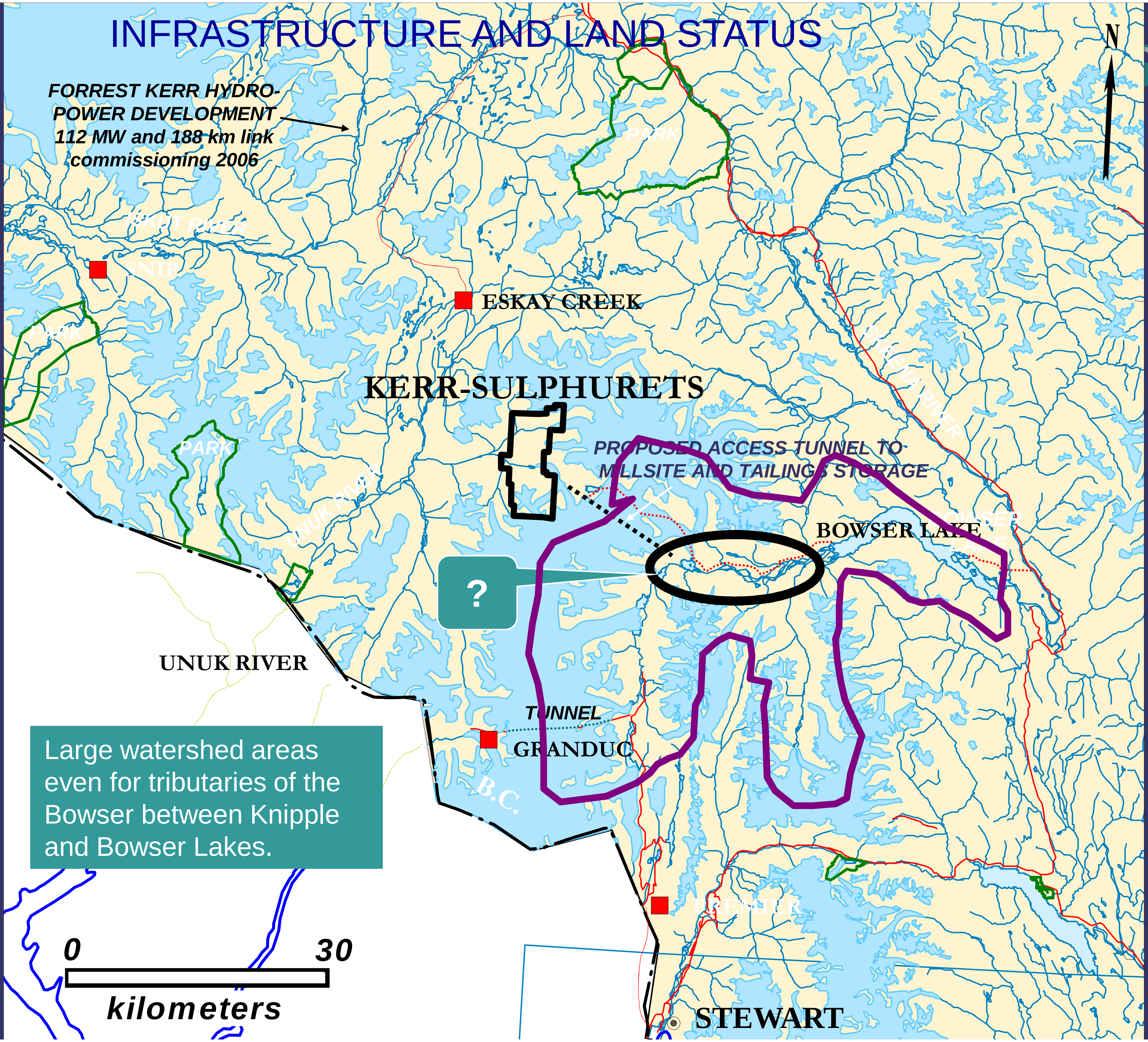
Alternative D3 – Tailings

Crush ore at minesite, tunnel to plantsite near Knipple Lake, truck/convey ore to plant, pipe tailings for submarine disposal (with dams as needed) into Knipple Lake

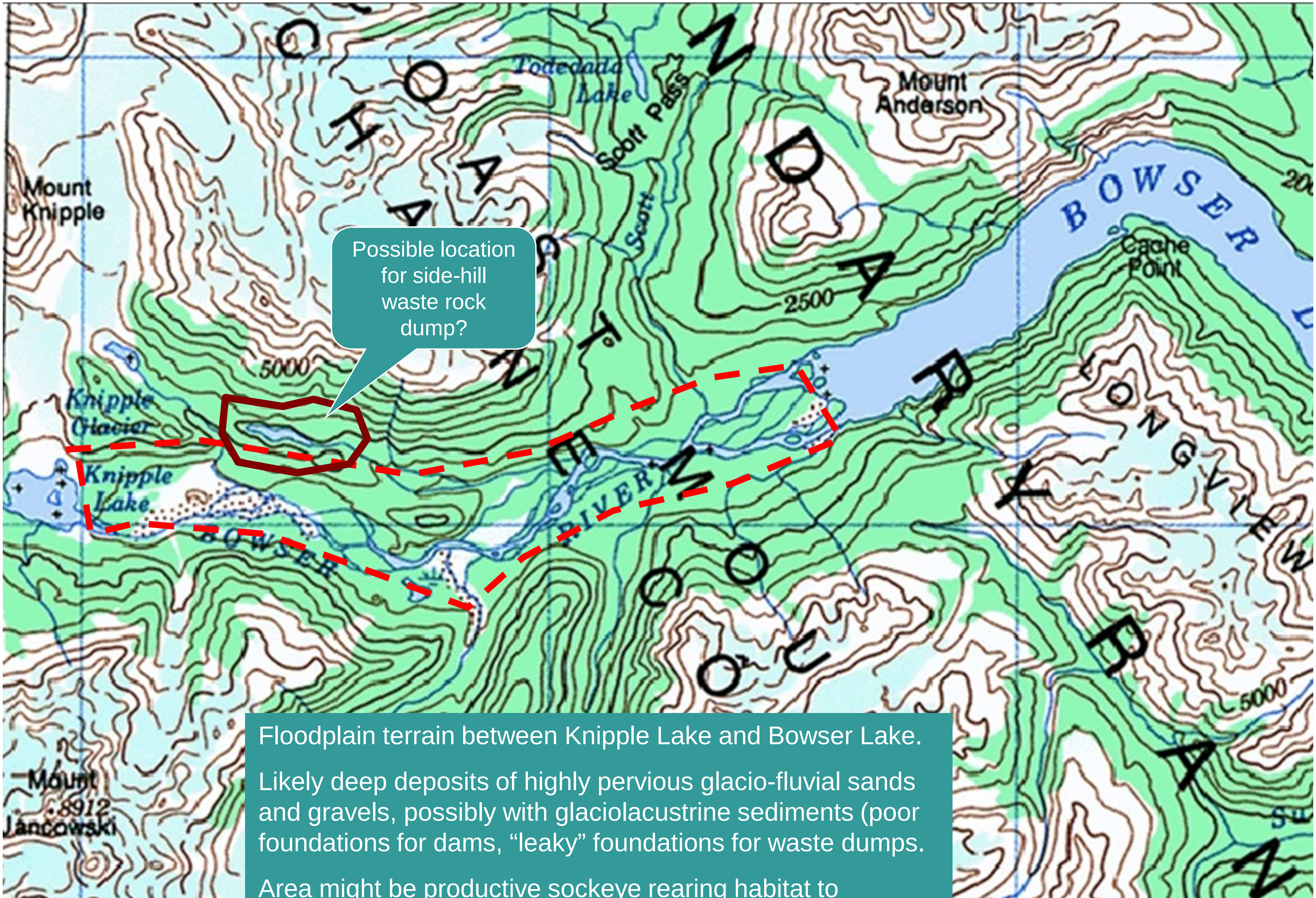
The concept……..

- Access tunnel to site from near Knipple Lake (about 19 km), at 0.3% grade, 5 m diameter
- Crush ore at mine area and convey via tunnel to plantsite near Knipple Lake
- Pipe tailings for subaqueous discharge and secure, permanent flooding within Knipple Lake, with dams as needed to increase storage capacity
- Tunnel has side-benefit in terms of site access, and reduced costs for concentrate haulage
- This option may avoid Bowser Lake fisheries issue

INFRASTRUCTURE AND LAND STATUS



Large watershed areas even for tributaries of the Bowser between Knipple and Bowser Lakes.



Floodplain terrain between Knipple Lake and Bowser Lake.

Likely deep deposits of highly pervious glacio-fluvial sands and gravels, possibly with glaciolacustrine sediments (poor foundations for dams, "leaky" foundations for waste dumps.

Area might be productive sockeye rearing habitat to undetermined distance upstream of Bowser Lake

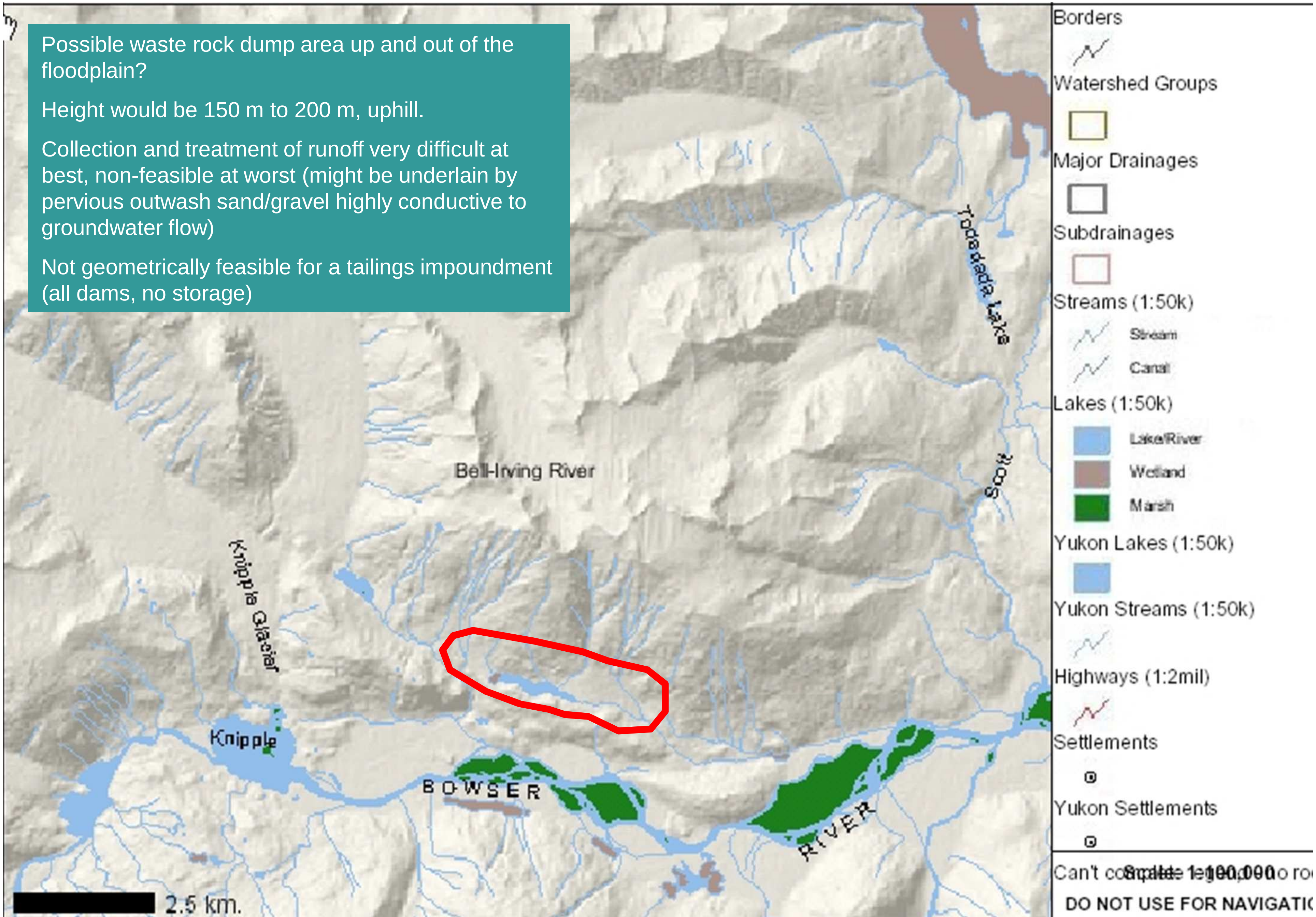
Note Knipple glacier terminus within Knipple Lake

Possible waste rock dump area up and out of the floodplain?

Height would be 150 m to 200 m, uphill.

Collection and treatment of runoff very difficult at best, non-feasible at worst (might be underlain by pervious outwash sand/gravel highly conductive to groundwater flow)

Not geometrically feasible for a tailings impoundment (all dams, no storage)



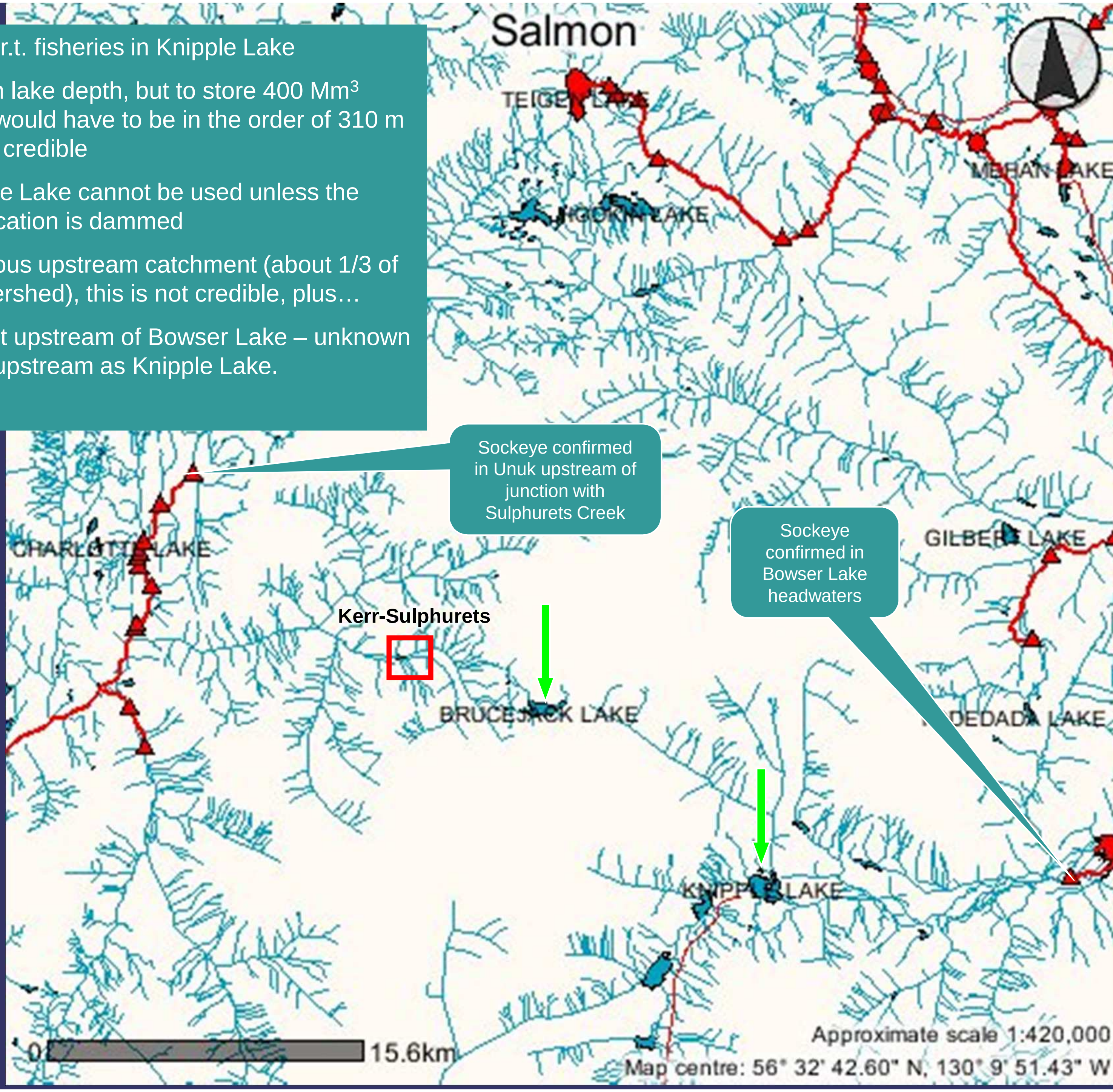
No information w.r.t. fisheries in Knipple Lake

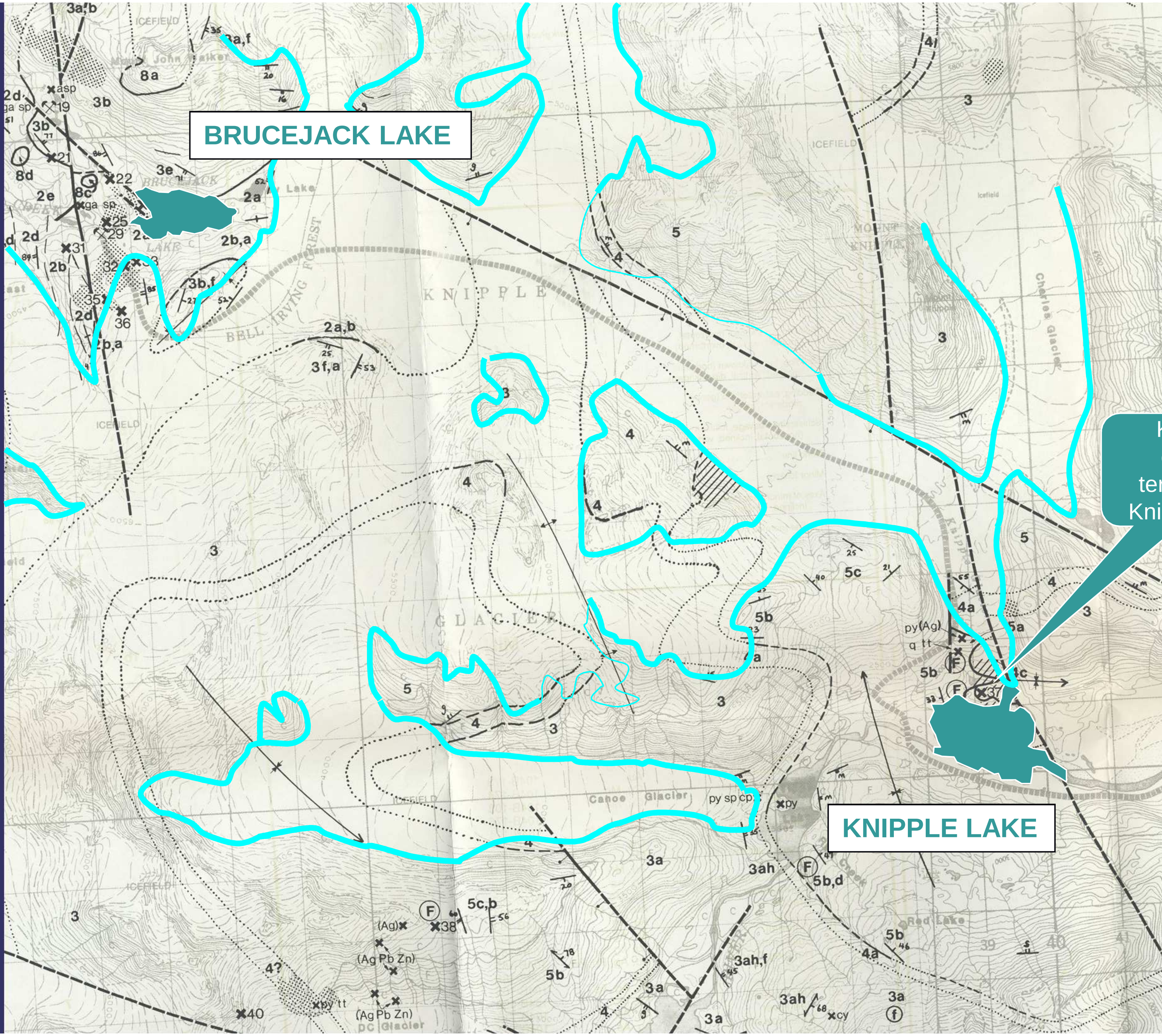
No information on lake depth, but to store 400 Mm^3 tailings, the lake would have to be in the order of 310 m deep – this is not credible

Therefore, Knipple Lake cannot be used unless the Bowser at that location is dammed

Given the enormous upstream catchment (about 1/3 of total Bowser watershed), this is not credible, plus…

Salmon noted just upstream of Bowser Lake – unknown if they get as far upstream as Knipple Lake.




BRUCEJACK LAKE
Knipple glacier terminus in Knipple Lake
KNIPPLE LAKE

Alternative D3 – Tailings

Crush ore at minesite, tunnel to plantsite near Knipple Lake, truck/convey ore to plant, pipe tailings for submarine disposal (with dams as needed) into Knipple Lake

The reality……..

- Very large catchment upstream of Knipple Lake
- Substantial diversions required unless sufficient storage in Knipple Lake for subaqueous deposition of the tailings – no way this lake is 300 m in depth (i.e. 3X as deep as Bowser Lake)
- Knipple glacier terminus on north side of the lake
- Impractical to dam the Bowser River Valley
- Sockeye known to be upstream of Bowser Lake – to what upstream extent currently unknown

Conclusion – this alternative is not viable and not worthy of further consideration.

Alternative E – Tailings

Float out sulphides, filter NAG tailings for dry stack storage, sulphide tailings to waste rock or separate flooded impoundment

The concept…..

- Filter NAG tailings and place in a dry stack (could use to encapsulate waste rock?)
- Progressive reclamation of dry stack (cover with native soils or NAG waste rock) as develops
- Float out sulphides for disposal in a separate flooded impoundment, or with the PAG waste rock in a single impoundment

Alternative E – Tailings

Float out sulphides, filter NAG tailings for dry stack storage, sulphide tailings to waste rock or separate flooded impoundment

The reality…..

- Filtering at 80,000 tpd is completely without precedent, though some large operations are beginning to contemplate it
- No flat real estate free of significant runoff for placement of a stable dry stack protected against erosion
- Notwithstanding the above two problems, dry stacking in such a wet climate is technically problematic
- Conclusion – this is not technically feasible (nor proven at this large scale), and not worthy of further consideration.

Alternative F – Tailings

Ocean disposal via Unuk, through Alaska

The concept…..

