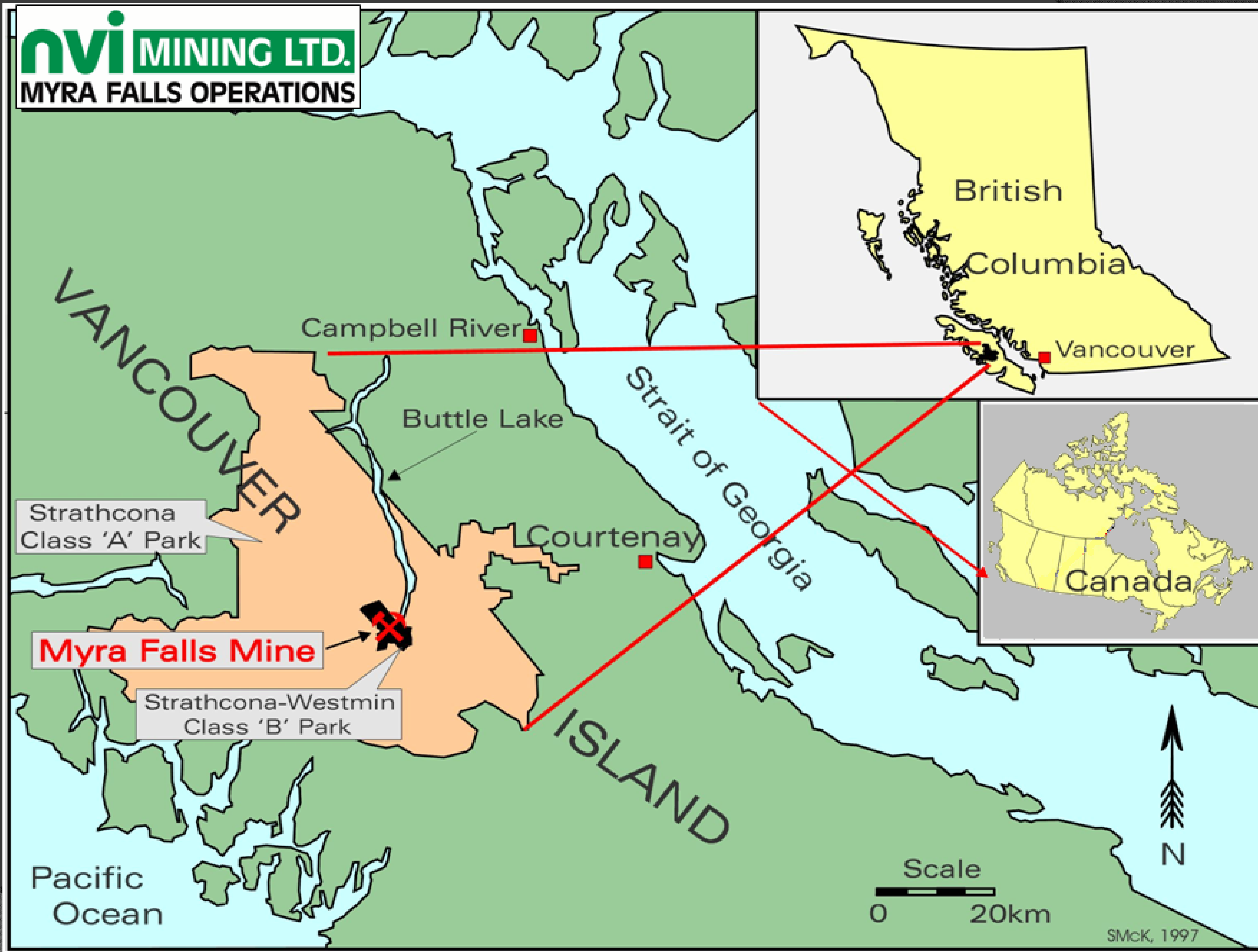
ML/ARD Workshop
December 3rd & 4th
Vancouver, BC

Authors: Ben Chalmers, Sharlene Henderson and Ivor McWilliams

A HISTORY OF TAILINGS MANAGEMENT AT MYRA FALLS OPERATIONS


nvi MINING LTD.
MYRA FALLS OPERATIONS
British
Columbia
Vancouver
Canada
Campbell River
Buttle Lake
VANCOUVER
Strait of Georgia
Strathcona
Class 'A' Park
Courtenay
Myra Falls Mine
Strathcona-Westmin
Class 'B' Park
ISLAND
N
Scale
0
20km
Pacific
Ocean
SMcK, 1997

MINE SITE OVERVIEW AND TOPOGRAPHY

A HISTORY OF TAILINGS DEPOSITION AT MYRA FALLS OPERATIONS

- 1966 – 1984 Sub-aqueous tailings deposition into Buttle Lake
- 1984 – 2003 Sub-aerial tailings deposition into the Tailings Disposal Facility
- 2003 – 2007 Deposition of paste on top of the old sub-aerial tailings
- 2008 – ???? Cemented paste deposition into the new Lynx Tailings Disposal Facility
- Future ? Full tails paste underground

Buttle Lake, downstream from mine site

TAILINGS PRODUCTION RATES AT MFO

- Ore milled since 1966:
  27 million tonnes
- Tailings Produced since 1966:
  23 million tonnes
- Tailings deposited above ground since 1966:
  11.5 million tonnes

50% of MFO’s tails is used as backfill underground and 50% are deposited above ground

Mineralogy of the Tailings

The ore mineralogy consists of the sulphide minerals

- Pyrite (FeS_2)
- Sphalerite (ZnS)
- Chalcopyrite ($CuFeS_2$)
- Bornite (Cu_5FeS_4)
- Galena (PbS)

associated with quartz, sericite and barite as the dominant gangue minerals.

In the last 5 yrs the percentage of pyrite has dropped significantly as mining has shifted from the HW ore body to the Battle-Gap ore body, resulting in a less acidic tailings product.

Meanwhile, the sericite percent has increased, producing a more plastic tailings product.

