IMPLICATIONS OF DIFFERENT TAILINGS DISPOSAL OPTIONS ON FUTURE REHABILITATION

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IMPLICATIONS OF DIFFERENT TAILINGS DISPOSAL OPTIONS ON FUTURE REHABILITATION

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1 INTRODUCTION

Tailings storage facilities are among the largest structures created by man; they frequently cover an area as large as 3,000 ha and have embankment heights in excess of 100m. Their impact on the environment is significant and long lasting; and this is so even if they are well designed, well constructed, and properly closed.

Tailings impoundments are geomorphologically unstable. They are susceptible to both wind and water erosion as a result of the fine particulate size of the tailings and the generally steep side slopes of the containment embankments. The geochemistry of the tailings has the potential to indefinitely affect air quality, surface water quality and groundwater quality. Surface water that comes into contact with the tailings, tailings evaporates, and/or tailings precipitates may affect water quality beyond the confines of the facility.

It is therefore necessary to isolate the tailings from the environment or at the least confine the tailings to a zone around the tailings storage facility. Costs associated with ensuring that this isolation lasts for hundreds of years can significantly affect the viability of mining projects; it is therefore vital that these costs be reliably accounted for at the project feasibility stage and appropriately minimised as the project progresses through design to operation.

The last thirty years have seen a significant change in design emphasis. Gone are the days when the key design focus was simply on minimising capital and operating cost with a small provision to establish “a bit of vegetation” at closure. Today it is necessary to evaluate alternative tailings storage options that have as their objective minimisation of total cost inclusive of realistic and defensible decommissioning cost.

This paper discusses the following:

- What it means to design for total cost inclusive of long-term, post closure cost,
- The primary motivators for this approach,
- What the primary considerations are and

- What methods are being used to assess options to realistically estimate as well as minimise the total cost.

The paper focuses on milled tailings that are disposed of as slurries since not only is this the most common situation in mining and mineral processing but it is also the situation where there is potential for the greatest impact at closure and post-closure.

2 WHY DESIGN FOR CLOSURE?

Newmont has stated their world-wide provision for closure of tailings and waste rock dumps constitutes some 65% of the total closure cost provision. Tailings storage facilities closure is the largest part of this cost. Other major mining corporations have found similar proportioning in their closure cost provisions as one by one they have been forced into taking serious, hard looks at realistic closure cost estimates. Looking back over the trends in closure cost estimation it has become apparent that over the past thirty years closure-cost estimates have doubled every 10 years. This exponential increase is not necessarily a function of the increased scale of a particular mine's operations but more a function of a more honest estimate combined with more stringent closure criteria. As these increases in closure cost have become apparent mining company CEO's have become increasingly sensitive to the effect of these increases on the balance sheet; and unit trust managers and shareholders have begun taking these issues into account in assessing share prices. Mining due diligence studies focus not only on the reserve and the quality of the mining operation but also on closure liability and closure cost provisions.

Investors, financiers, regulators and interested and affected parties are placing increasing emphasis on sustainability thereby elevating environmental liability to a similar status as economics and community health and safety. This is driven, in the mining industry by mounting dissatisfaction with the mining legacy and the apparent short term thinking that characterises this legacy.

It is estimated that in Western Australia alone there are over 300 tailings storage facilities, fewer than 100 of which are actually in operation. The majority are retired structures on mines which are no longer operational. The tailings facilities have never been formally closed. The main reason for this is that there is no money left to pay for the required closure measures as a result of inadequate provision and increasingly stringent closure requirements. So it is easier to delay the closure sign-off process and simply postpone the inevitable. Many of these facilities have been abandoned to the State Government with companies and directors long gone. Other

States also experience reluctance to proceed to closure through the negotiation of closure criteria and agreement of compliance periods. Understandably, therefore, elected officials are wary of expanding this legacy, and regulating officials are being given increasing powers to reject mine development applications on the grounds that the long-term liabilities have not been minimised. Indeed, past failure of a mining company to make adequate provision for closure of an existing property is an important issue being taken into consideration for future mining applications.

