Elko Roundtable 2017;
Site-wide mine closure, planning and management

by Bryan Ulrich and Rick Frechette

In March, Roundtable 2017 "Roundtable discussion on site-wide mine closure: Planning, implementation and management" was hosted by Knight Piésold and Co. (Knight Piésold) at the Red Lion Hotel and Casino in Elko, NV.

This topic is timely because, as an industry, the strategy and approaches available are constantly evolving and being refined to keep stride with expectations of interested parties, including the surrounding communities, regulatory agencies, land owners, etc.

Knight Piésold had local representatives (Bryan Ulrich and Brittany Hutchings), as well as representatives from its Denver office (Rick Frechette, senior vice president) to help facilitate the discussion. Ulrich is Knight Piésold's senior vice president in charge of the company's Nevada operations and Hutchings is a staff engineer. The event hosted more than a dozen attendees from several western states. One attendee dialed in by telephone to report on recent directives on tailings management in Canada. Attendees included personnel from numerous mining properties and various corporate offices.

Mine closure, in part or in whole, rightly deserves the undivided attention of mining companies, their consultants and their contractors to meet sustainability targets and to minimize negative environmental, social and economic impacts, as the project, in its post-closure years, will become the legacy we leave to our children and grandchildren. The actual performance of mine closure, that is, nature's determination of the success of the closure, is a key deciding factor of the public's assessment of the future viability of the mining industry. Without society's consent, it may be quite difficult for the mining industry to carry on mining in many areas of the world. Thus, establishing good mine closure practices is paramount to the continued good reputation of all world-class mine operators (Ulrich, 2006).

The purpose of the roundtable was to exchange ideas and information pertaining to broad topics revolving around the subject of closure planning, implementation and management. Compared with traditional conferences and symposia, the roundtable type of forum tends to provide a much less inhibited format for discussion. In the roundtable format, lively discussions and applicable tangential departures are encouraged.

This was the 11th in the series of Elko Roundtable events. Previous roundtables pertained to:

1. Heap leach pad design, construction and operation.
2. Design, construction and operation of tailings storage facilities.
3. Site-wide water considerations.
4. Mine closure and cover design.
5. Strides toward sustainability in mining.
6. High-density tailings, paste and filtered tailings.
7. Acid rock drainage for engineers and environmental scientists.
8. Material co-disposal/Co-placement in the mining industry.
9. Innovations in heap leaching and mine waste practices.
10. Geotechnical design – Constructability as a guiding principle.

The roundtable format generally follows a pre-set agenda, which is used as guidance, but the actual conversations during the event tend to be rather fluid in nature. The initial subtopics for Roundtable 2017 included:

- Greetings and introductions/safety share.
- Design for closure vs. operate for closure.
- The GARD guide and closure covers.
- Pit closure (backfill, pit lake, pit slope design).
- E-cells versus ET-cells, and the evolution of E-cells.
- Passive treatment.
- Subsurface discharges.
- Discussion on new and novel approaches.
- Social and community involvement.
- Closure of infrastructure.
- Round robin: What does design for closure mean to you?
- Closing comments.

There were also three brief presentations given by Knight Piésold during the roundtable:

- Two approaches to closure.
- Closure trends in Nevada.

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- A novel closure approach for TSFs.

The day began with a safety share. On the evening prior to the roundtable, Knight Piésold's hosts briefly discussed potential safety share topics. One topic that always deserves a reminder is back health and safe lifting procedures. One author of these proceedings broke his back in high school, and as such can be prone to throwing out his back whenever he lets his guard down. Stretching, exercise, weight management, awareness of danger-prone situations and proper lifting techniques are all tools in the toolbox for good back health. However, later that evening, when preparing dinner, that author cut his finger. He had been wearing a food grade cut-resistant glove to slice onions. But when he then washed a bell pepper, he removed the glove, and failed to put it back on prior to cutting the pepper. The injury was minor, but clearly signaled that the use of the cutting glove had not yet been made a habit. Safety has to become a habit in order to work effectively. The attendees shared several personal accounts of their own recent observations, including ladder safety, powered tools and the importance of bringing a culture of safety into the home.