MINERALOGY OF THE TAILINGS

Acid Base Accounting (ABA) of fine tails

	2000	2007
Sulphide	30.2%	9.8%
Neutralization Potential (NP)	66 kg/t $CaCO_3$	25 kg/t $CaCO_3$
Acid Potential (AP)	942 kg/t $CaCO_3$	306 kg/t $CaCO_3$
Neutraliziation Potential Ratio (NPR)	0.07	0.08

SUB-AQUEOUS TAILINGS DEPOSITION IN BUTTLE LAKE

- Tailings deposited in Buttle Lake between 1967 and 1984
- 2 million tonnes of tailings deposited into Buttle Lake over 16 years
- Deposition switched to a land based facility in 1984 as a permit condition following expansion and the discovery of the H-W ore body
- Community concerns contributed to the decision to change deposition strategies

ZINC CONCENTRATIONS IN BUTTLE LAKE 1966-1995

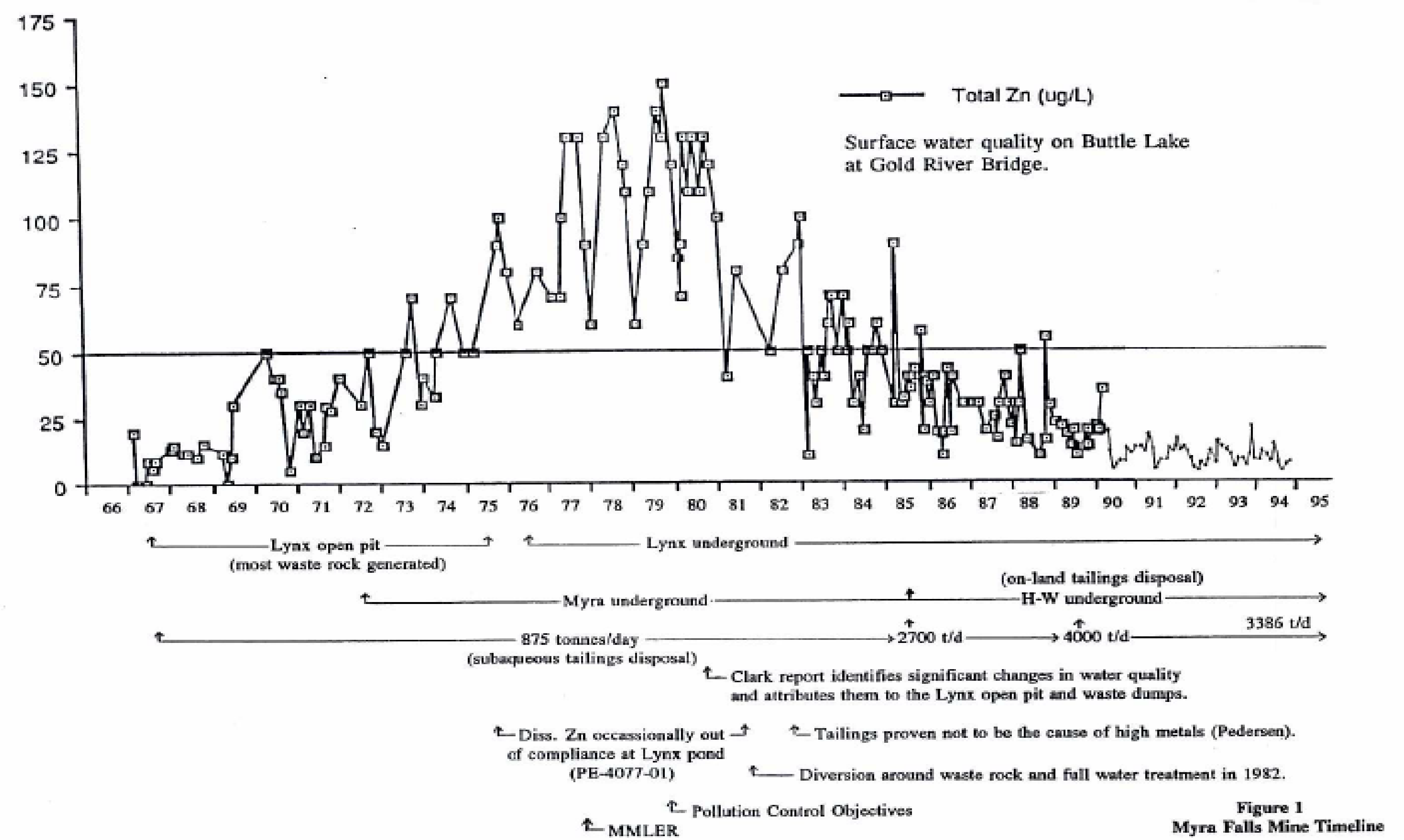


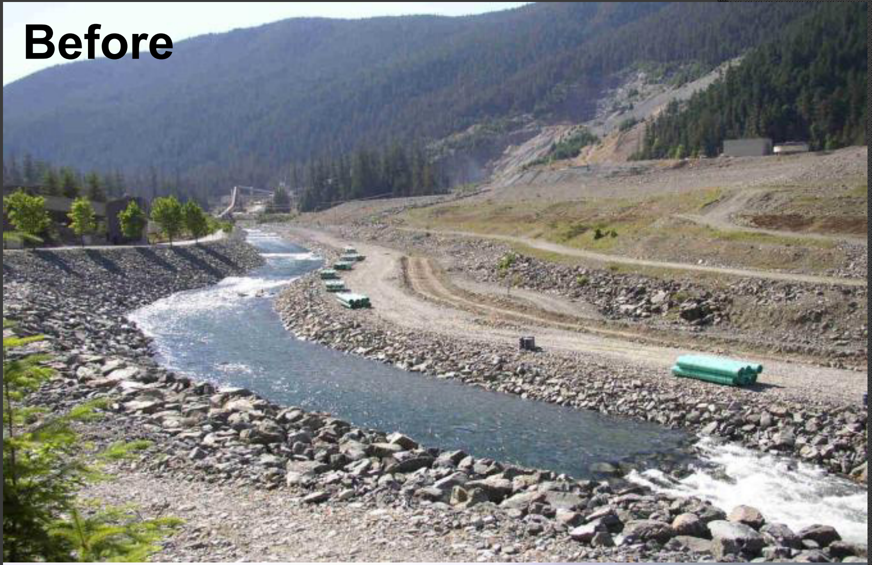
Figure 1
Myra Falls Mine Timeline

MODEL OF MYRA VALLEY PRIOR TO LAND BASED TAILINGS DEPOSTION - 1982

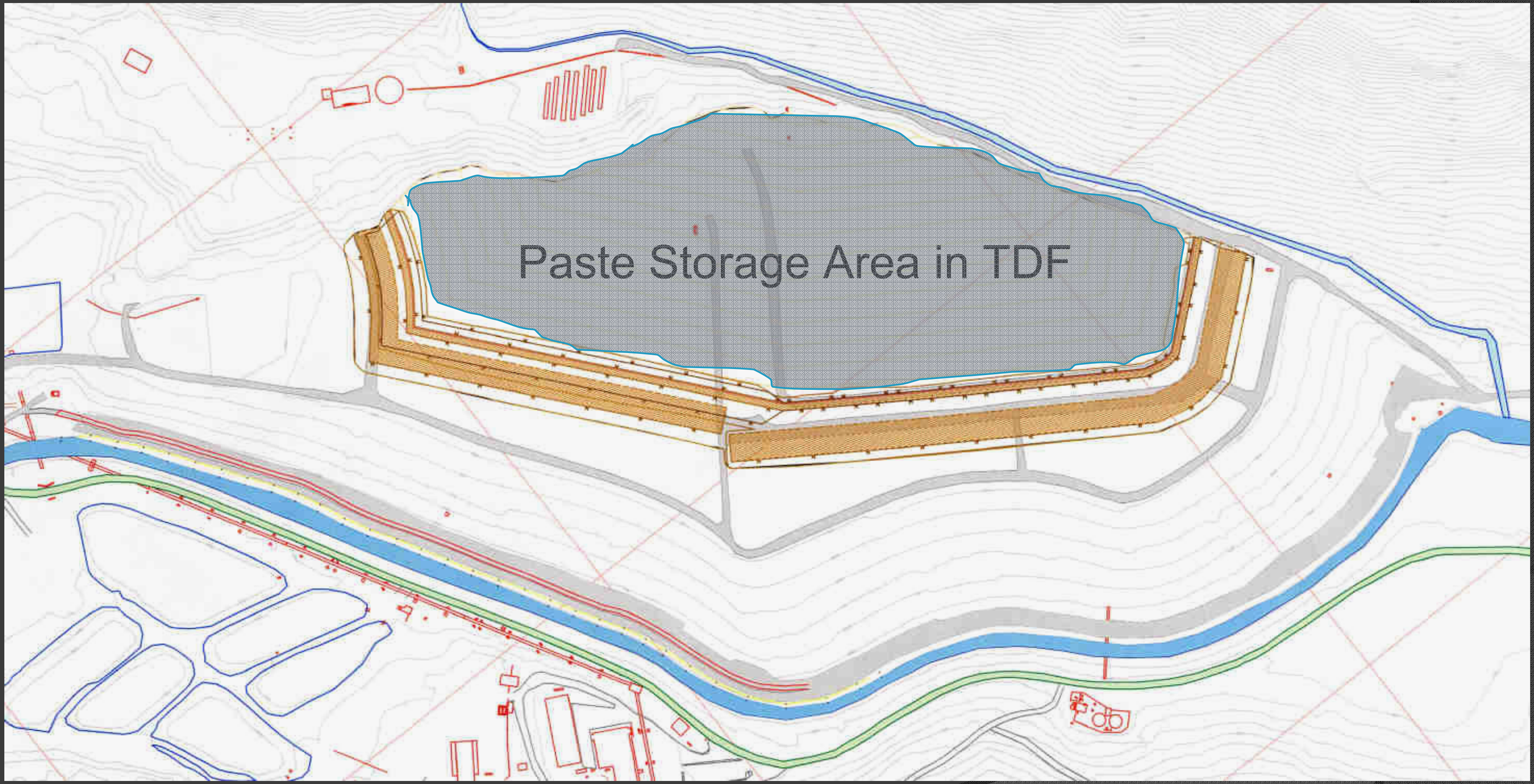
LAND BASED TAILINGS DEPOSITION 1984 - 2003

SEISMIC UPGRADE OF TDF 1999 - 2009

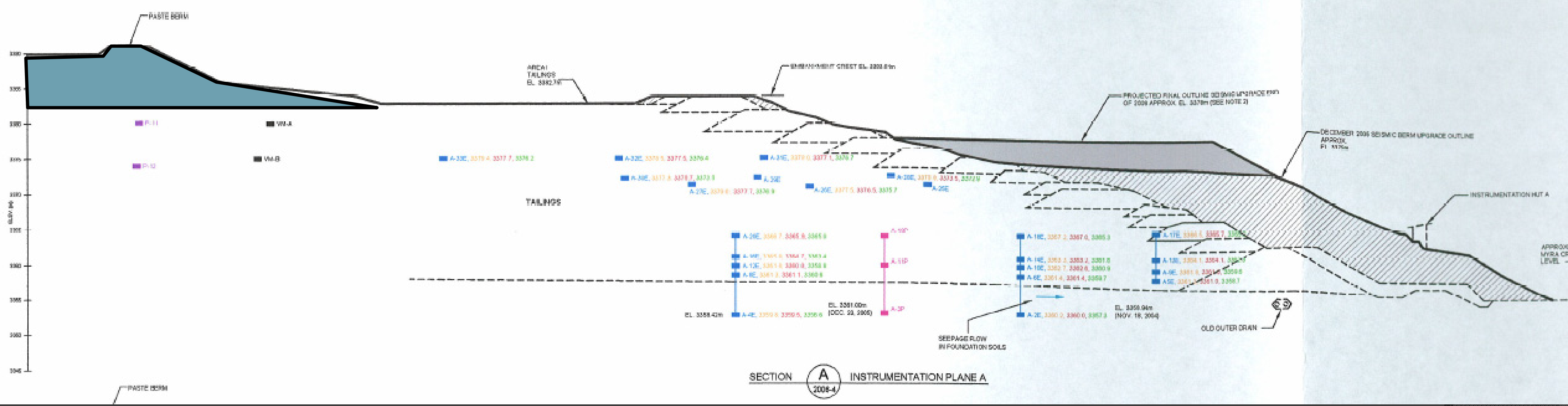
- Realigned of Myra Creek
- Dynamic compaction of seismic berm foundation soils
- Upgraded under drain system
- Buttress with PAG rock core, NAG rock "shell"
- Fills placed and compacted in approx. 0.5 m lifts
- Ongoing in staged manner ever since, gradually reducing risk