As a result, closure has become an essential up-front design consideration through the permitting and licensing processes and tailings storage facilities feature high up on the check list.

3 TAILINGS OPERATIONAL DESIGN REQUIREMENTS

It is appropriate, at this stage, in order to contextualise “design for closure” to explore the primary requirements for a tailings storage facility that simply meets operational requirements. These may be listed as:

- Minimum capital cost which translates into lowest possible confining embankment heights, close proximity to the process plant so as to minimise the cost of pipelines and pumping systems.
- Containment of the tailings in a safe and secure manner during operation. This translates into the incorporation of sufficient underdrainage systems that will enable slope stability criteria to be met.
- Low operating cost both in terms of costs for raising confining embankments with time as well as for operating personnel commitments. This translates into low technology and a proven, robust design.
- Minimisation of seepage to surface, to the regolith and to groundwater aquifers through location of the tailings facility on low permeability soils and the provision of appropriate underdrainage systems.
- Safe management of the supernatant pond which generally necessitates the provision of a holding facility for the tailings liquor and, if permissible, discharge of excess stormwater to the environment.

Under this scenario liability issues centre around a duty of care and the standard of that care in respect of:

- Health and safety

- Environmental protection

The nature of most mineral extraction operations is such that the tailings generally emerge as a mix of liquor and milled rock which form tailings solids. While there have been great strides in the development of large scale filtration facilities that enable separation of the solids and the effluent within the process plant area the costs of this technology are sufficiently high that they are only applied in situations where water is in particularly short supply or there are concerns about groundwater contamination. The majority of tailings storage facilities are operated as slurry containment facilities into which the tailings are pumped as a mixture of water and solids. In most of these instances the slurry has undergone a degree of thickening in the process plant such that the percent solids in the slurry is between 45% and 55%. Increasingly advantage is being taken of improving thickening and pumping technology and solids of higher consistency are being generated at percent solids above 60% and even up to 80% by which stage the slurry generally behaves as a thick paste.

Typically, tailings facilities that emerge from an assessment of the operational design considerations have the following features:

- Earthfill confining embankments constructed with outer slopes at 1:3 to allow for contour ripping and the establishment of vegetation on the side slopes.
- Underdrains at ground level along the inside toe of high embankments generally only along the lowest topographical parts of the perimeter.
- A pad drain located under the supernatant pond area.
- A decant system to remove supernatant as well as storm water from the surface of the tailings facility.
- A reclaim pond.

It is now appropriate to explore the potential closure issues that need to be considered in "designing for closure".

4 TAILINGS REHABILITATION AND CLOSURE CONSIDERATIONS

The principal environmental problem at closure and over the long term in regard to tailings storage facilities is one of ensuring that the tailings and related by-products remain confined within the facility. Failure to ensure containment increases legal liability through a duty of care to prevent nuisance or negligence. Increasingly mining companies are being sued years after closure as a result of contamination or health effects arising from dispersion of tailings and related by-products. Factors that make long-term containment difficult and expensive to achieve relate primarily to water and wind dispersion which may be summarised as:

- Dispersion of dissolved contaminants by water, both surface as well as subsurface water.
- Dispersion of tailings and by-product solids by water erosion.
- Dispersion of solids by wind erosion.

Parties living in close proximity to a tailings facility may not only be directly affected by dispersion of the contaminants but may also undergo injury should they access the facility and fall into sinkholes, fall down near-vertical slopes generated by water erosion, or be trapped by the collapsing side slope of an erosion gully.

The persistent and pervasive liabilities of nuisance and negligence remain attached to the tailings facility in perpetuity. These liabilities are strongly related to control of dispersion.

The dispersion modes are elaborated on below.

