Parent company of Canadian Zinc

Prairie Creek Project

MINEWATER TREATMENT CONTINGENCY PLAN FOR WATER LICENCE MV2019L2-0006

April, 2020

Preamble

This *Minewater Treatment Contingency Plan* applies to the underground activities of Canadian Zinc Corporation during exploration at the Prairie Creek Property associated with Water Licence MV2019L2-0006.

The following formal distribution has been made of this plan:

Mackenzie Valley Land and Water Board

Canadian Zinc Corporation - Prairie Creek Site Office

Canadian Zinc Corporation - Vancouver Office

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1.0 INTRODUCTION

As part of the mineral exploration process of establishing, confirming and enhancing the mineral resource at the Prairie Creek property, Canadian Zinc (CZN) constructed a new decline tunnel and underground development in 2006-2007 to permit access for underground exploration, including drilling of the stratabound deposit underlying the Zone 3 quartz vein mineralization. Further delineation of the vein-type mineralization was undertaken at the same time. The new decline was planned to be accessed from a new 905 m level portal. However, at the time of decline development, it was decided to gain access via the existing portal site at the 870 m elevation. The 870 m level extends approximately 800 m into the mountain to where the collar of the Decline occurs.

During permitting, CZN undertook to also manage mine water emanating from the existing workings during the exploration Decline project. The expectation at the time of the commitment was that the settling of sediment may be required. Upon receipt of a Water Licence with Effluent Quality Criteria (EQC), it was then clear that treatment of mine water would be required to meet EQC, specifically to remove zinc. Water treatment had not occurred on the property prior to 2006.

CZN currently holds NWT Surface Lease #95F/10-5, originally issued to Procan Exploration in 1987 by Indian and Northern Affairs Canada (now AANDC). CZN assumed responsibility for the Lease when it acquired Procan's interest in the property. CZN's current liability in connection with the site is limited by the terms of the Lease and the Abandonment and Restoration Plan (ARP) attached to it as a schedule. This plan defines the required restoration actions and responsibilities of the Lessee. For example, the Lessee has the option to remove buildings and equipment, or to leave them on-site. Also, the Lessee is required to barricade the mine openings, but is not required to address mine water discharge. The existing ore stockpile is to be capped with clay and left in-place. Therefore, CZN's current liability for the site is limited. It is clear from the terms of the Lease that the majority of site liability would revert to the Crown unless mine operations proceed. CZN has every intention of eventually proceeding with mine operations and assuming all site liability.

Since the completion of the first Decline project, CZN has continued to manage water from the Decline and the old workings, although the Company believes it is not responsible for continuing to manage water from the old workings. Flows from the Decline are directed into a pipe for delivery to the 870 portal. This water does not require treatment to meet EQC. Water from the old underground workings flows along the adit to the portal. This water requires treatment due to elevated dissolved zinc.

CZN holds a Land Use Permit for a second Decline, which would also be accessed from the 870 portal. This Decline, if built, would be expected to generate water flows similar in volume and quality to the first Decline. During development of the first Decline, no sudden in-rushes of water occurred. Water flow was controlled by regulating valves on drill holes. The first Decline is presently flooded and produces 3 L/sec in flow in summer.

CZN also has an Effluent Treatment Options Plan (ETP) which explains how CZN:

- collects mine water flows (section 2.1);
- plans to continue to treat mine water under Water Licence MV2019L2-0006 (sections 2.1 to 3.3, and also summarized in section 2 below); and,
- monitor treated water quality (section 3.4).

The ETP essentially describes how the mine water management and treatment system operates, and should be read in conjunction with this Mine Water Contingency Plan. This plan explains how CZN manages mine water flows and contingencies adopted for treated mine water quality in order to meet the EQC listed in Water Licence MV2019L2-0006.

2.0 MINEWATER TREATMENT

CZN treats mine water at a culvert which receives mine water from the 870 portal. Secondary treatment of the culvert stream is integrated with a connected delivery line to the Polishing Pond.

Sodium sulphide is the primary treatment chemical which converts dissolved zinc to a solid sulphide form. The sulphide dose (12 mg/L) is mainly determined by the mine water flow rate, which is monitored at the outflow of the Polishing Pond. This is followed by secondary treatment with iron (4 mg/L) in the form of ferric sulphate which acts as a coagulant, and a flocculant before the water is delivered to the first cell in the Polishing Pond.

The Polishing Pond provides retention time for the settlement of fine particles, followed by discharge to the Catchment Pond prior to final discharge to Harrison Creek.

Monitoring of zinc concentrations in mine water after treatment is performed on-site using a portable ultra-violet spectrophotometer which determines zinc content by colourimetry, with a quoted test range of 0.2-3.0 mg/L.