PASTE STORAGE IN THE TDF 2003 - 2008

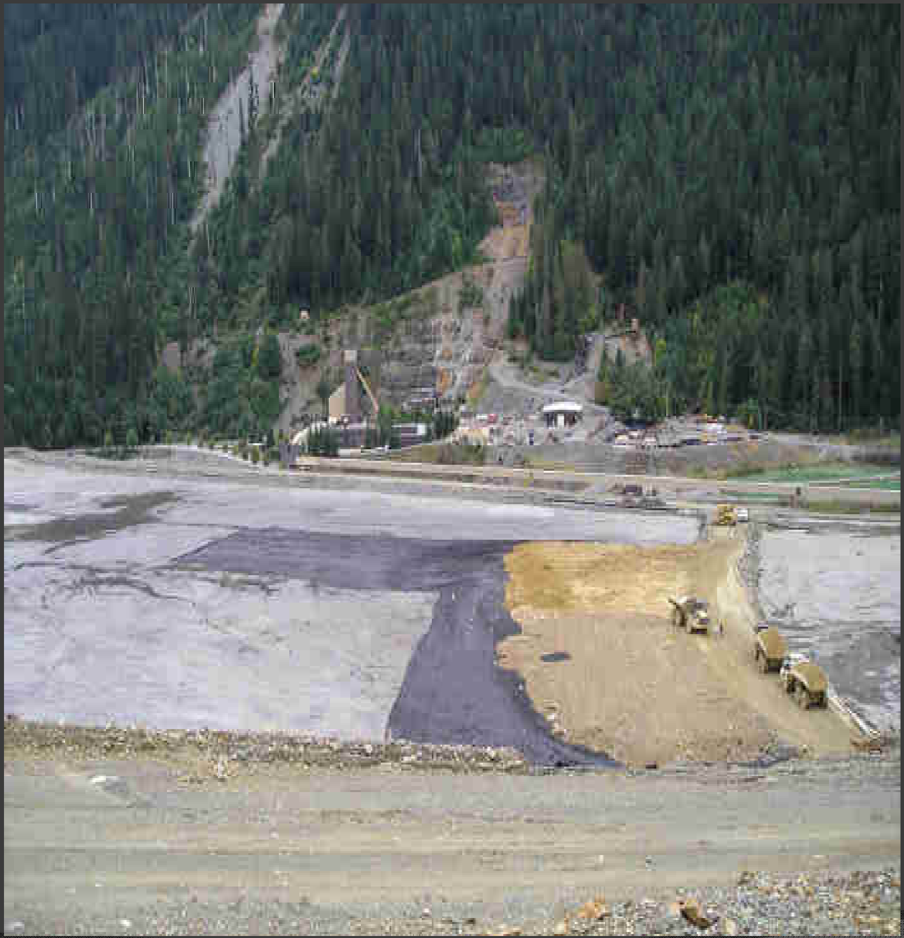


PASTE CONTAINMENT BERM BUILT TO INCREASE STORAGE CAPACITY



Paste Containment Berm floats on previously deposited conventional tailings

CONSTRUCTION OF THE PASTE BERM



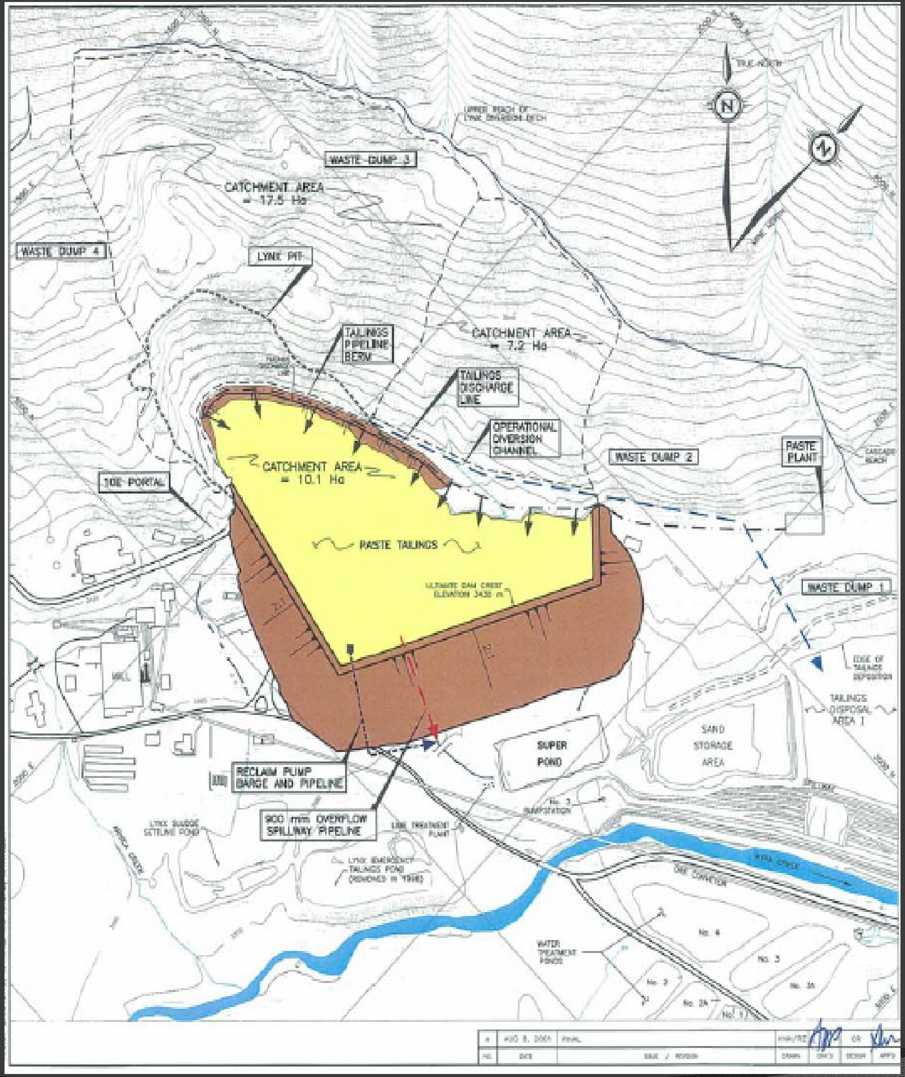
PASTE TAILINGS SLOPE

TAILINGS DISPOSAL FACILITY JUNE 2008

CLOSURE STRATEGIES

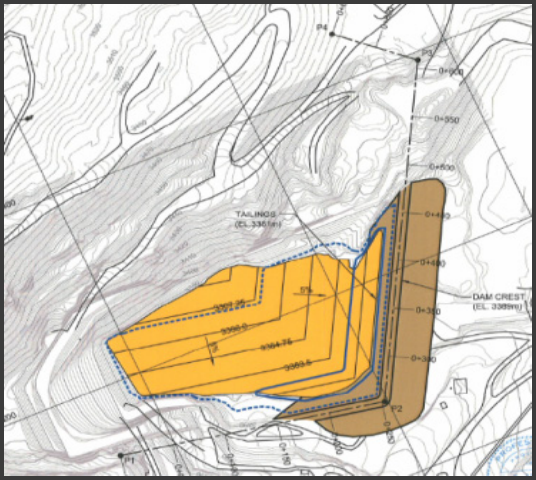
- Cover sloped paste tails with a combination of non-acid generating waste rock and native till
- Sloped land form will channel surface runoff to an armored spillway
- Drainage not meeting water quality criteria will be collected via toe drains and treated prior to release (~30 gal/min)
- Under drains will capture any seepage and be pumped to the water treatment facility(~4000 gal/min)
- The cover design facilitates re-vegetation with both trees and grasses
- Overall goal is to reclaim Myra Valley, including the Tailings Disposal Areas, to a state consistent with Class “A” wilderness parkland
- Next step is to conduct 2-D land form design work