- Approximately 70 km to tidewater across border and through national park
- Secure, underwater storage

Alternative F – Tailings

Ocean disposal via Unuk, through Alaska

The reality…..

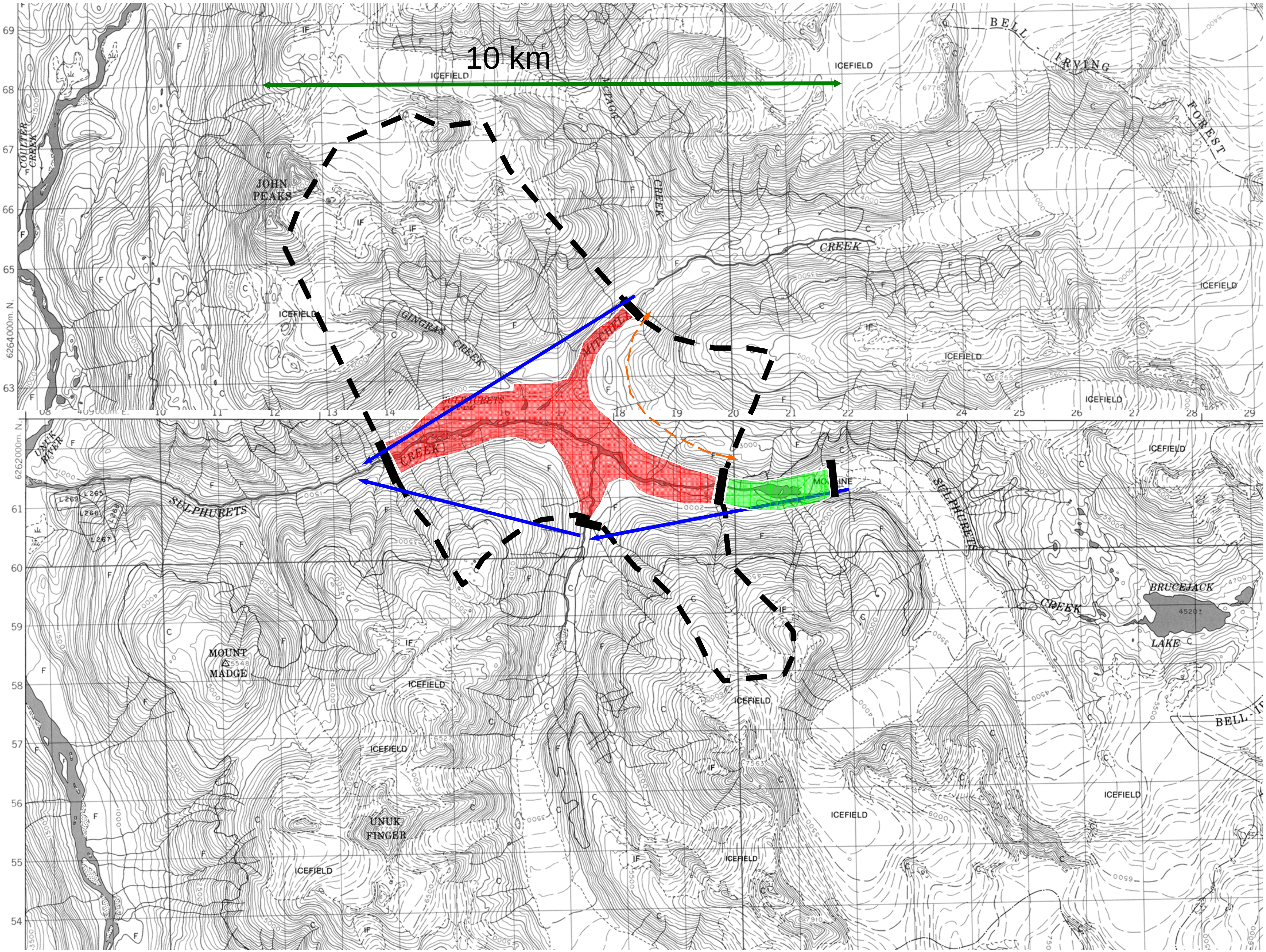
- NGO/public opposition to submarine disposal, likely to be especially vehement in North America
- Trans-border issues – essentially zero chance of being permitted, discharge is into "waters of the State"
- Fisheries issues with the Unuk
- Technically viable, though high risk of spills over 70 km of pipeline in difficult terrain
- Conclusion – zero chance of being permitted, not worthy of further consideration

Alternative G – Tailings

Flooded impoundment further downstream in Sulphurets Creek, waste rock impounded separately for eventual submergence

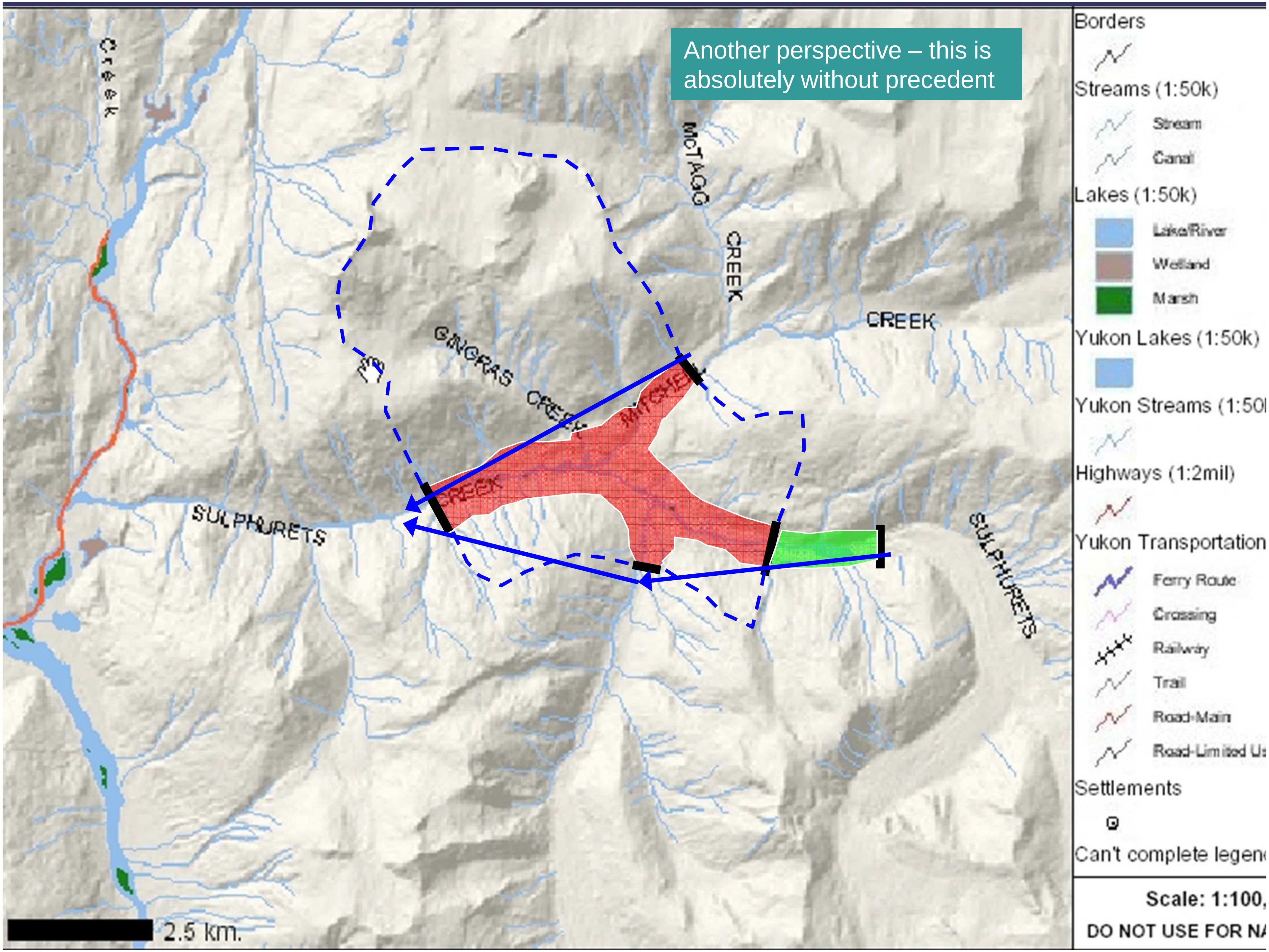
The concept…..

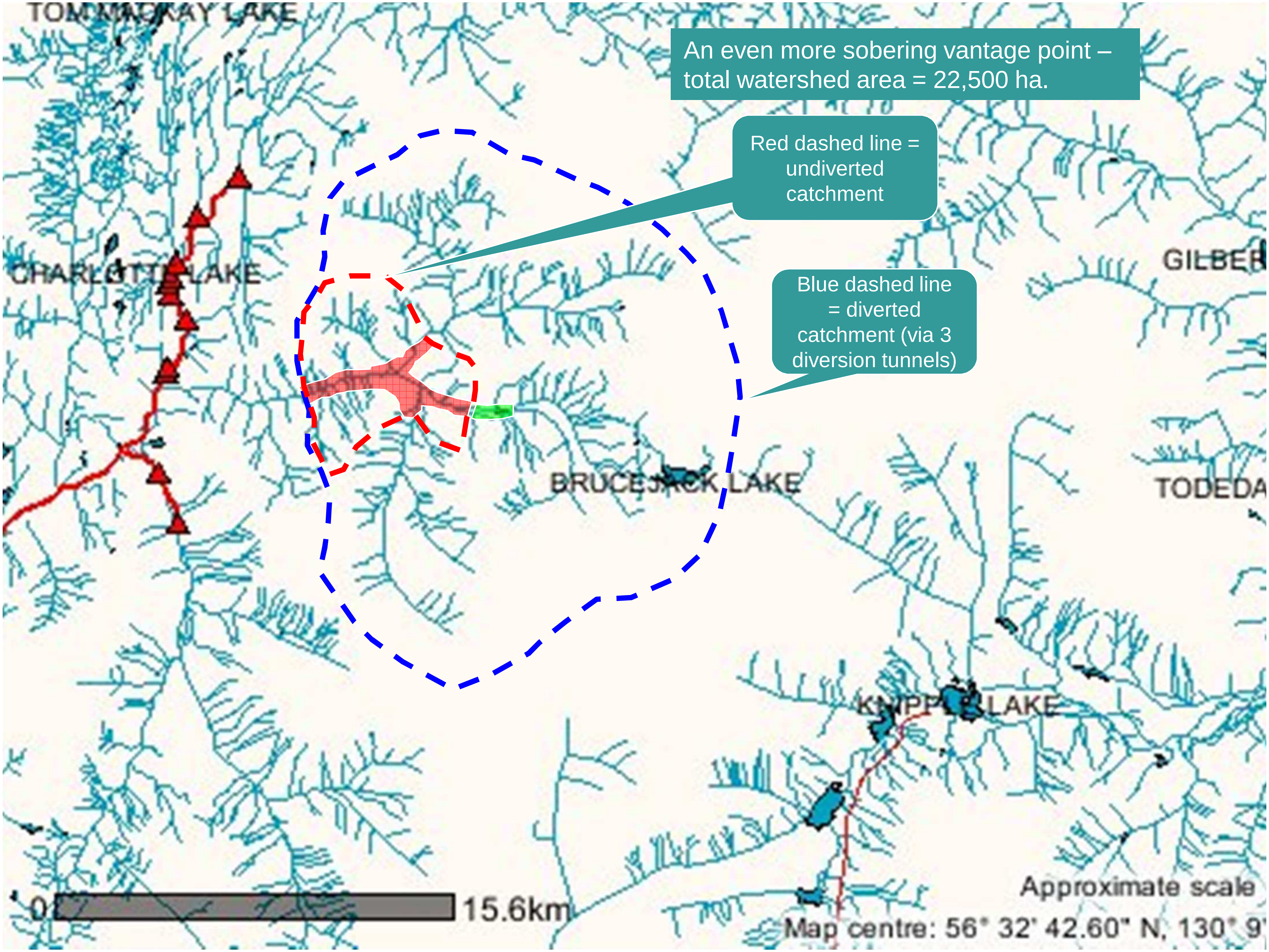
- Construct 5 dams, highest of these about 160 m
- Dams impound tailings to one side, function as diversion dams on other side, each with diversion tunnel (3 m dia., lined) outlet (channels not feasible)
- Now have sufficient real estate for both waste rock and tailings storage in the KS area
- At closure, plug the tunnel diversions, allow flooding on both sides of all but the largest, downstream dam, with large open channel spillway(s), possibly supplemented by tunnel, on one or both of the main dam abutments
- Float out sulphides to permit above-water NAG tailings beach against the most downstream of the dams in the final several years of operation (enhancement of safety of the dam).



10 km
ICEFIELD
JOHN PEAKS
COULTER CREEK
GINGRAS CREEK
MITCHELL
SULPHURETS CREEK
CREEK
BELL IRVING
FOREST
UNUK RIVER
SULPHURETS
MOUNT MADGE
UNUK FINGER
BRUCEJACK LAKE
CREEK
BELL
6264000m. N.
6262000m. N.
409000m. E.

Another perspective – this is absolutely without precedent





TOM MACKAY LAKE
An even more sobering vantage point – total watershed area = 22,500 ha.
Red dashed line = undiverted catchment
CHARLOTTE LAKE
GILBER
Blue dashed line = diverted catchment (via 3 diversion tunnels)
BRUCEJACK LAKE
TODEDA
KNIPPLE LAKE
0
15.6km
Approximate scale
Map centre: 56° 32' 42.60" N, 130° 9'

Alternative G – Tailings

Flooded impoundment further downstream in Sulphurets Creek, waste rock impounded separately for eventual submergence

The reality…..

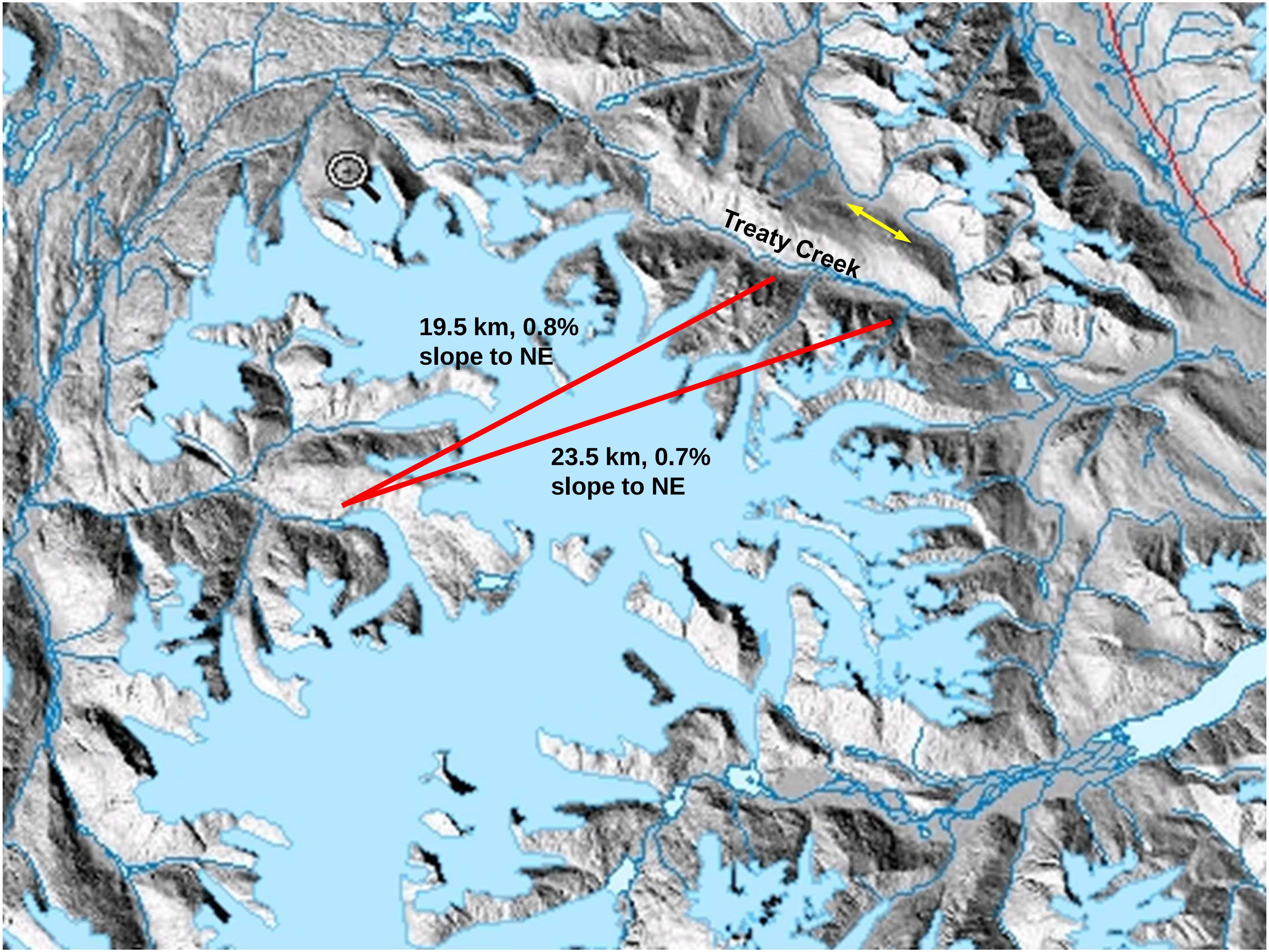
- 5 substantial dams to be constructed on glacial drift, the most downstream would require substantial cofferdam and diversion tunnel
- Approx. 13 km total of diversion tunnels
- Even more km of tailings pipelines
- Still have large undiverted catchment providing runoff to impoundment area, creating large annual water balance surplus – significant treatment and release requirements
- This large and complex a tailings management system in such challenging glacially active terrain is (to AMEC's knowledge) without precedent
- Conclusion – "theoretically" viable, but is a high cost, high risk and unprecedented solution with significant long term liability, and not worth further consideration.

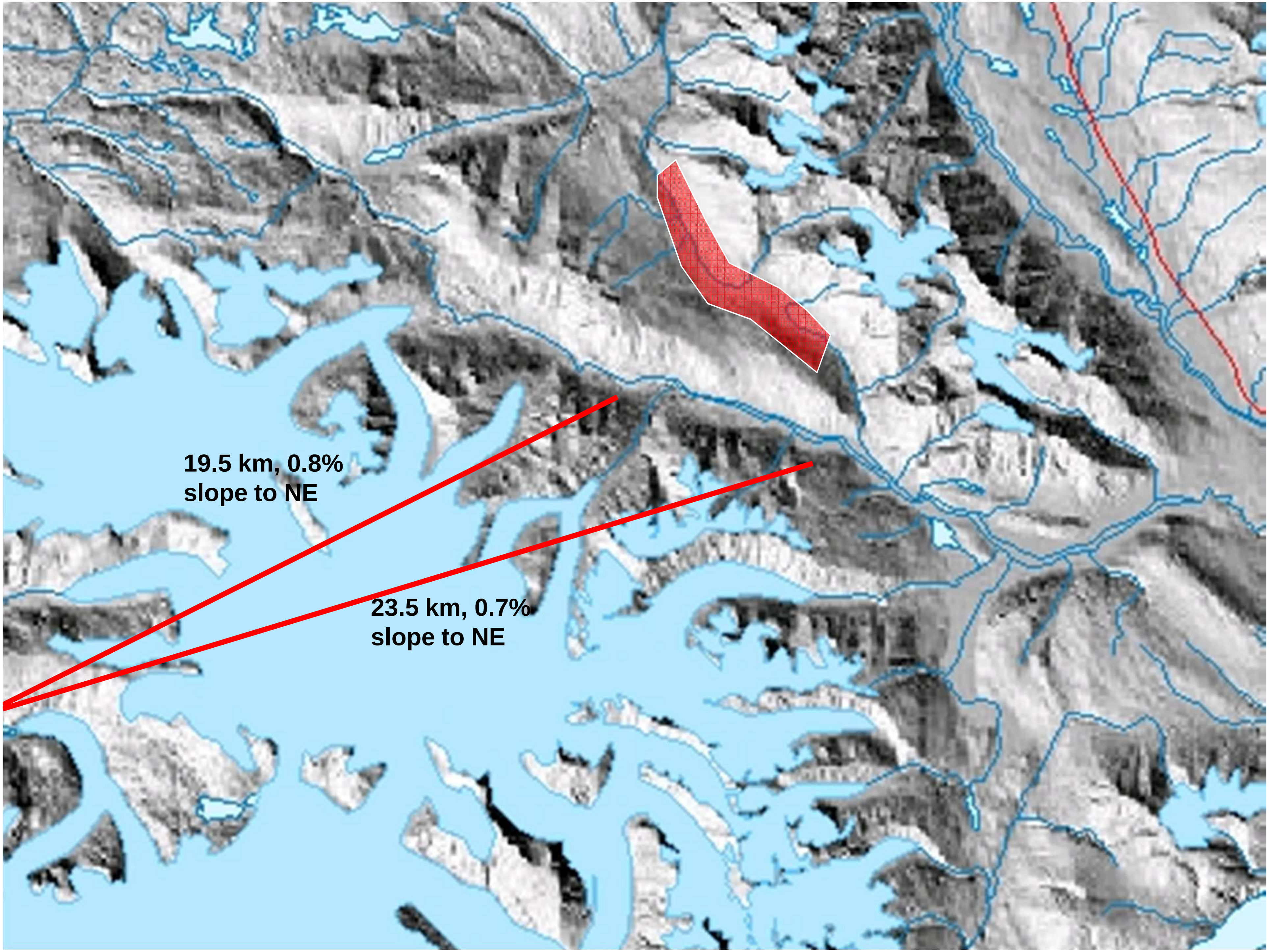
Alternative H – Tailings

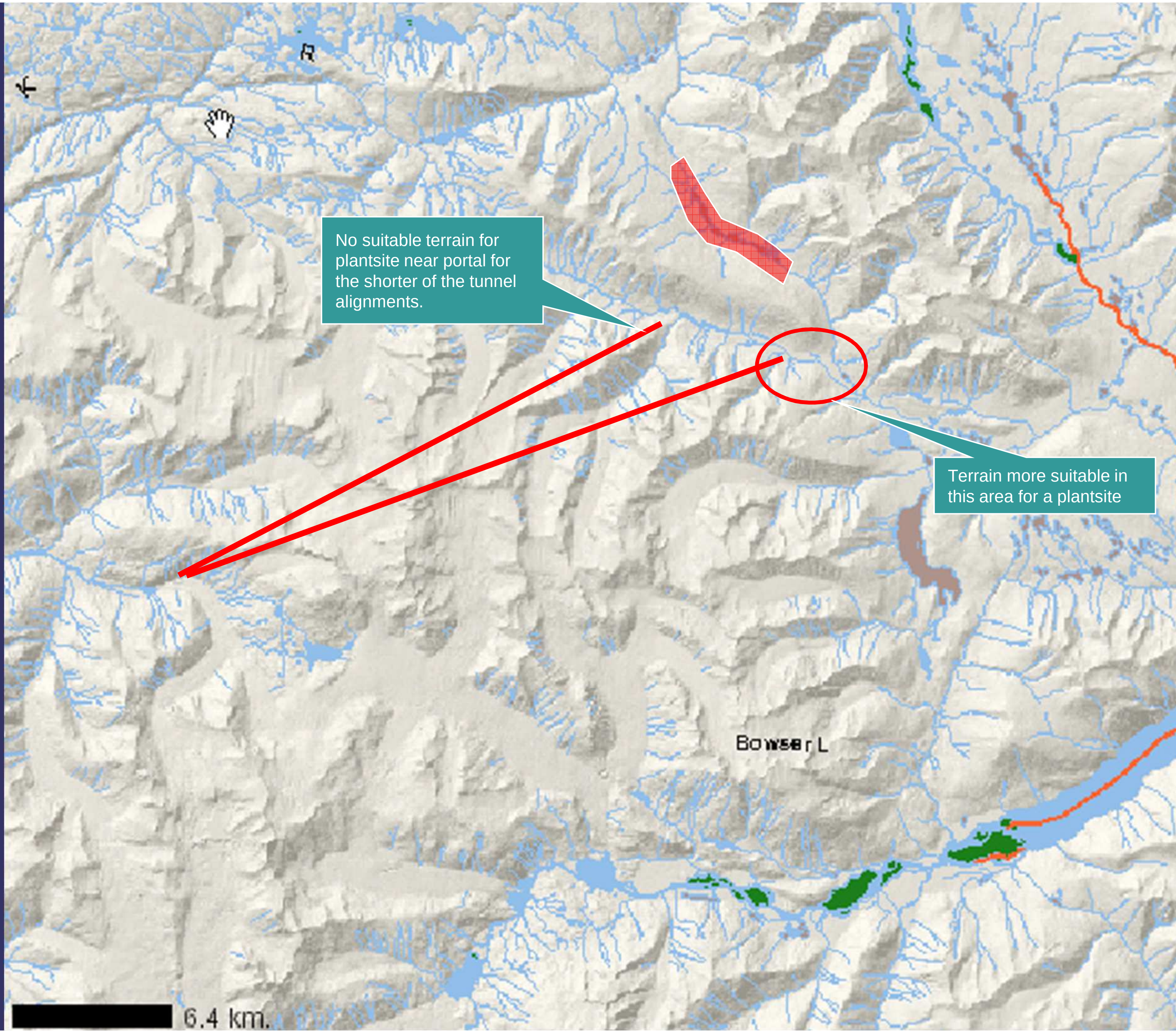
Tailings impoundment to northwest of Bowser Lake, tunnel from KS site to NE