4.1 Dispersion of dissolved contaminants

During operation of the tailings storage facility provision for the maintenance of decant water, underdrainage water and seepage recovery water systems is a straight forward matter. At the cessation of operations on the facility there is no process-related water to contend with or a need to return this water to the processing plant, but, there is a need to control stormwater which may, as a result of contact with the tailings, be contaminated. Somebody has to be on site and ready and able to deal with excess water. The way around this is of course to shape the final facility to preclude capture and/or containment of stormwaters.

In addition, for a number of years after closure, generally 5 to 20 years, depending on the nature of the tailings and the seepage conditions at closure, there will be continued drainage through the underdrainage systems as well as into and through the near surface soils - unless the facility is lined. This water will most likely be contaminated and will require capture and control. Again it will be necessary to have somebody on site to do this. Unless the final cover is essentially impermeable, this requirement will continue forever.

Over the long term, depending on the nature of the cover placed over the tailings surface, rainfall will infiltrate into the tailings over the course of the wet season. Some of this infiltrated water will be exfiltrated during the dry season as a result of capillary action but this will bring to surface salts and precipitates that will dry and dust on the surface. These salts will be dissolved by rainwater which will, as a result, be contaminated.

In designing for closure it is therefore necessary to focus on a cover design that will allow appropriate long-term management of water infiltrating the tailings as well as management of migrating salts.

4.2 Water erosion

Of the issues to be confronted at closure that of water erosion is the most intractable and has the potential to attract the greatest liability.

Water accumulating on the surface of the tailings facility will be elevated and therefore contain potential energy. Provided this water is not released for example by paddocking off the top surface and holding the water, the effect of the potential energy will not be of concern. However, if the water escapes suddenly the accumulated potential energy will generate severe erosion. Moreover, to minimise the volumes of infiltrated water that need to be dealt with it is preferable to avoid storage and allow this water to flow off the facility to ground level naturally and at shallow, steady gradients so as to minimise erosion. The sides of the channel also need to be shallow to prevent erosion.

Water flowing down the side slopes after closure will erode the cover and may expose the tailings. As the flow rate increases so will the erosive power. Evaluation of most commonly applied erosion equations will show, however, that while erosion is directly related to flow rate it is more sensitive to slope angle. It is therefore generally preferable to have a longer flatter slope than a shorter steeper slope.

In designing a tailings cover for closure, therefore, it is essential to ensure that the surface topography and the armouring materials that form the outermost layer of the cover are matched so as to control the rate of long-term erosion. This may include placement of a layer of waste rock on the outer face of the slopes.

4.3 Wind erosion

As the surface of the tailings dries out it will become increasingly susceptible to wind erosion causing dust clouds and plumes. Generally, however, measures taken to address infiltration, such as covers, and storm water erosion such as armouring layers, all but eliminate wind erosion as a factor. Where the tailings is considered benign, such is in alluvial diamond mining where no reagents are added to the tailings, it will often be sufficient to provide for vegetation of the surface of the tailings. This too will be effective in minimising wind erosion once it is fully established. The challenge, in this case, lies in getting the vegetation established. This is because vegetation takes place after the cessation of operations and the near surface tailings dries out. As the tailings dries it becomes more susceptible to wind erosion and duning over seedlings, preventing their establishment.

5 CLOSURE VERSUS OPERATIONAL REQUIREMENTS

In many ways the purely operational requirements for a tailings storage facility are at odds with the requirements for long-term duty of care. It will therefore be necessary to strike a compromise on a number of issues. Typical examples are:

- Proximity to the plant. The closer the tailings facility is to the plant the less the operational cost. Conversely a site with low permeability in situ soils and geomorphic stability may be further from the plant and more costly to operate but cheaper to close.
- Side slopes. Operational economics require that side slopes should be as steep as stability will permit. This minimises foot print and minimises earthworks volumes and cost. However, closure requirements call for shallow slopes to minimise long-term erosion and promote the establishment of vegetation. If real estate allows, it would be preferable to create an outer profile that can be re-shaped to yield a slope face of 1:6 or flatter depending on the nature of available armouring material.
- Underdrainage. The operational requirement to maintain stability and reduce groundwater contamination through the inclusion of underdrainage systems introduces a need to manage the residual flow from the underdrains long after closure. Design options that should be evaluated include:
  - Evaporation of this water in a lined pond that is rendered inaccessible to wildlife and people
  - Discharge to the abandoned mine workings via boreholes into the workings
  - Where there are no other options but to seal off the underdrain outlets and retain the infiltrated water within the storage facility there will be little choice but to cover the surface with a series of cover materials one of these being a geomembrane liner.

- Beach profiles. During operations, to control stormwater, reliance is often placed on the freeboard generated by the beach slope from the confining embankment to the pond. However, at closure, it is preferable not to hold the water on the facility and therefore desirable to cut a discharge channel from pond level to ground level through the tailings. The steep beach slope will increase the volume of material to be excavated to form the channel. The design approach would be to orientate the layout of the facility such that the channel is as short as possible and drains to a topographic high on the natural topography. This will keep the depth of the channel at a minimum.
- Gravity decant. During operation is often more convenient to install and operate a gravity decant. This involves low maintenance and is simple. However, historically, buried structures such as pipes and decant towers have, post-closure, deteriorated with time and caused sinkholes, subsidences, and concentrated erosion. Design should consider using a pumped decant system.
- Slurry density. Thickening equipment is both expensive and difficult to operate as are slurry pump systems. As the slurry density increases these issues increase accordingly. For example, in the case of hard rock, milled tailings products, it is much more convenient operationally to thicken and pump a slurry at conventional percentage solids of 45% to 50% solids than at 68% solids, and to manage the water at the tailings facility. However, to manage this volume of water it is necessary to provide a concave top surface so as to provide capacity to capture and control the supernatant water on the tailings surface as well as provide a suitably sized reclaim facility. At 68% solids it is possible to develop a high density tailings storage with a convex surface profile and minimal supernatant water. In the case of an advancing cone it is possible to reduce the storm holding capacity through progressive reclamation of the placed tailings as the cone moves forward. High density facilities have the additional advantage in that it is much simpler to get heavy earth moving equipment required for placement of covers than is the situation for conventionally deposited tailings where the fines in the pond area can prove particularly difficult and costly to traverse equipment over.

6 COST CONSIDERATIONS

Compliance with regulatory and sustainability requirements in respect of operation and closure requirements generally boils down to a trade off between cost and reliability. However, the technology of closure is an inexact science and therefore while it is straightforward to specify requirements to be met it is considerably more difficult to be confident that these requirements will be met over hundreds of years regardless of the levels of expenditure. What is practical is to aim to apply the 80:20 principle which argues that it is possible to achieve 80% of the requirement through the expenditure of the first 20% of the money. Thereafter returns begin to diminish to the stage where the expenditure taken to achieve 90% of the requirement is doubled to raise this to 95%.

A sensible way to approach this conundrum is to set about the design process by considering a number of alternative tailings storage facility geometries each of which meet the operational requirements of capacity, stability and ease of operation, but variably meet closure requirements. The differences between the alternatives will be reduced to:

- cost
- implementability or practicality, and
- reliability or risk of failure.

These are discussed in more detail below:

6.1 Cost

Logically, in order to effect comparison on the basis of cost between alternatives, it is necessary to derive a life of project capital cost for the tailings storage facility where this capital includes those monies that would be expended at the time of closure. Costs should be determined in present day terms and grouped by time of expenditure. Equally logically, it is necessary to derive operating costs but it is suggested that these operating costs should include maintenance costs that would extend into the compliance period ie that period after which regulators, who are ultimately destined to take over the closed facility in perpetuity, would need to be convinced that closure criteria have been met.