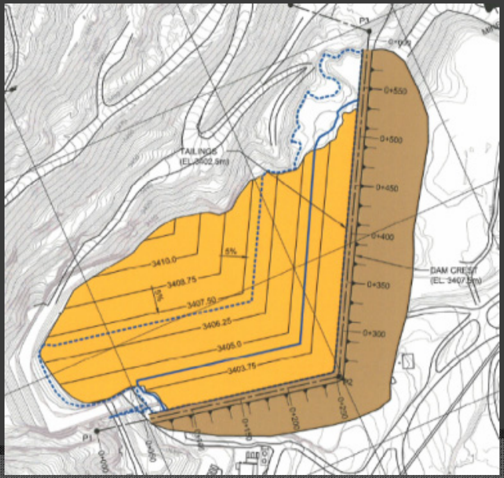
LYNX TDF DESIGN



Plan of the Ultimate Lynx Paste Storage Facility

PROGRESSION OF THE LYNX TDF DEVELOPMENT





LYNX TDF DESIGN

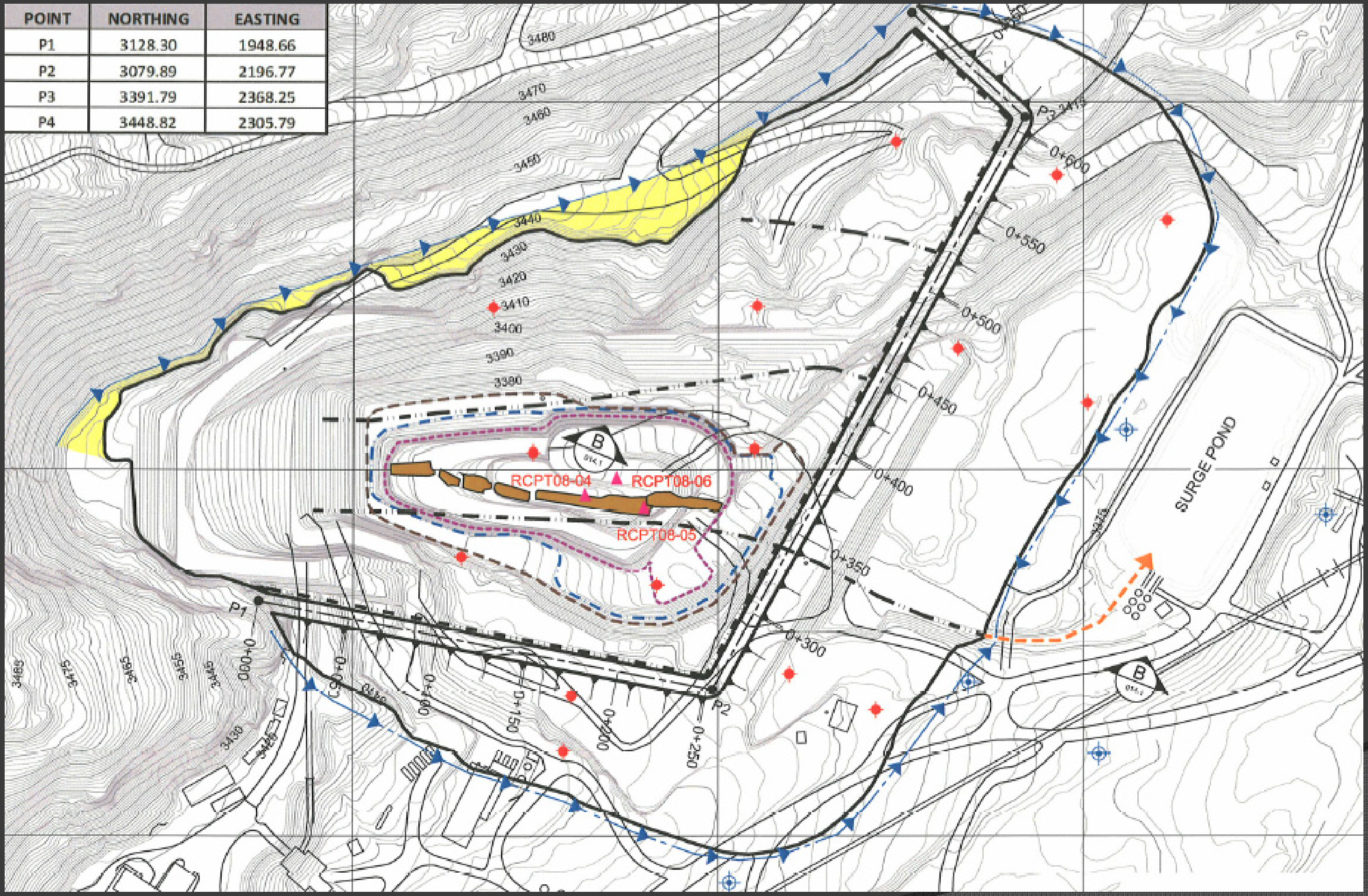
- Lynx TDF to be a waste disposal facility, not just a tailings disposal facility
- Other waste streams to be included:
  - Water treatment system sludge
  - Excess tailings sand that cannot be used as backfill
  - General site refuse
  - Sewage discharge
  - Fines from sump cleanouts
