The party's over, now what?

by Peter Werner

Technological advances in mine equipment and milling processes have enabled mining companies to exploit ever lower grades of ore. The result has been larger disturbances, greater volumes of waste, a complex web of infrastructure, and an overall trend toward mega projects that can extend over several square kilometers. This explosive growth in a mining operation's disturbance footprint provokes an obvious question: What is it going to cost to reclaim all of this? At face value, this can be an enormous financial liability for a company, but since the timing of reclamation may be years in the future for many operations, these costs can be heavily discounted, thereby limiting the burden on the corporate balance sheet. Nonetheless, mining companies are eager to remove these liabilities as quickly as possible; conversely, regulators want assurance reclamation will, in fact, occur. How might one bridge these competing interests? Navigating the practical and financial requirements of a post-closure landscape requires foresight, judgement and assumptions; however, companies that do not adequately plan for these future expenditures when there is no offsetting income stream will likely face some difficult decisions. Simple risk analysis tools and utilizing the time value of money can help bring some clarity to this end-of-mine life phase.

Photo courtesy of Montana Department of Environmental Quality

Landusky Mine in Montana: five years after reclamation.

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Asset retirement obligations

Moody's Ratings published in 2024 a review of asset retirement obligations (AROs) for 24 of the largest listings in its metals and mining sector (Moody's Ratings, 2024). Some of the results should be reason for alarm. One of the more remarkable findings was the increase in ARO obligations compared to long-term debt. The total outstanding reclamation obligations for the companies surveyed are the equivalent of 42 percent of their combined long-term debt. Moody's estimated compounded annual growth in AROs since 2018 at 9.7 percent and rising, and if current trends continue, AROs could eclipse long-term debt within 10 years. For one company, its combined outstanding AROs represented more than 50 percent of its most recent annual revenue. The growing significance of a company's AROs in combination with servicing long-term debt, ties up capital that otherwise could be used for the exploration and development of new properties, putting a company at risk from nonincome-producing assets.

Some companies are taking steps to reduce this liability by reclaiming parts of their operations during active mine life, but the contribution to the bottom line is often minimal, especially for operations with an openpit or multiple active waste rock dumps or a tailings impoundment, all of which may be needed right to the end of mine life. Alternatively, through discounting these future financial obligations or offloading expiring properties, companies are able to avoid a balance sheet awash in red ink and maintain a favorable credit rating. Despite these maneuvers, ever-increasing AROs point to a future day of reckoning for somebody, whether it is a company that cannot meet its ARO obligations or the regulator who inherits an environmental liability.

How long is long term?

It is not uncommon for a mine plan to include language that states post-closure monitoring and maintenance will continue for some finite length of time — say, 30 years — after which the company may apply for bond release. This approach begs the question: What is so different about year 31 and beyond that makes monitoring and maintenance unnecessary? Assigning an arbitrary benchmark for when a mining company has fulfilled its reclamation obligations suggests: (1) a site will achieve a state of perpetual environmental equilibrium, and (2) one can predict when this will occur. We know neither of these to be true. Moreover, we fail to fully appreciate reclaimed mine features are simply artificial landforms that will change and evolve over time just as their natural counterparts do.

In the last few years, there has been growing recognition by nongovernmental organizations (NGOs) and industry organizations that some mine facilities may require long-term care and maintenance (Australian National Committee on Large Dams (ANCOLD), 2012; International Council on Mining and Metals (ICMM), 2019; Mining Association of Canada (MAC), 2019). This acknowledgment is primarily addressing the long-term risks posed by closed tailings facilities, but certainly could be applied to most any reclaimed mine facility. While recognizing some closed mine facilities may pose long-term risks or may require long-term monitoring, what appears to be missing is an answer to the question: How long is "long term"? This lack of a working definition underscores the regulator's dilemma: How do you calculate financial assurance if you do not know how long to apply costs? The federal mining regulations do not address this conundrum, and current guidelines struggle to provide a precise definition (ICMM, 2019; MAC, 2019). Without a common understanding of what long term means, it is difficult to address mine closure in a meaningful way.

A start to defining long term in the context of mine reclamation could include addressing the following three questions:

1. How should one think of long-term care and maintenance?
2. What should be included in long-term care and maintenance?

Photos courtesy of U.S. Department of Agriculture

Riley Pass Uranium Mine Complex in South Dakota: landform reclamation in progress (top) and completed (bottom).

