Cost Effective Management of AMD Sludge at Stockton Coal Mine

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Abstract

One of the key aspects of Acid Mine Drainage (AMD) treatment is the management of the sediment and metal precipitates (sludge) generated throughout the neutralisation process. Use of a processed limestone product such as calcium oxide (CaO) can result in a very low density and voluminous sludge that requires a large storage volume. Actively removing the accumulated sludge from within the retention structures can be a high risk, costly and time-consuming process. A variety of methods have been implemented to manage the sludge accumulation and retain clean water freeboard while maintaining good water quality and continuity of mining operations.

Keywords: Acid Mine Drainage, Sludge, Sump Accumulation, Filter Beds

Introduction

Stockton Mine on the West Coast of the South Island in New Zealand receives an average annual rainfall of 5.5 m. The Brunner coal measures from which coal is extracted at the mine, is classified as potentially acid forming and runoff across exposed surfaces produces AMD. The resulting acid load of up to 10,000 tons per annum from within the Mangatini catchment at Stockton Mine, requires an alkaline reagent and sludge capture within a large retention structure. Mangatini Sump was commissioned in 2009 for this purpose, with a total construction cost of approximately $20 M. Treatment and collection of the sludge caused both the dead and active storage within Mangatini Sump to be consumed in a shorter than expected timeframe. The sludge accumulation rate was estimated initially as 100,000 m^3 per year, accelerating to 200,000 m^3 per year following a change of the alkaline reagent from ultrafine limestone (UFL) to CaO.

The large quantity of sludge produced endorses the desire to manage the sludge, rather than continually build new structures and rehabilitate old ones. Given that sludge management is likely to be an ongoing requirement, it was decided to investigate sludge removal methods that would provide a continuous and sustainable system rather than an extensive clean out every few years. This would also enable the removed sludge to be disposed of in smaller manageable quantities. Management of the AMD sludge accumulation has required a multi-method approach based upon weather conditions and dewatering availability. These developed systems have proved themselves capable of maintaining sludge levels and resultant free board in a cost effective manner.

Methods

During fine weather the sludge is pumped to filter beds, geotube bags or recycled back into the raw water. When sump water levels are low, the coarser sludge accumulated at the sump inlet can be removed by a digger and trucks. Consistent rainfall and high stream levels provides the opportunity to discharge controlled quantities of the lower density sludge from the sump directly into the original stream. Pumping to filter beds for dewatering and decant discharge to the original stream are the methods outlined in the following sections.

Pumping system

A submersible water pump suspended 4 m below the water surface on a pontoon is moved around the sump picking up the sludge. Currently the pump is shifted approximately 5 metres every 15 minutes using a hand winch. This pumps to a staging sump where variable solids percentage within the pumped flow can mix creating a slurry with a consistent solids content. From the staging sump the slurry can be directed to either a filter bed or geotube bag for dewatering or a raw water stream for recycling.

Filter beds

Filter beds were created using stripped overburden material from a mining pit, lined with a pH neutral sealing layer, strategically placed Megaflo drainage pipe that was covered in drainage metal, then a 0.5 m layer of coal fines. These coal fines are a reject material from the coal handling and processing plant and provide an ideal filter medium that retain the solids from the slurry while allowing free draining of the water. Reject coal fines typically have a particle size range from fine silt to pebble. The dewatered sludge is of a density that can be removed from the filter beds using diggers and trucks.

Stream discharge

During consistent rainfall and high stream flows the sludge can be released from Mangatini Sump via the floating decants or pumped directly into the natural stream. The inlet culvert to Mangatini Sump is blocked and stream flows are bypassed around the side spill of the sump. Water level is lowered in the sump until the floating decants draw from the sludge. Rates of discharge are controlled depending upon the stream flows and turbidity of the decanting water. Telemetry from MG sump and downstream is monitored in real time to ensure compliance with granted consent conditions.