  - Waste Rock

LYNX TDF WATER MANAGEMENT

- Two diversion ditches each designed to accommodate 1 in 200 year, 24-hour flood
- Total catchment 33 ha
  - Upslope area: 23 ha
  - Lynx TDF: 10 ha
- Lynx TDF will accommodate 1 in 1,000 year, 24-hour flood
- This event represents estimated inflow of 78,000 m^3

LYNX TDF WATER MANAGEMENT INFRASTRUCTURE

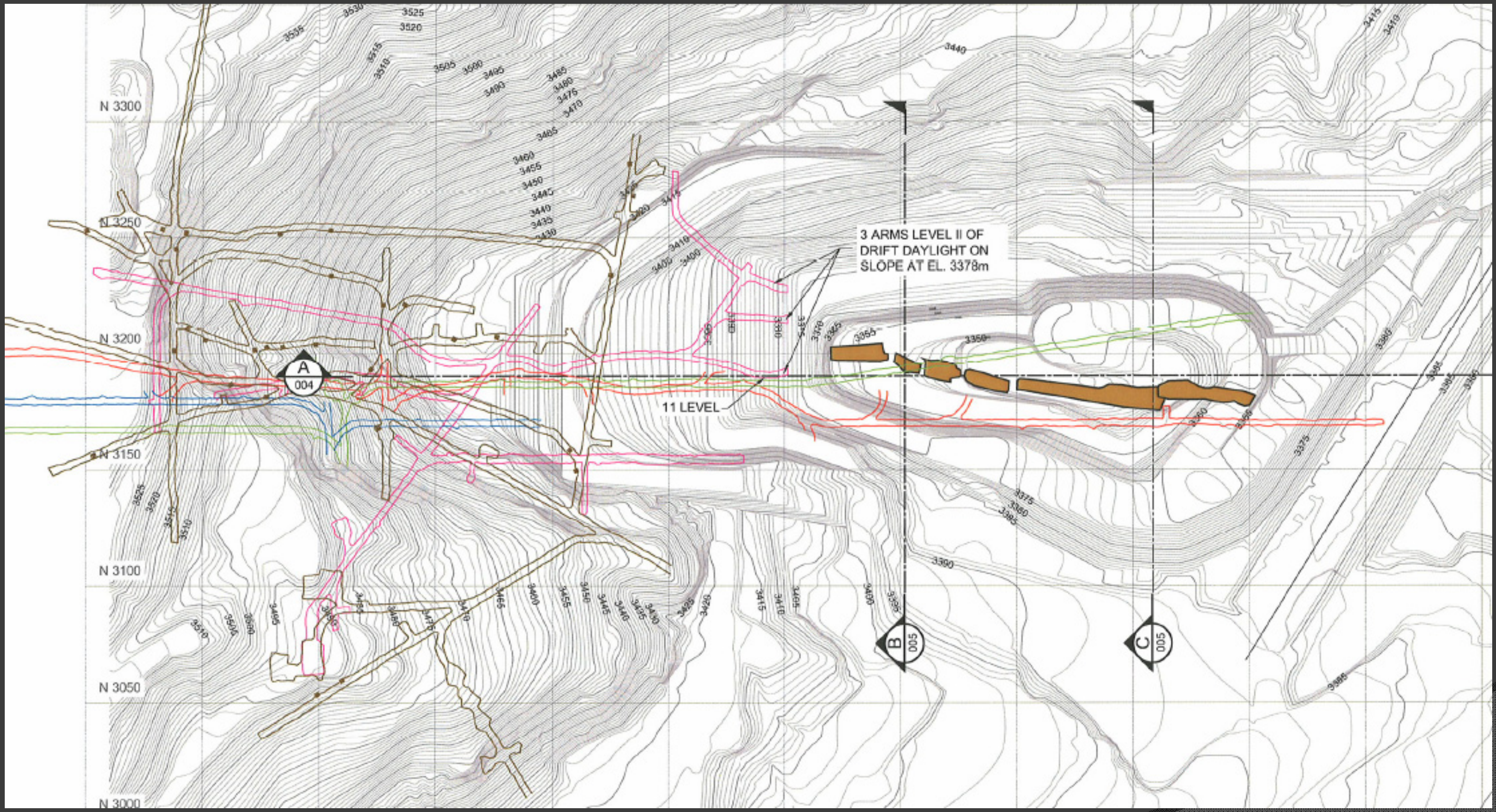
POINT	NORTHING	EASTING
P1	3128.30	1948.66
P2	3079.89	2196.77
P3	3391.79	2368.25
P4	3448.82	2305.79