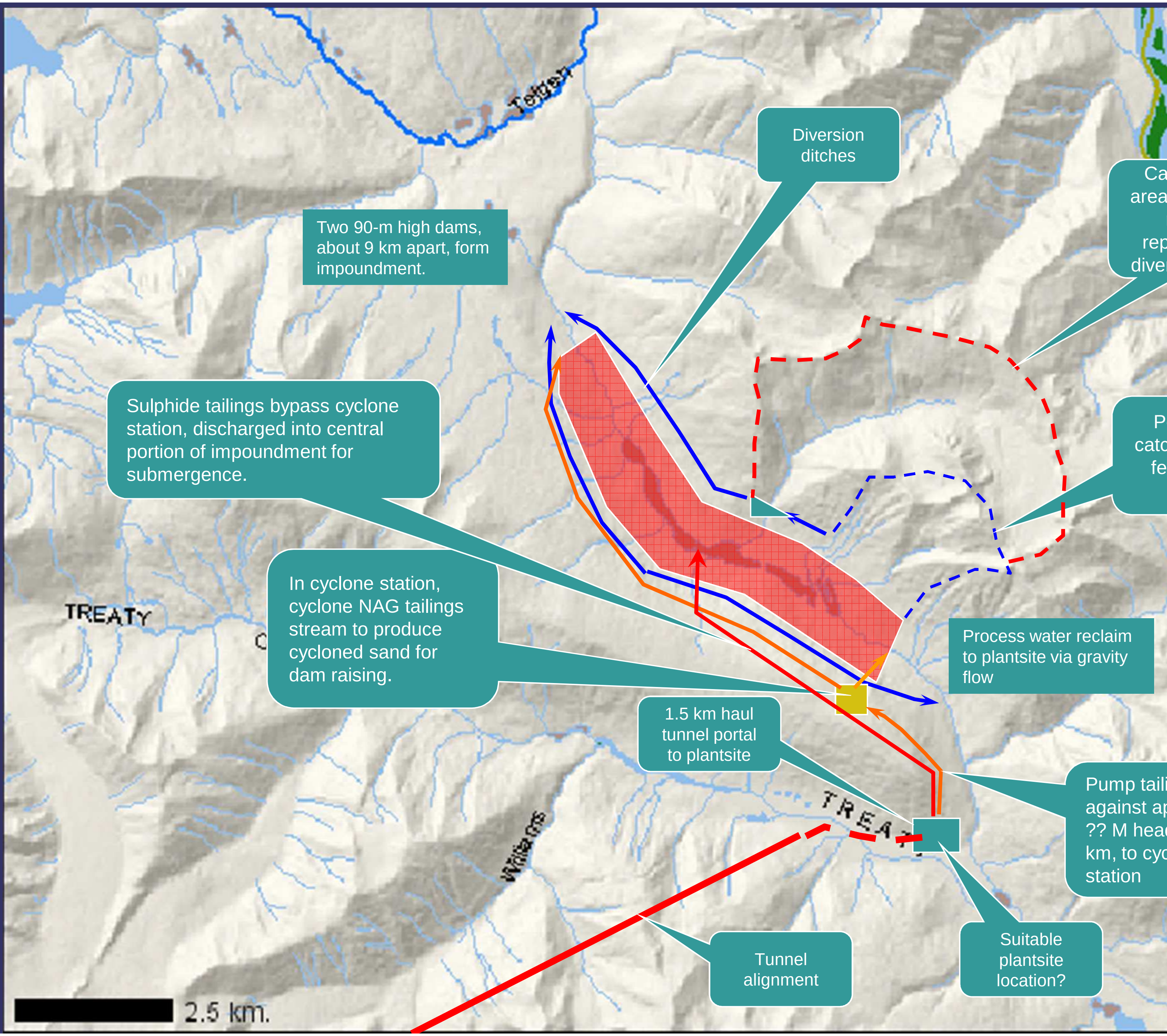
The concept…..

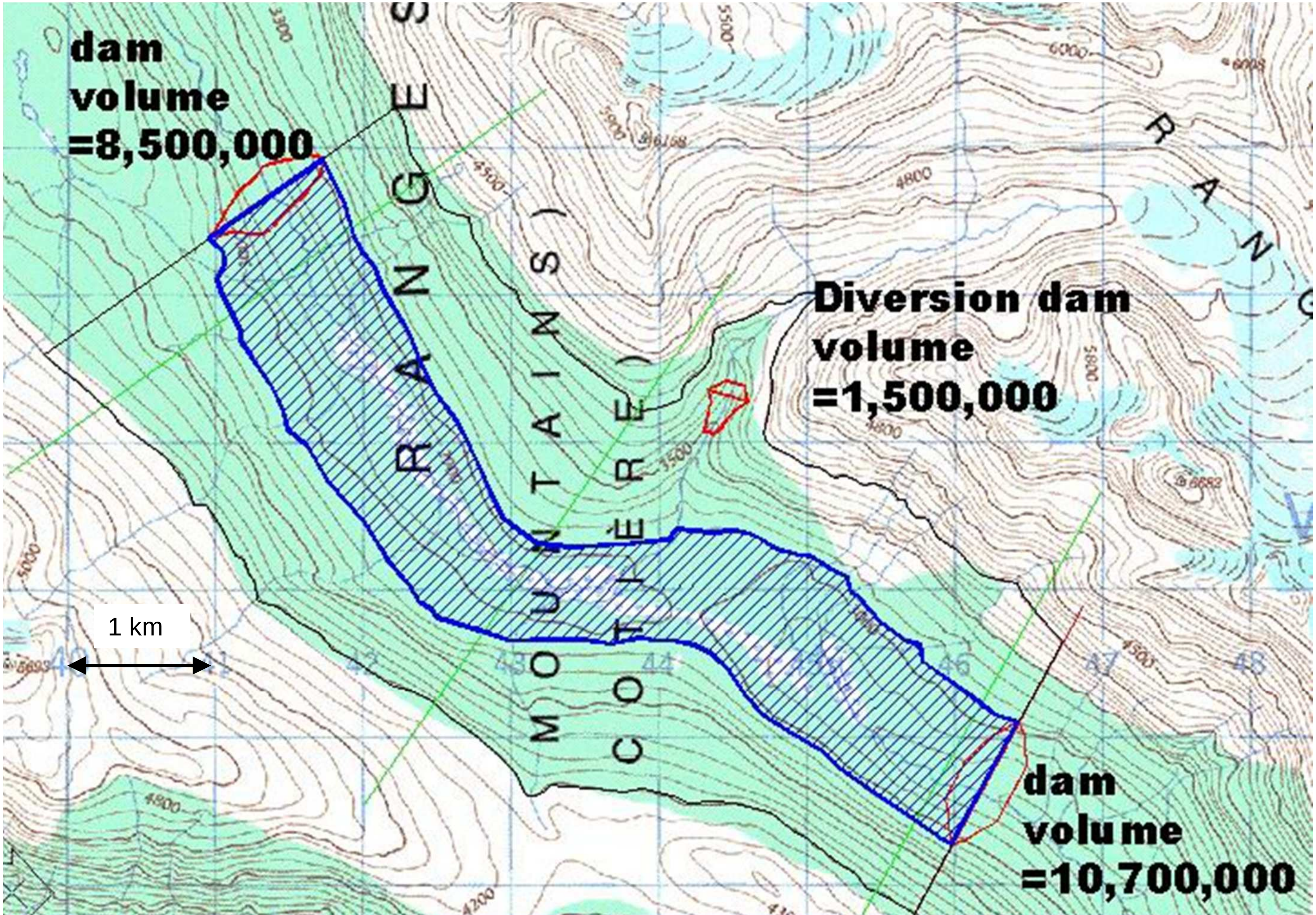
- 19-23 km, 6-m dia. tunnel northeast from KS area to Treaty Creek valley, provides year round access (still need a summer road for large equipment)
- Plantsite in Treaty Creek valley, easy access to Highway 37 via approx. 15 km road
- Crush ore at KS and convey via tunnel to plantsite
- Pump tailings approx. 3 km to impoundment (max. elevation difference about 300 m), that straddles a watershed divide, in a tributary valley north of Treaty Creek. From cyclone station, tailings flow via gravity.
- Impoundment formed by two 90-m high dams
- Cyclone station + flotation circuit near impoundment, on south abutment of the southern dam, to create NAG cycloned sand for dam raising (e.g. Kemess)
- PAG tailings to center of impoundment, NAG tailings used for downstream shell construction and upstream beach construction in front of both dams
- Open channel diversions along most of tailings impoundment perimeter, and one diversion dam/conduit


Treaty Creek
19.5 km, 0.8% slope to NE
23.5 km, 0.7% slope to NE

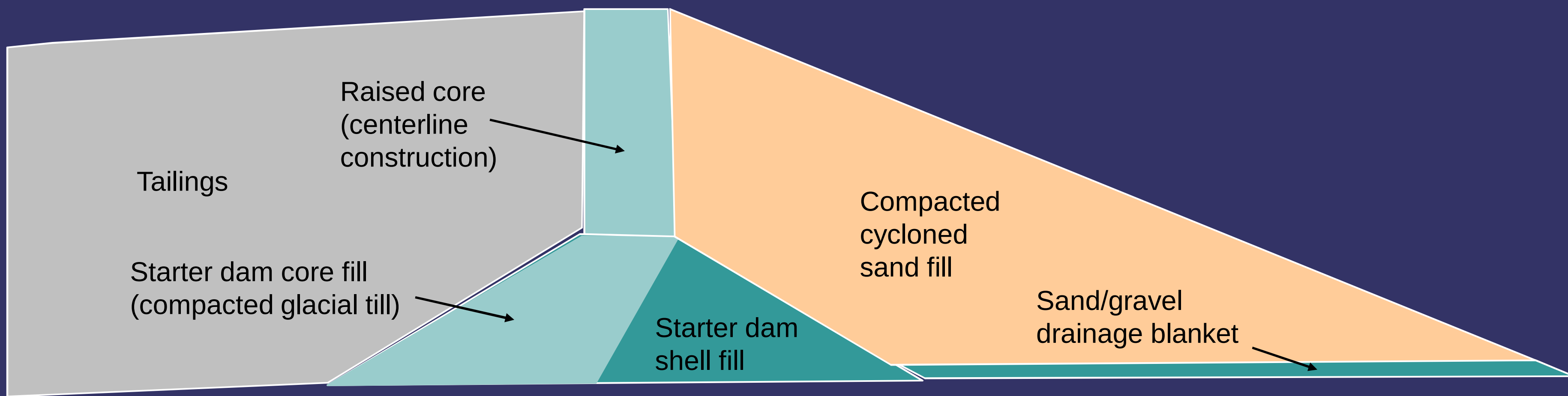

19.5 km, 0.8%
slope to NE
23.5 km, 0.7%
slope to NE


No suitable terrain for plantsite near portal for the shorter of the tunnel alignments.
Terrain more suitable in this area for a plantsite
Bowser L
6.4 km.


Telegraph
Diversion ditches
Catchment area providing runoff reporting to diversion dam
Two 90-m high dams, about 9 km apart, form impoundment.
Sulphide tailings bypass cyclone station, discharged into central portion of impoundment for submergence.
Portion of catchment not feasible to divert
TREATY
In cyclone station, cyclone NAG tailings stream to produce cycloned sand for dam raising.
Process water reclaim to plantsite via gravity flow
1.5 km haul tunnel portal to plantsite
TREATY
Pump tailings against approx. ?? M head, 2 km, to cyclone station
Tunnel alignment
Suitable plantsite location?
2.5 km.


dam
volume
=8,500,000
Diversion dam
volume
=1,500,000
dam
volume
=10,700,000
1 km
RANGES
MOUNTAINS
RANGE
COTIÈRE
RANG

Conceptual dam design section

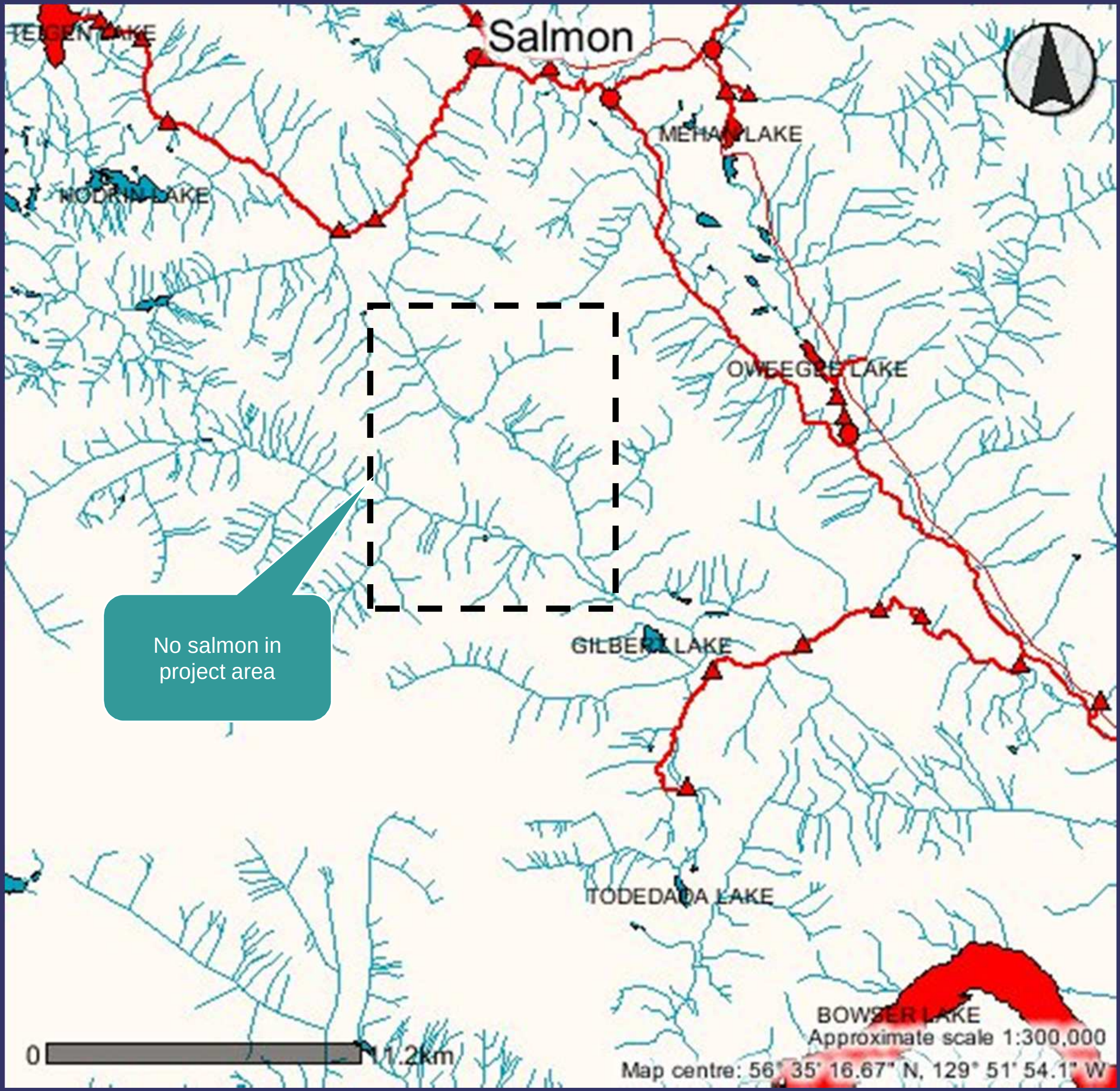


- Via flotation (sulphides removal) and cycloning, produce clean cycloned sand for dam construction
- At Kemess, plant operating cost + sand placement cost about $2.50/$m^3$
- Cycloned sand to upstream allows centerline raising, which reduces raising fill volumes (above starter dams) by about 50%.
- Starter dam shell fill possibly comprised of spoil (assuming it is NAG) from the tunnel construction (approx. 800,000 m^3, accounting for bulking factor)
- Upstream beach comprised of NAG tailings, so can maintain above water beaches during operations and at closure – simplifies dam design and construction, lowers costs, and enhances long term dam safety
- Sulphidic tailings discharged to central portion of impoundment for permanent submergence

Cycloned sand construction – feasible for this project?

- Same concept (cyclone plant) in place at Kemess, where cycloned sand construction takes place almost 12 months per year, except that at Kemess the flotation for sulphides removal occurs in cyclone plant – at KS:
  - Flotation for sulphides removal could take place in cyclone plant (in which case only one tailings stream is pumped uphill) or
  - Flotation takes place in the plantsite (in which case two separate streams, one NAG and one PAG) are pumped
- Assume 20% of total dam volumes required for starter dams construction, = 0.2 x 20 Mm^3 = 4 Mm^3
- With centerline raising, then remaining 16 Mm^3 fill volume is reduced by about 50%, giving 8 Mm^3 (based on assumed 3H:1V dam slopes, which should suffice unless there are very weak soils (e.g. glaciolacustrine clays) in the valley fill
- Over 12 years of dam raising, this requires production of say 1 Mm^3/year (actually 0.67 Mm^3 averaged over mine life, but dam raising is more rapid in the earlier years)
- Assuming:
  - 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)
  - In place compacted sand density = 1.65 t/m^3
  - 85% plant operating factor
- Then require 107 days (say 4 months) of downstream cycloning to place
  - This is easily achievable based on the Kemess experience
  - Leaves additional margin in case flatter dam slopes required based on foundation conditions
  - Also allows for extended periods of cycloning to the upstream to develop and maintain above-water (NAG) beaches

Treaty Creek Salmon Distribution



Alternative H – Tailings

Tailings impoundment to northwest of Bowser Lake, tunnel from KS site to NE

The reality…..

- Appears to be technically viable – unknowns w.r.t. tunnel (geology along alignment, degree of support required, groundwater conditions, etc.)
- Access points for ventilation shafts a problem because most of alignment underlies glacier-covered terrain
- Portal, plantsite and tailings impoundments in areas upstream of limit of reported salmon presence in Treaty Creek
- Tailings impoundment site appears favourable (foundation conditions unknown)
- Fewer permitting issues with this alternative vis a vis alternatives involving use of Bowser Lake
- This alternative is worthy of further consideration

Tailings Alternatives

Where do we stand?

Alternative		Technically Feasible?	Worthy of Further Consideration?
A	Co-disposal with waste rock in flooded impoundment in Sulphurets Valley	NO	NO
B	Float sulphides to create NAG/PAG streams, separate co-disposal with waste rock in Sulphurets Valley	NO	NO
C	Tailings initially to flooded impoundment in Sulphurets Valley, then to 1st mined-out pit	NO	NO
D1	Crush ore at mine, convey via tunnel to plantsite at Knipple Lake, pipe tailings to subaqueous deposition in Bowser Lake	YES	**YES**
D2	Crush ore at mine, convey via tunnel to plantsite at Knipple Lake, pipe tailings to subaqueous deposition in portion of Bowser Lake segmented via rockfill causeways	YES	YES
D3	Crush ore at mine, convey via tunnel to plantsite at Knipple Lake, pipe tailings to subaqueous deposition in Knipple Lake	NO	NO
E1	Float sulphides, filter NAG tailings and dry stack, co-dispose sulphidic tailings and waste rock in Sulphurets Valley impound.	NO	NO
E2	Float sulphides, filter NAG tailings and dry stack in Bowser drainage, sulphidic tailings to subaqueous deposition in Bowser Lake.	YES	NO
F	Ocean disposal via Unuk River into Alaskan Fjord	YES	NO
G	Tailings impoundment further down Sulphurets Creek, 5 dams, separate impoundment to flood waste rock	YES	NO
H	Tailings to impoundment NW of Bowser Lake, convey crushed ore to plantsite to northeast of KS site.	YES	YES

Tailings Alternatives

Where do we stand?

