

The role of key performance indicators throughout the mine life in achieving closure objectives

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Abstract

At the industry level, there is recognition that the principle of designing and operating for closure is necessary to achieve successful and sustainable post-mining outcomes. Despite recognising the benefits of applying these principles, many mine operators struggle with the apparently conflicting objectives of run-of-mine profitability and life-of-mine costs and liabilities. This paper makes the following interrelated arguments from our experience. Closure efforts can be made significantly more effective (and ultimately less expensive) if closure considerations are included in the day-to-day operations of a mine. Closure is currently not being adequately considered and embedded into all stages of the mine lifecycle due to a reluctance to accept present expenditures to reduce long-term costs. An integrated and progressive approach to closure is not merely about the temporal redistribution of costs; rather, there are real, immediate and long-term benefits to incorporating closure into day-to-day activities that need to be considered alongside other financial calculations. Key performance indicators (KPIs) can be a useful tool to facilitate the cultural and organisational change required to shift towards a more embedded, integrated, progressive, and ultimately effective closure process. Incorporating KPIs earlier in the mine lifecycle will offer the greatest benefit, and KPIs developed as part of a closure execution project can also increase the likelihood of achieving positive closure outcomes. After elucidating these arguments and providing examples of the benefits of KPIs as a vehicle for organisational change, this paper suggests some areas to consider for KPIs for companies looking to effectively integrate progressive closure considerations into their broader mine plans.

Keywords: *behavioural change, life of asset value, KPIs, NPV, organisational change, progressive closure*

1 Introduction

Despite the increased recognition and governance of mine closure within most mining jurisdictions, significant challenges remain for companies seeking to pursue effective closure processes, including ill-defined closure completion criteria, pursuit of unrealistic and/or non-optimal end-goals (i.e. returning land to pre-use conditions and relinquishment), unclear standards, and confused expectations from stakeholders (Holmes et al. 2015). Companies which designed and developed assets prior to the emergence of mandated closure requirements face particular challenges, as they often have limited financing set aside for closure planning and reclamation activities at these sites (Pedlar-Hobbs et al. 2015).

Based on our experience in the mining sector and other industries, we consider the following interrelated arguments to be true:

1. Closure efforts can be made significantly more effective (and ultimately less expensive) if closure considerations are included in the day-to-day planning and operations of a mine, (i.e. 'progressive closure').
2. A reluctance to accept present expenditures to reduce long-term costs and/or generate added business value drives a behaviour of closure not being adequately considered and embedded into all stages of the mine lifecycle.

3. Contrary to many companies' beliefs, an integrated and progressive approach to closure is not merely about the temporal redistribution of costs; rather, there are real, immediate and long-term benefits to incorporating closure into day-to-day activities that need to be considered alongside other financial calculations.
4. Key performance indicators (KPIs) can be a useful tool to facilitate the cultural and organisational change required to shift towards a more embedded, integrated, progressive, and ultimately effective closure process.
5. Incorporating KPIs earlier in the life-of-mine (LOM) will offer the greatest benefit; however, KPIs developed as part of a closure execution project can also increase the likelihood of achieving positive closure outcomes.

In general there is a recognition within the industry that progressive closure should be fully integrated into LOM plans. As a consequence, practices and legislature are adapting to encourage progressive closure but we still see examples of operational decision-making which even the operators acknowledge is going to have a detrimental effect on closure costs and outcomes. This raises the question: what more can the industry do to undergo the organisational and behavioural changes required to drive an integrated and progressive approach to closure throughout the mine lifecycle?

2 Current approaches to closure: kicking the bucket down the road

There are many examples of mines opened and/or closed before modern mine closure legislation and practices (see for example Canada's National Orphaned/Abandoned Mines Initiative, or the Geological Survey of Western Australia's inventories of abandoned mine sites). While acceptable closure outcomes can still result, they are often at the expense of costs and/or timelines that are many times higher than ever anticipated. Elliot Lake in Ontario is an example of this. The mines and mills at Elliot Lake operated on and off from 1955 to 1996 and closure planning started in the early 1990s (Berthelot et al. 2019). The town area has been successfully repurposed to attract retirees and there have been some successes with managing the environmental legacy of the tailings (Nicholson et al. 2012). Notwithstanding these successful outcomes, the area is subject to a post-closure system providing for perpetual monitoring and management due in part to 'mistakes ... made in the handling of these uranium mine wastes in the past ...' (Kirkwood et al. 1996).