3.0 CONTINGENCY PLAN

3.1 EXCESS WATER

The water treatment system is not prone to inundation from excess flows. Mine drainage flows vary according to season and rainfall. Since 2007, the volume of this discharge during summer months has averaged approximately 15 L/sec, but a peak of 28 L/sec has been recorded and was managed. Higher flows can be treated by increasing the doses of chemicals to maintain treatment efficiency. High flows are still relatively small compared to the size of the Polishing Pond, and therefore settling time is well within prescribed levels.

Water flows have not posed any significant issues since treatment started in 2006, a period that included the development of the first decline. If a second decline is developed, no issues would be expected either.

Apart from infiltration primarily during the summer months, the mine water management and treatment system is not affected by surface water runoff. Only mine water reports to the culvert where primary treatment occurs (see photo below). Treated water is then delivered to the Polishing Pond by a pipeline. The Polishing Pond is a raised structure with four berms. There is no run-on into the pond. The pond does receive incident precipitation, but this does not negatively affect pond function, which is the settling of sediment, and pond volume stays constant as inflows are matched by outflows which occur over a weir at a constant elevation below freeboard.

Site surface water runoff collects in pre-existing ditches which drain to the Catchment Pond. There, surface water co-mingles with treated mine water before discharge to Harrison Creek via a culvert which has a gate weir control point.

Mine water flows are monitored at SNP Station 3-4, Polishing Pond outflow, via a calibrated weir gauge and recorded daily when site is open.

3.2 WATER QUALITY

The rate of sodium sulphide addition is based on the flow rate, measured at the weir downstream of the Polishing Pond.

During prolonged periods of intense rainfall, which increases the volume of mine water flowing by gravity from the 870 adit, a flow-based sulphide dose alone is not sufficient to reduce metal concentrations sufficiently. It appears the metal load during such periods also increases, although there appears to be a lag between the flow and load increases. At times when the tested zinc concentration from on-site monitoring using colourimetry (see the ETP for details) of water in the Polishing Pond exceeds 0.3 mg/L, the dose is increased to match the demand and reduce zinc concentrations. However, the dose increase occurs after zinc concentrations have increased.

To rectify this problem, when a flow increase is measured coincident with prolonged rainfall (i.e. a more sudden increase rather than a steady increase due to a change in season), the sulphide dose will be increased by the same amount over the normal range. For example, if the flow rate increases by 10%, the sulphide dose will be increased 20%, 10% for the new flow rate and 10% for the anticipated higher load. Monitoring will still be conducted in the Polishing Pond using colourimetry, and the dose further increased if zinc concentrations are too high. The dose will return progressively to the normal range once flows stabilize or drop.

Sulphide treatment produces fine sediment that can be very difficult to settle. Total zinc concentrations related to this sediment have been the cause of the majority of non-compliance events.

Testing indicated that 4 mg/L iron as ferric sulphate is required as a coagulant followed by flocculant to promote settling and achieve compliant effluent. On-site testing of zinc by colourimetry is not well suited to detecting zinc in sediment, and therefore settling performance is based on the weekly samples collected for laboratory analysis. As noted, in the ETP, recent assessment by water treatment consultants indicates that settling can be enhanced by using a pre-mixed flocculant. In addition, adjustments to the baffles in the Polishing Pond will be made to maximize settling and minimize space not contributing to settling. In the unlikely event these measures are not sufficient to produce compliant effluent, the use of a sand filter on Polishing Pond outflow was recommended after the weir, and just before SNP monitoring Station 3-4.

Regarding alternative options that are viable that will prevent the release of effluent that does not meet the EQC, it is important to note that it has been demonstrated that the use of sodium sulphide is effective in converting dissolved zinc to a total form. Laboratory testing has indicated that it is feasible to settle the resulting zinc particles such that total zinc concentrations comfortably meet the EQC. CZN is confident that the adoption of the recent consultant recommendations regarding flocculation and adjustment of the Polishing Pond baffles will result in compliant effluent. It is also important to note, that because of the limitations of colourimetric analysis, it is not possible to know if effluent is in fact compliant until the results of laboratory analysis are received. It is not feasible to retain treated water for that length of time as the Catchment Pond has limited capacity. As such, laboratory results are received after the treated water has been released.