- Only viable tailings alternatives incorporate conveyance of crushed ore via tunnel to plantsite outside of the Kerr-Sulphurets property
- Fisheries issues a possible permitting “fatal flaw” for the Bowser Lake alternative

Revisit Alternative F – Waste Rock

Co-disposal of PAG waste rock with tailings in Treaty Creek tailings impoundment

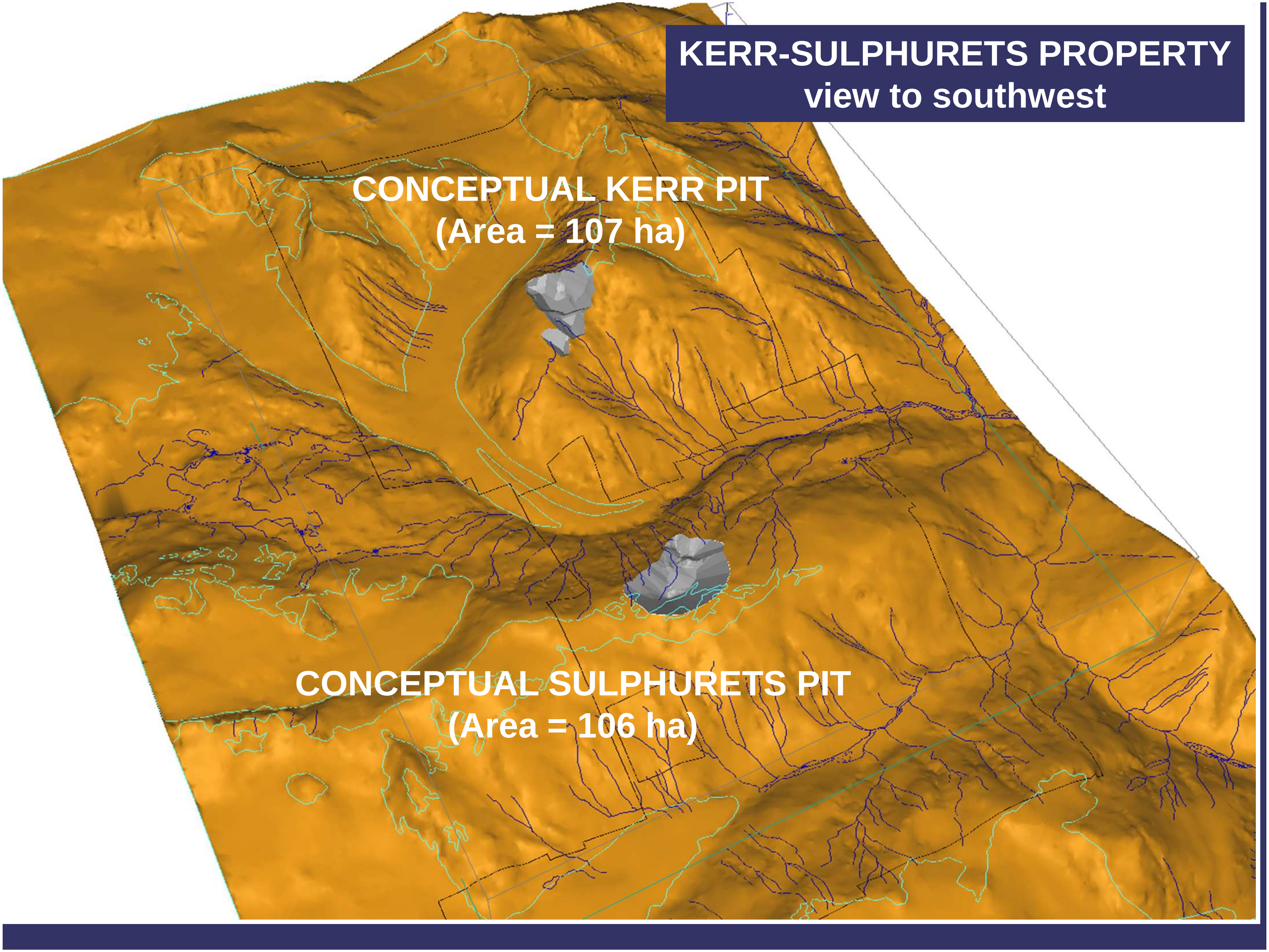
The concept…..

Alternative A – Pit Wall Rock

Perpetual collection and treatment

The concept……..

- Collect drainage from pits, treat and discharge
- Treatment plant location flexible, could pipe/pump water to Knipple Lake for treatment (if the tunnel option is selected for tailings management)
- Locate treatment plant in Sulphurets Valley bottom, running pit drainage there via gravity
- No significant runoff catchments draining into pits – their catchment areas are effectively their outlines
- May need some very minor saddle dams at low points to provide enough storage to handle the freshet water without uncontrolled spillage


KERR-SULPHURETS PROPERTY
view to southwest
CONCEPTUAL KERR PIT
(Area = 107 ha)
CONCEPTUAL SULPHURETS PIT
(Area = 106 ha)

Typical annual runoff volumes in pits for treatment

- Based on 2.2 m/year, and assuming runoff coeff. of 1 (accounts to some extent for seepage inflows, then annual runoff (per pit) = 2.3 Mm^3
- For May, with 60% of the 1.5 m/year snowmelt, then monthly runoff = 0.95 Mm3, averaging 0.37 m^3/sec (370 litres/sec)

Alternative A – Pit Wall Rock

Perpetual collection and treatment

The reality……..

- This is technically viable
- Annual treatment volumes are relatively minor
- The challenge, if treatment is at KS, is maintaining permanent access and power
- Largely automated system possible?
- Worthy of further consideration

Alternative B – Pit Wall Rock

In-pit treatment, high wall runoff into anoxic zone near bottom of pit lake

The concept…….

- Collect high wall runoff and put into anoxic zone near bottom of the pit lake
- Can possibly avoid treatment plant using some engineered biological activity in the anoxic zone
- This is proven technology, being used at Island Copper, several operations in Montana
- An alternative, and more passive, form of perpetual treatment

NORTH-SOUTH CROSS SECTION, VIEW TO WEST

The pits are bowls with one side missing, there is essentially no in-pit storage capacity without significant dam construction.

Alternative B – Pit Wall Rock

In-pit treatment, high wall runoff into anoxic zone near bottom of pit lake

The reality…….

- Not viable based on the current pit shells
- Can the pit designs be significantly modified to allow for better storage capacity and still have an economic mining project?
- If not, then this option does not appear viable.

Alternative C – Pit Wall Rock

Backfill the pits

The concept…….

- Backfill pits to (or close to) pre-mining configuration
- Cap the surface with compacted, low permeability till
- Will still have infiltration and seepage from pit walls to contend with, so will need drains from the low points of the pits to collect water for feeding to water treatment plant

Alternative C – Pit Wall Rock

Backfill the pits

The reality…….

- A lot of material to be rehandled
- Benefit is reduction in volume of ARD water to be treated, but at what cost?
- Cannot put all PAG rock back into the pits and cap, so will have ARD management of other rock to content with in any case
- Technically viable, but probably not worthwhile considering further due to cost-benefit ratio?

Alternative D – Pit Wall Rock

Extend pit excavation so that final walls are in rock that is NAG

The concept…….

- Extend pit excavation to remove "offending" rock from walls for placement in dumps/impoundments
- Do this in conjunction with flooded impoundment in Sulphurets Valley
- The "prize" is elimination of ARD and water treatment plant post-closure (if all PAG waste rock is flooded)

Alternative D – Pit Wall Rock

Extend pit excavation so that final walls are in rock that is NAG

The reality…….

- Is there a significant pyritic halo around these ore bodies?
- How much additional rock excavation would be required to achieve this?
- Will this generate a large additional amount of PAG rock requiring submergence (hence higher containment dam)?
- Additional work needed to assess technical viability of this
- Could run alternative pit shells to see at what point the economics of doing this become nonsensical?
- Conclusion – pyritic halo is significant, no precedent for doing this – economics do not make sense, not worthy of further consideration

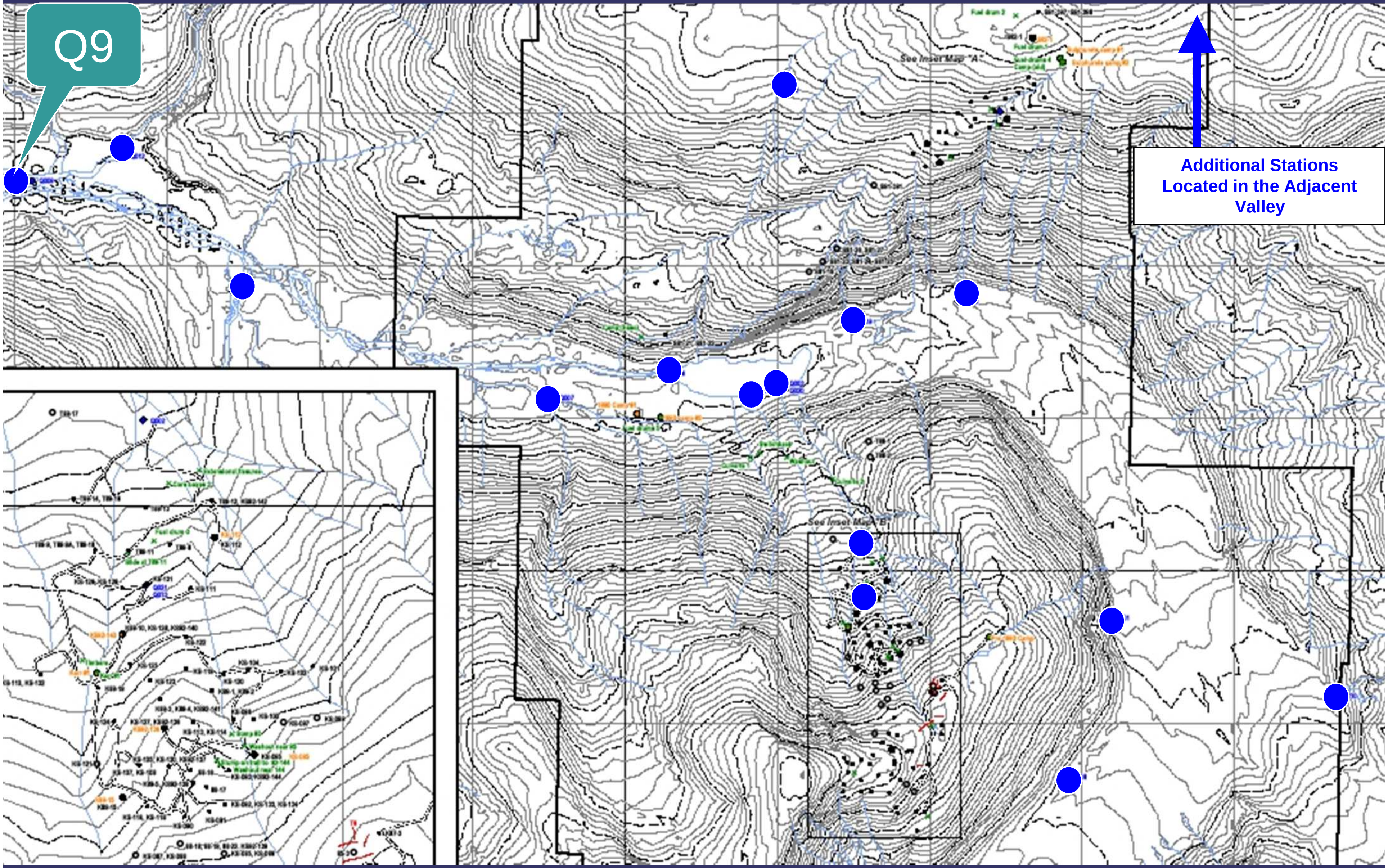
Alternative E – Pit Wall Rock

Do nothing

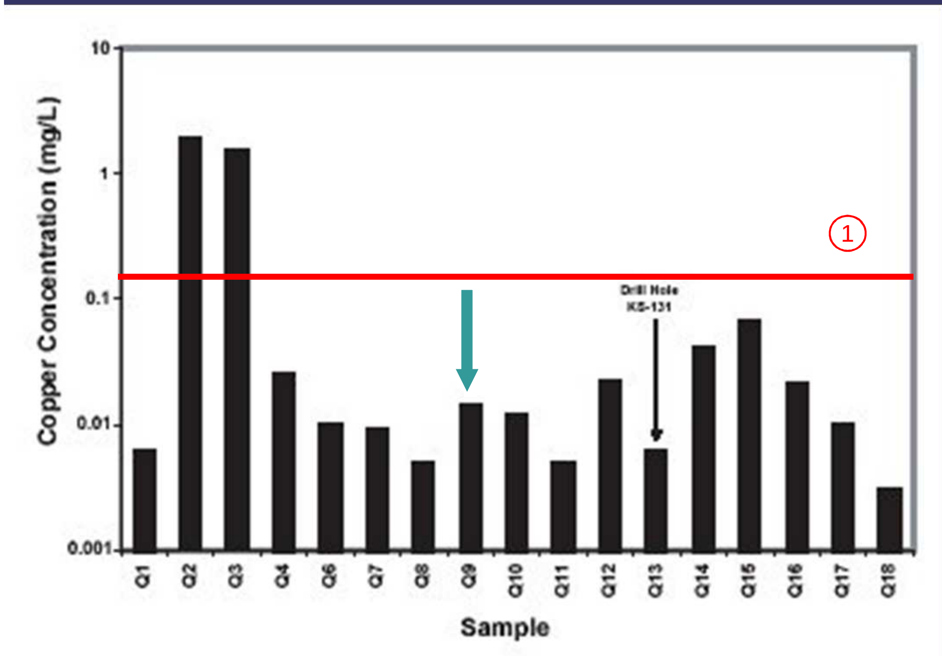
The concept…….

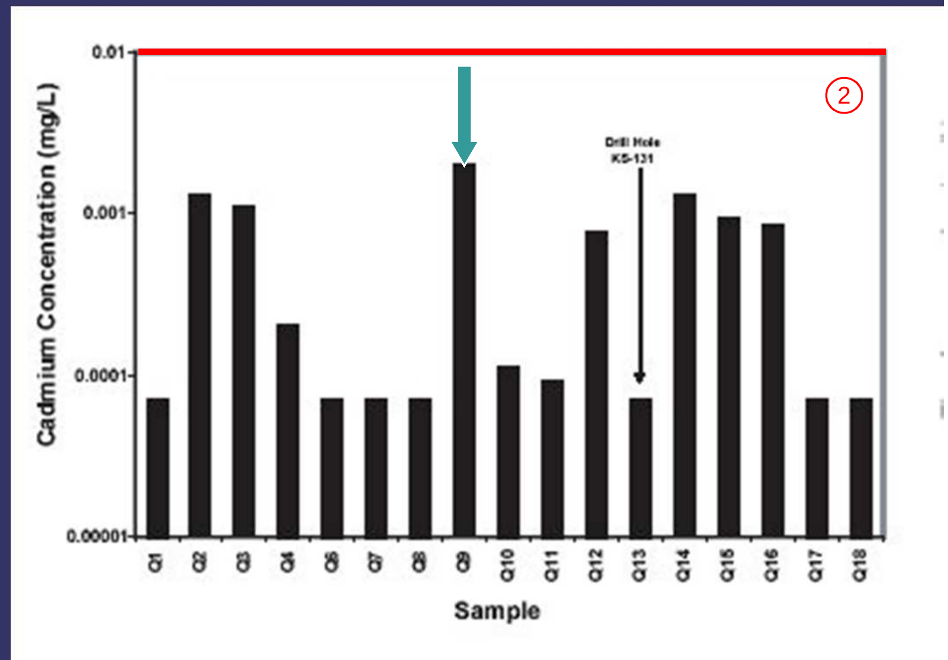
- No collection and treatment of pit walls ARD
- Argument in favor of this options is either:
  - Pit drainage quality and flows would not result in water quality any worse than current baseline conditions; or
  - Water quality would be somewhat worse but sufficient dilution available downstream prior to drainage reaching productive fisheries streams and Unuk system
- Do baseline water quality conditions provide a basis for this as a starting position or as “upside” potential?

Water Quality Monitoring Stations



Comparison of Surface Water Chemistry for Samples Collected at Kerr-Sulphurets Property During Aug/Sept. 2003 with Recognized Industry Standards

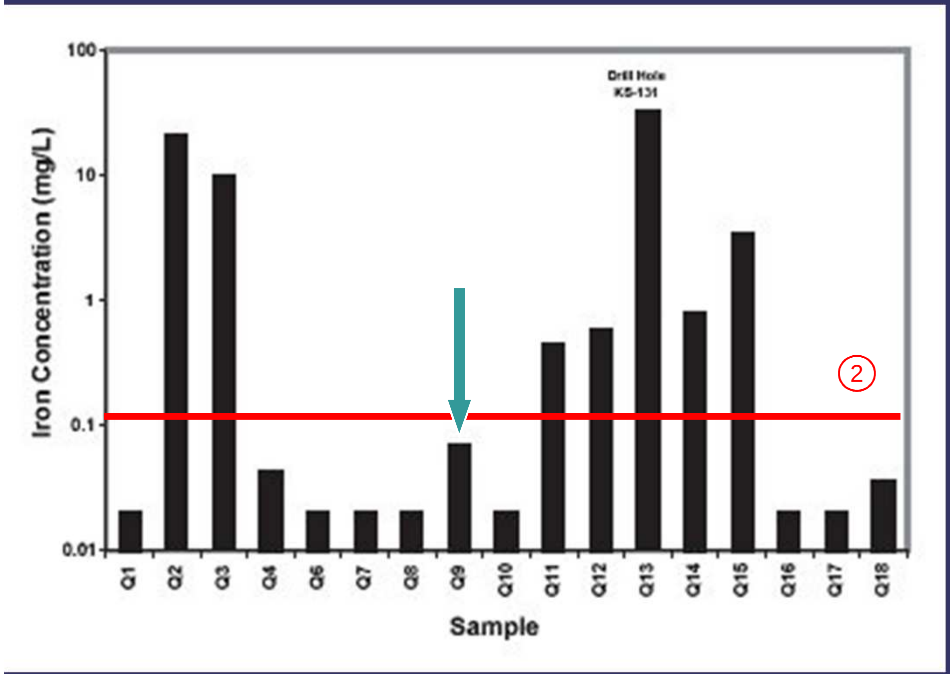


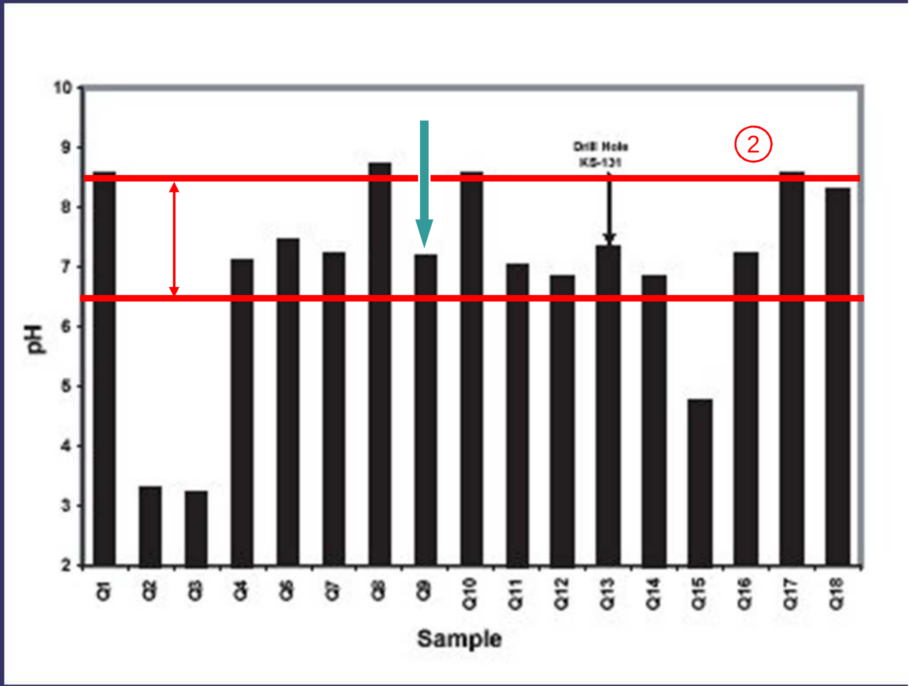


1 Metal and Mines Effluent Regulations (Fisheries Act) – June, 2002

2 BC Water Quality Objectives (BC Ministry of Environment)), 1979

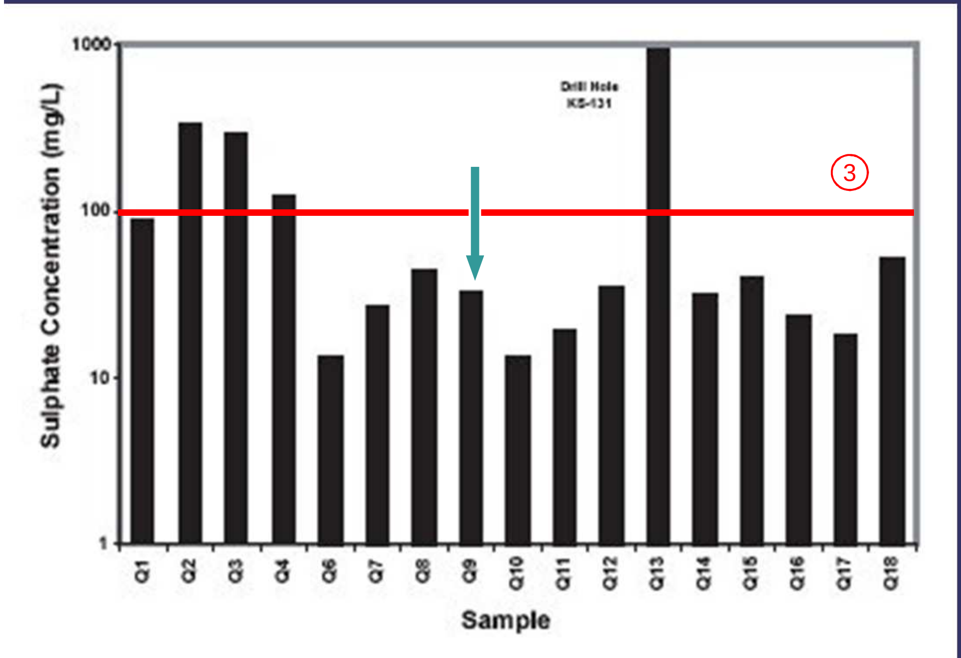
Comparison of Surface Water Chemistry for Samples Collected at Kerr-Sulphurets Property During Aug/Sept. 2003 with Recognized Industry Standards

