Mine Closure Risk Assessment
A living process during the operation

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## Closure chronology – Chilean reality

### Gov.

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>Environmental basis law – Health &amp; Safety</td>
</tr>
<tr>
<td>2011-2012</td>
<td>Closure law starts to operate</td>
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<tr>
<td>2014</td>
<td>&quot;Transition&quot; closure plan</td>
</tr>
<tr>
<td>2015 – to date</td>
<td>General application of the law (Risk Analysis)</td>
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</tbody>
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### Conceptual closure – Closure measures “put” into a document

- Let put all closure measures committed to different authorities into a single document
- Closure measures had to be costed.
- Based on those costs, put a warranty

### Mining Company

- Closure is costless
- Closure measures had to be quantified and costed.
- 1st Surprise: there are commitments that are impracticable or extremely expensive
- 2nd Surprise: I have to cost them and put a warranty for them.

### Cost

- Opportunities to review and comprehensively defined closure measures
- Now the closure measures had to be technically approved by the authorities. Closure measures definition is part of a risk analysis. Costs are related to the amount of risk that the companies are willing to have.
Presentation outline

- Introduction
- Closure risk assessment
- Operational data related to closure
- Uncertainty at closure
- Conclusions
Introduction

- Do we really understand how facilities will behave after closure?

- Do we completely know what are the risks associated to closure and their consequences?

- Have we considered closure aspects/conditions during design phases of our projects?
Closure risk assessment

- The process where potential failure modes and their significances are identified, based on the combination of their probability of occurrence and their consequences.

- Risks are then generally formed by three main components: a triggering event (i.e. heavy rainfall, earthquake, flood), its probability of occurrence (which is related to its magnitude), and its consequence.
But these three components are not independent…

- Facility design criteria
- Triggering event
- Consequence

Probability of occurrence
The identification of the triggering events, their quantification and how facilities should response to those events, is generally known.

But, is the understanding of how they were constructed and operated, what really indicates their real state and can help in predicting their behavior after extreme events.

If design criteria were not met during construction or operation, they may significantly underestimate closure risks and, therefore underestimate the needs for closure measures and their costs.

Part of understanding closure behavior and the real significance of closure risks is to have the information and the date required to project different events to a post closure scenario.
Operational data related to closure

- A great deal of information measured and stored during the operation of mines can be useful for closure risk assessment, providing the evaluation team with solid data to support projections over the long term.

- But data management is a key challenge. Operational information may exist in servers, but distributed over many folders and years of operations, and operators may change or leave mines (especially as it approaches closure), resulting in a loss of continuity and access to the information.

- Or it may simply have been never collected or properly stored in the first place…
Uncertainty at closure

- Misunderstanding of the potential risks can lead to making wrong decisions based on over or under-valuing the consequences and probabilities.

- Misunderstanding variables involved in closure could lead to not identifying and evaluating relevant risks scenarios, with potential serious consequences.

- Minimizing uncertainty to the degree possible is closure goal for proper data collection and management during operation.
Uncertainty at closure

- Minimizing uncertainties not only helps controlling risks, but it also helps controlling costs as closure provisions can be better dimensioned.

- Uncertainty can produce significant costs overruns during closure, as new closure measures need to be design and implemented or the consequences of unwanted events rehabilitated.

- In some jurisdictions, sites are not transferred to the regulatory authority until a complete rehabilitation is achieved.

- Adequate dimensioning of the post closure period is needed to develop an accurate estimate of costs for post closure.
Good quality operational information can provide the needed data for better estimates of post closure requirements.
Uncertainty at closure

- Reduced closure uncertainty also provides benefits for the relationship with communities and stakeholders.

- Reducing closure uncertainty and demonstrating that the risks inherent to mine closure are controlled, well dimensioned and well managed, is very important for gaining community support and acceptance of both mining projects and their eventual closure.

- Managing closure as a living process during the operation provides benefits for reduced uncertainty in closure and long term planning, as well as for the relationship between mining companies and stakeholders.
Conclusions

- Understanding mine behavior after closure is a key factor in determining the actions and closure measures required to achieve effective closure solutions.

- Design criteria are often available, but they only represent how facilities were planned. Their construction and operation is what really controls their behavior in the long term.

- As construction and operation of mine facilities typically bridges many years, a disaggregated source of relevant data is often generated. Knowing which types of information are relevant for closure needs, and keeping organized records can be critical for the closure risk evaluation.
Conclusions

- Closure planning and evaluation has to be understood as an activity that has to be developed in close alignment with how facilities were planned, constructed and operated – with relatively few surprises (if possible). Then, it can be understood as:
  - A process that starts with the facilities design and continues through its construction and operation;
  - A process that is planned and understood as a continuation of the operational life;
  - A process that is typically going to be defined and carried out by professionals who were not involved in its design, construction and operation;
  - A process that needs to achieve a certain level of accuracy, as it is involved in the company’s finances (closure provisions) and legacy (stakeholder’s opinion), as well as continued social license for operation.
Thank you.