The group introduction was an interesting segment, as it was lengthy, interactive and yet focused on the following prompt: Name a closure project you've worked on. Because attendees came from a broad range of experiences and current employment positions, the examples of closure project were equally diverse.

The roundtable created a very good environment to discuss the current practices, challenges and accomplishments associated with closure planning, implementation and management. Since there is considerable overlap between the roundtable's subtopics, the conversations frequently departed from topic to topic and back again. In keeping with the spirit of an open roundtable discussion with unbridled conversation, the choice was made to create a version of "sanitized minutes" of the meeting, wherein specific quotes are not attributed to their originator, but rather the proceedings of the discussions are presented in a rather stripped down version in order to avoid stifling the free exchange of ideas. The following is partly a tangential discussion and partly the proceedings of the roundtable.

Mine closure

In a world of ever-changing expectations, new technologies and applications, advances and innovations in the available products to improve facility performance and a growing body of regulations, accomplishing mine closure can be increasingly challenging. If complete closure is defined as the relinquishing of the closure bond and permit, plus pulling up the fences, do we dream an impossible dream to actually achieve that goal? Is it the Holy Grail of mining? An elusive unicorn? The roundtable attendees thought not. There are a variety of approaches that can be made to implement mine closure, and just as there is no single, unique panacea for mine closure, so can it be said that no closure applications or technologies should be disregarded outright without first properly vetting them.

Some things just make sense. For example, backfilling mined-out pits — if this can be carried out in an environmentally-friendly manner, and preferably during mining operations. This could be especially possible if the mine plan includes several openpits that will be mined sequentially. Backfilling can be a remedy against the formation of a pit lake, which sometimes could be beneficial. Backfilling materials could be waste rock or overburden, or in some cases, it could be tailings, especially if they are made to be benign or if they are self-contained, for example by the addition of cement.

It was interesting to segue to the philosophical topic of what does design for closure mean? During this discussion, it was found that design for closure was an important and necessary philosophy that first gained significant momentum in the 1990s. However, a trend toward operating to close is becoming more prevalent as miners understand that closure is a moving target as mining inherently deviates from the original plans and various operational activities can be altered to anticipate and cater to associated closure needs, which are also subject to change with changes in the mine plan.

In this vein, Frechette gave a brief presentation on designing for closure versus operating for closure (Frechette, 2016). As participants mentioned, there can be several assurances given during the planning and early operations of a facility and conditions further down the road may render those assurances non-viable. For instance, changes in commodity prices may convert waste material into ore. Thus, closure planning must be a somewhat fluid process. Initial closure plans are developed based on expectations, experience and available information. Throughout the mining process, additional information becomes available and mine expansions (and in some cases curtailments) impact that initial plan. Accordingly, mines often begin with the end in

mind, but the end will keep changing; operating in an ongoing manner with the end (and its variant forms) in mind becomes the true goal.

The group discussed the practice of adaptive waste rock management plans. Adaptive management is a structured and iterative process of decision-making to accommodate uncertainty, aimed at reducing uncertainty over time via monitoring performance and data as they are obtained. Attendees of the roundtable discussed the need not only to collect data, but to use adequate database management tools such that the data are useful.

Adaptive management is used not only to change a system, but also to learn about the system. Using adaptive management, decision-making meets one (or more) management objectives and accumulates information needed to improve future management. Because adaptive management is based on a learning process, it improves management outcomes. The challenge in using the adaptive management approach lies in finding the balance between gaining knowledge to improve management in the future and achieving the best short-term outcomes based on current knowledge. The U.S. Geological Survey (USGS) (2017) defines adaptive management as:

- Management in the face of uncertainty, with a focus on the reduction of that uncertainty, and,
- Management that recognizes uncertainty in its consequences, and seeks to improve understanding so as to improve decision-making.

