Tailings Design and Operation Safety
You may have heard about:

- Mount Polley
- Buenavista de Cobre
- KUC
- Pinto Valley
Recent Case Events

August 4, 2014-Imperial Metals, Mount Polley Operation, BC Canada

*Incident*

- Embankment Breach
- 17 Million Tonnes of Tailings and Water escaped through breach and into neighboring lakes (}
**Impacts and Response**

- Investigation Underway on August 5th
- Water Quality concerns impacted 300 residents downstream temporarily
- Independent water quality program initiated
- Mine shutdown indefinitely, 300 employees
- Cofferdams constructed through breach and cleanup underway
- Independent review team (international experts) to assess cause of breach (January deadline for preliminary assessment)
- November 12, Mine still closed, large impact clean up nearing completion, Majority Employer in nearby Williams Lake
August 6, 2014-Buenavista de Cobre, Cananea, Mexico-Process Pond Breach

**Incident**
- Originally Reported as Tailings Breach-Corrected on August 19th
- Failure of underflow line on a leach pond-13 million gallons of affluent (Copper Sulfate +Sulfuric Acid) lost in drainage basin
- 25,000 affected directly downstream,

**Impacts and Response**
- Tributary of the Sonora River, main water source for State
- 1 Month period of misinformation and unclear impacts
- 150 M dollar fund setup by the company+3 million dollar fine for negligence assessed by the Mexican Environmental Agency
- Cleanup underway, downstream impacts being assessed
Historic Case Events

April 10, 2013-Bingham Canyon Slide, Utah

Incident

- Defined ground movement detected in February
- Notification to public, evacuation of lower pit area
- 155 million ton slide, loss of ramp access, lower pit equipment, portal.
- Temporary closure of northeastern pit area and offices.

Impacts and Response

- Established lower pit access within a week of the slide.
- Initiation of a reliance and communication plan to establish permanent access across the slide area. Completed in November.
- Initiated mitigation plan to reduce risk to the south of the current slide area.
- 530 M dollar write-down on asset
October 22, 1997-BHP Pinto Creek, Arizona

Incident
- Second lift of waste rock was being placed on top of an old tailings facility (decommissioned in 1970s)
- Tailings embankment failure releasing 300,000 cu yards of tailings down into Pinto Canyon.
- Three employees on top of facility when it failed, no injuries.
- Tailings impacted a mile upstream and downstream of Pinto Creek

Impacts and Response
- Without shorter haul, mine was closed with impact to roughly 600 employees
- Regress of permitting process for Carlotta Project
- A coffer dam was built downstream and tailings removed, cost roughly 35 million dollars
- Tailings pond stabilized and reclaimed.
Tailings Dam Failures: A Review of the Last One Hundred Years (Shahid Azam, Qiren Li)

- Tailings dams failures peaked in 1960s to 1980’s 50 per decade globally
- Dropped down to 10 to 20 per decade globally in last 20 years
- Frequency of events shifted from developed countries to developing countries
- Failures predominantly in small to medium sized dams
- About 1/5th of contained tailings typically released on failure
- Causes include – “unusual” rain, lack of rules, regulations, oversight, poor management
- Failures can be managed and minimized by proper engineering standards and monitoring
Physical design factors to consider

- Adequate Capacity?
- Earthquakes?
- Physical Properties?
- Chemical Properties?
- Climate?
- Foundation geology and hydrology?
What are the root causes of tailings failure and controls?

- Static Liquefaction
- Seismic Liquefaction
- Overtopping
- Slope and Foundation Instability
- Seepage and piping
- Chemical material modification
What are some of the HUMAN factors to avoid?

• Lack of a monitor and review strategy
• Failure to use the observational method to refine design
• Reliance on key personnel rather than systems
• Lack of independent third party assessment
Design Versus Operation
Life cycle of a tailings dam

**Design**

**Criteria**
- Earthquake
- Storm Events
- Foundation Conditions

**Operation**

**Monitoring**
- Conditions
- Technical Advancement
- Regulation
- Community + Peer
Holistic Approach to Design/Operation

- **Design**
  - 4 Incrementally Expanded Phases
  - Establish competent engineering oversight and practice plus, regulatory and community outreach

- **Operations**
  - Multiple Internal and External Peer Reviews After Each Phase
  - Establish operations protocols that are fixed to the design criteria. External engineering due diligence required.

- **Monitor/Review**
  - Track monitoring and match to baseline and design criteria. Third party and community programs.

- **Assess**
  - Assess performance and level of compliance to design specifications
  - Internal and external technical assessment

- **Modify**
  - Modify design or correct practice to match reality of conditions
  - Modifications under the direction of the external engineer of record, peer reviewed prior to initiation
Regulatory Requirements

Standards or Regulations

- Arizona BADCT Guidelines
- Aquifer Permit (APP)
- Clean Air Act
- Clean Water Act
- NEPA
- ICOLD

Requirements

- Chemistry
  - Risks and Probabilities
  - Consequences
  - Mitigation and Controls
- Groundwater
  - Stability
  - Proximity/Impact
  - Technical Requirements and Assurances
Conclusion

• Holistic approach from design through closure
• Key risk focus is on consequences, other factors are important but Secondary
• Implement review programs through life by peer and expert boards
• Regulatory review including federal and state appointed experts
• Fit best design to current knowledge but verify with monitoring
• If the conditions or control requirements change, modify design to match the change-NO COMPROMISE
• Incorporate stakeholders (Community) in the process and communicate issues as they arise
• Regulated public input e.g. NEPA and Operating Permits