Sludge build up around the floating decant pipes is removed by a submersible pump that is located between the two pipes. Consolidated sludge that does not free flow is stirred up by an air compressed bubbler and is carried to the decants by a small flow that is permitted past the inlet culvert block.

A contaminant load model was created using extensive water quality data collected over many years in the receiving streams. This model proved there would be neglible influence on the natural streams from the discharged sludge. A biennial review is carried out to update the discharge control matrix and verify the natural environment suffered no adverse effects from this operation.

Results

Through engaging the above methods, the sludge accumulation rate in Mangatini Sump has reduced over the past 5 years that these systems have been in operation. Regular

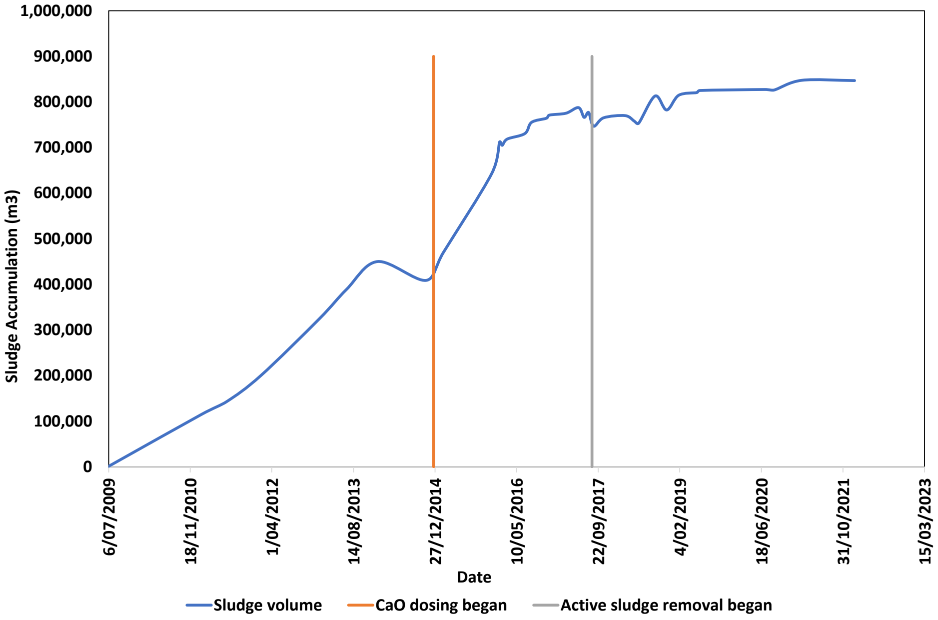

Figure 1 *Sludge volume calculated from sonar surveys*

sonar surveys are conducted over the sump to monitor sludge levels. Insitu samples are taken from depth to identify any changes in consolidation and subsequent density of the sludge product over time.

Figure 1 shows the sludge accumulation rate before and after active sludge management began. CaO dosing date is also shown as an increased rate of sludge accumulation was observed with CaO compared with the previous rate for UFL. The small dip in volume was due to the Mangatini Sump being bypassed for 5 months during remediation to the floating decant system. 8,000 m^3 was removed over this time by diggers and trucks with the remaining drop in volume likely to be consolidation of the sludge.

Dewatered sludge captured in the filter beds is successfully removed using diggers and trucks to a final dump location (fig. 2). 18 Decant discharges have successfully taken place over the past 2 years.

