Tailings Facility Risk Assessment and Risk Management

Jack Caldwell, Robertson Geoconsultants
Colleen Crystal, GeoLogic Consultants

Tailings and Mine Waste 2017
The TSF

- Buritica Mine
- Columbia
- Continental Gold
The Valley
Final Layout
Foundation Soils
Cross Section
Channel
Natural Rip Rap
Risk Assessment Objectives

• Comply with developing standards
• Expand understanding of facility
• Provide a basis for engineering judgment
• Compile Risk Registers
• Provide a basis for Risk Management
Risk Periods

- During Design
- Construction
- Operation
- Closure
- Post Closure
Fault Tree

These Types of Hazards could cause failure:

- Natural Factors
- Mining-related factors
- TSF Performance
- Human Factors
Fish Bone Diagram: Channel Flooding

- Excess Flow
  - High Precipitation
  - Wet Soils
- Excess Debris in Flow
  - Fire
  - Failed Debris Dam
- Increased Runoff
  - Increase housing and paving
- Channel Impedance
  - Hillside Blockage
Bow Tie: Channel Flooding

- **Hazard**
  - High Precipitation
  - Lots of Entrained Debris
  - Channel Impeded by Hillside Rock Fall

- **Consequence**
  - Damage Access Road
  - Erode Toe Buttress
  - Expose Tailings
  - Tailings in Flood Waters
Event Tree: Slope Stability

- Channel Flow / Flujo del Canal
  - Short / Corto
  - Long / Prolongado
    - Small Rise / Incremento Pequeño
      - Big Rise / Incremento Considerable
        - Some Water / Algo de Agua
          - No Pressure / Sin Presión
            - Saturated / Saturado
              - No Impact / Sin Impacto
                - Reduced FOS / FOS Reducido
                  - >10
                  - <10
  - Impact of Channel Flooding on TSF Stability / Impacto de la Inundación de Canales con la Estabilidad del TSF
The Most Bothersome Hazards

• Natural Hazards
  • Big earthquakes
  • Flood flows in channels

• Mining Hazards
  • Shortage of waste rock for berms
  • Filter pressed tailings too wet

• TSF Performance
  • Slope Stability
  • Erosion
  • Foundation Deformation

• Human Factors
  • Management
Consequences

• Natural Hazards
  • Big earthquakes: **Slope deformation**
  • Flood flows in channels: **Toe erosion**

• Mining Hazards
  • Shortage of waste rock: **Use alternative sources**
  • Filter pressed tailings too wet: **Rework or add lime**

• TSF Performance
  • Erosion: **Gulleys, Sediment**
  • Foundation Deformation: **Slope deformation, Cover cracking**

• Human Factors
  • Management: **Money, Men, Materials**
Tolerability

• Natural Hazards
  • Slope deformation: No flowable tailings so just regrade deformed areas
  • Toe erosion: To exposure of tailings so just rebuild toe roads

• Mining Hazards
  • Use alternative sources: Added cost acceptable
  • Rework or add lime: Added cost tolerable

• TSF Performance
  • Erosion: Fill In Gulleys, Catch or Collect Sediment
  • Foundation Deformation: Repair Cover cracking

• Human Factors
  • Management: Robust Landform
Post-Closure Risks

• 1 to 100 Years
  • Landslides Block Channel
  • Big floods wash away access road, toe erosion
  • Big earthquakes induce TSF Deformation

• 101 to 1,000 Years
  • PMF
  • PME
  • Channel Infilling

• 1,000 Years Plus
  • Geomorphic Change
  • Climate Change
Risk Registers

- Area
- Component
- Hazard
- Consequence
- Mitigation
Conclusion

- Comprehensive Risk Assessment
- TSF Design to Mitigate Hazards and Consequences
- All Risk Considered Tolerable
- Regulators Accept
- Construction in Progress