Tailings Dams
They Need to Stay Here Forever

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Tailings Storage Facility Importance

• Necessary and permanent infrastructure of most mines
• Varying technical, operational, and closure requirements
• Major contributor to Capex and Sustaining Capital expenditures
• Significant pressure on Return on Investment
• A top challenge in obtaining “Social License to Operate”
• High contributor to Corporate risk during and after mining
• The risk stays forever so need continued monitoring & surveillance
• Incidents and failures do happen (e.g. Mount Polley, 2014)

Tailings Dams versus Water Dams

• Locations – Tailings dams are for mine support where ore deposits are found and are often remote. Water dams are for human convenience and mostly near communities.
• Liability / Asset - Tailings dams are a non profitable part of a mine operation because they store waste which is a liability instead of water which is an asset
Tailings Dams versus Water Dams

- Locations – Tailings dams are for mine support where ore deposits are found and are often remote. Water dams are for human convenience and mostly near communities.
- Liability / Asset - Tailings dams are a non profitable part of a mine operation because they store waste which is a liability instead of water which is an asset.
- Observational Approach - Design & construction evolve as during mining. Tailings rise. Plans, design codes, regulatory guidelines and technologies change. Lessons are learned.
- Tailings Use - Tailings properties and disposal methods can be optimized to influence a dam design including the use of tailings as construction materials and building on tailings.
- Facility Life - Tailings are a waste and must be stored forever with monitoring & surveillance. Water dams can be removed when they no longer serve a useful purpose.

Tailings Reclamation Plan Approach

- Plan and develop with closure in mind
- This requires continued integration of:
  - Pre-feasibility & Feasibility - years to decades
  - Planning & Design – years to decades
  - Construction & Operation - years to decades
  - Closure - years to decades
  - Post-closure - forever
- To reduce long-term liability, must consider:
  - All phases of facility
  - How they interact
Project # 1- Planned Tailings Pond

- Confidential project in North America
- Climate extremes with sub-zero winters
- Short construction season
- Flat terrain & shallow groundwater
- At pre-feasibility study level
- Tailings storage ring dam planned
- Tailings area estimate ~ 1485 acres
- Tailings surface dimension ~ 8000’ x 8000’

Closure Options

- Option 1 - Dry Closure Out Slope
  - Mound with perimeter drain water discharge
- Option 2 – Wet Closure
  - Lake with spillway water discharge
- Option 3 – Dry Closure In Slope
  - Depression with central decant water discharge

Conceptual Tailings Initial Cell Layout

Option 1 – Dry Closure Out Slope
Option 3 – Dry Closure In Slope

Planning Level Cost Comparisons

- Option 1A $2,082 M
- Option 1B $1,435 M
- Option 2 $125 M + water treatment
- Option 3 $119 M

- All cost estimates consider CAPEX only
- Option 2 water treatment cost in perpetuity

Project #2 – Lucky Friday Tailings Ponds

- My introduction to tailings dams - 1976
- TP 1 thought to be as high as could go
- TP 2 squeezed in by property boundaries
- TP 3 planned at new greenfield site
- TP 1 looked worth evaluating for expansion
  - Performed geotechnical investigation
  - Completed cyclic shear tests for liquefaction
  - Designed & raised in three upstream lifts
  - Benched raises back on tailings for stability
- TP 3 starter dam and creek diversion deferred
Tailings Pond 1 Raise Instrumentation

Tailings Pond 1 Raise Construction

Tailings Pond 3 Construction

Tailings Pond 3 Construction
**Project # 3 – Sunshine Tailings Ponds**

- Follow up to Lucky Friday & Star pond work
- Existing ring tailings pond topped out
- New pond designed on old golf course
- New golf course built on upper terrace
- Big Creek relocated around new dam site
- New starter dam built of gravels & mine waste
- Dam later raised by upstream construction
- Mining ceased and pond shuttered
- Pond can be reactivated if mining resumes

**Project # 4 – Holden Mine Tailings Ponds**

- Cu, Zn & Au mined - 1935 to 1957 in WA
- Remote mountain terrain, sub-zero winters
- Operated own school & rope toe ski hill
- Three tailings ponds up to 120’ high
- All built by upstream construction
- Deeded to Lutheran Bible Institute
- Now Holden Village USFS Special Use Permit
- 5,000 to 6,000 visitors/year, 70 residents
- Remediation & reclamation 2011 to date
Project # 5 – Red Dog Mine Tailings Dam

- Stage I (starter dam) built 1988
- Stage II to VI raises built 1989 to 1994
- Stage VII to IX raise built 2003 to 2013
- Stage X widening planned to start 2014
- All raises by downstream construction
- Tailings single point moving discharge
- Draft closure plan developed 2004 to 2009
- Current closure plan is wet closure (lake)
- 300’ wide tailings beach reduces seepage
- 600’ wide beach driven by closure plan
Project #6 – Tundra Mine Tailings Dams

- Tundra & Salmita Mines, NT, Canada
- Tailings deposited in lake 1960s & 1980s
- Dams built along low lake shores 1980s
- Tailings facility partly remediated late 1980s
- Entire mine facility abandoned in early 1990s
- Tailings dam safety inspections started 2001
- Lake received and discharged water to 2013
- Discharged water impacted by tailings contact
- Lake water treated & discharged 2010 to 2013
- Tailings facility remediation 2010 to 2015
Project # 7 – Farley Mine Tailings Ponds

- Former Ni mine, Northern Manitoba
- 800 acres tailings ponds
- Closure issues - terrain, rainfall & freshet
- Acid generation affecting fishing grounds
- Key closure element surface runoff ditch.
- Low permeability cover placed over tailings
- Tailings sand covered with geomembrane
- Tailings fines covered with crushed rock
Farley Mine Tailings Closure

- 3M cy soil/waste-rock/tailings moved
- 64,000 cy sediment dredged
- 450 acres geomembrane installed
- 700 million gallons of water treated
- 30,000’ dykes buttressed & armored
- 500,000 cy rock cover installed
Project # 8 – Cerro Negro Tailings Ponds

- Two side by side contiguous tailings ponds
- Pond 1 inactive and dry with no surface pond
- Pond 2 active and wet with surface pond
- Earthquake in 2003
- Pond 1 remained intact
- Pond 2 failed
- Tailings flowed 20 km down Rio La Ligua
- Lesson – keep ponds as dry as possible
- Lesson – maintain dry ponds at closure

Two Ponds After Earthquake - 2003

Project # 9 – Castro Cove Sediment Cleanup

- Operations never considered legal liability associated with oily waste.
- Could have staged waste disposal and closed smaller cells of waste ponds.
- Used innovative approach:
  - $100M liability turned out to be
  - $43M construction that generated
  - $130M value for the owner.
- This is an exception, not the general rule
- Shows how liability can become opportunity.

Castro Cove Sediment Cleanup

Castro Cove Project Area
THANK YOU

QUESTIONS?