Optimizing Contact Water Treatment during the Lupin Mine Closure

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Extended Abstract

Introduction

The Lupin Gold Mine (Lupin) is located approximately 285 km southeast of Kugluktuk, Nunavut and is owned by Lupin Mines Incorporated (LMI). Lupin is a remote sub-arctic site that is situated in an area of continuous permafrost. In 2017, LMI decided to end their Care and Maintenance period and enter Active Closure. During active operation and every 2-3 years during Care and Maintenance (C&M) activities, a slurry lime solution had been dosed into the tailings containment area (TCA) to raise the water pH from its tailings-impacted acidic condition and to precipitate metals to meet LMI's Water License discharge requirements.

The TCA consists of three open water bodies and five tailings cells (see Figure below). As part of the Active Closure works, LMI is tasked with covering the tailings cells with esker sand to stop oxidation of the underlying tailings. In order to place the cover effectively, standing water on the uncovered portions of the cells must be removed. The acidic cell water is pumped to the first of the three disconnected water bodies, where it passes through a serious of syphons and two additional water bodies before being treated and discharged to the environment. Given the remoteness of the site, lime has typically been ordered in bulk and transported at the beginning of the season; it is very difficult to resupply once the treatment season has begun.

Although used historically at the site, lime has several limitations for use in the sub-arctic region and Stantec was concerned that it might not be efficient enough to meet the schedule during accelerated treatment activities under Active Closure. Lime doesn't dissolve readily without sufficient heat and mixing, and the lime slurry can clog pumps and pipes due to the limited mixing and dosing equipment at the remote cold-climate site, resulting in constant flushing or low productivity treatment. Additionally, lime does not leave any residual alkalinity in the treated water; as such the TCA water would become quite acidic between dosing regimes (approximately pH 5) due to the low residual alkalinity and buffering capacity in the treated water. Based on Stantec's experience on other closure and mine water treatment projects, we investigated the use of soda ash in place of lime. Although soda ash is only half as concentrated a neutralizing agent as lime by weight, its increased solubility, residual alkalinity, and comparable price made it an attractive alternative to lime.

Bench-Scale Testing

Given that the bulk materials needed to be transported to Lupin on an ice-road prior to the 2020 water treatment season, bench-scale testing had to be conducted in 2019 on site water to ensure suitability of soda ash treatment and quantify the amount of required soda ash. Samples of acidic site water were collected at the end of the 2019 summer season and taken to an accredited laboratory for titration to various pH endpoints with a representative soda ash solution. Based on the results of the titrations and site bathymetric survey (for volumetric estimate), a quantity of soda ash plus contingency was ordered and transported to site during the winter of 2019/2020 via ice road during the closure fleet mobilization.

Existing Treatment Retrofit and Additional Treatment Location

Under historical Care and Maintenance, dosing of the lime slurry had taken place at one location and involved pumping untreated water to a mixing vat where lime was introduced, creating a dosing batch over a period of hours. Once the slurry reached the desired consistency, it was released back to the water body receiving treatment through a perforated line. Given the relatively low solubility of lime at typical site temperatures, water treatment under Care and Maintenance was a time-consuming and personnel-intensive process.

Once the switch was made to soda ash, mixing dosing batches now took minutes instead of hours. The soda ash was mechanically introduced to the dosing vat in 1-ton mega-bags; previously, 50-lb lime back were added manually to the dosing vat. The reduced manpower requirements allowed the site dewatering contractor to commission a second upstream treatment location~~ located earlier in the treatment train~~. The results of the bench-scale analyses were used to develop an inline dosing plan based on field measurements and adjustment. The second location dosed soda ash directly inline to the transfer syphon between water bodies, instead of only one location in the largest water body, greatly enhancing mixing and decreasing the need for additional water treatment at the downstream treatment location. Monitoring locations were established in the TCA waterbodies to inform dosing concentration and frequency of dosing and pumping activities.

In-Situ Treatment and Monitoring

Once the transfer, inline dosing, and environmental discharge were complete, there was still acidic contact water in the upstream water bodies that was at too low an elevation to be accessible with the syphon transfer system. For those isolated waterbodies, the second treatment location was retrofitted to dose a soda ash solution directly into the waterbodies rather than having to move that water through the transfer/treatment system. By leaving the upgradient waterbodies at a neutral pH, the impact that upgradient drainage will have on downgradient pH values should be decreased. This hypothesis will be confirmed during freshet sampling in 2022. This upgradient treatment is referred to in-situ treatment to differentiate it from the batch dosing and transfer system used for primary water treatment. After the in-situ treatment was complete, the site entered two years of monitoring to observe if the TCA pH values will remain consistent over time. If they do, then the site may be cleared for passive environmental discharge at the end of the monitoring season. The residual alkalinity from the soda ash treatment should be more effective in buffering the treated water again future pH reductions. This hypothesis was evidenced during freshet 2021, when the TCA pH was more than a full order of magnitude (>pH 6) higher than during previous freshets, which reduced the cost and time associated with yearly treatment.

2022 Closure Activities

Water treatment is not expected in 2022 as the inline dosing and in-situ treatment should have left the TCA waterbodies at the required pH values at the end of 2021. Water sampling activities will occur during freshet 2022 to observe if pH values remained consistent with those observed at the end of 2021. There has been contingency neutralizing agent left onsite should future water treatment be required.

Conclusion

Although Lupin had been using lime slurry successfully for neutralization of acidic water for decades, concerns were raised that the treatment system was not robust enough to meet the requirements of the aggressive Active Closure schedule. Initially, we investigated the retrofitting or replacement of equipment to increase the efficiency of the lime treatment, but ultimately a change in neutralizing agent was selected. Through applied scientific investigation, we were able to demonstrate to the client and the regulatory agencies that the change in neutralizing agent would improve the ease of treatment operation and increase the treatment efficiency, without any associated decrease in treatment effectiveness. Once the water treatment process was simplified, site personnel were free to complete other closure works.

LMI has been using the new soda ash treatment system for two years with significantly increased efficiency, reduced dosing time, and fewer operational challenges, and has successfully discharged millions of cubic meters of treated water to the environment since the change. The residual alkalinity left in the TCA water after treatment has raised the yearly freshet pH more than a full order of magnitude (>pH 6) vs. previous years, which has reduced the cost and time associated with yearly treatment.

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