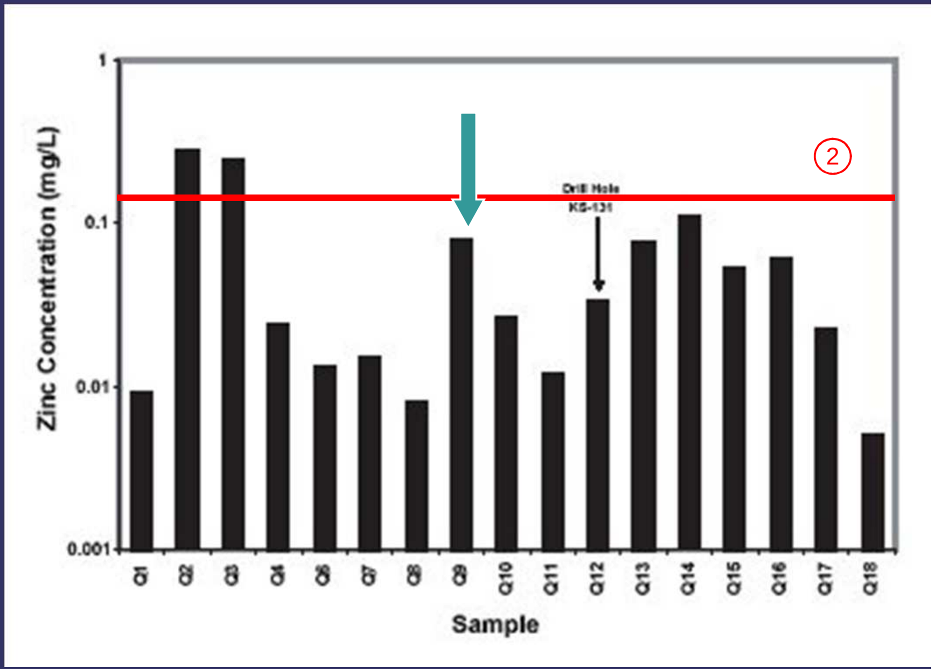




(2) BC Water Quality Objectives (BC Ministry of Environment)), 1979

Comparison of Surface Water Chemistry for Samples Collected at Kerr-Sulphurets Property During Aug/Sept. 2003 with Recognized Industry Standards





(2) BC Water Quality Objectives (BC Ministry of Environment)), 1979

(3) Ambient Water Quality Guidelines For Sulphate (Ministry of Environment, Lands and Parks) – Nov. 2000

Water quality data available to assess this alternative

Component	Units	BC Water Quality Criteria[1]	Q1 03-Sep-2003	Q2 03-Sep-2003	Q3 31-Aug-2003	Q20 03-Sep-2003 *Q3 Duplicate*	Q4 31-Aug-2003	Q6 31-Aug-2003	Q7 31-Aug-2003	Q8 03-Sep-2003	Q9 31-Aug-2003	Q10 03-Sep-2003	Q11 31-Aug-2003
pH			8.56	3.31	3.22	3.63	7.11	7.45	7.20	8.69	7.16	8.56	7.00
Hardness (as CaCO3)	mg/L		180	200	210	190	170	32	64	140	52	30	40
Sulphate (as SO4)	mg/L	100	88	**330**	**290**	**280**	**120**	13	26	43	32	13	19
Dissolved Metals													
Aluminum	mg/L	f(pH)	0.031	**3.3**	**3.5**	3.3	**0.12**	0.071	0.034	0.03	0.051	0.05	**0.31**
Antimony	mg/L	0.02 [2]	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Arsenic	mg/L	0.005 [2]	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002
Barium	mg/L	5 [2]	0.022	0.009	0.012	0.012	0.02	0.019	0.017	0.019	0.026	0.03	0.023
Beryllium	mg/L	0.053 [2]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	<0.005	<0.005
Cadmium	mg/L	f(Hardness) [2]	<0.00007	**0.0013**	**0.0011**	**0.0013**	**0.0002**	<0.00007	<0.00007	<0.00007	**0.002**	**0.00011**	**0.00009**
Chromium	mg/L	0.009 [2]	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Cobalt	mg/L	0.0009 [2]	<0.0005	**0.024**	**0.018**	**0.017**	**0.0017**	<0.001	<0.0005	<0.0005	**0.0015**	<0.0005	<0.0005
Copper	mg/L	f(Hardness)	0.006	**1.9**	**1.5**	**1.5**	**0.025**	**0.01**	**0.009**	**0.005**	**0.014**	**0.012**	0.005
Iron	mg/L	0.3 [2]	<0.020	**21**	**9.7**	**11**	0.042	<0.020	<0.020	<0.020	0.069	<0.020	**0.44**
Lead	mg/L	0.0004 [2]	<0.0005	**0.0009**	**0.0032**	0.0012	<0.0005	**0.0005**	<0.0005	<0.0005	**0.14**	**0.0008**	**0.0007**
Molybdenum	mg/L	2	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Nickel	mg/L	f(Hardness) [2]	<0.002	0.015	0.01	0.01	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Selenium	mg/L	0.002	0.002	0.002	<0.002	0.002	**0.003**	<0.002	<0.002	<0.002	0.002	<0.002	<0.002
Silver	mg/L	f(Hardness)	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	**0.0002**	<0.0001	<0.0001
Vanadium	mg/L		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Zinc	mg/L	f(Hardness)	0.009	**0.28**	**0.24**	**0.23**	0.024	0.013	0.015	0.008	**0.078**	0.026	0.012

Source: Stantec Report, 2003. Data shown is for August/September 2003.

Environment Canada – water quality sampling from Unuk (near border), 1991-1993

Unuk River near US border, 1991 - 1993

The Unuk River is located in northwest British Columbia, flowing southwest to Alaska and the Pacific Ocean. Proposed and active mining projects are located within the Unuk River watershed. Also, the Unuk is important to sport and commercial fishing, mainly in the Alaskan portion of the river. This report assesses water quality data collected at the monitoring station 3 km upstream from the Alaska border and 65 km northwest of Stewart, BC. Water quality samples were collected between 1991 and 1993 by Environment Canada. Flow was measured at a Water Survey of Canada flow gauge at the water quality monitoring station. There were several main conclusions:

1. Not enough data were available to comment on trends in water quality, although a slight downward trend in pH was apparent.
2. High metals and non-filterable residue occurred together. This suggests that metals were in a particulate form, probably not biologically available, and would be removed by the turbidity removal needed before drinking.
3. Total aluminum, cadmium, chromium, copper, iron, lead, manganese and zinc, apparent colour, non-filterable residue and turbidity values did not meet various water quality criteria at times due to high levels of suspended sediment in the water during freshet.
4. Copper levels exceeded the aquatic life criteria at all times, suggesting a naturally high copper mineralization in the watershed.
5. The river had a low sensitivity to acid inputs.
6. Hardness levels were generally below the optimum range for drinking water in the summer and within the optimum range in the winter.
7. Treatment to remove turbidity, plus disinfection, would be necessary before the water was used for drinking.
8. The water was cool enough to be aesthetically pleasing for drinking, but too cold for water-contact recreation such as swimming.

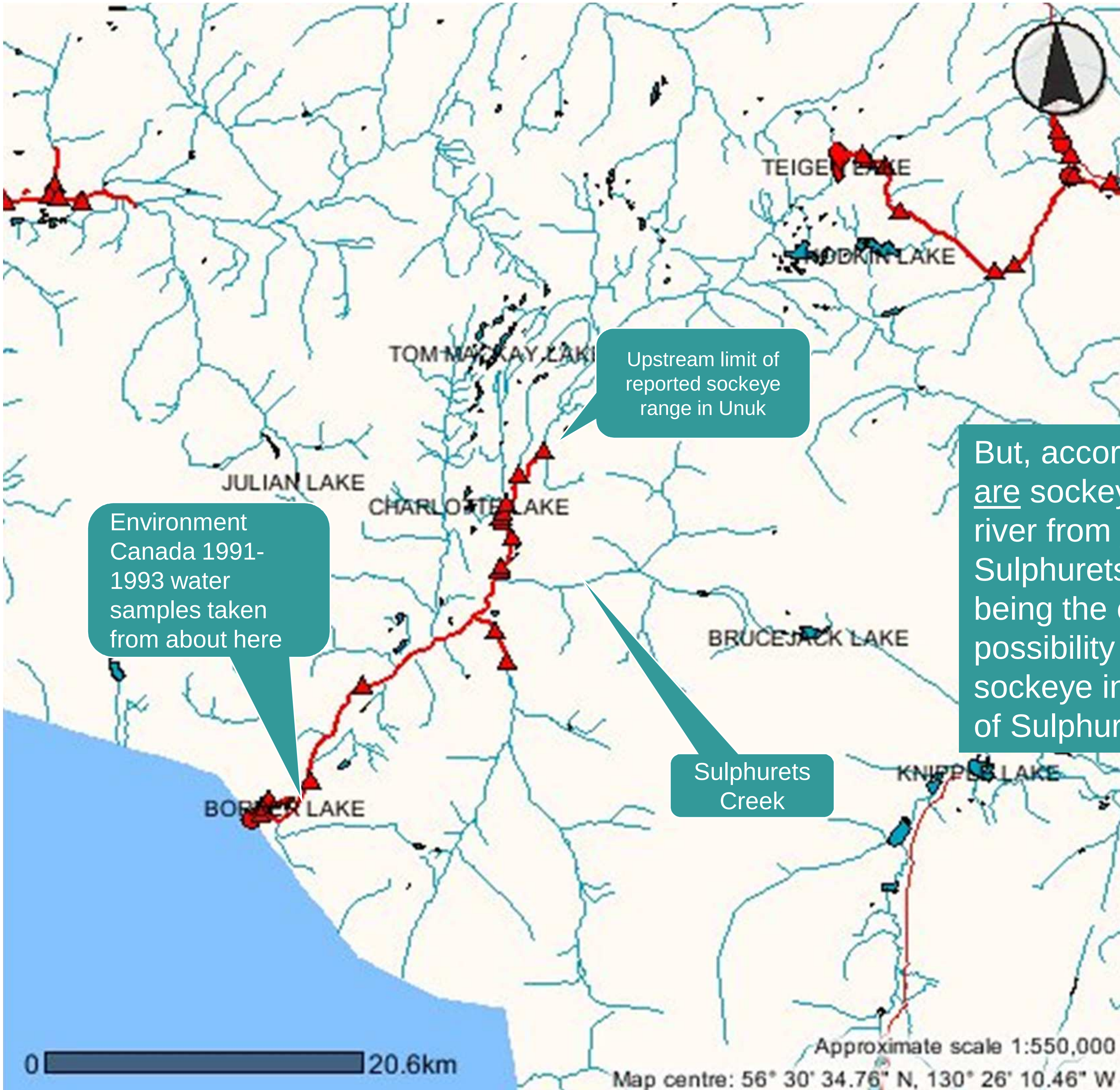
Environment Canada – water quality sampling from Unuk (near border), 1991-1993

It is recommended that reactivation of water quality monitoring be considered for the Unuk River near the US border for the following reasons:

a. It is a trans-boundary river that supports an important fishery.
b. There are active and potential mine sites within the watershed.
c. The watershed is relatively small, 1480 km^2, and thus potentially sensitive to change.
d. The existing baseline water quality record is short and sparse.
e. The forthcoming road construction will improve access for the purpose of monitoring.

Source: http://wlapwww.gov.bc.ca/wat/wq/quality/sowq.html#unuk

The data suggest that fisheries issues within the Unuk exist with Alaska, not within B.C. As such, given downstream dilution, pit wall drainage would have negligible cumulative impact on water quality by the time flow reaches lower stretches of the Unuk which have fisheries value. Currently appears that water quality baseline conditions within the Unuk, at least seasonally, do not meet criteria for aquatic protection.



But, according to DFO, there are sockeye in the Unuk, up-river from junction with Sulphurets Creek. This being the case, there is the possibility that might have sockeye in the lower reaches of Sulphurets Creek.

Pit Wall Rock Alternatives

Where do we stand?

	Alternative	Technically Feasible?	Preliminary Ranking	Worthy of Further Consideration?
A	Perpetual collection and treatment	YES	1	YES
B	In-pit biological treatment, pit lake anoxic zone (alternative to treatment plant)	NO?	-	NO (unless significant change to pit shells is possible)
C	Backfill the pits and cap	YES	-	NO
D	Extend pit shells so that final pit walls are NAG (remove all offending rock)	NO	-	NO – pyritic halo around orebody is substantial.
E	Do nothing	YES	2	YES

3 project cases are considered worth further consideration

<table>
<tr><th>Case</th><th>Tailings Management</th><th>Waste Rock Management</th><th>Pit Walls Drainage</th></tr>
<tr><td>1</td><td>Subaqueous disposal to Bowser Lake

Crushed ore conveyed to plantsite at Knipple Lake via 19.4 km, 5 m dia. tunnel</td><td rowspan="2">Side-hill dumps in Sulphurets Valley

ARD collection and treatment in perpetuity, two dams in Sulphurets Valley isolating the dumps.

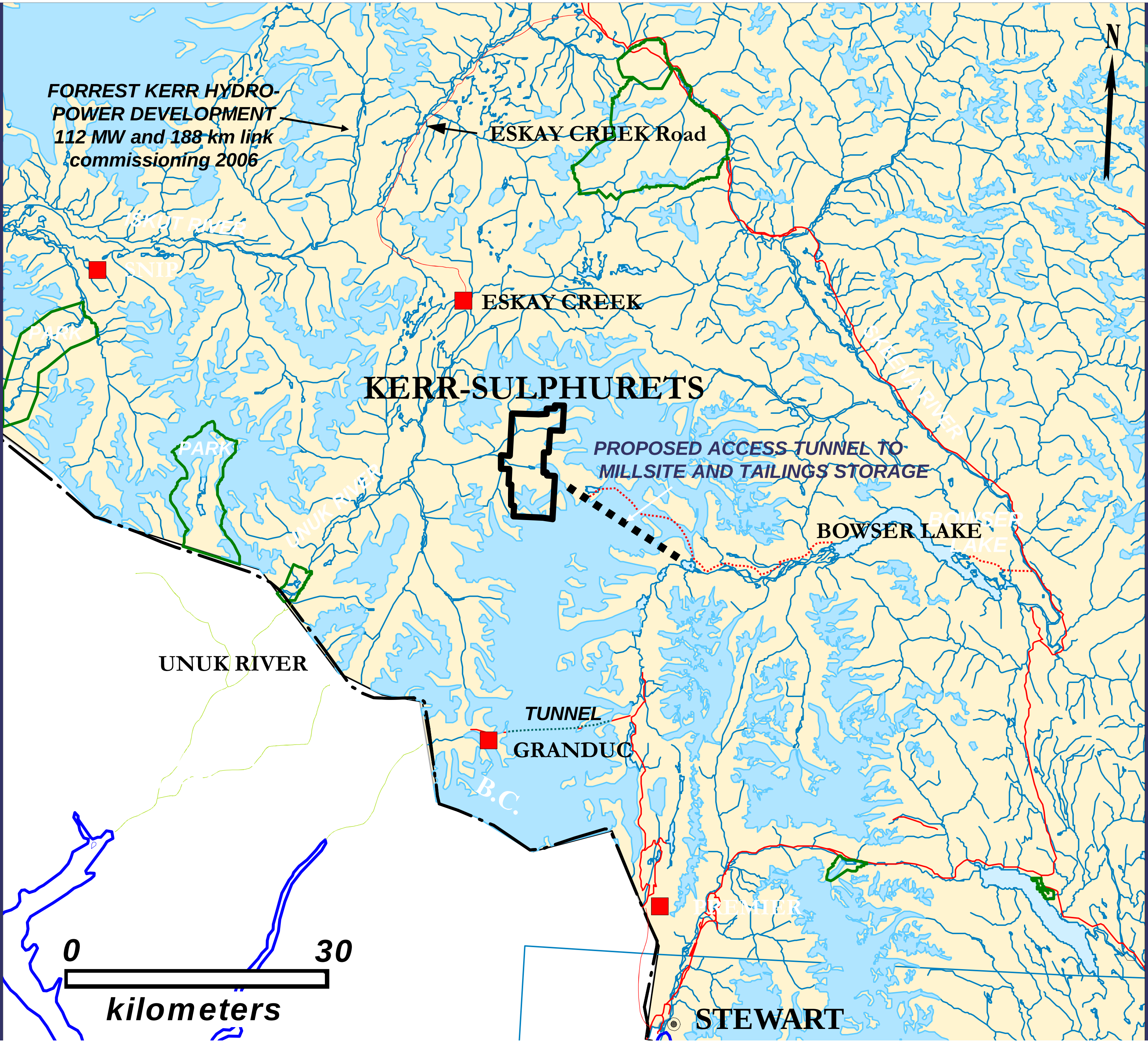
Water Treatment Plant adjacent to the downstream of the two dams, probably on the north side of the valley.</td><td rowspan="2">ARD reports to the same pond as runoff from the sidehill waste rock dumps</td></tr>
<tr><td>2</td><td>Storage in impoundment in tributary valley of Treaty Creek, between two dams approx. 90 m in height

Crushed ore conveyed to plantsite at Treaty Creek via 23 km, 5 m dia. tunnel</td></tr>
<tr><td>3</td><td>Storage in impoundment in tributary valley of Treaty Creek, between two dams approx. 140 m in height.

Crushed ore and PAG waste rock conveyed to plantsite at Treaty Creek via 23 km, 6 m dia. tunnel</td><td>Waste rock crushed at KS and conveyed to Treaty Creek portal (campaigned with ore on a single conveyor). Hauled 9 km (uphill) for storage and eventual permanent submergence within the tailings impoundment.</td><td>Perpetual collection and treatment at KS, or, if possible, “do nothing” if site runoff water quality is no worse than baseline conditions (already have natural ARD occurring).</td></tr>
</table>

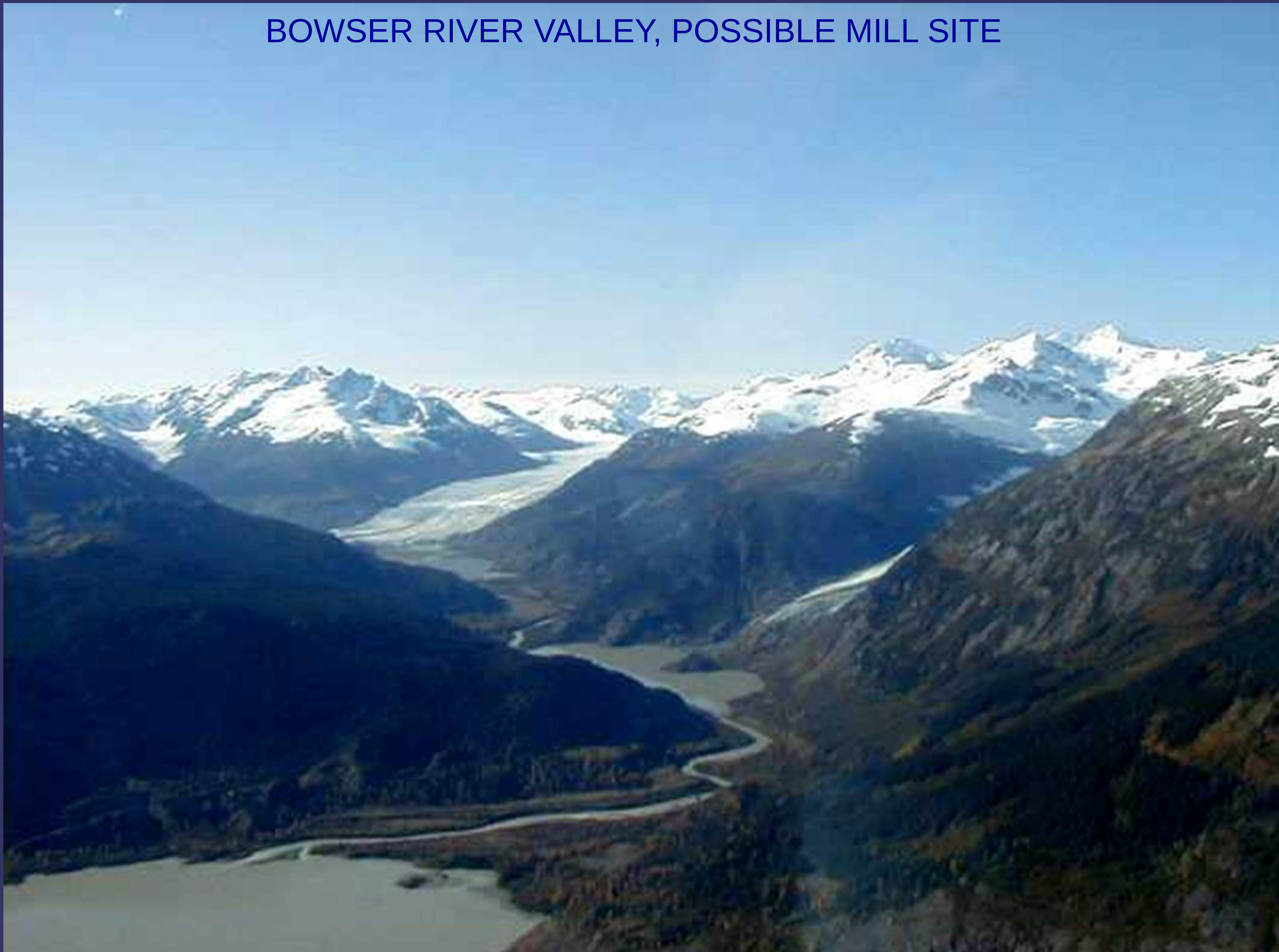
Case 1 is described as follows:

- 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 Mm3 (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.