Figure 2 *Dewatered sludge being removed from within a filter bed*

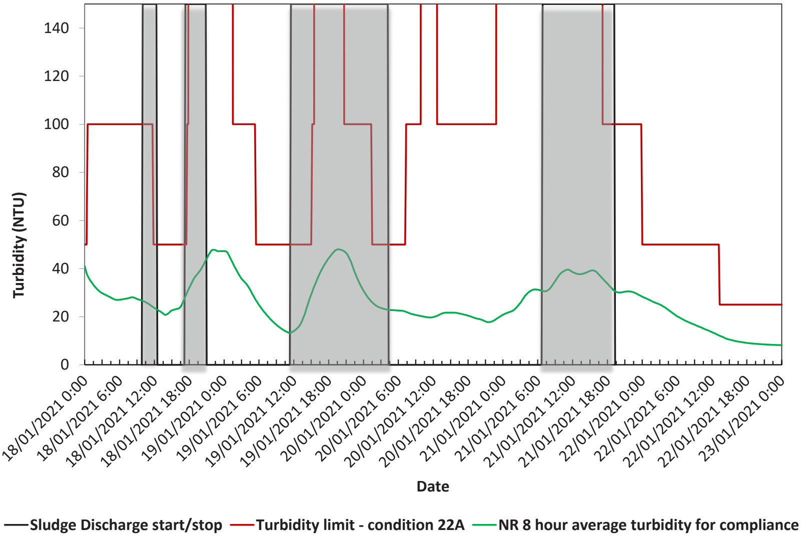

Figure 3 *Compliance plot for a decant discharge event*

An example of the compliance plot for a decant discharge event is shown in Figure 3 where the red turbidity limit is based on the stream flows, the green line is the 8 hour averaged turbidity as measured by a real time telemetry sensor and the grey shaded areas are the blocks of time sludge was being discharged through the decants of Mangatini Sump. Compliance requires the green line to be beneath the red line at all times.

Discussion

Reject coal fines provide a ideal medium to filter the sludge and allow clean water to be discharged from the bed. Currently the discharge from the filter bed is required to be directed to site water systems as the coal fines have a pH of approximately 3.8, so although the supernatant water in the filter beds has a pH of around 6, it gets affected by the coal fines filter. The dewatered sludge generally has a moisture content of between 88 and 93%.

The majority of the acidity load reporting to the Mangatini Sump is aluminium (Al) and iron (Fe) and the treated pH target of 5.5 at the sump discharge was selected to capture these metals. Throughout the lime treatment process, the pH can peak above this target resulting in precipitation of other metals such as nickel (Ni) and zinc (Zn) as these are adsorbed to the Fe and Al (hydr)oxides present in the sludge (Pope and Christensen 2016). A concern of actively decanting sludge with these metals contained within it was the potential for dissolution within a lower pH enviroment. As Zn typically has a stronger affinity for metal oxide surfaces compared with Ni, we would expect to see more mobilisation of Ni than Zn at the same pH (Pope and Christensen 2016).

Manual water quality samples are taken at the Ngakawau River (NR) monitoring site throughout a decant discharge. Figures 4 and 5 show the pH and dissolved Al and dissolved Ni and Zn respectively with comparisons between normal daily samples and samples taken with decant sludge inclusion.

These results show that the concentrations of the analysed metals are not greater than typical conditions and dissolution is not occuring at excessive rates. This is likely due to the pH generally staying above 6 in the receiving streams throughout a decant discharge.

Optimisation of the sludge management systems is continuing with the following improvements underway:

- Semi-automatic shifting of the sludge pumping pontoon using slow moving winches and a pivot system.