3. Why is long-term care and maintenance important?

The answer to how one should think about long-term care and maintenance (LTCM) requires accepting that it should be viewed in terms of geologic time and not simply in engineering time. Consider the time a mine will be in a closed state will be far, far longer than it ever was in operation.

Mining creates landforms, whether they be waste dumps, tailings impoundments or some other constructed mine feature. These, however, are artificial landforms, different from those that have evolved through natural processes; yet, both types will continue to change in shape and size in response to climatic and environmental forces. The most recognizable landforms on a mine site are tailings impoundments, waste dumps and openpits. Certainly, these have the potential to pose significant risk to human health, safety and the environment, but many other lesser landforms also inhabit the mining landscape: diversion ditches, portals, sediment ponds and roads, to name a few. While a mine is in operation, these facilities are maintained as part of the normal mining cycle, as part of regularly scheduled maintenance, or in response to some system failure. After closure, when the regulator has determined the operator has met the requirements of the closure plan and the intent of the regulations have been satisfied, the operator's bond may be released and the permit retired. At this point there is no longer a designated responsible party to maintain these facilities, and they become part of the surrounding landscape where they are subject to the same natural forces and processes that have driven geomorphological change for millennia. Indeed, regulators and NGOs have recognized that some reclaimed mine facilities — specifically, tailings dams — may need care and maintenance exceeding 1,000 years (International Commission on Large Dams (ICOLD), 2013). As mine closure guidelines (ANCOLD, 2012; ICOLD, 2013) extend the time frame for post-reclamation care and maintenance, companies should begin preparing for a much longer site presence and financial commitment at their closed properties.

What should be included in LTCM requires thinking beyond water treatment. While a significant feature of any post-closure regimen where it may be required, water treatment is not necessarily the only system that requires long-term oversight. Reclaimed mine facilities and their components can be highly engineered with very narrow construction and operating tolerances. Water balance covers, underdrains and seepage collection systems, pipeline valves, couplers and gauges, electronic monitoring arrays, drain filters, passive treatment systems and dewatering devices, are commonly found as part of reclaimed mine facilities. Some systems include synthetic or reactive materials like geomembranes or metals that may degrade over time, while natural processes such as settlement and slope creep can compromise buried components. Inclusion of these elements in the reclamation design implies they are necessary for that facility's proper function whether during operations or in post-closure. To assume these systems will function as designed indefinitely is misguided.

The answer to why LTCM is important can be reduced to simple economics: It can be really expensive.

Beal Mountain Mine in Montana: leach pad cover maintenance after 10 years.

Risk-based closure

While many mining risk analysis exercises concentrate on the operations phase, applying it to the post-closure environment can highlight potentially vulnerable facilities and reclamation components that may not otherwise be flagged during operations.

Reclaimed mine sites can be a complex of integrated systems where each component may have a specific function in support of another dependent system. An underdrain must work to prevent the buildup of a phreatic surface in an embankment to ensure stability is not compromised; a diversion ditch must function to prevent stormwater from eroding a reclamation cover and exposing harmful materials, or an electronic monitoring array needs to remain operational to capture incremental slope movement that may lead to more consequential stability problems.

A common theme in the analyses from the Mount Polley (2015), Fundão (2016) and Brumadinho (2019) tailings dam failures was that multiple, interdependent system breakdowns and conditions led to eventual dam collapse. Warning signs of system performance irregularities at these sites were evident, that if addressed, may have averted a complete system failure.

To further illustrate the point about long-term integrity, after a tailings facility is closed it still must function as a stable repository for tailings; however, the operating requirements applied during mining to ensure a safe facility may be less relevant after closure. The risk drivers present during operations (such as water holding capacity, liquefaction potential, seepage) may no longer be as critical to facility stability, replaced by closure-related concerns such as cap integrity, underdrain performance or stormwater routing. While likely different, the potential failure modes and consequences from a tailings facility's nonperformance after closure still exist in some form, and it may continue to be a threat to human health and the environment. To dismiss the importance of tailings impoundment integrity based on a facility coming to the end of its operating life is ill advised, as this phase will be replaced by a state of functional life that can extend in perpetuity.