At this stage most cost accountants and senior managers would apply a net present cost calculation to take into account the time value of money. This is the traditional approach but has its flaws. The most important flaw is that the calculation continually shows that, for a life of mine of more than 10 years it is financially more attractive to spend less up front and more at closure. As a consequence most mining operations minimise up front capital only to find later that:

- The costs were underestimated at the time of design and selection between alternatives
- Costs have escalated more than anticipated, since while new technologies for tailings closure are continually being developed these are generally aimed at improving performance and reliability at closure thereby raising an expectation of what can be achieved even if this costs more
- Goal posts have moved over the period up to closure and therefore closure requirements are more onerous. The past 35 years of environmental revolution are testament of the extent to which public expectation and associated legal liability have ramped up closure minima.
- While money has been provided for in the accounts, at closure there is insufficient cash available to cover the closure expenditure and a gap between what is available and what is required to effect closure. Bonds levied by the regulators have never been considered adequate to bridge this gap and, to exacerbate matters, these have fallen further behind as goal posts have moved.

It is contended that the cumulative affect of the above factors is the primary reason so few mines have been closed in Western Australia and indeed over the rest of Australia.

Of the above factors that relating to adequate cash availability is the most straight forward to manage as this simply requires financial discipline. To some extent the issues of initial under-estimation and escalation can be accounted for by regularly, say every two years, re-visiting the closure cost estimate and updating the provision and indeed this is a practice followed by most of the major mining corporations.

It is the factor of moving goal posts that is most difficult to account for as it requires "crystal ball gazing". The development of sustainability and responsible mining concepts over the past 10 years has, however, enabled the ideal long term vision to gain focus. Most mining companies still, however, consider the actual end effects of sustainability thinking too idealistic and too expensive. As a result "long term" becomes "whatever the regulators will accept" instead of 500 years and uncertainty in the costs as a result of blurs on the intended end result remains high.

It is suggested that this uncertainty largely offsets the financial "benefit" of expenditure being delayed through to closure. It is therefore suggested that it would be more prudent and pragmatic to base ost comparisons and selection between alternatives on present day costs, i.e., put aside the net present cost comparison. It is reasoned that it is more responsible to base the selection on the best present day estimate which, in turn, is based on present day technology and predictive ability, and present day closure requirements. This approach will not improve closure cost estimation – that can best be achieved by regular reviews of closure costs with time – but it will prevent selection of alternatives that are based on short term thinking but have severe long term consequences

Consider an example. A mining company has two alternative designs for a new tailings storage facility. Alternative 1 has a capital cost of $6m, an annual operating cost over 10 years of $3m and an estimated closure cost of $15m ie a total cost of $50m. Alternative 2 has a capital cost of $9m to establish flatter side slopes, an annual operating cost of $3.5m to allow for progressive rehabilitation over 10 years and an estimated closure cost of $5m. Assume the discount interest rate is 5%. Table 1 summarises the financial analysis at design and at closure under the assumption that, for the reasons outlined above, closure costs for the tailings storage facility have doubled over the 10 years of operation.

Table 1: Comparison of alternatives at design and at closure – doubling of final closure cost (all values in $m, period is 10 years, rate of return is 5%, closure costs double over 10 years)

Cost Comparison at Design					
	Capital	**Annual Operating**	**Closure**	**Total**	**NPC analysis**
Alternative 1	5	3	15	50	$37.37
Alternative 2	9	3.5	5	49	$39.10
	Final Comparison				
	Capital	**Annual Operating**	**Closure**	**Total**	**NPC analysis**
Alternative 1	5	3	30	65	$46.58
Alternative 2	9	3.5	10	54	$42.17

It is evident from the table that at design stage the net present cost (NPC) analysis would have recommended Alternative 1 whereas at closure Alternative 2 is clearly the better option. If the decision at design stage were based on total cost exclusive of the discounted cash flow analysis the decision would have been in favour of Alternative 2 from the outset. In fact even if the closure costs increased by 25% the analysis would show that Alternatives 1 and 2 would have been equivalent in an NPC analysis as indicated in Table 2 below but the more cost effective proposal would still have been Alternative 2.