While a lack of regulatory pressure or socio-environmental understanding may in part explain delayed closure planning in the past, we have observed when working with current operators, examples of reactive rather than proactive approaches to closure planning, where end of mining consequences have not been adequately considered and untenable costs and delays have resulted.

Without fully considering during initial design and through operations issues such as final landforms, the size of the operational footprint, prevention or operational clean-up of impacts to the environment, or sustainability of local communities, amplified challenges are introduced in achieving acceptable and cost-effective closure outcomes. Late closure planning exposes the company to the combined constraints of fewer human and financial resources and a disturbed environment that is likely to restrict the cost-effective choices available.

There may be several stated and unstated reasons that companies have yet to adopt an integrated, progressive approach to closure. These may include: an assumption that 'mine closure' occurs after production ceases, uncertainty of some or all aspects of the final physical or geochemical stability, a reluctance to set unrealistic expectations due to potential stakeholder reaction regarding closure options, concerns about staff retention or unease surrounding the duration of their employment if closure is discussed, cash flow pressures or a belief that incorporating closure into operating practices requires expenditure beyond yearly operation requirements.

In our experience, we have seen managers and executives who are reluctant to accept what they see as a temporal redistribution of costs from the future (i.e. at point of mine closure, which is not immediately relevant to their day-to-day performance and metrics) to the present (i.e. day-to-day operations, the

performance of which directly and presently affects them) due to the time value of money, where ‘a net present value (NPV) analysis may show a strong financial argument for pushing closure works to as late a date as possible’ (International Council on Mining and Metals [ICMM] 2019). Where cash flow is constrained or there are competing priorities for equipment and labour, companies – and the individuals responsible for decisions within them – may push planned closure activities aside as there is little incentive for them to make the future a priority when they are being measured based on what they accomplish today.

While important, NPV is not a complete business case for a number of reasons, described below.

2.1 NPV assumes the scope (and cost) of an activity will remain static if delayed, which is often not the case with closure

Failure to consider and plan for closure throughout the mine life can actually complicate closure efforts, expanding the scope and costs of closure planning beyond what it would have been if done systematically.

An additional factor contributing to the increases in closure costs over time is that conceptual closure plans often fall short of reality. This may occur when companies make promises and raise expectations about what closure will entail (often underestimating what will be required) in order to facilitate project approvals. The financial implications of this lack of imagination and underestimation of what a successful closure process will entail may be exacerbated by changes in mine development, operating practices, and waste management approaches over the LOM that are not well-accounted for in conceptual closure plans. These factors (underestimation of closure demands in conceptual closure plans and changing conditions on the ground that are not accounted for) combined can drastically increase the future scope and costs of closure, unless companies pay ongoing attention to developing closure-related requirements and opportunities through a progressive closure approach.

2.2 The integration of closure activities in progressive manner can actually increase the NPV of the mine

A study by Churr et al. (2014) for example found that, if a company integrates relinquishment planning into the broader mine plan, the costs for specific metrics (in this case water management) can be significantly reduced over the LOM as well as post-closure. Specifically, they used a case study of an opencast coal mine in South Africa to demonstrate the effects that changing the stripping and backfill methods during mining operations might have on the NPV (according to financial models). Critically, they concluded that a change in rehabilitation practices actually increased the NPV of the mine by 20 to 45% by increasing the probability of relinquishment post-closure.

2.3 Progressive, integrated closure can also have other immediate financial benefits that may help offset the temporal distribution of costs from future to present

As an example, at the Rio Tinto Diavik Diamond mine in Canada’s Northwest Territories, project managers worked towards closure as part of day-to-day operations. Specifically, instead of depositing waste rock on a short haul dump and then moving it to its final location at closure, the material was directly hauled to its final location to meet closure criteria. In this case, net present costs were reduced by 10%, and closure landforms were completed ahead of schedule and acid rock drainage (ARD) risks are reduced (ICMM 2019, p. 42).

In general, companies recognise the importance of a clear closure plan, and would be hard pressed to dismiss the benefits (both short- and long-term) of adopting a progressive closure plan. Nevertheless, in our experience, actually implementing progressive closure remains ancillary and under-prioritised in many cases, seen as a ‘nice to have’ but not critical to day-to-day business operations. This prioritisation of NPV (often with static and unrealistic cost assumptions and exclusions) combined with a failure to fully integrate progressive closure considerations calls for a cultural shift within organisations to allow them to see progressive closure actions as critical to a mine’s overall success as the extraction of ore.

