A difficult balance between engineering, environmental, social and economic aspects

At the end of a mine's life, the scars of mining remain. For an open-pit mine typically the landmarks include the pit, the overburden or waste rock dumps, and tailings storage facility(s) (TSF). For an underground mine the remnants may only be the TSFs, on the assumption that the waste rock dumps are used to rehabilitate the TSFs and the shaft headgear is removed and the shaft sealed. The common element is the TSF. For now, there is no alternative to the extraction of metals and minerals but to produce tailings, whether it is in the form of rejects, discards or a range of fine and coarse fractions. Backfilling of underground mines with tailings at best would reduce surface storage by 40-45% due to the volumetric increase from rock to "soil". Backfilling of open pits is generally not possible unless strip mining is used, and even then there may be a remnant TSF from the initial years of operation.

Design for Closure:
Therefore, TSFs must be designed for closure. This is easier said than done. It requires a balance between engineering from the starter works, through the operational phase and into final rehabilitation that is aimed at an acceptable and sustainable post-closure land-use. This requires long term planning and early engagement with communities and stakeholders. It also involves assessment of the risks of what might change during the mine life, such as an extension of the original mine life, change in ownership, changes in downstream land-uses and encroachment of people to the mining area.

In the design phase of a TSF, the base case is often hydraulic deposition of a slurry to create a self-impounding dam as this is the cheapest method. However, alternatives must be considered, and should include;

- Filtration of the tailings to produce a cake that can be stacked by means of trucking or conveying, with or without compaction,
- Engineered impoundments of a centre-line or downstream type, that create stable walls inside of which a slurry can be deposited.

Physical Stability:
Sustainable closure of TSFs is inherently linked to stable outer slopes (physical stability). If this cannot be achieved by flattening the slope angle, vegetation cover, armouring and/or a combination of them to protect against water and wind erosion, then the TSF cannot be considered to have been adequately rehabilitated (flawed). The engineered impoundment option may achieve this easier than the other options where the tailings is exposed to erosion, however the final slopes cannot be rehabilitated until the end of life.

Progressive closure is always a preferred as this allows trials and the success of rehabilitation measures to be proven, i.e. subjected to heavy rain, fire, and drought and possibly over-grazing. The types of cover material, vegetation species, fertilizer or nutrient addition and slope angles can be evaluated and modified to improve the final rehabilitation solution.

Chemical Stability:
Sustainable closure is also strongly linked to chemical stability. Not all tailings lead to poor quality seepage or leachate and may be inert. For those that are reactive, and especially those that result in acidic and metal leaching, the design must account for this. Many new TSFs have to be lined (barrier system) to protect the environment from seepage to ground and surface water. This lining has to extend to all perimeter leachate collection systems, silt traps and pollution control dams. The design of the liner itself has to last well beyond the TSF life, and the use of natural materials (clay) should not deteriorate with time (i.e. become dispersive and then leak). In addition, the over-liner drainage system needs to perform beyond the TSF life, and should not clog with precipitation of metals or salts. If the barrier system effectively deals with the groundwater aspects, surface water may require additional measures to minimise contact with reactive tailings. This is not just limited to the side slopes, but also the basin. Infiltration on the basin may lead to saturation and mobilization of leachate well beyond closure, and may require a thick cover medium, or a synthetic barrier system. If this is not all considered in the design phase and the costs evaluated, the wrong design may be selected.

Environmental Stability:
Most often, mines don't strip and stockpile adequate topsoil to enable rehabilitation of the TSF at closure. The shape of the landform always requires more topsoil to cover than was originally preserved. Topsoil stripping is often seen as an unnecessary upfront cost. The lack of topsoil is one of the most significant closure risks faced by mines, regardless of location or type of mineral. Without topsoil, revegetation becomes difficult and costly, as ameliorants and organic matter must be applied before vegetation can establish. In most instances, a robust grass layer is the best defence against erosion of the rehabilitated landform. Mines must therefore realise the value of preserving as much topsoil as possible during the early development phases. The objective is a non-eroding landform where pioneer vegetation is established and ecological succession leads to a self-sustaining vegetation layer over time.