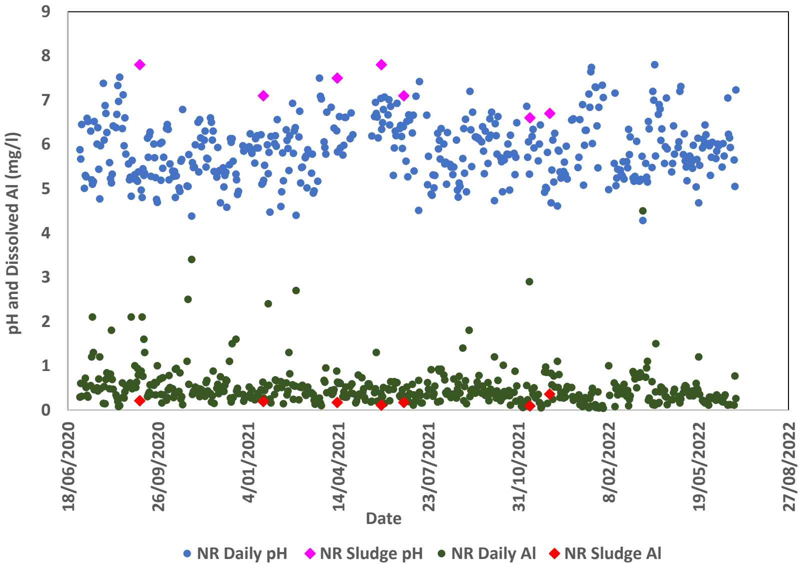

Figure 4 pH and dissolved Al at NR monitoring site

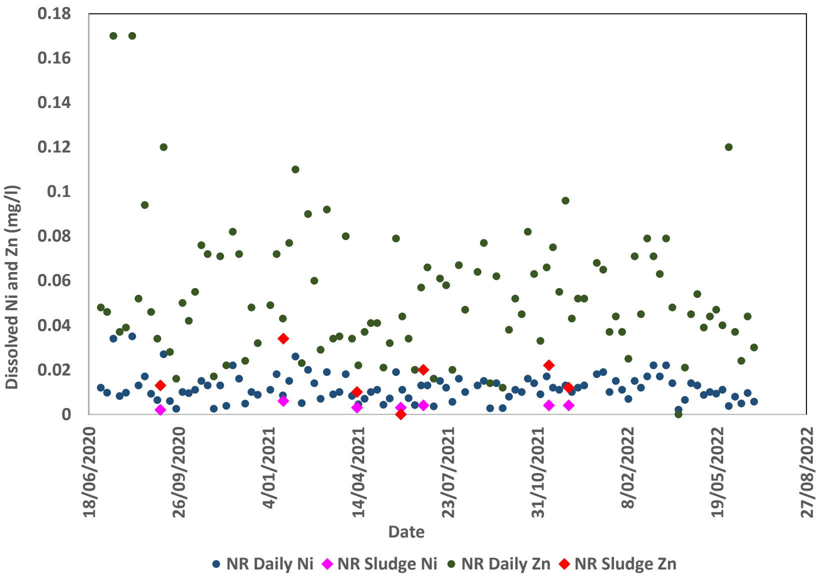

Figure 5 *Dissolved Ni and Zn at NR monitoring site*

- Improved control of the Mangatini Sump inlet culvert seal during decant discharges to allow required flows to enter the sump, assisting in sludge movement to the decants.
- Semi-automatic shifting of the compressed air bubbler along designated sludge routes.
- Progressive rehabilitation of overburden dumps to reduce the AMD runoff.

If no action had been taken to reduce the sludge accumulation rate in Mangatini Sump, it is anticipated that available freeboard would have been consumed by 2019. At a spend of $20 M to construct, that is $2 M per year for sludge containment. The current sludge management methods are costing $0.5 M per year with a forecasted spend of $0.3 M per year once the optimised systems are all in place.

Conclusions

The desired outcome of utilising the above methods to manage sludge accumulation in the Mangatini Sump is to provide sustainable operational control of sludge levels. The cost to construct treatment sumps and then rehabilitate at the end of their lifespan is substantial and ongoing. By actively managing the sludge accumulation to maintain operational freeboard, the sump and associated infrastructure can stay in use for its required timeframe. Smaller volumes of continuously removed sludge can be managed within existing disposal systems without the need to construct a specific structure. Sludge management has become part of the operational and management system of the Mangatini Sump at Stockton, providing a cost effective solution to an ongoing challenge of AMD treatment.

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References

Pope J, Christensen H [2016] Summary document – Mangatini Sump sludge disposal options report.