3 Planning and operating for closure

According to the ICMM, ‘progressive’ closure is the implementation of closure activities through the LOM. This can include components of mine management, optimisation of physical mine operations, ongoing stakeholder engagement, financial decisions and efforts to mitigate risks and reduce liabilities, and identification of opportunities for broader, more integrated contributions to the mine area such as re-purposing/co-purposing of mine infrastructure and lands. It can be summarised as planning and operating the operation with closure in mind.

A progressive approach to closure can also give an organisation direct experience with closure implementation, thereby reducing uncertainties in closure costs, leading to increased investor confidence and potentially freeing up credit (ICMM 2019, p. 40–41).

With a progressive approach to closure, a wide range of opportunities for lasting benefits that companies might otherwise not realise can also be recognised and planned for adequately (ICMM 2019 p. 8; Churr et al. 2014). Companies and regulations (see for example, Clark & Clark 2005; Hockley and Hockley 2015; Vivoda et al. 2019) have historically tended to conceptualise closure in terms of ensuring physical and chemical stability, with social transition being a more recent consideration. However, there are broader, more integrated components of closure that can bring significant value to a company’s efforts to manage an asset in the post-mining phase (i.e. after mine closure). These higher-value components include beneficial use of site land and assets (which may entail various forms of re-purposing/co-purposing) as well as a more integrated approach to planning and execution that contributes long-term sustainable value to the region in which closure will occur, and seeks to manage closure progressively (i.e. across the LOM). A progressive approach to closure can therefore be helpful both in addressing day-to-day decisions within the fence-line (i.e. direct mining operations) but it can also help facilitate a truly integrated approach to land use planning by routinely considering the physical, social, and economic landscape of a mining region and identifying evolving opportunities for positive closure contributions therein.

However, it is not simply about capitalising on benefits flowing from an integrated, progressive approach to closure; beginning to not only plan but also act early to prepare for closure can have additional benefits in the case that a mine closes unexpectedly (see discussion below). To demonstrate the frequency of this early closure phenomenon, one study of Australian mines found almost 70% of mines closed over the last 25 years of the previous century were closed unexpectedly or prematurely (Laurence 2002, in Commonwealth of Australia 2006). Therefore, working towards closure on a daily basis, versus waiting until the anticipated end of mine life, can help mitigate the negative effects of early/unexpected closure (Commonwealth of Australia 2006).

4 Current KPIs in the industry

It is for the above reasons that external stakeholders are increasingly demanding that companies integrate closure considerations into their day-to-day operations and decisions. Thus, we see enhanced focus by industry and financiers as evidenced by the publication of guidance documents such as the ICMM Tool Kit and the IFC Performance Standards and Guidelines for closure. The objectives of these various criteria are not intended to be an end-of-life one-off checklist, but rather are meant to ‘serve as a key planning and risk management tool’ to be used throughout the LOM cycle; that is, from conception/design to operations and, ultimately, closure (Holmes et al. 2015). The ICMM guidelines suggest a range of potential KPIs covering the following aspects:

- Closure risk and management systems.
- Closure liability management (financial).
- Stakeholder engagement and social impact.
- Operational management.

Regulatory bodies are also introducing requirements to track progressive closure activities, for example the Queensland (Queensland Government 2021) and New South Wales (NSW Government 2021) governments recent requirements to track and report annually on progressive rehabilitation. A more common regulatory requirement is to require a company to submit a bond based on the closure liability outlined in a mine closure plan. Even this level of assurance and tracking is not universal; a recent survey of member governments by the Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF) found that 24% do not require a mine closure plan, 14% do not require any form of financial assurance, and only 45% require that the full amount of the estimated closure cost (based on the company's submitted closure plan) is secured through financial assurance (Stevens 2021).

A review for this paper of publicly available information on executive bonuses for ten medium to large mining companies based in North America, South America, the UK and Australia indicates that they still focus largely on cash (in the form of measures around free cash flow, earnings per share, total shareholder return, and return on capital employed) and safety statistics, but are also starting to incorporate some ESG elements. The latter KPIs are still relatively broad; they often only specify climate change metrics amongst broader ESG goals. Closure objectives or whole life of asset value, (i.e. including the active and passive closure periods), are not (yet) called out specifically.

5 The role of KPIs in encouraging organisational change

KPIs are important to organisations in the following ways (Parmenter 2015):

- Aligning and linking daily actions to the critical success factors of the organisation.
- Improving performance.
- Encouraging ownership of the wider goals leading to empowerment and fulfilment.

In order to be successful, KPIs need to be carefully and thoughtfully derived considering all the above factors. KPIs which are not well thought out and do not consider the foreseeable behavioural consequences are very likely to drive unintended and unwanted behaviours (Parmenter 2015).