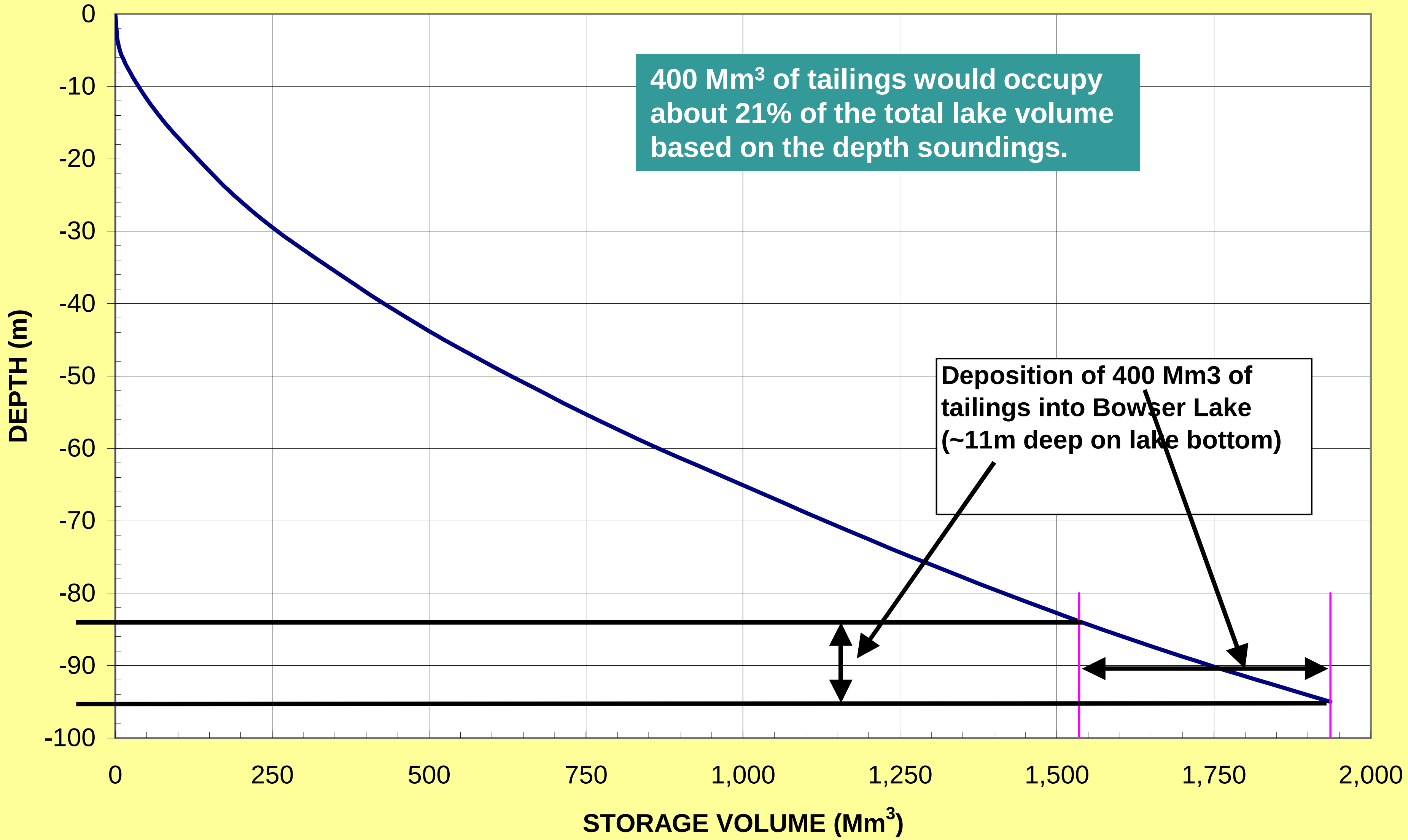
FORREST KERR HYDRO-POWER DEVELOPMENT 112 MW and 188 km link commissioning 2006
ESKAY CREEK Road
N
ESKAY CREEK
KERR-SULPHURETS
PARK
PARK
PROPOSED ACCESS TUNNEL TO MILLSITE AND TAILINGS STORAGE
BOWSER LAKE
UNUK RIVER
TUNNEL
GRANDUC
B.C.
0
30
kilometers
STEWART

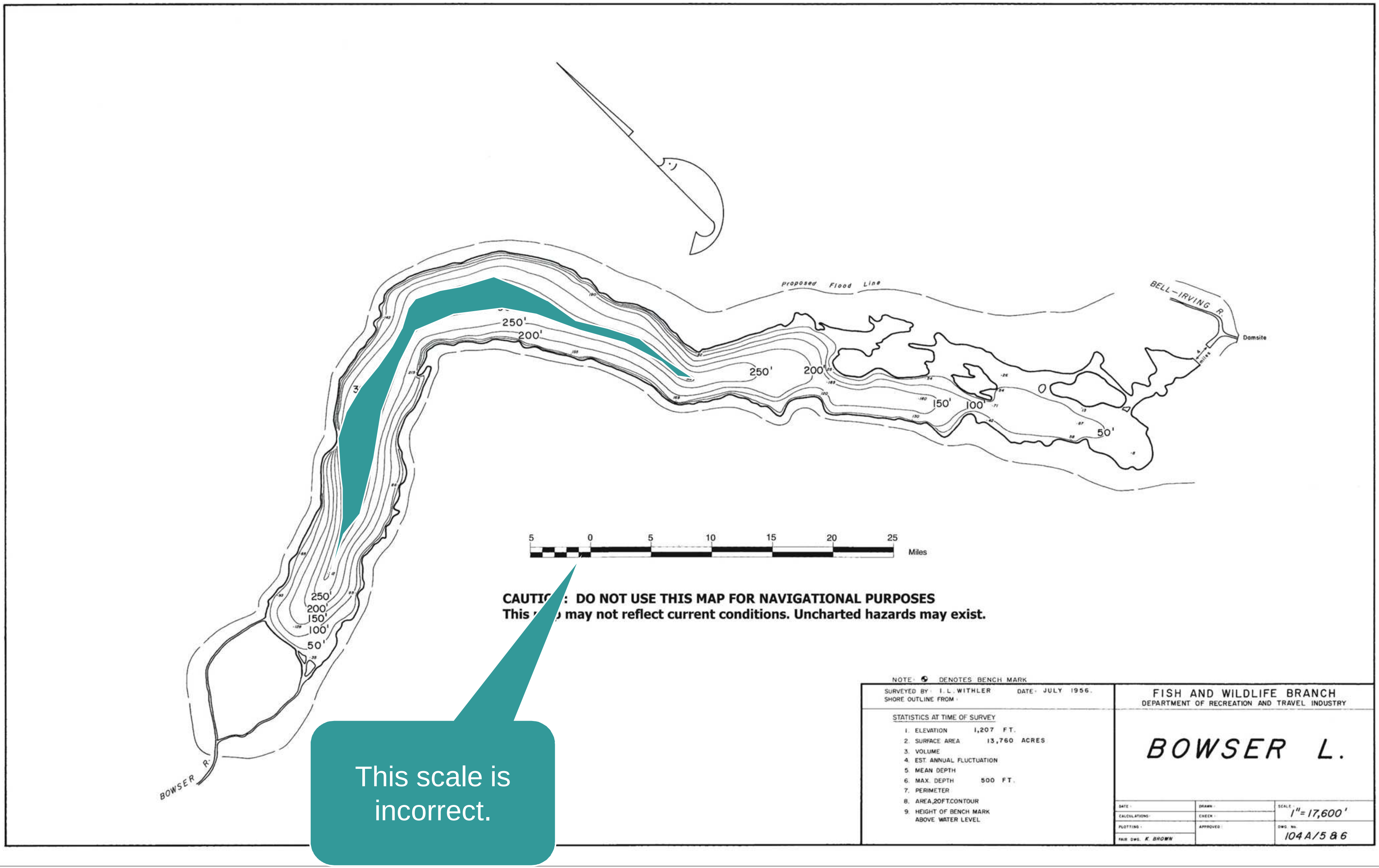
BOWSER RIVER VALLEY, POSSIBLE MILL SITE



BOWSER LAKE

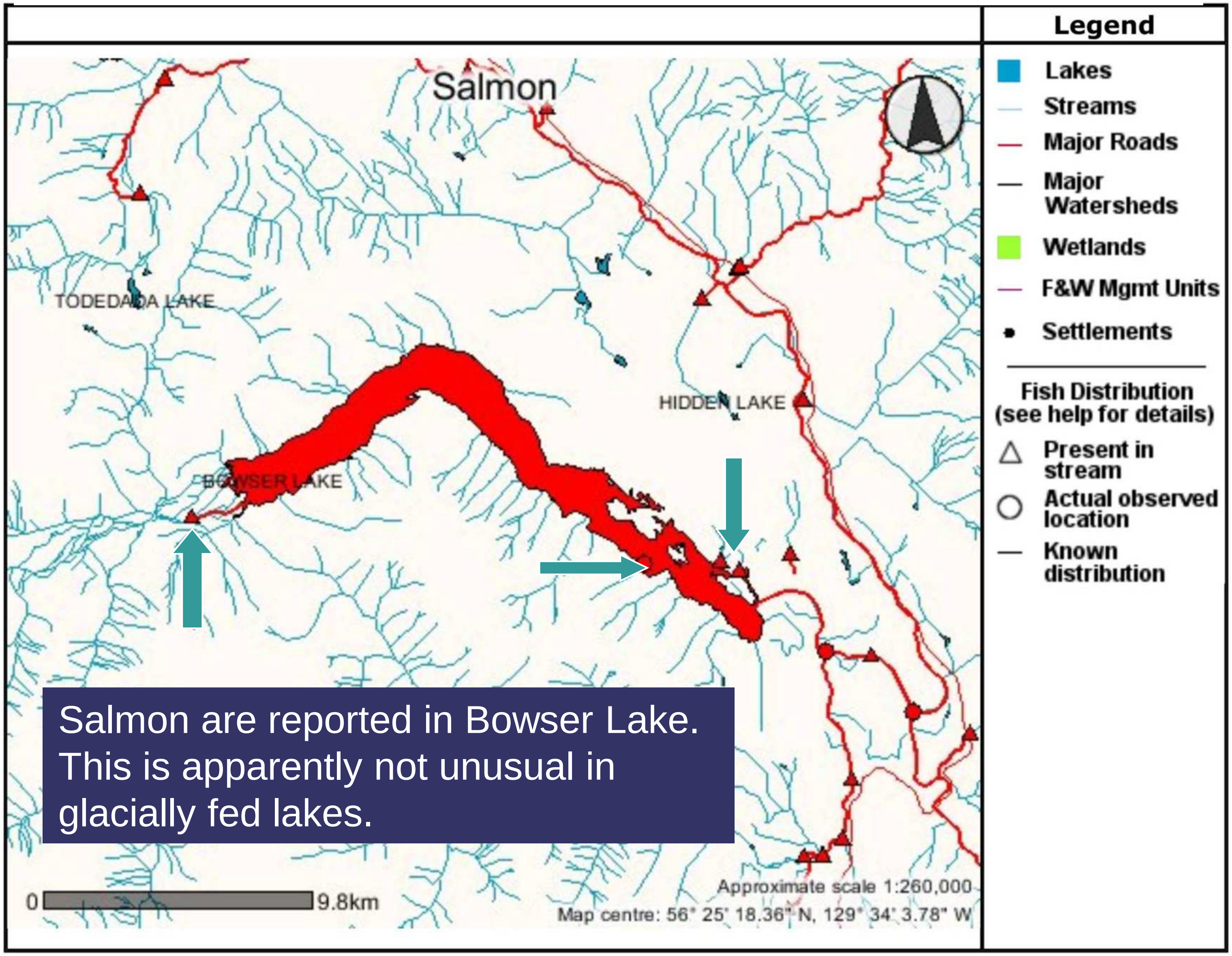
BOWSER LAKE STORAGE




Proposed Flood Line
BELL-IRVING R.
Damsite
BOWSER R.
5 0 5 10 15 20 25
Miles
CAUTION: DO NOT USE THIS MAP FOR NAVIGATIONAL PURPOSES
This map may not reflect current conditions. Uncharted hazards may exist.
NOTE: DENOTES BENCH MARK
SURVEYED BY: I. L. WITHLER DATE: JULY 1956.
SHORE OUTLINE FROM:
STATISTICS AT TIME OF SURVEY
1. ELEVATION 1,207 FT.
2. SURFACE AREA 13,760 ACRES
3. VOLUME
4. EST. ANNUAL FLUCTUATION
5. MEAN DEPTH
6. MAX. DEPTH 500 FT.
7. PERIMETER
8. AREA 20 FT CONTOUR
9. HEIGHT OF BENCH MARK ABOVE WATER LEVEL
FISH AND WILDLIFE BRANCH
DEPARTMENT OF RECREATION AND TRAVEL INDUSTRY
BOWSER L.
1" = 17,600'
FAIR DWG. K. BROWN
104 A/5 & 6
This scale is incorrect.

FishWizard Map

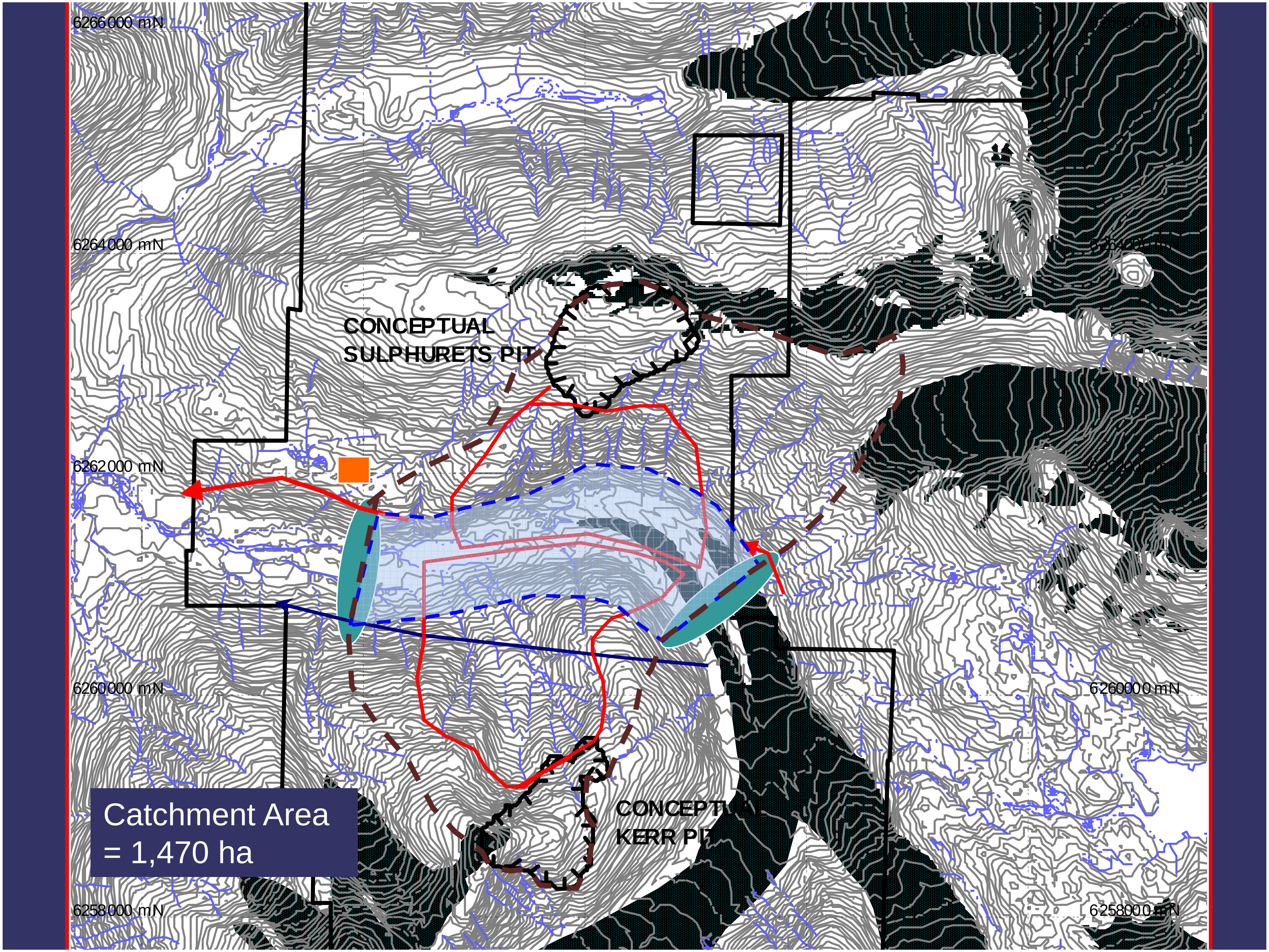
FishWizard is a co-operative presentation of
BC Fisheries and **Fisheries and Oceans Canada**.

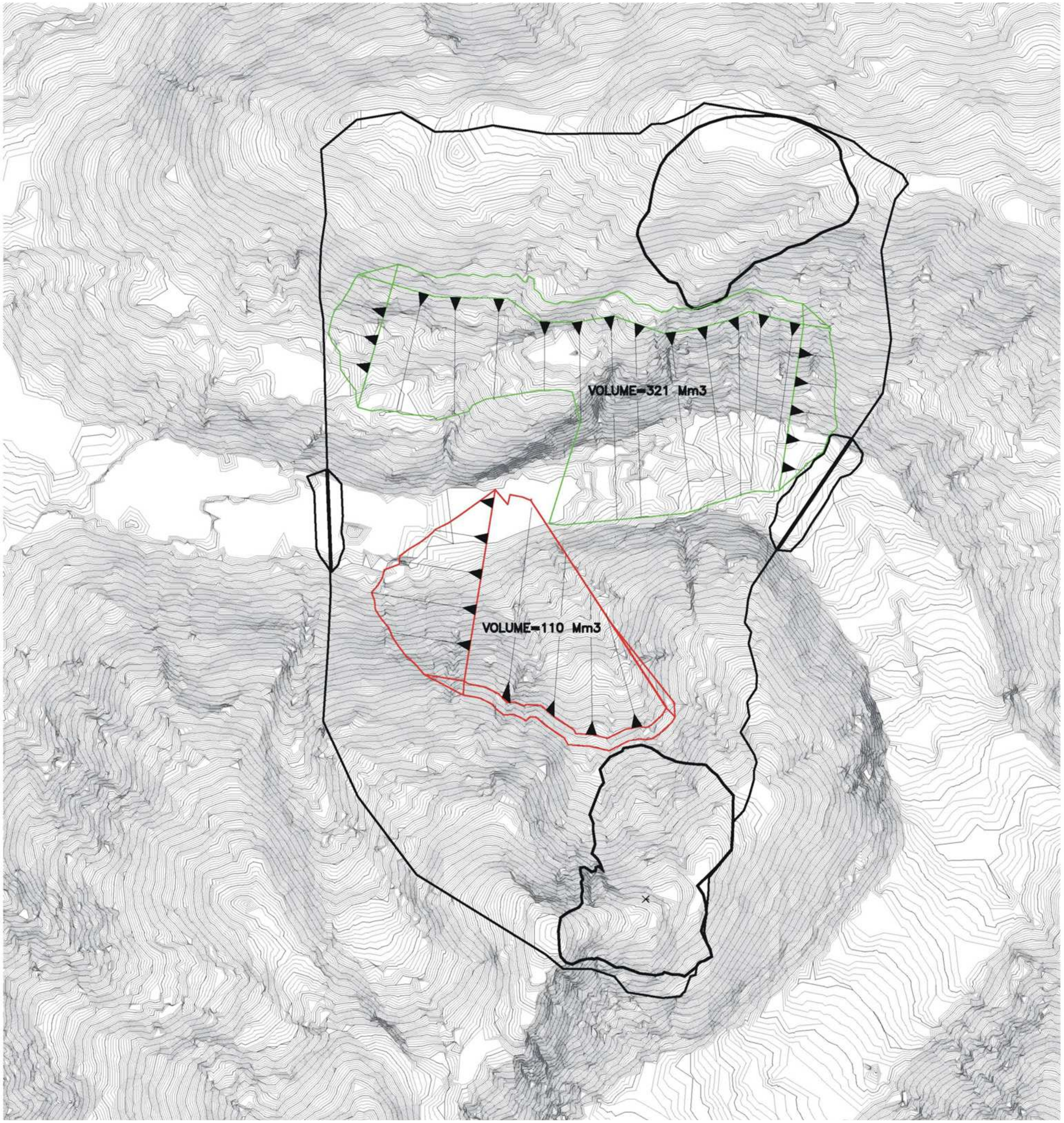


Salmon are reported in Bowser Lake. This is apparently not unusual in glacially fed lakes.

Looking into Bowser Lake fisheries a bit further…..

- Bowser Lake is a "significant sockeye salmon producer" (Bocking et al., 2002)
- Highest sockeye escapement on the Nass system next to Meziadin Lake/River (slightly over 10% of Nass system total, 1980-1999)
- Salmon use the lake for access to tributary streams for spawning
- Salmon reported in Bowser Lake headwaters, but unsure how far upstream they go
- Approval for lake disposal is unlikely unless it can be demonstrated that there would be no disturbance to salmon spawning/rearing
- Would this be a case of trying to "prove the un-provable"?
- What about the water quality of the process water discharged in the tailings slurry?
  - @ 80,000 tpd and 30% solids by weight, then water discharge into lake is about 187,000 m^3/day (2.2 m^3/sec)
  - To assess effects of process water on lake water quality, consider 2.2 m^3/sec inflow against the base inflow (assume = outflow) to lake during low flow periods (winter)


6266000 mN
6264000 mN
6262000 mN
6260000 mN
6258000 mN
CONCEPTUAL
SULPHURETS PIT
CONCEPTUAL
KERR PIT
6260000 mN
6258000 mN
Catchment Area
= 1,470 ha


VOLUME=321 Mm3
VOLUME=110 Mm3

Runoff volumes

- Catchment reporting to pond = 1,470 ha
- Includes open pits and waste rock dumps
- Runoff volumes estimated as follows:
  - Avg. annual runoff = 19.4 Mm^3 (annual avg. = 0.6 m^3/sec)
  - May runoff (60% of 1.5 m/year snowmelt, + 144 mm rainfall) = 9.2 Mm^3 (averaging, for the month, 3.6 m^3/sec).
- Based on these volumes, the dam heights required for the downstream dam and the upstream (diversion) dam will be very modest relative to those required for submergence of all PAG rock in Sulphurets

Scope of diversion dam/tunnel

- What combination of diversion dam reservoir capacity and tunnel diameter/length/grade is required to route 92 Mm^3 (avg. 35 m^3/sec) in a single month?
- Tunnel parameters:
  - Lined (to reduce friction coefficient that restricts flow)
  - Length – about 4 km
  - Gradient – 5% (200 m head drop portal to outlet)
  - Require energy dissipation measures at outlet to prevent erosion
- Tradeoff between tunnel diameter and height (i.e. reservoir capacity) of diversion dam
- Height of diversion dam is limited by the presence of the Sulphurets glacier – too high a dam results in transient flooding of the lower reaches of the glacier – is this a concern??