Table 2: Comparison of alternatives at design and at closure – increase of 25% in final closure cost (all values in $m, period is 10 years, rate of return is 5%, closure costs increase by 25% over 10 years)

Cost Comparison at Design					
	Capital	**Annual Operating**	**Closure**	**Total**	**NPC analysis**
Alternative 1	5	3	15	50	$37.37
Alternative 2	9	3.5	5	49	$39.10
	Final Comparison				
	Capital	**Annual Operating**	**Closure**	**Total**	**NPC analysis**
Alternative 1	5	3	18.75	53.75	$39.68
Alternative 2	9	3.5	6.25	50.25	$39.86

7 RISK ASSESSMENT STRATEGY

Since cost and reliability are congruent if not linearly related it is essential, in comparing alternatives, to bring to bear an assessment of reliability. The focusing question relates to whether, if a given cost is expended, the closure measure will achieve the expected performance. The most practical method of evaluating reliability is through a failure mode and effects analysis (FMEA) that brings together the likelihood and consequence each accounted for separately for each failure mode. The Australian Standard 4360-2004 provides a companion document with guidelines that set out a number of practical methods for carrying out an FMEA that leads to the development of a qualitative risk level for each tailings storage facility alternative. Inputs and considerations for the assessment process are set out below.

7.1 Typical failure modes

Typical failure modes that should be considered for the closure situation are:

- Discharge of contaminated water to surface from underdrains
- Dispersion of tailings due to erosion through the cover
- Development of gulley depths in excess of 1m on the side slopes of the confining embankment
- Formation of sinkholes around decant structures

7.2 Assessing likelihood ratings

In deriving the levels for the likelihood of each failure mode it is prudent to take into consideration the following factors in order to better differentiate between the alternative closure designs:

- The reliability with which the designed closure measure can be implemented. This would incorporate the concept of practicality. Factors that may influence this may include access conditions, practically achievable construction quality, availability of construction materials etc
- Technical complexity or design elegance and track record
- The reliability of methods of prediction of the performance of the closure measure

These factors would be used to qualify the selection of likelihood ratings and would be incorporated into the likelihood assessment tables. Table 1 sets out potential descriptors

Table 3: Suggested descriptors for incorporating implementability, technical complexity and predictability into closure risk assessment

Implementability	Technical complexity	Predictability of performance
Easily implemented	Established, reliable technology	Well established
A little tricky	Pilot scale trialling required	Limited testing and analysis required for confirmation of long term performance
Difficult	Requires full scale trials over two to four years	Extensive testing and analysis required for confirmation of long term performance
Very difficult	Requires full scale trials over five or more years	Untried. Testing and analysis highly approximate , long term performance uncertain

7.3 Typical consequences

Typical consequences that may need to be considered are:

- Impact on health and safety
- Impact on the natural environment
- Impact on social, cultural or heritage
- Impact on reputation in respect of the community, regulators, media and public
- Exposure in respect of legal liability

7.4 Risk levels

Typically the output of a risk assessment is a risk level for each category of consequence as determined from a risk matrix such as set out in Figure 1 below.

Figure 1: Typical risk Matrix

Likelihood Rating	Consequence rating				
	1	2	3	4	5
A	1	3	6	10	15
B	2	5	9	14	19
C	4	8	13	18	22
D	7	12	17	21	24
E	11	16	29	23	25

