Operations & Maintenance of Environmental Control Facilities, Keno Hill, Yukon

Galkeno 300 Adit Drainage

Treatment Study

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1.0 Scope of Treatment Study

The water from the mine site was collected from the adit, which is contaminated with heavy metals requiring treatment to meet proposed discharge criteria for the receiving environment. The water from adit will be piped to new proposed in-situ lime treatment and separating the solids (newly formed metal hydroxides) in an approximate 24-hour retention time settling pond. This is considered to be a short-term treatment and if the drainage continues to require treatment, an appropriate treatment system should be engineered. A provision of added liquid flocculent should be considered if the solids carry over exceeds the allowable limits for suspended solids.

The focus of this study was to evaluate the effluent quality at various treatment pH targets and to determine the lime requirements. Additional solids generation data was also collected at various pH values. In the event of the current treatment process optimization does not achieve the desired objectives and/or is not a long-term solution, an alternate process may have to be evaluated such as the HDS process. The alternate process is not part of this study and will have to be investigated pending the outcome of the long-term requirements.

2.0 Experimental Approach

Access Consulting Group personnel sampled the drainage stream and CEMI submitted the sample for pH and metals analysis. Sample was collected in 10 litre jugs and shipped to CEMI in coolers to Vancouver for bench scale testing to simulate treatment strategy.

2.1 Testing Program

Five neutralization tests were planned and tested as follows:

Test at five pH targets for a reaction time of 15 minutes to determine treated water quality and lime consumption. The tests are not designed to optimize the treatment process but to provide guidelines of operating parameters in relation to metals removal.

2.2 Testing Setup and Procedures

A test program was developed after a review of potential treatment alternatives and the lime treatment appeared to the most viable and cost effective treatment option for short-term treatment.

Preliminary testing parameters were selected based upon previous experience with similar water treatment projects. The main indicator that was used during the tests to evaluate treatment efficiency was the effluent water quality. The water samples were tested by taking a 2.0 litre sub-samples and placed in a 4.0 litre reaction vessel equipped with high agitation mixer, baffles, air spargers, and a pH controller. Lime slurry prepared at 5% solids was added slowly to the desired pH allowing a reaction time of 15 minutes. At the end of the test, the slurry was filtered, filter cake was dried and weighed. The filtrate was filtered through a 0.45 micron membrane filter, preserved and analyzed for ICP-OES 32 element scan.

3.0 Results and Discussion

Tests were conducted on the drainage emanating from the Galkeno 300 adit using 5% hydrated lime slurry to target pH of 7.5, 8.0, 8.5, 9.0 and 9.5. Complete neutralization test results are attached in Appendix A.