Preliminary tunnel calculations

Discharge	m^3/sec	35	40	45	50
Tunnel Diameter	m	1.8	1.9	2.0	2.1
Head loss	m	260	260	260	260

- Flow capacity is controlled by tunnel length, grade and head losses
- Tunnel flow capacity is therefore insensitive to driving head (height of water in diversion reservoir above the tunnel inlet)
- Therefore, sizing of diversion dam is primarily driven by:
  - Developing sufficient "dead" storage capacity so that portal is off the valley floor and suitably "clean" water (i.e. not heavily sediment laden) is discharged
  - Surcharge storage capacity for large storm events
  - Inlet sufficiently high above valley floor that risk of blockage is significantly reduced
- For margin of safety and preliminary costing purposes, probably best to assume a 3 m diameter tunnel

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 m3, 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:

o Sulphides split = 10% of total tailings = 8,000 tpd

o Double cycloning of 72,000 tpd of NAG tailings

o 25% sand recovery after double cycloning (= 18,000 tpd of NAG sand)

o In place compacted sand density = 1.65 t/m3

o 85% plant operating factor

o Total volume required for construction of the two dams, assuming centerline raising above starter dam configuration, is about 12 Mm3, based on 3H:1V downstream slopes.

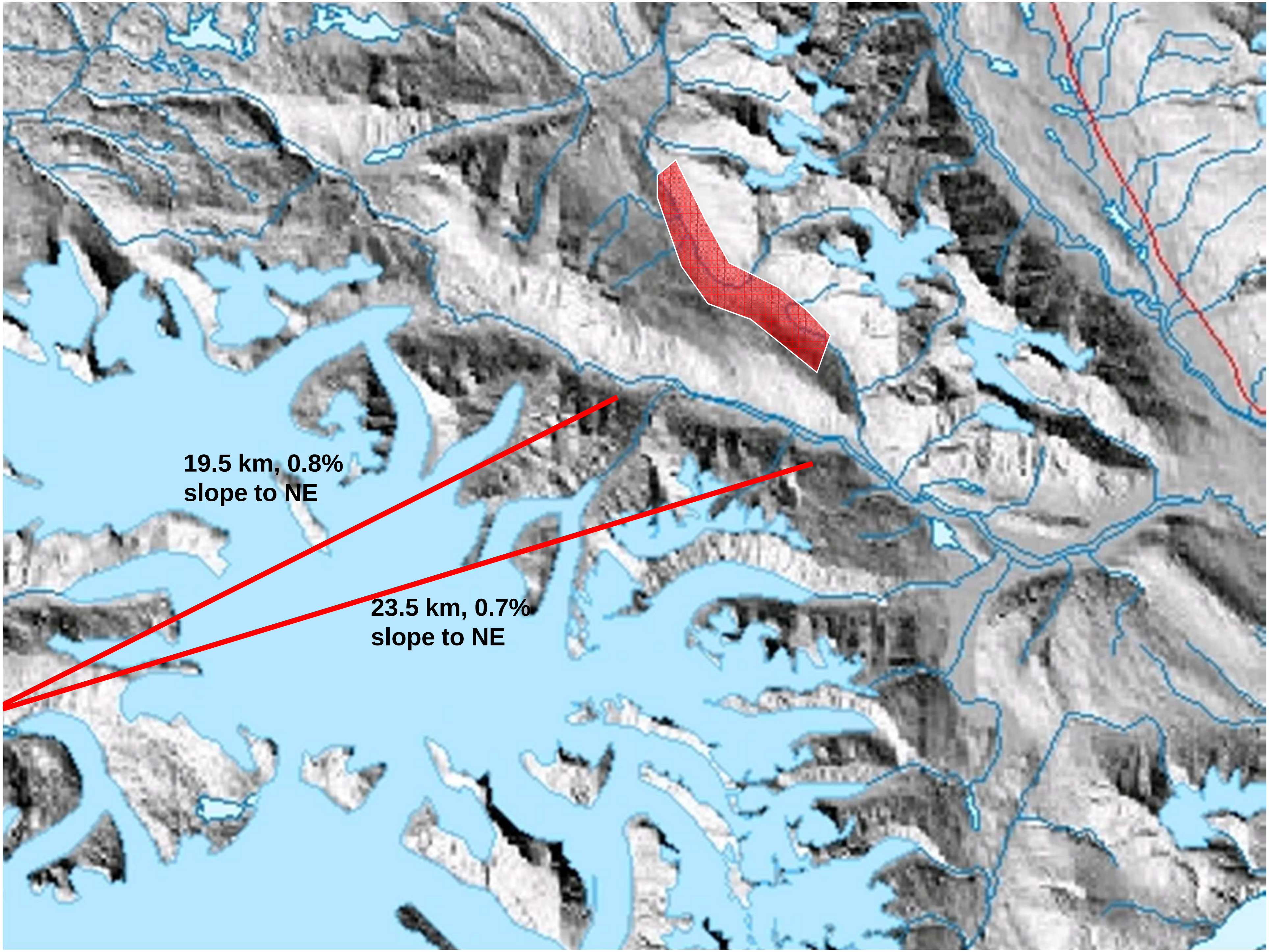
o Sand shell volume required for raising/extension = 1 Mm3/year

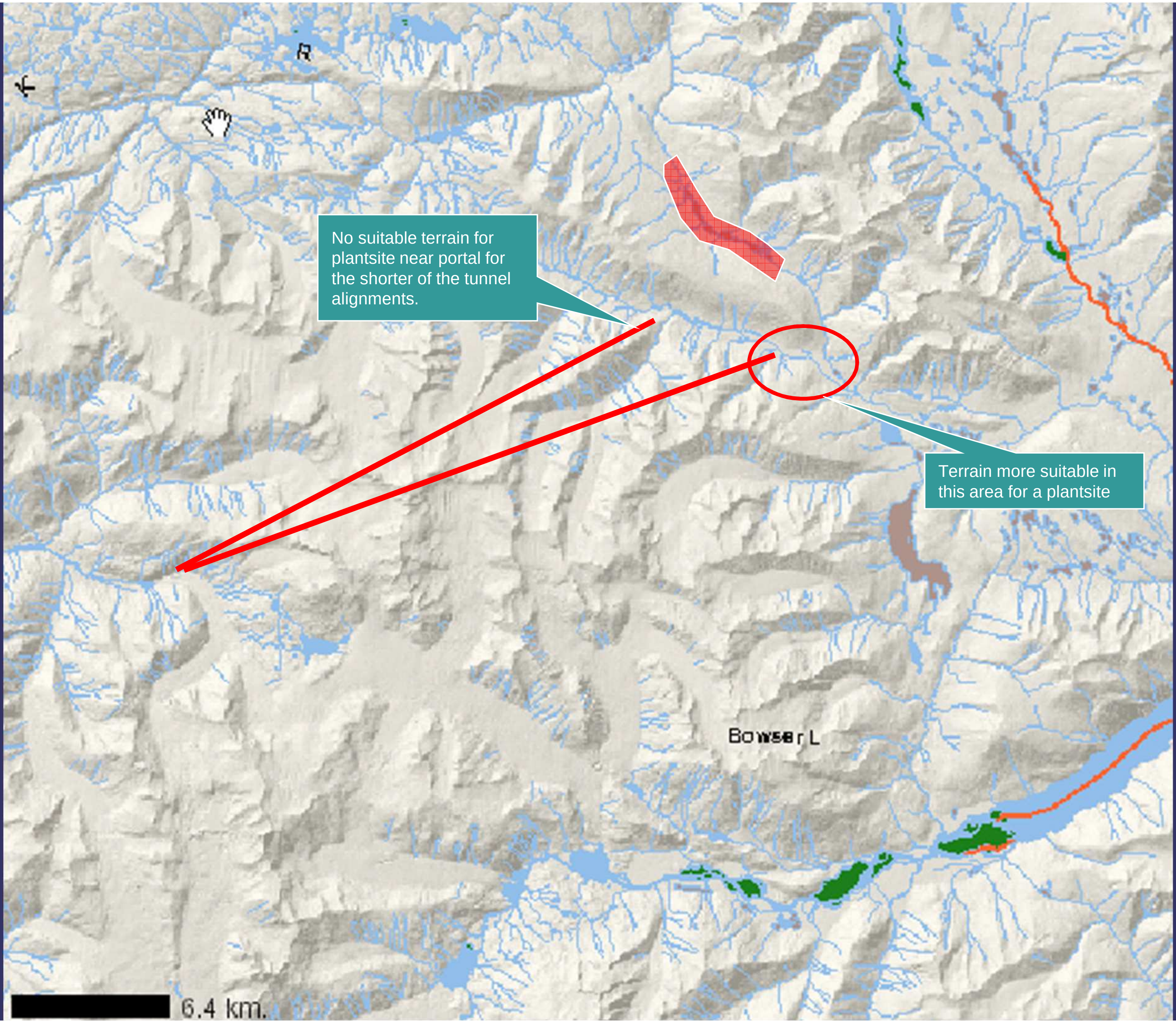
· When not required for downstream shell extension, the NAG cycloned sand will be discharged from the upstream of both dams to create above water beaches of NAG tailings. This will result in exposed beaches acceptable for closure, greatly enhancing the safety of the dams relative to a closure configuration where water is in direct contact with the upstream face of the dam.

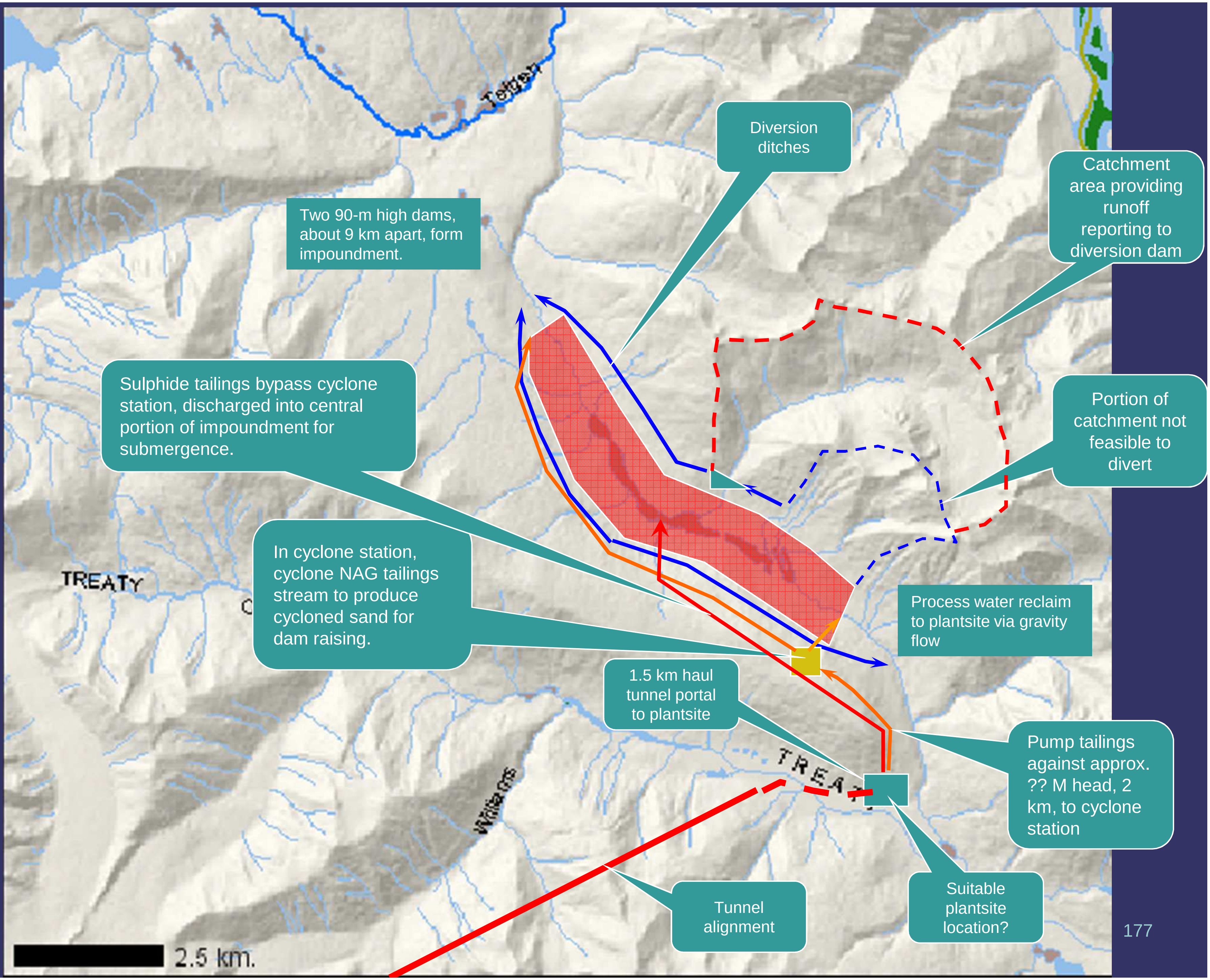
· Open channel runoff diversions would be constructed along the west perimeter of the tailings impoundment, and along most of the east perimeter (the exception being a portion near the southern dam where terrain is too steep). An approximately 60-m high diversion dam (fill volume about 1.5 Mm3) would 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.

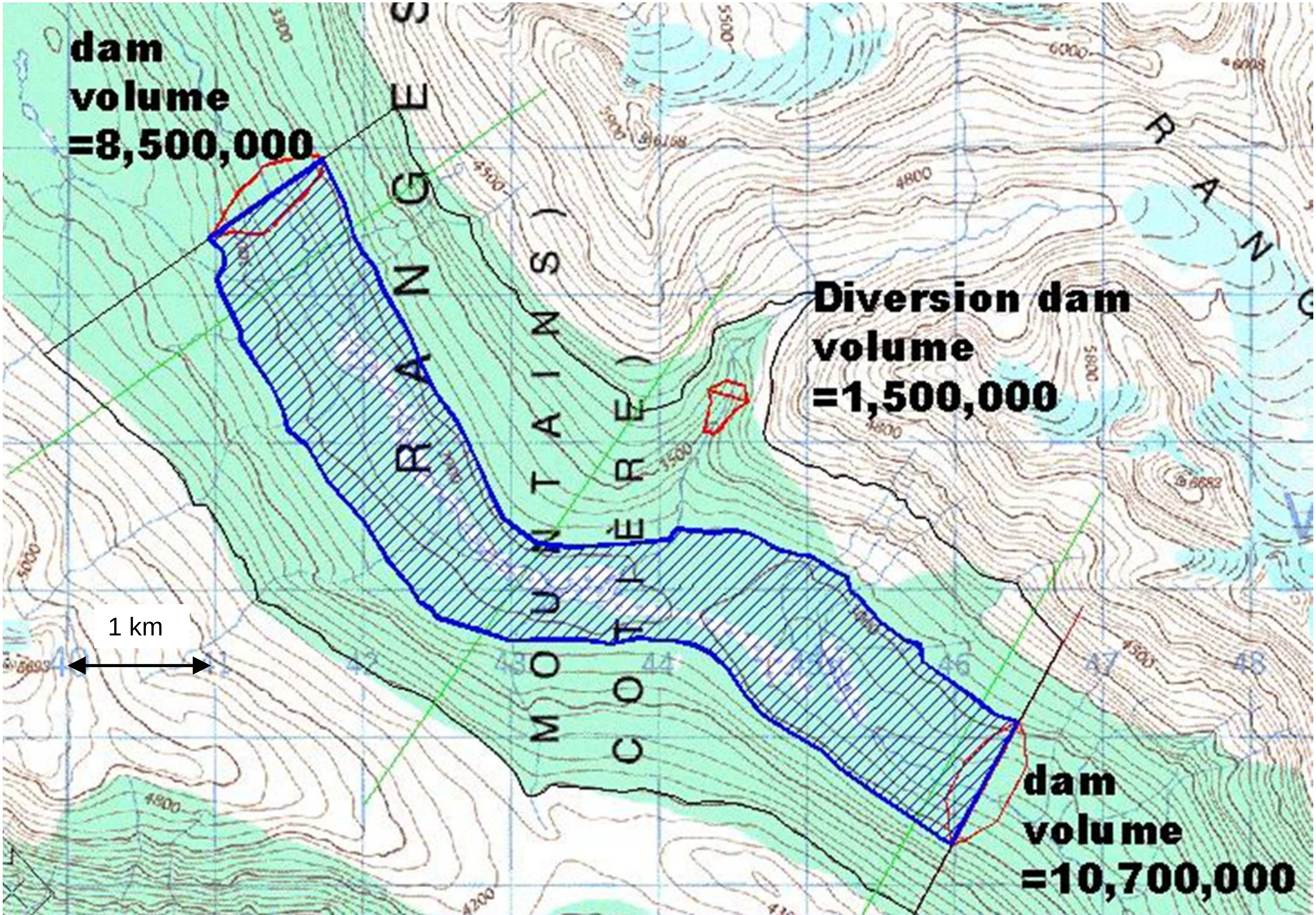
· At closure, an open channel spillway would be constructed likely on the west abutment of the northern dam (more gentle terrain there). Above-water NAG tailings beaches, likely 200 m or so in minimum width, would be maintained in front of the dams. All sulphide-bearing tailings would be submerged within 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.

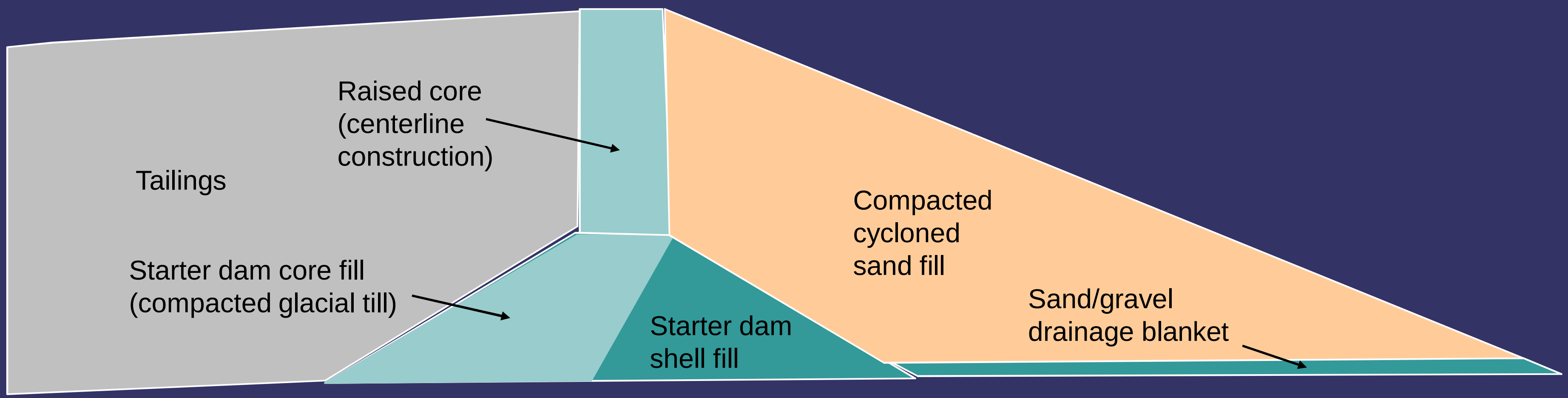

19.5 km, 0.8%
slope to NE
23.5 km, 0.7%
slope to NE


No suitable terrain for plantsite near portal for the shorter of the tunnel alignments.
Terrain more suitable in this area for a plantsite
Bowser L
6.4 km.


Diversion ditches
Catchment area providing runoff reporting to diversion dam
Two 90-m high dams, about 9 km apart, form impoundment.
Sulphide tailings bypass cyclone station, discharged into central portion of impoundment for submergence.
Portion of catchment not feasible to divert
In cyclone station, cyclone NAG tailings stream to produce cycloned sand for dam raising.
Process water reclaim to plantsite via gravity flow
1.5 km haul tunnel portal to plantsite
Pump tailings against approx. ?? M head, 2 km, to cyclone station
Tunnel alignment
Suitable plantsite location?
TREATY
2.5 km.


dam
volume
=8,500,000
Diversion dam
volume
=1,500,000
dam
volume
=10,700,000
1 km
RANGES
RANGE
MOUNTAINS
COTIÈRE

Conceptual dam design section

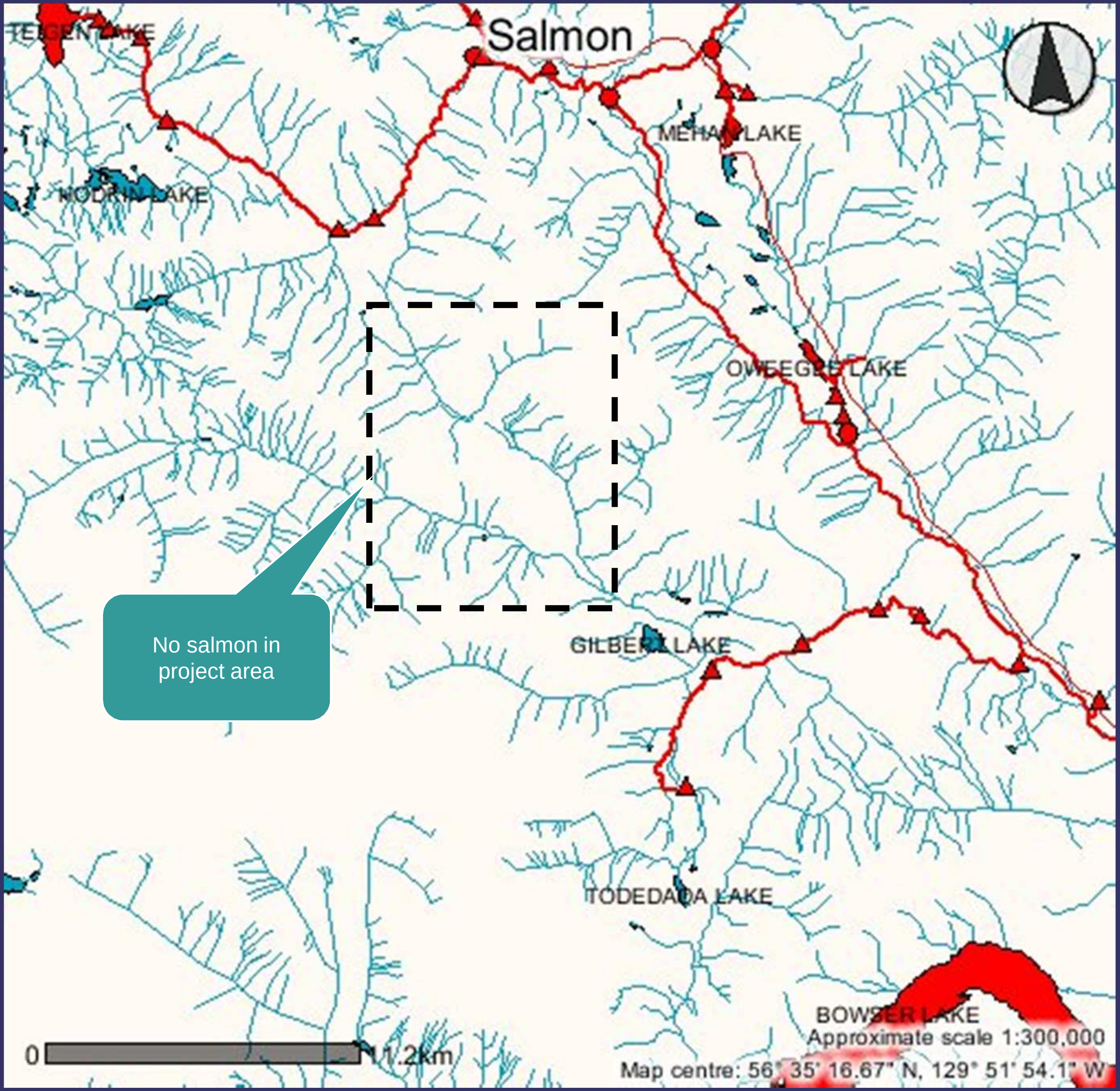


- Via flotation (sulphides removal) and cycloning, produce clean cycloned sand for dam construction
- At Kemess, plant operating cost + sand placement cost about $2.50/m^3
- Cycloned sand to upstream allows centerline raising, which reduces raising fill volumes (above starter dams) by about 50%.
- Starter dam shell fill possibly comprised of spoil (assuming it is NAG) from the tunnel construction (approx. 800,000 m^3, accounting for bulking factor)
- Upstream beach comprised of NAG tailings, so can maintain above water beaches during operations and at closure – simplifies dam design and construction, lowers costs, and enhances long term dam safety
- Sulphidic tailings discharged to central portion of impoundment for permanent submergence

Cycloned sand construction – feasible for this project?