Adaptive management is seen as a systematic approach for improving management plans, with an emphasis on learning about management outcomes and incorporating what is learned into ongoing management. Adaptive management can be viewed as a special case of structured decision-making, which deals with an important subset of decision problems for which recurrent decisions are needed and uncertainty about management impacts is high.

The group discussed the idea of using adaptive management for site-wide closure planning. In geotechnical engineering, there is a similar concept, referred to as the observational method which was formulated by Karl Terzaghi. In this discipline, during the construction of earth structures (dams, for example) the observational method is a continuous, managed and integrated process of design, construction control, monitoring and review enabling appropriate, previously-defined modifications to be incorporated during (or after) construction. All these aspects must be demonstrably robust. The objective is to achieve greater overall economy, without compromising safety (Nicholson et al., 1999).

Peck (1969) noted that the most serious error in using the observational method is failing to select in advance an appropriate course of action for all foreseeable deviations (that may be disclosed by observation) from those assumed in the design. The engineer must devise solutions to all problems which could arise under the least-favorable conditions. If he or she cannot solve these hypothetical problems (even if the probability of their occurrence is very low), he or she must revert to a design based on the least-favorable conditions.

It may be observed that the adaptive management approach and the observational method share many traits. Referring back to the adaptive management approach, one would aim at predicting outcomes, but adapting the plan to conform to data and observations that are gained during operation. These methodologies could easily be adapted for site-wide closure planning. For example, if waste rock volumes change significantly over the operational life of a mine, it may be advantageous to assess whether it may be beneficial to stockpile some of that material to locations closer to where they may be needed at closure.

Ulrich gave a brief presentation about a novel approach to bringing tailings facilities into closure. In many tailings facilities, the final gradient of the beach is not always advantageous for efficient closure. For example, given a four-sided tailings facility where tailings spigotting occurs from the embankment crest, a supernatant pond is formed toward the center of the facility. For many such facilities, it would be beneficial for placing a closure cover with greater efficiency if the central portions of the facility were domed up such that positive drainage from the cover could be promoted. In many cases, the fill that would be required to achieve such a condition could be substantial. Since tailings slurry pumped during the mining operation is the most economical material to use as fill, a means of using tailings to overcome this conditional would be beneficial. The authors have been developing a method to take advantage of this potential efficiency as follows:

1. The thickened surface tailings disposal concept developed by Eli Robinsky in the 1970s has been used at numerous mining operations for several decades, including the Kidd Creek Mine in

northern Ontario, and for managing red muds produced by the alumina industry. One of Robinsky's approaches was to arrange a tailings discharge tower that is centrally positioned within the tailings facility, and the discharged tailings form a low, shallowly sloping cone radiating out from the tower. This method of tailings management became known as central thickened discharge (CTD), or alternatively, the Robinsky method (Robinsky, 1999).

2. A potential tailings facility closure approach would be to convert a perimeter discharging facility to a CTD operation, as closure approaches. There are many challenges imposed by this change in operations, such as surface water management, but that issue is at least reduced through the use of high-density, thickened tailings (not paste tailings). And, since the finest-grained tailings would have accumulated in the central area of the perimeter discharged tailings facility, those fine tailings would be subjected to the highest consolidation pressures by the CTD tailings deposit. Much of that consolidation could occur during the mining operations such that mechanically-placed fill could be significantly reduced if this system is employed soon enough. This methodology has yet to be employed in this application, but it is being investigated for possible adoption at one facility in Nevada.

The attendees also discussed the issue of sulfide ores. Some mining operations are investigating the use of a double flotation process to remove essentially all sulfides from tailings so that they can be accommodated in specific, and much smaller, containment. Such an operation could provide very significantly enhanced environmental protection and long-term (legacy issues) could be avoided altogether.

By all accounts, Roundtable 2017 was seen as being highly successful. Next year, Knight Piésold plans to once again host a roundtable discussion in Elko, NV. ■