CZN proposes that the results of enhanced flocculant mixing and revised baffle orientation be awaited to assess compliance with EQC before considering other alternatives. We propose that if the average total zinc concentration in effluent discharge exceeds requirements after two consecutive months, and that the treatment system was otherwise operating normally, then additional sediment filtering be adopted by way of a sand filter or other suitable device. If the average total zinc concentration in effluent discharge still exceeds requirements after two further consecutive months, then CZN will have to accept that the sulphide treatment system cannot yield compliant effluent because it is not feasible to sufficiently settle the resulting sediment. If that proves to be the case, then CZN will convert the existing treatment plant to a lime-based system. Lime is known to be effective in removing dissolved metals, especially zinc, and is also known to be an effective coagulant, resulting in effluent with low suspended solids. Treatment tests using lime were conducted previously and confirmed that compliant effluent can be obtained (CEMI, 2007 (Appendix A). Lime was not adopted because the Prairie Creek Mine site is currently only accessible by air, and new equipment as well as the lime, which is heavy, would have to be flown in. If conversion to a lime-based treatment system is to occur, the Effluent Treatment Plan will be revised and submitted for review.

It should be noted that, as explained in the introduction, CZN believes it is not responsible for continuing to manage water from the old workings which requires treatment and is the source of non-compliance events, and which was not subject to any treatment prior to 2006.

4.0 RESPONSE FRAMEWORK

This section provides a description of the response framework that will be implemented to link the results of monitoring to those corrective actions necessary to ensure that the objectives listed in the Licence are met. Note that during water treatment operations and when the Polishing Pond is in use, all facilities are inspected by site personnel on a daily basis.

4.1 GEOTECHNICAL STABILITY

The water treatment apparatus includes a culvert, delivery pipes, metal-fame reaction tanks and the Polishing Pond. With respect to geotechnical stability, only the Polishing Pond is appropriate for consideration.

A preliminary design of the Polishing Pond was prepared by EBA Engineering Consultants dated April 26, 2005. The design consisted of a four-sided bermed structure with height up to 3.2 m and with slopes 2.5 horizontal to 1 vertical. The structure was to include a hypalon liner consisting of welded segments retrieved from the large pond already constructed on site but not in use, an overflow weir and a drain pipe at the base of the structure.

Golder Associates were subsequently appointed to advise on pond construction requirements and inspect and approve the final structure for use. A memorandum to CZN dated August 10, 2005 provided construction directions. Following an inspection on May 18, 2006 after pond construction as per the design and construction directions, Golder approved the pond for use.

There have been no significant structural issues with the pond since construction. Some relatively minor settlement cracks in the dykes were noted in some locations, but these stabilized soon after formation. As a precaution, CZN added buttressing material in the form of loose shale rock around the downstream toe of the structure and draped up the sides of the slopes to reduce slope angle. Annual inspections have not detected any issues with dyke conditions, such as cracks, slumping or other apparent movement. If any of these items is noted, a geotechnical engineer will inspect the structure to determine any need for, and the form of, response actions.

No seepage has been noted from the pond, other than minor leakage from the drain valve below the weir when the pond is full and discharging water over the weir. The hypalon liner is inspected annually. A few relatively minor leaks at weld locations and tears from settlement have been noted and patched. This process will continue to promote structural integrity. Note that this is a structural concern, not a water quality concern. The pond receives treated water for polishing (settling of sediment). Any water leakage through the liner would be filtered by the granular material forming the pond, and/or the underlying alluvial gravels, and report to the pond discharge location where water flows into a ditch carrying the water to the Catchment Pond.

The drain valve is to allow emptying of the pond during seasonal shut-down to prevent ice formation when the site is dormant over winter. The valve is connected to a pipe through the dyke. The inner end of the pipe is attached to, and sealed into, the liner. This seal is inspected each spring before water treatment and pond use resumes. If any cracking were to be observed, sealer would be applied. The drain vale remains open during the dormant period, and closed when treatment resumes. The pond then fills and discharge only occurs once the pond level reaches the weir.

It is physically impossible for treated mine water in the Polishing Pond to exceed the freeboard limit. The water level in the pond is determined by the weir elevation at the outflow. The flow rate of water entering the pond is the flow rate of water level leaving the pond. The water level does not change once it reaches the weir elevation.

4.2 THERMAL CHARACTERISTICS

Water treatment typically does not occur in winter when there are no activities occurring underground. Mine water flows at the 870 portal reduce to 1-2 L/sec and freeze at the portal entrance where an ice plug forms.

The Polishing Pond is drained prior to winter to avoid ice formation which would otherwise delay pond use the following spring.

When activities are occurring underground in winter, if mine water is being pumped out, treatment lines are kept open by heat tracing, and the Polishing Pond is kept operational by using compressed air bubblers to prevent the outlet from icing. These bubblers are not prone to break down since a compressor will provide air provided there is power, and the site has main and reserve power generators.

The alluvial materials underlying the Polishing Pond are too coarse to host permafrost. Similarly, frost penetration into the pond dykes has not been observed. Any type of deformity would trigger an inspection by a geotechnical engineer.