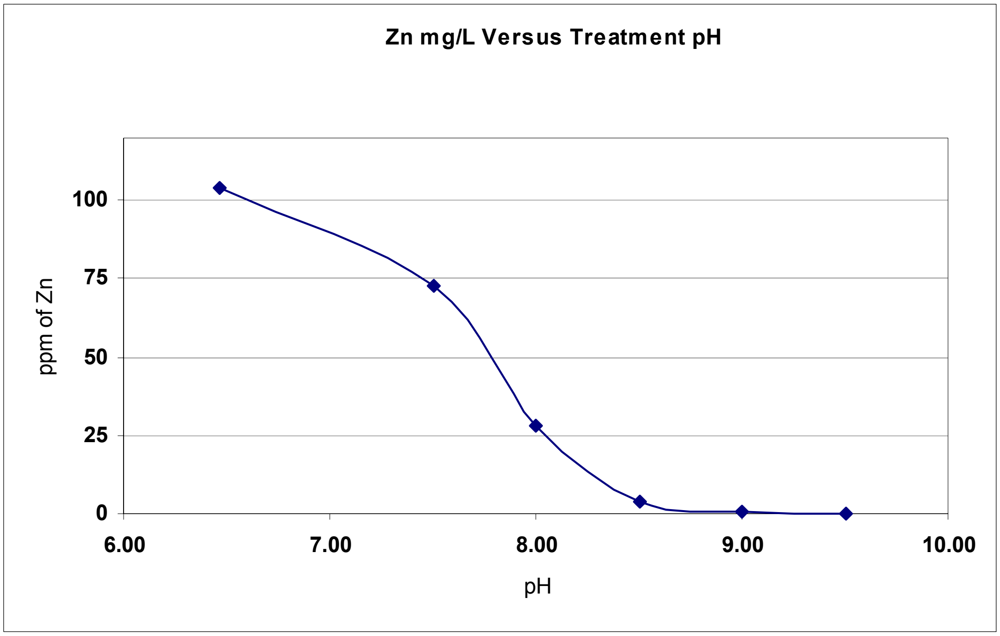
3.1 Effluent Chemistry

Feed sample and effluent samples from all five tests were submitted for ICP-OES analysis, acidity, alkalinity, conductivity and sulphate; complete results are attached in Appendix A. Table 3.1 summarizes the results of major metals at various pH values. Zinc concentration was below the allowable limit of 0.50 mg/L for operating pH of 9.5. The zinc concentration increased as expected with lower pH targets. Based on experience at other mine sites and also indicated by the test results conducted at various pH values, zinc precipitation requires the treatment pH of 9.3 to 9.7, however site conditions for downstream blending or dilution and soil absorption may decrease zinc concentration if lower operating pH is selected. Most metals dropped to very low level except manganese was reported at much higher concentration. Manganese requires much higher pH for precipitation (>9.7), which would generate more sludge and would consume significantly more lime to precipitate it to a range of 1 to 5 mg/L. In operating the pH above 9.5, significant amount of magnesium is also precipitated which also increase both, the lime consumption and sludge production.

This could be a key parameter to consider in the design of the overall treatment strategy for short and long term treatment configuration. It is evident based on the initial bench scale tests that the effluent treatment at Galkeno 300 can meet the objectives to lower the treatment pH to below pH 9.5 while meeting the zinc concentration in the final effluent. However to operate a treatment process at close tolerance requires a high level of process control, instrumentation and flexibility.

The following graph illustrates the results of zinc concentration as a function of pH.

Graph 3.1 pH versus Lime Consumption



An operating pH of 8.5 achieves a zinc concentration of 3.53 mg/L in the effluent, which may be sufficient to obtain the objectives of the treatment process. However lower zinc concentration can be obtained by raising he pH to 9.0.

3.1.1 Current Flow Conditions

The ARD was treated by contacting it with dilute lime slurry in a well agitated reactor. The lime consumption may be higher in the field due inefficient mixing and other site constraints. The following table shows the metal concentration as a function of treatment pH. The reactors were well agitated and the reaction was allowed to complete over a 15-minute period.

Table 3.1 Effluent Quality Versus pH

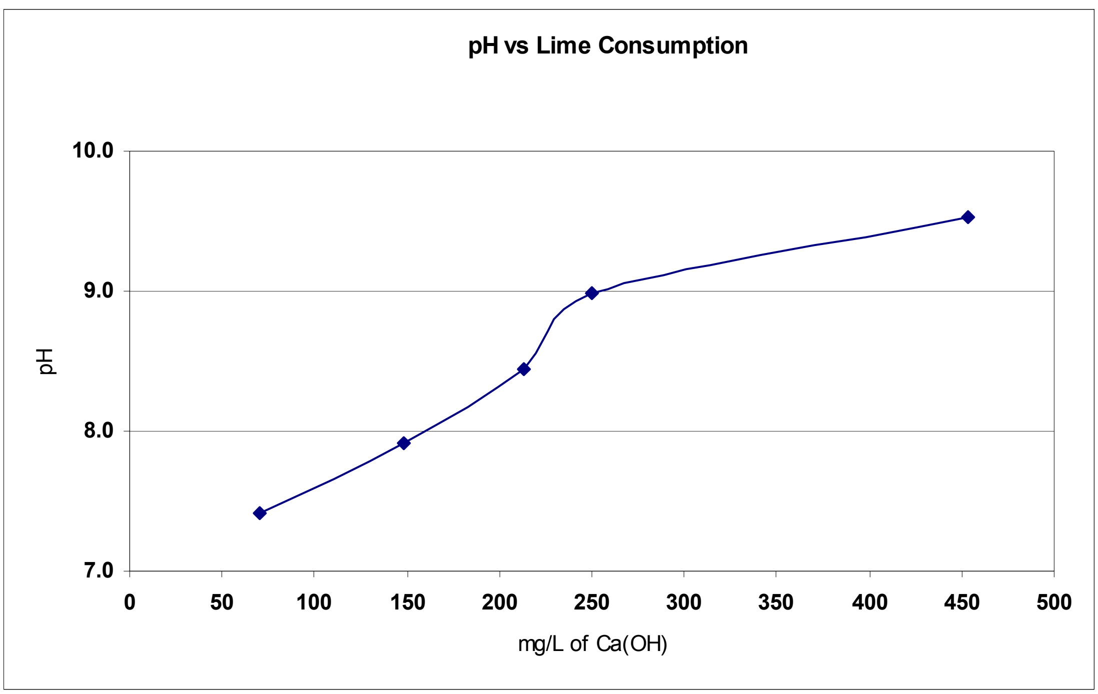
	Feed Total	pH 7.5	pH 8.0	pH 8.5	pH 9.0	pH 9.5
Manganese (mg/L)	159	161	154	144	133	11.8
Zinc (mg/L)	104	72.9	27.9	3.53	0.67	0.03