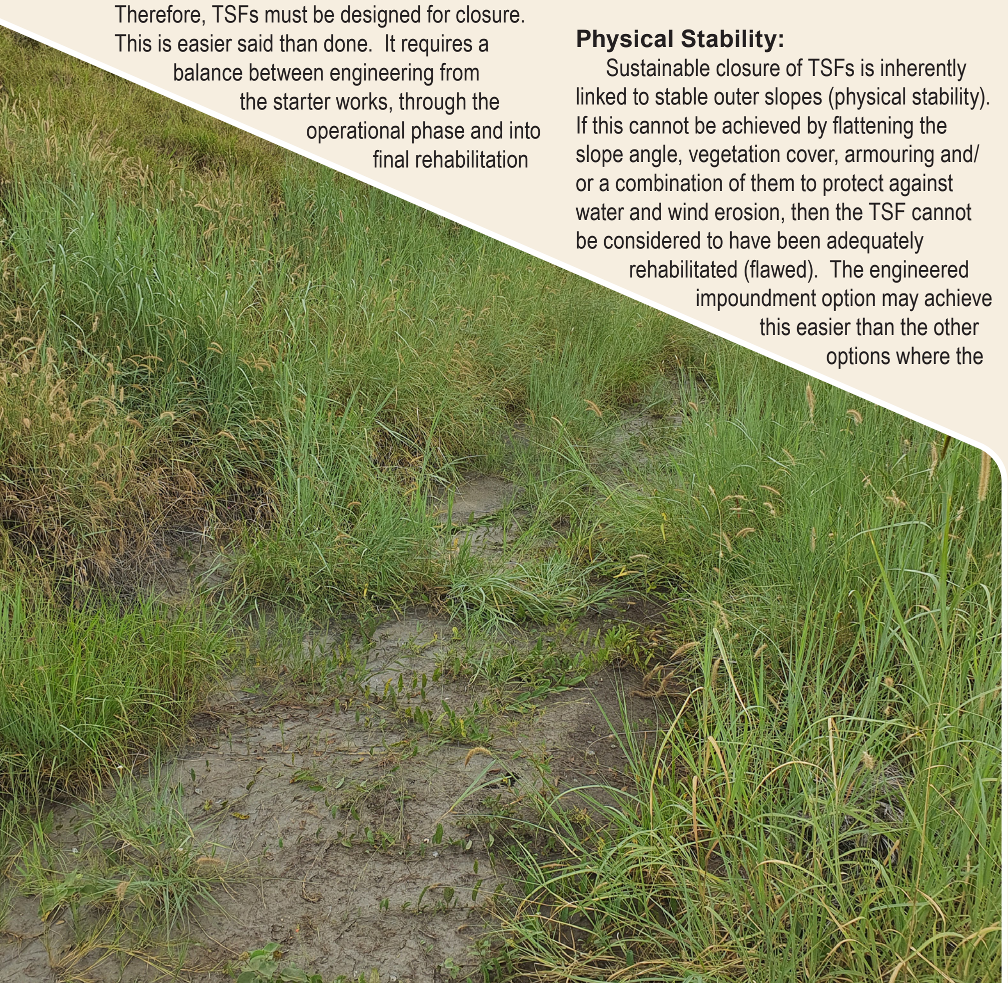
Economic Assessment and Strategy:
As was highlighted earlier, the default design case is hydraulic deposition of tailings in a self-impounded TSF because this has the lowest capital and operating cost. However, it may have very high rehabilitation costs, that either must be accurately accounted for, or considered in the trade-off studies with the alterative impoundment methods.

Finding the balance between a cost-effective design and a sustainable closure solution is becoming a much more complex and multi-disciplinary task than was previously undertaken in feasibility studies, or even during the operational life of a TSF. To encounter a hefty and unbudgeted closure cost within the last 5 years of a mine's life, can either make the mine uneconomic or lead to unsustainable closure. It is the role of mining companies, TSF consultants and regulators to make sure that;

- long term planning for closure is done in the design phase, and for mine life extensions,
- designs are sustainable and not just based on low capital costs,
- communities and stakeholders are engaged early such that a post closure land-use is agreed and all parties cooperate in achieving it,
- projects are not approved without a clear and implementable closure intent,
- mines are not sold to a more junior company prior to closure without a full commitment to closure and possibly some liability for closure remaining with the original owner, and
- budgeting for closure is adequate (based on detailed designs and studies), funding is secure and not drawn down until successful rehabilitation can be proven.

A walk-away solution is desirable for every closed TSF, but in reality this is difficult to achieve and should not be under-estimated. A much more concerted effort is required if the mining industry is to change its legacy related to closure, and while some mining companies are endeavouring to turn the titanic, it is not a quick process.

Knight Piésold is able to undertake all aspects of TSF design and integrated closure studies, and where necessary bring in specialists to support them. Many mining codes require a design for closure approach, and in particular the Global Industry Standard for Tailings Management requires that feasibility level closure designs/studies are in place pre-mining, and updated during operations, before being converted into detailed designs shortly before closure.



Knight Piésold (Pty) Ltd

Tel: +27 11 806 7111
1 Discovery Place, The Ridge, Sandhurst, Sandton | Gauteng | South Africa | 2196