- Same concept (cyclone plant) in place at Kemess, where cycloned sand construction takes place almost 12 months per year, except that at Kemess the flotation for sulphides removal occurs in cyclone plant – at KS:
  - Flotation for sulphides removal could take place in cyclone plant (in which case only one tailings stream is pumped uphill) or
  - Flotation takes place in the plantsite (in which case two separate streams, one NAG and one PAG) are pumped
- Assume 20% of total dam volumes required for starter dams construction, = 0.2 x 20 Mm^3 = 4 Mm^3
- With centerline raising, then remaining 16 Mm^3 fill volume is reduced by about 50%, giving 8 Mm^3 (based on assumed 3H:1V dam slopes, which should suffice unless there are very weak soils (e.g. glaciolacustrine clays) in the valley fill
- Over 12 years of dam raising, this requires production of say 1 Mm^3/year (actually 0.67 Mm^3 averaged over mine life, but dam raising is more rapid in the earlier years)
- Assuming:
  - 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)
  - In place compacted sand density = 1.65 t/m^3
  - 85% plant operating factor
- Then require 107 days (say 4 months) of downstream cycloning to place
  - This is easily achievable based on the Kemess experience
  - Leaves additional margin in case flatter dam slopes required based on foundation conditions
  - Also allows for extended periods of cycloning to the upstream to develop and maintain above-water (NAG) beaches

Treaty Creek Salmon Distribution



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 Mm3 (with 3H:1V upstream and downstream slopes), reducing to about 48 Mm3 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 Mm3, 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/m3, cost for imported fill = $12/m3, 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/m3.
- 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 Mm3) 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.

Ranking of the 3 Cases….

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

Potential Problem Analysis (PPA)

- Identifies and groups hazards using brainstorming
- Assigns to each hazard likelihood and consequence ranges along with confidence in each measure
- Ranks and prioritizes risk, and provides graphical (matrix) representation
- Allows evaluation of currently in place and potential mitigative measures
- Consistent reporting framework

Potential Problem Analyses (PPA) Overview

- Risk = likelihood x consequences
- PPA allows:
  - Identification of components and/or conditions whose failure, or undesired function, pose risk to health and safety, environmental issues and/or economic viability of the operation
  - Identification of dominant risk factors
  - Development of overall sense of the reliability of the system
  - Risk assessment in a transparent and repeatable format (non “Black Box”)

PPA Framework

1. System Description
2. Hazard Listing (= “what can go wrong?”)
   - Identify the potential issues of concern and associated effects ***if*** this issue occurred
   - DO NOT assess likelihood when doing hazard listing (brainstorming)
3. Consequence Categories
4. Likelihood Categories
5. Confidence Categories
6. Project Stages
7. Binning
8. Mitigation/Protection Features

PPA Framework
1. System Description

- Consider the elements of the project
- PPA is limited to these components

ID	Component	Description
1	Permitting	DFO, NGO’s, First Nations, Trans-border drainage
2	Tunnel & Conveyor	Constructability, cost/schedule over-runs, groundwater conditions, ARD, safety, maintenance
3	Dams	Foundation conditions, flood events, stability, erosion, construction season length, fill availability
4	Diversions	Ditches, diversion dams & tunnels, flood events, avalanche risk, slope stability
5	ARD Management	Waste rock, pit walls, tailings, tunnel, Water Treatment Plant,
6	Mining & Waste Rock	Crushing & conveying, hauling, runoff collection, till cover, segregation of NAG vs PAG

PPA Framework

2. Potential Concerns and Associated Effects

- Describe the potential concerns associated with each project element
- What is the failure mode, issue/trigger or permitting issue?
- What would be the outcome of the issue if it occurred?

PPA Framework

3. Consequence Categories

- Describe the outcome if a failure mode/trigger or permitting issue were to occur
- How bad will the damage be to the environment? Health and Safety? Economics of the project? Reality versus Perception
- Most often includes dollar amounts
- At this stage of project, should also address permitting risk specifically
- Each potential issue for concern is assigned a value based on its consequence category
- Example:
  Will the consequences of the given failure mode/event/issue be?
  Very Low (1)? Low (2)? Moderate (3)? High (4)? Extreme (5)?

PPA Framework

3. Consequence Categories

RATING	CATEGORY	DESCRIPTION
1	VERY LOW (VL) (<$100,000)	***Minor incident or inefficiency of little or no consequence.*** ***No impediments to permitting.*** • No health & safety incidents • Total loss <$100,000 • No equipment outages • No substance release • Minor or no media attention
2	LOW (L) ($100,000 to $1 Million)	***Minor incident or inefficiency that may require engineering review and is easily and predictably remediated*** ***No impediments to permitting.*** • Minor injury, no threat to public • Total loss between $100,000 and $1,000,000 • Outages measured in hours or equipment produces degraded quality • Substance release approaching license limits • Local media coverage
3	MODERATE (M) ($1 Million to $10 Million)	***Moderate event or inefficiency that may need some physical attention and certainly engineering review.*** ***Manageable permitting issue.*** • Medical treatment or restricted duty • Total loss between $1 million and $10 million • Equipment outages of one day to one week. Plant is largely unaffected • Substance release has outside impact or exceeds license limits • Regional media coverage
4	HIGH (H) ($10 Million to $100 Million)	***Significant event or inefficiency that can be addressed but with great effort.*** ***Highly unlikely this can be permitted.*** • Lost time or exposure of the public to a hazard that could cause injuries or long term health effects • Total loss between $10 million to $100 million • One-week or longer interruption for equipment or one day to one week for a Unit • Permanent on lease ecological damage • National media coverage
5	EXTREME (E) (>$100 Million)	***Major uncontrolled event or inefficiency with uncertain and prohibitively costly remediation.*** ***Not permittable.*** • Fatality, or harm to public sector or exposure of the public to a severe health or life-threatening hazard • Loss of critical equipment or equipment/facilities damage over $100 million • One month or longer outage for a critical piece of equipment or greater than one week for a Unit • Widespread permanent off lease damage • International media coverage

PPA Framework
4. Likelihood Categories

- Determine the likelihood of a failure mode/trigger to occur
- Mainly intended to be qualitative but numerical probabilities may be assigned
- Example:
  What is the likelihood of any given event/failure mode occurring? Negligible (1)? Low (2)? Moderate (3)? Probable (4)? Highly Probable (5)?

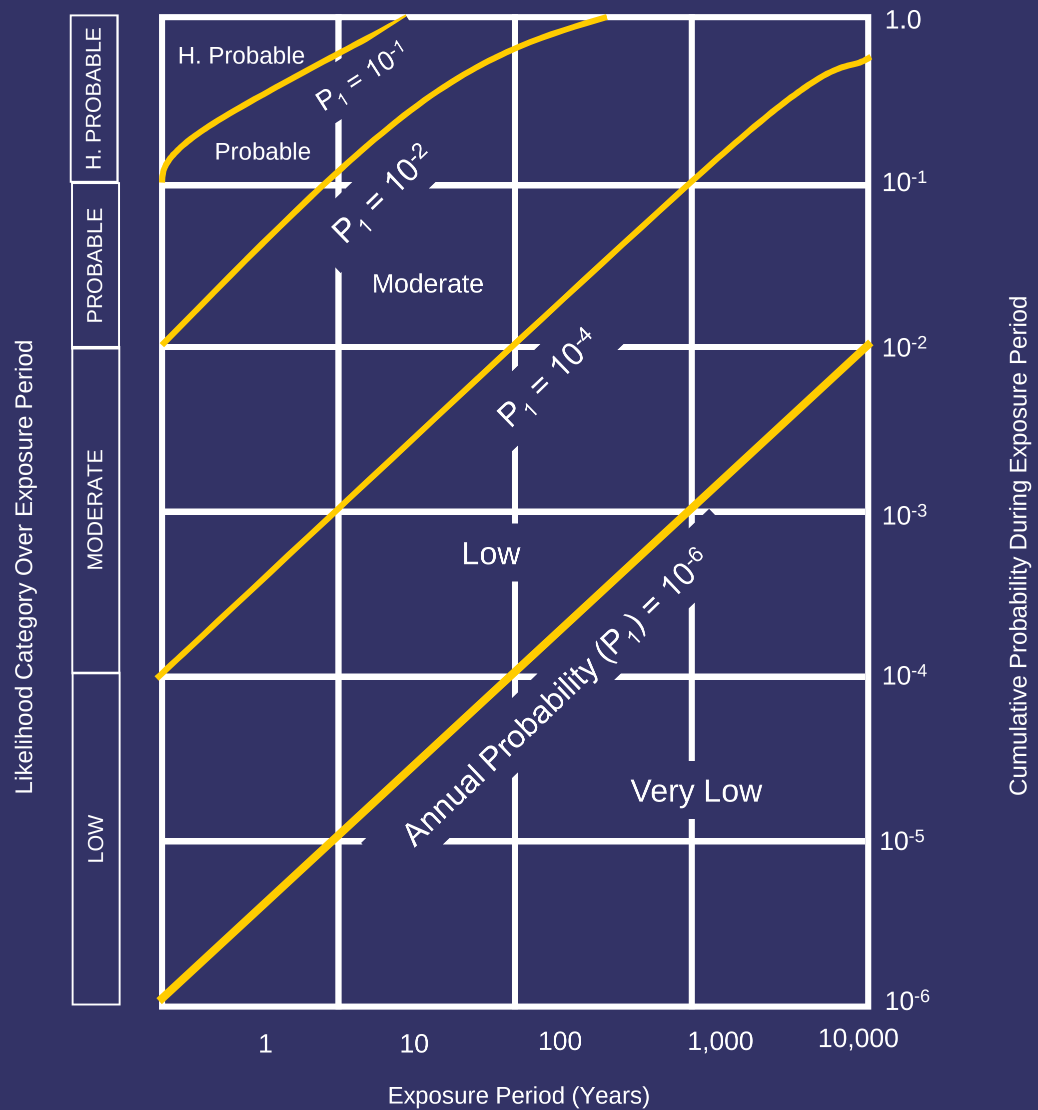
PPA Framework

4. Likelihood Categories

Category	Annual	Description
VL- Very Low	$<10^{-6}$	Doubt it could happen
L- Low	$10^{-6} – 10^{-4}$	Unlikely to happen
M- Moderate	$10^{-4} – 10^{-2}$	It could happen
H - High	$10^{-2} – 10^{-1}$	Has or probably will happen
VH – Very High	$>10^{-1}$	Happens regularly

PPA Framework

4. Likelihood Categories



Transformation mapping from annual to cumulative likelihoods

PPA Framework

5. Confidence Categories

- Assess the degree of confidence in the categories chosen for likelihood and consequence
- Confidence depends on
  - Amount of information available
  - Consistency of information
  - How well the issues of concern are understood

Confidence Level	Description
Low (L)	Do not have confidence in estimate, could vary significantly
Moderate (M)	Have some confidence in estimate, moderate variability
High (H)	Confident, low variability

PPA Framework
6. Project Stages

Determine what stage of the project
the failure mode/trigger occurs in
– may be more than one

Example:
Stages of Mining Projects

- What stage(s) does any given failure mode/event/issue occur in?

Stage	Definition
Acquisition, Exploration and Permitting (P)	Decision on asset, environment assessment, corporate funding, regulatory process etc.
Engineering - Construction (ECO)	Site development plan, analysis and review followed by mine development
Operations (O)	Mining, processing, marketing, mine waste management, water management
Closure (CL)	Mine activities cease, reclamation, monitoring

For Kerr-Sulphurets, consider all four project stages

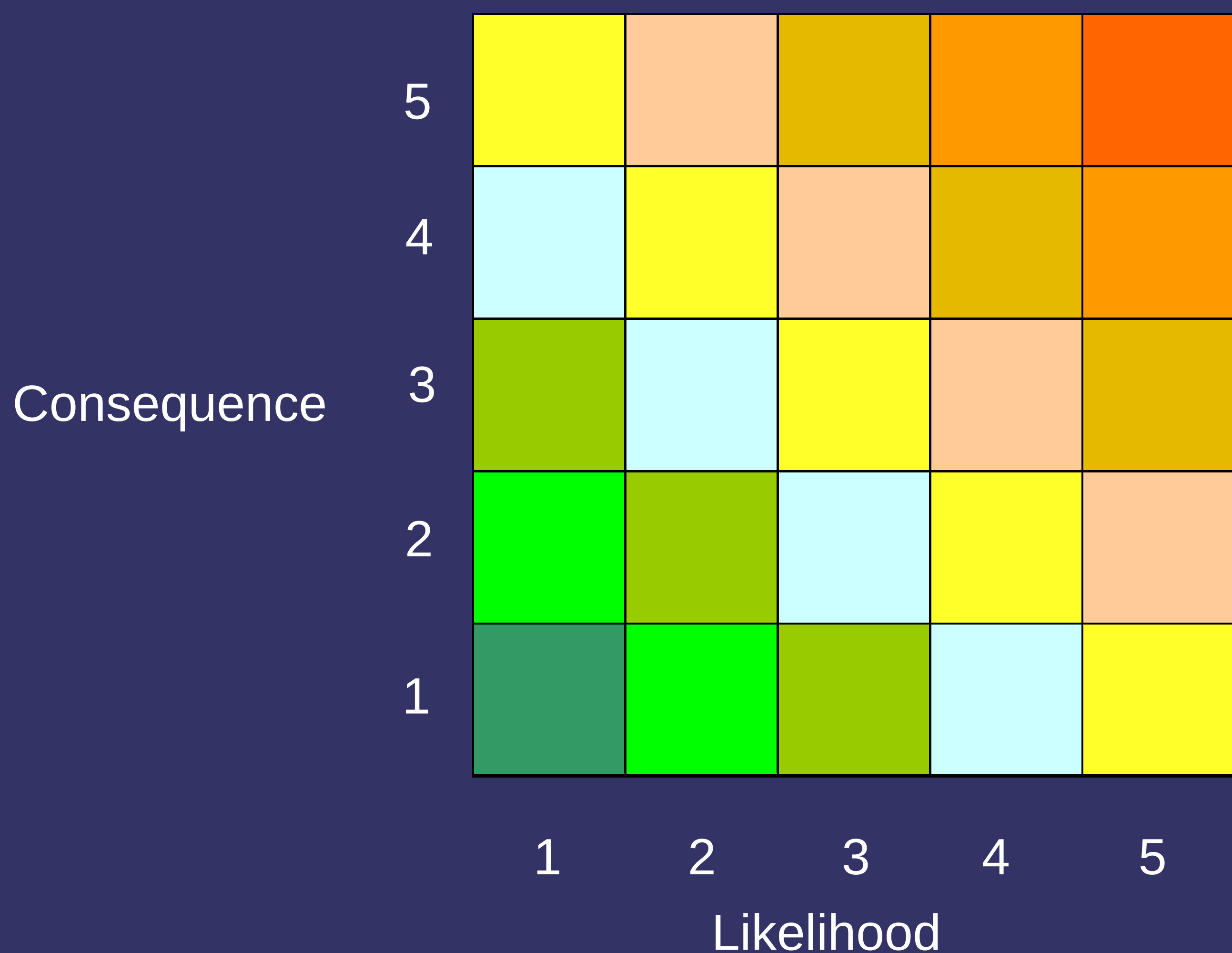
PPA Framework
7. Binning

- Categorize likelihood/consequence pairs for each failure mode/trigger
- Method of summarizing results of PPA
- Examples of general binning categories

Likelihood	Consequence	Description
Low	Very Low	Low risk, not a significant failure mode
Highly Probable	Extreme	Major risk, possibly constituting “fatal flaw”
Probable	Very Low	Failure mode/issue occurs frequently without serious effect
Very Low	Extreme	Risk commonly associated with effects of extreme events (earthquakes, floods)

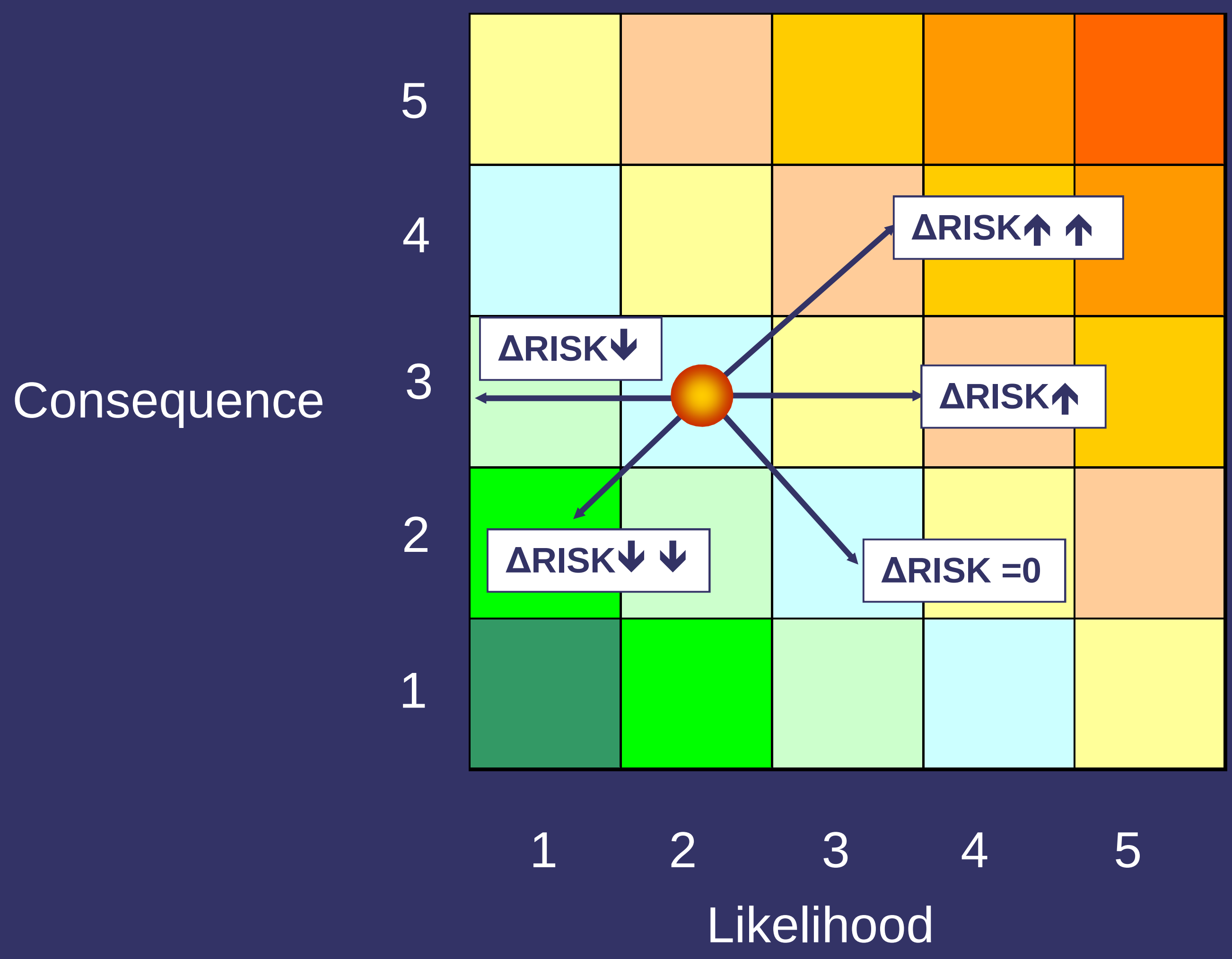
PPA Framework
7. Binning – Typical Risk Management Sample Matrix for Mining Projects

Issue stewardship depends on where the issue is situated in the matrix



PPA Framework

7. Binning – Suggested Risk Management Matrix



Issue stewardship depends on where the issue is situated in the matrix

PPA Framework

8. Mitigation / Protection Features

- Define defensive measures and conditions currently in place for each potential issue of concern
- Define additional measures that could be implemented to reduce risk

PPA Table

Project Component	Potential Issue for Concern	Potential Effect (s)	Likelihood		Consequence	
			Cat.	Conf.	Cat.	Conf.

Binning Code	Project Stage	Defensive Measures & Conditions Currently in Place	Additional Measures to Reduce Risk	Conf.	Approx. Cost

Example:
Stability Issues – PPA Summary

Consequence \ Likelihood	1	2	3	4	5
5	1.2, 1.4, 1.6, 1.8, 1.10, 1.12, 1.14, 1.16, 1.18, 1.20, 1.28, 1.29, 1.31, 1.33, 1.36, 1.40	1.22			
4		1.24, 1.42, 1.44			
3	1.25, 1.32, 1.35, 1.38, 1.39	1.5, 1.9, 1.17, 1.25, 1.27, 1.30, 1.37, 1.45, 1.46	1.11, 1.13, 1.15, 1.19, 1.21, 1.23, 1.26, 1.41, 1.43	1.1	
2		1.7	1.34	1.3	
1					

Consequence

Likelihood

56 Issues Assessed
- No "fatal flaws"
- Several low confidence issues requiring further evaluation