The above table shows that the zinc precipitate is directly related to pH and at pH of 8.5 the dissolved zinc concentration is 3.53 mg/L, which is well below the discharge requirement. However, a small drop in the pH elevates the zinc concentration to 27.9 mg/L. Operating the treatment process at this pH presents a high risk of discharging non-compliant effluent. The process should be operated at pH 9.5 to allow for small fluctuations in the treatment pH and operating at a slightly higher pH also offers extra alkalinity for further buffer downstream. Although zinc was the key parameter for treatment, iron was also precipitated level below 0.5 mg/L. However, manganese remained in solution until pH 9.5 was tested, this may be an issue for toxicity in the future.

3.3 Lime Consumption

The lime requirement was very difficult to measure at the bench scale testing, as lime consumed was very low. The detailed results from each test are provided in Appendix A.

The graph below shows the lime consumption as a function of treatment pH.

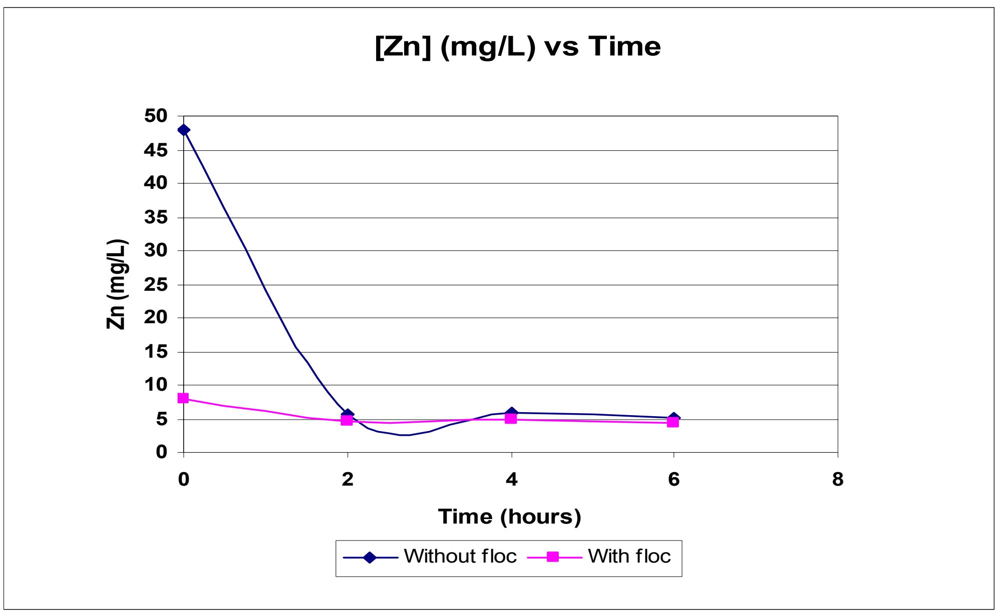


3.4 Sludge Settling

The acid drainage was neutralized to pH 8.5 and split into 2 – 1 litre graduated cylinders. One of the tests was conducted with addition of Percol E10 flocculent and one test without flocculent.

Samples of the overflow were taken over time for a period of 8 hours and submitted for total metals concentration as a measure of suspended solids in the over to determine the settling time required. The test with the flocculent addition settled very quickly within 5 minutes as indicated by the zinc concentration in the overflow sample. The test without flocculent addition also settled quickly, however it took longer initially. In both cases the zinc concentration was very similar after 8 hours, indicating that flocculent may not be required. However these tests were conducted under ideal and static conditions, therefore the results may vary in the field due mixing caused by influent water velocity to the pond as well as other factors.

The graph below shows the total zinc concentration in the overflow solution over time.



4.0 Recommendations

The water treatment system at the Galkeno 300 adit drainage can be treated by making a simple lime addition process to precipitate metals of immediate concern. As illustrated with the initial test work dissolved zinc can be precipitated at a lower pH of 9.0 to 9.5. It is extremely important to have the appropriate instrumentation for proper process control to operate a treatment process in the tight pH range. It is important to point out that the test work completed in the initial stage is preliminary and needs to be confirmed with multiple tests at various times of the year and with fresh effluent samples. The confirmatory tests should be carried out onsite as a pilot study to create a database to confirm the test results.

Following are some of the recommendations to enhance the effluent treatment process:

- Develop a short and long term treatment plan and strategy.
- Upgrade the instrumentation to have proper control of pH for lime addition which may require a lime-circulating loop.
- Install a sludge-circulating loop from the settling pond to a premix tank immediately ahead of the neutralization tanks. This will enhance precipitation process, increase sludge density, and increase settling rate, and lower lime consumption by re-circulating un-reacted lime.