Therefore it is important, when designing mine closure KPIs, that we understand and express explicitly what behaviours are we trying to drive, and the issues we're trying to avoid. The following are a few examples based on our experience.

5.1 Closure planning decisions based on unrealistic/incomplete closure costs

Evidence from the industry shows that published closure costs can often underestimate the true cost of closure by orders of magnitude (Pearce 2021). There are several reasons for this, partly driven by measures put in place to manage closure costs:

- Regulatory requirements to submit a bond based on estimated costs in regulatory closure plans encourage reduced, deterministic costs which exclude uncertainties and unknowns, activities to be carried out over the life of the operation, as well as research plans that will address the uncertainties and provide closure solutions at the end of life. They do not reflect the costs for production challenges unexpectedly encountered during the LOM. Importantly, they also do not account for unplanned closure, which as described above, has occurred in as many as 70% of cases (Laurence 2002, in Commonwealth of Australia 2006).
- Executives are not specifically penalised, but rarely rewarded, based on the magnitude of closure liabilities and hence any costs which can be pushed into the post-closure 'unknown' period are not included in the cost estimate.
- A generally over optimistic view that technology will be available in the future to fix problems generated during operations (e.g. effective passive water treatment technologies will be available

rather than permanent treatment), rather than putting in place measures during operations to avoid the problems.

- A poor understanding of the risk cost drivers, i.e. which aspects of the closure have the highest uncertainty and could significantly impact eventual closure costs. For example, the ARD potential of pit lakes or seepage.

5.2 Conflict in terms of day-to-day cash flow versus long-term value

As already stated, a survey of a selection of publicly available executive bonus information indicates that they place a significant weight on cash flow and other short-term financial measures. This naturally drives behaviour which maximises this year's profit over considerations of erosion of long-term value, for example by considering the impact this year's decision will have on the closure goals and flexibility of post-closure choices.

Executive incentives are rarely based on periods longer than 3–4 years so by their very nature these KPIs do not drive long-term value thinking around closure unless the mine is already close to closure. By which stage the options for closure are more limited and/or more costly due to the established mine footprint and impact.

5.3 Focusing only on physical closure

These tend to be the easiest and most obvious closure measures for mine operators to address. They have the skills and equipment to plan and manage physical progressive rehabilitation, if done right it can easily be put in the context of the day-to-day running and operation of a mine. However, as experience and all the guidelines indicate, successful mine closure is about far more than progressive rehabilitation. Social and stakeholder engagement and long-term spatial and development planning are specialist skills which miners as a rule have to import into the operation. Additionally, progress in these areas is much less linear and much harder to measure accurately. As such they are often neglected until something goes wrong or until the end of production is in sight, by which stage, options are much more limited and likely to be costlier, both in terms of financial and reputational liability.

5.4 Treating closure as a race to relinquishment

Many operations assume that everything will work exactly as described within a closure plan, or within very limited and easily manageable boundaries. They often expect to be relinquishing licences after a few (sometimes as low as 5) years of post-closure monitoring. When in reality, not only do well planned aspects of closure sometimes go seriously awry (e.g. when a pit lake becomes much more acidic than studies anticipated), but there are very often issues created by leaving 'closure' to the last few years of operation (e.g. residual liabilities from groundwater contamination) and/or a lack of appropriate consideration of the less tangible aspects of closure (e.g. social transition, unwillingness of the regulator to accept licence surrender, changes over the life-of-mine in stakeholder expectations rendering aspects of original closure plans null and void). Studies indicate that the actual post-closure duration of many mines is decades longer than anticipated (Pearce 2021) and that considering closure planning as a means to an end rather than actively engaging as appropriate throughout the LOM is likely to result in never reaching that end.

6 KPI areas to consider to drive the behavioural and organisational change

When designing mine closure KPIs it is important to consider how they will make people behave and whether that behaviour will drive the organisation towards its strategic goals. KPIs at site level need to evolve over the life-of-mine as certain milestones towards the strategic goals are met and/or internal or external changes require revision of shorter term milestones. The KPIs must be appropriate in each functional area, that is, an

individual or team must recognise the KPIs as being appropriate to the strategic goals and their personal responsibility to meet.

Company strategic goals around mine closure are generally stated along the follow lines:

- “We aspire to leave a positive legacy for future generations” (Rio Tinto 2021).
- “...to deliver optimised closure outcomes for our operated assets in consultation with local communities and other stakeholders” (BHP 2021).
- “...leave behind self-sufficient and self-sustaining communities, whose future is brighter for the mine having been there than if it had never been there at all” (Anglo American 2013).