The U.S. Forest Service recently conducted a risk assessment of a mine facility on National Forest System lands using the failure modes and effects analysis (FMEA) methodology. Mine features included a tailings storage facility, waste rock dumps, mine portals and shafts, a water treatment facility, mill and administrative buildings and related mine infrastructure. The exercise focused strictly on the post-closure time frame and did not limit the analysis period to a specific future end date. The outcome of the FMEA (unpublished) yielded interesting results. The exercise identified that the risk drivers were not the extreme events such as the probable maximum flood or maximum credible earthquake; rather, they were the smaller, chronic events like seasonal storms that impacted ancillary structures and facilities such as diversion ditches, or it was the failure of engineered systems such as underdrains and electronic monitoring stations that posed the greatest risks over time.

The FMEA showed recurrent natural processes (such as wildfire, storm runoff, vegetation succession, slope creep, freeze-thaw cycling) were the principal drivers behind eventual reclamation failure over an extended time horizon. This is due to the incremental degradation of individual component performance leading to more acute nonperformance and eventual system-wide breakdown. Not surprisingly, simple periodic care and maintenance such as cleaning diversion ditches, repairing rills and gullies, and replacing electronic monitoring systems can reduce risk levels and help avert eventual widespread facility failure.

The FMEA participants concluded that the natural processes that drove risk would always be present and would slowly degrade the reclaimed facilities over time. The only solution to maintaining system performance was a commitment to site care and maintenance — well, forever.

Cost considerations

Water treatment is often the most expensive ongoing post-closure activity at a reclaimed mine site and can easily cost millions of dollars per year, but even relatively simple, low-cost care and maintenance activities, such as site inspections, data retrieval, cleaning diversion ditches or minor site regrading, can run tens of thousands of dollars per year depending on site conditions. Often a third party is retained to oversee the annual care and maintenance work, adding an additional layer of cost. So, even without a water treatment component, a site may require tens to hundreds of thousands of dollars in annual care and maintenance to ensure reclaimed facilities remain stable and function as intended during the post-closure period.

Financing such annual costs when they occur would likely be unsustainable for any length of time. Alternatively, taking advantage of the time value of money to create a trust account to finance the recurring out-year cost requirements can ensure funding will be available for ongoing future care and maintenance. When faced with an open-ended time frame, an interest-bearing account is likely the most cost-effective means to fund LTCM.

A simple example can illustrate the effectiveness of this concept. Assume an annual care and maintenance requirement of $50,000 and a discount rate of 3 percent. Running the calculation to a future date when the present value of the out-year annual expenditure drops below $1 yields a net present value (NPV) of $1.7 million. The point in time when this occurs is approximately 400 years in the future and is effectively the same as running the calculation as a perpetual fund calculation. Conversely, if one simply pays $50,000 per year and adjusts for inflation over this same time period, the total cash outflow would be $6.6 billion. Increase the annual care and maintenance to $500,000 and the NPV is $17.5 million, while the nondiscounted approach yields $322.7 billion. A one-time payment of $17.5 million is certainly a manageable sum for most mining companies to eliminate what otherwise would be a chronic drag on the balance sheet.

Assumptions about inflation, appropriate discount rates, annual cost requirements and unexpected site developments present challenges when forecasting far into the future. Using NPV is an imperfect tool precisely because of these uncertainties, but the alternative is to assume, wrongly, care and maintenance requirements will be short lived, and risk a crushing future financial burden.

The financial benefits of using a trust fund for a company should be evident, and it provides the regulator with more confidence than counting on a company's year in, year out financial wherewithal to fulfill its reclamation obligations. Some jurisdictions have developed additional incentives for companies to fund LTCM trusts. The Canadian province of Saskatchewan has developed a program where a company can establish a LTCM fund and relinquish the site to the management of the regulatory authority (Saskatchewan, 2009), an attractive proposition for a company wanting to remove this liability altogether from its balance sheet.

Closing remarks

In summary, what appears at times to be a company's singular focus on developing and operating a mine overlooks the significant financial liability a mining operation presents on the back end, a time when there is limited positive cash flow to offset reclamation costs. There is no expiration date on reclamation integrity, and mining companies should recognize their post-closure care and maintenance obligations may last far longer than they have currently planned for and, in some instances, may be a forever proposition. As the Moody's report highlighted, the AROs of mining companies are becoming an ever-increasing liability and could significantly handicap a company's financial viability. Finding a means to lighten this financial burden while ensuring a company's commitment to reclamation should be of interest to all parties. Funding future reclamation obligations in advance using trust funds is one approach that could provide a measure of relief. ■

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