Economic evaluation for the disposal of slurry versus thickened tailings in WA – A case study

Aida Carneiro
PhD Candidate

Andy Fourie
Supervisor

Richard Durham
Co-Supervisor

School of Civil, Environmental and Mining Engineering
Perth, WA
Introduction

• Sustainable development principles and leading practices
• TSFs under increasing scrutiny
• Current evaluation methodologies are limited
• CAPEX and OPEX only, and just of certain items
• Underestimation of closure costs, and overlook of non-technical issues
Review of increasing tailings management challenges

- Need to balance economic, environmental and social issues
- Water shortage and its increasing cost
- Desalination cost in Chile US$5/m³
- Social and environmental disputes
- Onerous obstacles to obtain SLO

http://www.yestolifenotomining.org/tia-maria-shouts-to-defend-their-land-peru/
Review of increasing tailings management challenges

- Catastrophic environmental and public health impacts from TSF failures
Review of increasing tailings management challenges

Samarco
Brazil, November 2015

Mount Polley
Canada, August 2014

Lithgow
Australia, July 2015
Review of increasing tailings management challenges

- TSF failures drive public perception
- Increase regulatory burden and government oversight
- Brazil’s bill PL 3676-2016: ban upstream method
- Mining Rehabilitation Fund (MRF) – July 2013
Tailings physical characteristics, operating parameters, and design considerations

- Non-acid generating gold tailings in WA
- 75-80% < 75 μm
- 266 mm rainfall, 2,500 mm evaporation
- Flat topography
- 2M dry tonnes per year
- 15 years operating LOM
- Conceptual TSF designs

- Conventional slurry tailings (55% w/w) \( \rho_d = 1.4 \text{ t/m}^3 \)
- Thickened tailings (65% w/w) \( \rho_d = 1.5 \text{ t/m}^3 \)
Typical Tailings Storage Facilities in the Goldfields of WA

Slurry tailings disposal in a paddock-type dam

940 m

Decant road

Thickened tailings disposal using CTD method

2 km

Pond for surface water management

Source: Google Maps
Supply and Installation

- High-rate thickener (HRT)
- Pumps and pipeline (tailings, return and make-up water)
- Pipe for spigot dropper
- Spigot offtakes
- Earthworks (site preparation, embankment construction, underdrainage and decant systems)
TSF design for thickened tailings

- High-compression thickener
- Pumps and pipeline (tailings, return and make-up water)
- Spigot offtakes
- Earthworks (site preparation, embankment construction, tailings deposition system, pond for water management)
## Comparative evaluation summary

<table>
<thead>
<tr>
<th>Item</th>
<th>Conventional Slurry</th>
<th>Thickened Tailings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solids content of discharged tailings</td>
<td>55% (w/w)</td>
<td>65% (w/w)</td>
</tr>
<tr>
<td>Dewatering unit type</td>
<td>High-rate thickener</td>
<td>High-compression thickener</td>
</tr>
<tr>
<td>Tailings discharge method</td>
<td>Spigotting from a ring dyke in a paddock dam</td>
<td>Central Thickened Discharge (2% beach angle)</td>
</tr>
<tr>
<td>Deposited tailings dry density</td>
<td>1.4 t/m³</td>
<td>1.5 t/m³</td>
</tr>
<tr>
<td>TSF footprint area</td>
<td>94 ha</td>
<td>324 ha</td>
</tr>
<tr>
<td>Tailings pump system</td>
<td>5 centrifugal + 5 standby</td>
<td>1 piston-diaphragm PD pump + 2 charge pumps</td>
</tr>
<tr>
<td>Flow of water discharged with tailings</td>
<td>189 m³/h</td>
<td>125 m³/h</td>
</tr>
</tbody>
</table>
Results and Discussion

<table>
<thead>
<tr>
<th>Component</th>
<th>Thickened Tailings</th>
<th>Slurry Tailings</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL NPC @ 10%</td>
<td>1%</td>
<td>56%</td>
</tr>
<tr>
<td>CAPEX</td>
<td>50%</td>
<td>78%</td>
</tr>
<tr>
<td>OPEX</td>
<td></td>
<td>50%</td>
</tr>
<tr>
<td>CLOSURE COSTS</td>
<td>56%</td>
<td></td>
</tr>
</tbody>
</table>
CAPEX comparison

- High-compression vs conventional thickener
- PD pump vs centrifugal pump
- Tailings pipeline (discharge method)
- Earthworks for large area, pond, and embankment construction
OPEX comparison

- Increase TSF capacity
- Pump slurry and make-up water
- If water costs $3/m^3 = costs of make-up water would represent 50% of OPEX for slurry option, and 71% of OPEX for CTD option
- MRF higher for CTD option
OPEX comparison

- MRF rehabilitation cost = $50,000/ha
- Rehabilitation cost from this case study = $270,000/ha (slurry), $70,000/ha (CTD)
- If MRF change to $100,000/ha and FCR 1.5% = levy payable to the MRF for the CTD option = 1/3 of total OPEX
- Unit rate of land under rehabilitation = $2,000/ha

ESTIMATED OPEX – CTD OPTION
Closure and rehabilitation cost comparison

• Rehabilitation cost is 56% higher for CTD option

• Complex rehabilitation works for wet tailings

• Different life-cycle considered for discounting rehabilitation costs
  – LOM 29 years for slurry option
  – LOM 25 years for CTD option
Conclusion

- Technology to improve water efficiency and lower the risks of catastrophic TSF failures
- Key elements driving the cost of disposal
  - Large footprint for tailings storage
  - Volume of retaining embankment
  - Water loss
  - Rehabilitation work
- Due account of environmental, social and risk costs for the selection of the most cost-effective option
Ongoing research:

- LCA to characterize environmental impacts
- Identify risks and quantify clean-up and risk mitigation measure costs
- Assign financial costs to delays on permitting processes and conflicts solving
- Disposal method should be selected based on the assessment of the accumulated costs using an integrated approach

What are the real costs of disposing tailings?
References