Hence, it is apparent that many in the industry already recognise that the mine operation is just one stage in the life of an area and its community but can be a platform for growth and development of that area. Industry and regulatory guidelines as well as the experience of the mine operators provide insight into how to translate those goals at a site level – what is possible, what is needed, what would fit with the existing, surrounding environment, and what can we do to fit into the overall growth of the area?

Bearing in mind the problem issues described above and the unintended consequences of ill-judged KPIs, the following are some areas to consider when setting KPIs.

- **Reducing the real cost of closure looked at from the life of asset perspective.** The life of the asset doesn't end when the ore is gone because the operator will have commitments going forward regarding physical and chemical stability of landforms, and staff and stakeholder expectations. Consider actions during planning and operation of the mine which will negatively impact future closure costs and have limited benefit today, or vice versa, are there simple actions which can be taken today which will positively impact total life of asset value?
- **Reducing the uncertainty around the real cost.** There will always be uncertainty in cost estimates, this may be because of a lack of data, or multiple options without a clear preferred option, etc. Understanding which uncertain elements of the closure costs are most significant, either due to the size of the potential cost range or the potential to impact on the choice of closure option, will allow for prioritisation and focus of studies to fill data gaps and reduce uncertainty.
- **Generating meaningful value.** This may be as a means to reducing total cost or as part of a strategic goal to leave behind a positive legacy. Work to define how to do this while in operation will give time to test and improve such that it continues sustainably beyond the life of the mine. One example of this is the wind power generation which was installed on unused areas of the licence at Lisheen mine in Ireland. This generated revenue for the operation for some years before closure and enhanced the site's suitability for conversion to the National Bioeconomy campus it is now.
- **When to spend the money to generate the value.** How can the day-to-day cash flow metric be married with the closure objectives? Are there ways to generate cash flow before closure which can fit into the overall closure plan? For example, the wind turbines at Lisheen.
- **Windows to create value.** When are the optimum times to create value? This could be an opportunity created in a regional development plan or through partnering with external organisations, or through up-coming technologies. For instance, the initiative of bird watching on progressively rehabilitated areas at Richards Bay in South Africa, which provides skills and employment for local entrepreneurs and can be carried on after all mining ceases.

Including well thought out progressive closure objectives and targets into site KPIs can therefore ensure closure stays on the agenda and individual KPIs tied to site KPIs and corporate strategic goals can motivate staff and encourage them to incorporate closure goals into their daily responsibilities. This applies equally:

- When planning a new mine or an expansion of an existing mine, for it is at the stage of capital planning that most of the decisions with implications for closure are made (e.g. the design of the footprint, the selection of technology).
- During the operational period when the materials are being moved, the environment is being disturbed, there is time to experiment, and the human and financial capital are readily available.
- During the closure and post-closure phase when site transition, including re-purposing or relinquishment depends onsite conditions and the relationships with stakeholders and regulators.

By assigning key closure tasks to individual managers to get them invested in when/how projects are completed, KPIs can act as vehicles to make closure important to individual employees upon whose creativity, problem-solving, and adaptation skills executives must rely on to implement cultural change. The success of KPIs as a tool to translate aspirational concepts at the executive level into broad-based cultural change within an organisation has precedence in the realm of health and safety. The incorporation of health and safety based KPIs (such as working days without injury) into managers' performance objectives has helped facilitate a cultural shift towards recognising that ongoing investment in worker safety ultimately reduces the longer-term and/or unexpected costs arising from employee injury and illness (Veltri et al. 2007; Sochorova 2017). Similar results have been seen with respect to the incorporation of KPIs to measure progress on corporate sustainability objectives.

7 Conclusion

Companies, industry bodies, and regulators recognise the need for, and advantages of, progressive closure and have made steps towards providing the tools and drivers to embed it into day-to-day LOM operations. Nevertheless, many of these tools and regulatory drivers are relatively new and not widely implemented. Additionally, they are currently in conflict with other site and executive KPIs around cash flow and other short-term financial measures. The progressive closure KPIs currently in place are not necessarily going to drive behavioural change within a business that is going to help generate long-term value.

The role of safety in KPIs as demonstrated elsewhere in the mining and other industries, shows that they are an effective way to focus an organisation's minds and drive innovation whilst maintaining company short-term profitability and long-term licence to operate. Well considered progressive closure KPIs which are appropriate for the stage of the operation and tied to the appropriate people can lead to greater value creation on both short and long timeframes. Involving the wider workforce in these activities can lead to greater innovation and a sense of ownership and empowerment.

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