LYNX TDF DESIGN CHALLENGES

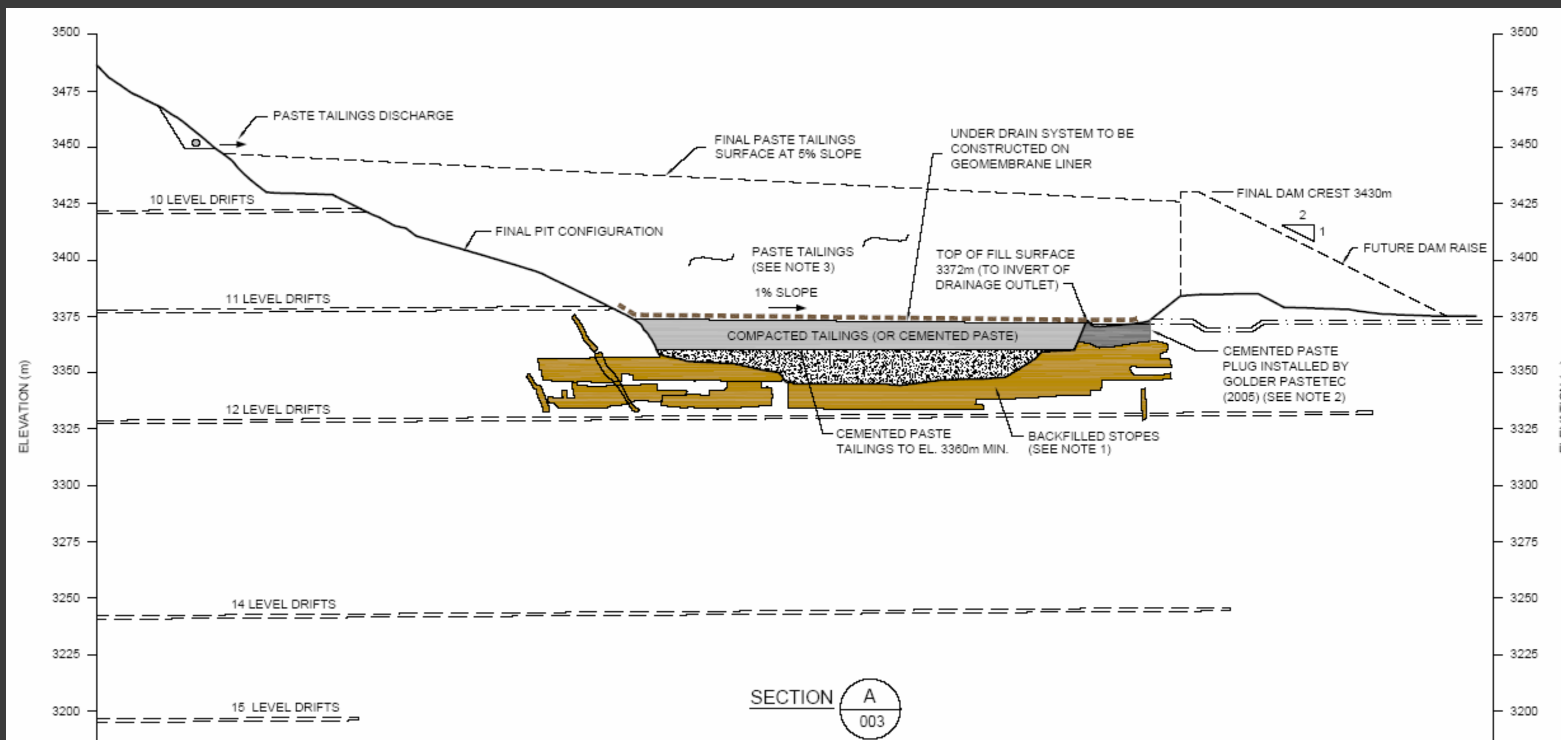
- The Lynx Pit sits on top of stopes partially backfilled with hydraulically placed sand
- This is an area of the mine that has not been actively mined since 1993
- These stopes are connected to the active mine workings through a distance of approximately 2 km of drifts and raises
- In order to reduce the risk of an inflow of tailings into active parts of the mine the tailings placed in the Lynx TDF need to be rendered non-liquefiable

UNDERGROUND WORKINGS AND SAND FILLED STOPES BELOW THE LYNX TDF



Mine personnel underground are well removed from the area.

LONG AXIS SECTION THROUGH THE LYNX TDF AND UNDERGROUND



CEMENTED PASTE IN LYNX TDF

- Paste typ. 60-65% solids by weight
- Further consolidation has been observed

Paste Mix – 0.033 parts cement : 1 part dry tailings solids : 0.63 parts water

CEMENTED PASTE IN LYNX TDF

CEMENTED PASTE TEST PIT

Looking north at the test pit after 3.5 hours. Test pit depth is 6 m. Width is approximately 1.3 m (width of digging bucket).

West wall of the test pit looking north after 3.5 hours.

Pile of excavated material after 3.5 hours. Note the cohesion within the material, with no indications of liquefaction-type behaviour under high strains imposed by the excavation process.

Collapsed test pit, June 10. Note the cohesion within the mass, with no indications of liquefaction-type behaviour.