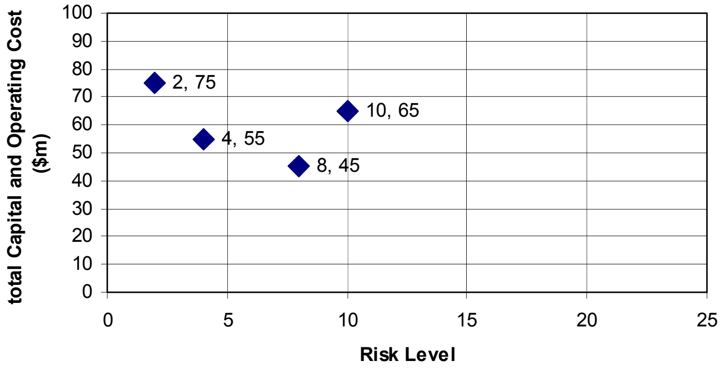
Most mining companies will have established risk level tables relating the likelihood and consequence ratings. More specifically, these organisations will have pre-defined risk levels below which they are committed to conduct their business and will not accept projects that have risk levels in excess of the pre-defined level.

7.5 Comparison of alternatives on the basis of cost and risk

Commonly the design process is iterative. An alternative layout and mode of operation is defined a conceptual design beyond closure prepared and a risk assessment carried out. The results of the risk assessment are used to refine the design details in such a way that a design that meets the pre-defined risk level is produced. Where this proves impractical the alternative is eliminated as being fatally flawed.

After design the risk assessment process is repeated and the alternatives compared. It is possible that at this stage that a plot of cost against risk level could resemble that in Figure 2 below. The alternatives that plot closest to the origin would be regarded as most favourable.

Figure 2: Typical Cost vs risk level plot



8 CONCLUDING REMARKS

Detailed consideration of closure during the siting, selection and design of a tailings storage facility in order to manage risks and financial provisions is not only prudent but is fast becoming mandatory in the current era of emphasis on responsible mining, sustainability, and good governance. Mining CEO's are increasingly sensitive to surprises on the balance sheet and unit trust managers and shareholders are taking these issues into account in assessing share prices.

Tailings storage facilities can account for the lion's share of the closure cost of a mine but, equally importantly, they are usually responsible for the majority of the residual liability associated with a mining operation.

Water erosion and the resulting geomorphological changes remain the most intractable challenge facing tailings engineers. Erosion is inevitable over the long term; it is a question of the rate of erosion and the extent to which it is practical to slow this rate down by means of surface water control and armouring.

There are a range of methods for storing hydraulically placed mill tailings with options available in respect of geometry, method of tailings discharge, pond management and tailings deposition properties. For a given mine site these options have varying implications for closure that need to be thoroughly assessed at detailed design levels of accuracy through an iterative design-risk assessment process in which all alternatives are sufficiently engineered to comply with risk maxima.

It is vital that selection between the options be based on realistic and comprehensive estimates of capital and operating costs inclusive of closure up to hand over to the regulators and a comparative risk assessment. The historical practice of designing for operation and basing the design on a simplistic costing of a general cover has shown itself to be totally inadequate.

It is suggested that, in order to more realistically account for continual change in closure requirements and performance with time, net present cost analyses should be foregone in favour of a straight forward present day comparison of total costs where these costs are based on detailed design, present day technology and are made up of the capital cost, inclusive of the closure cost, plus the cumulated annual operating cost extended right through to the end of the compliance period. By excluding the discounted cash flow analysis and basing the assessment on the best information in the present day it will be possible to eliminate an important element of skewness that has become evident in of the net present cost analysis process.

Finally, it may be worth taking note of this author's considered opinion formed over nearly 30 years of designing and observing tailings storage facilities. The facility layout that enables shedding of water, slopes as flat as 1:20 or flatter and is of gently undulating topography will incur the minimum closure cost. This geometry is achievable through the application of thickening technology to generate high density tailings with which gently sloping tailings mounds can be formed. This method of tailings deposition reduces dependency on underdrainage, sometimes permitting its omission completely and has no need for a decant facility – a simple spillway arrangement that is external and easily dismantled at closure will suffice. Access for equipment is good and progressive rehabilitation is feasible if the site lends itself to an advancing cone geometry. Analyses to date indicate a considerable improvement in operating cost and a substantial reduction in closure cost compared with facilities based on conventional slurry densities.