OBJECTIVES OF CEMENTED PASTE FOR THE LYNX TDF

- Objectives:
  1. Produce material not susceptible to flow liquefaction at minor strains
  2. Produce material with enhanced post-liquefaction shear strength
  3. Water-tailings-cement ratio sufficient to permit pumping via positive displacement pumps without excessive line pressures
- Peak shear strength not an objective – in fact, want to avoid increasing brittleness of the material, do not want to inhibit consolidation and water content reduction

PRACTICAL CHALLENGES TO TAILINGS MANAGEMENT

- Changes in Ownership
  - Four different owners in the last 25 years
- Production changes
  - 875 tonnes/day → 2700 tonnes/day → 4000 tonnes/day → 1600 tonnes/day
- Different deposition facilities require changes to the operation
  - Sub-Aqueous → Land Based → Paste → Cemented Paste

CHALLENGES – SEISMIC ISSUES

- Exploratory drilling in the early 1990's to investigate the degree of consolidation of the tails in the TDF showed that there had been less consolidation than anticipated and that the tails remained saturated at depth.
- These conditions lead to an increase in the risk of liquefaction during or after an earthquake.

CHALLENGES – BUTTRESSING THE TDF

- In 1999 a plan was approved to build a buttress around the TDF to improve its seismic resistance
- The plan utilizes both acid generating material and non-acid generating materials
- Required moving in excess of 1.5 million m3 of fill
- One of the largest challenges was achieving fast turnaround times for the acid base accounting test work. The non-acid generating quality of each lift had to be confirmed before being covered by the next lift
- Working in and along a fish bearing stream

CHALLENGES – ACID GENERATION

- ARD from tailings has become a challenge in the last two years
- Exposed older tailings not covered by paste have started to generate acid
- Although ARD contributes only a small percentage of flow to our water treatment system it has a strong potential to disrupt the pH balance of that system
- Automation of lime addition to our water treatment system has improved our ability to handle these ARD flows
- In situ treatment of the ARD by spreading slaked lime with a water truck has further reduced the strain on our water treatment system

CHALLENGES – WATER MANAGEMENT

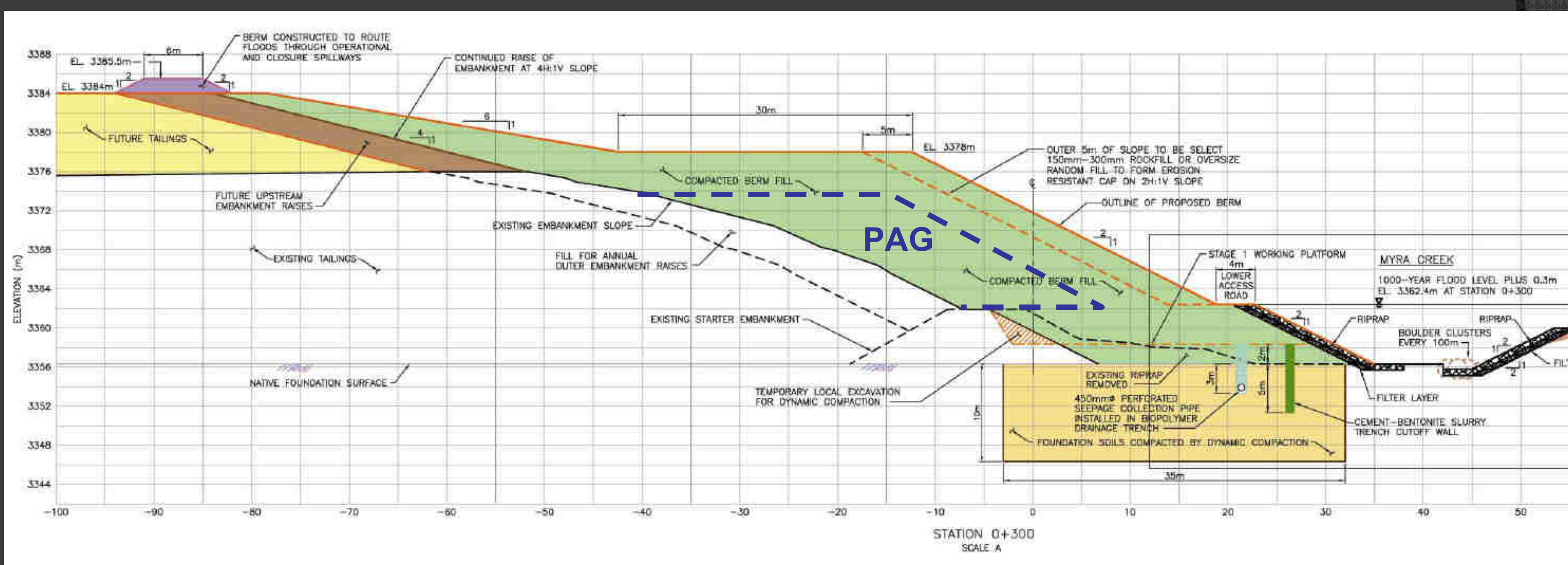
- Steep narrow valley
- Flashy runoff
- 2 storms in last two years in excess of our 1:200 year design criteria
- Challenges met by introducing redundancy into our water management system:
  - Redundant diversion ditches
  - Backup pumps

LESSONS LEARNED

- Waste streams such as tailings, effluent and sludge should be treated as products, and given similar quality control as our concentrate
- Moving forward MFO will focus on a comprehensive waste management plan rather than a tailings management plan
- Maintain a backup location for tailings deposition under upset conditions

LESSONS LEARNED

- Utilizing all available material for construction including acid generating waste rock



LESSONS LEARNED

- You can never have too much knowledge when it comes to planning
  - Understand material geochemical (ML/ARD) characteristics in advance and plan accordingly
  - Understand the hydraulic regime to design effective water management strategies
- Where adequate knowledge is unachievable, build in adaptive management and ongoing risk assessment
- Land-based storage may not always be the best solution for tailings disposal
  - Site specific characteristics such as seismic and geotechnical conditions must be taken into account in the design process
- Include stakeholder involvement early in design process