There are no other thermal considerations or issues with the water treatment system.

4.3 SEEPAGE QUALITY, QUANTITY AND RUN OFF

Seepage quality and quantity was addressed above in section 4.1. Run off is discussed in Section 3.1.

4.4 MONITORING

Monitoring is conducted to ensure performance. Regarding the Polishing Pond, the pond is inspected annually each spring for geotechnical stability, condition of the hypalon liner and condition of the drain line and valve and the weir. Other than the buttressing described in Section 4.1 above, and patching of the liner as needed, no other responses have been necessary. Any evidence of berm cracking or subsidence would trigger an inspection by a professional engineer. Also as noted in Sections 4.1 and 4.2 above, no significant issues have occurred of a thermal or seepage nature.

Surface water run off does not directly affect the water treatment system or Polishing Pond, so is not specifically monitored. Mine water flow and water treatment efficiency is monitored at Station 3-4, the outlet of the Polishing Pond. Water flow is only monitored to select chemical dosing requirements. Mine water flows have been well within the treatment system capacity since initiation of treatment and monitoring in 2006.

Regarding water treatment performance, as explained in Section 3.2, there are two aspects to water treatment performance: removal of dissolved metals by dosing with sodium sulphide; and, settling of the resulting suspended solids. Monitoring of the first step is done primarily by the use of a colourimeter to measure zinc concentrations. This method appears to respond mostly to dissolved zinc content, and is not conducive to monitoring total zinc concentrations. CZN takes a pro-active response to sulphide dosing i.e. we increase the dose before monitoring determines that a response is necessary. When a flow increase is measured coincident with prolonged rainfall, the sulphide dose is increased by the same amount over the normal range. As explained in Section 3.2, if the flow rate increases by 10%, the sulphide dose will be increased 20%, 10% for the new flow rate and 10% for the anticipated higher load. In this respect, there are no specific low, medium or high action levels, rather the action level (percentage of increased dose) is determined by the percentage of flow increase. Plant operators are also instructed to increase the sulphide dose incrementally if the zinc concentration measured by colourimeter exceeds 0.3 mg/L. These two corrective corrective actions usually result in over-dosing, which is gradually reduced as flow conditions and/or colourimter concentrations return to their normal range.

Regarding the second aspect of water treatment performance, settling of suspended solids, results are only available from laboratory analysis. These have indicated that settling performance is not optimal. However, the doses of coagulant and flocculant are not thought to be at fault, since we know from bench-scale testing that the doses are correct, rather the delivery of the chemicals and the arrangement of the baffles in the Polishing Pond are thought to be the cause, hence our proposal to change these. A contingency framework is described in Section 3.2 to achieve compliant effluent based on effluent sample laboratory results.

APPENDIX A

BATCH WATER TREATMENT SIMULATIONS

Prepared for:

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Mine Drainage
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Sept 2007

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1.0 INTRODUCTION

Canadian Zinc Corporation (CZN) is conducting advanced exploration at the Prairie Creek Mine, and this includes treating mine water to remove dissolved metals, mainly zinc. The mine water is a combination of water from vein stopes and from a new decline being driven from the main adit. Treated water is discharged to a polishing pond, the outlet of which is the compliance point (o.3 mg/L zinc). CZN started treating with soda ash in June 2006, sending a solution 270 m up the adit to an excavated sump. After problems with clogging and a difficulty of sustaining a pH 9.5 target, a switch to using sodium sulphide was made in mid-September which met with an immediate improvement. Work on the new decline was by then well underway. With the onset of winter, there was proportionately more decline water, and treatment results were variable. While dissolved zinc was being removed, suspended solids persisted, and were sufficient to keep total zinc concentrations over the target. It appears sulphide treatment produces a fine sediment that is difficult to settle. CZN requested Canadian Environmental & Metallurgical Inc. (CEMI) to undertake tests to determine suitable reagents and settling aids to address the treatment problems.

2.0 EXPERIMENTAL OUTLINE

2.1 Precipitation Using Hydrated Lime

The detailed procedure is as follows:

- The samples were received by CEMI and kept in cold storage when not being used for testing purposes.

The following samples were prepared and tested:

1) Test A: 2.5L of sample water

Use an initial volume of 2.5L of sample water. Prepare a 5% hydrated lime solution, add lime to sample water to desired pH, remove a 20 ml sample of water and add 3ml of E10 Floc then continue to next target pH. The target pH's were pH 8.0, pH 8.5, pH 9.0, pH 9.5, and pH 10. Record lime added at each pH value to determine lime consumption. Once final pH has been achieved transfer solution into 1.0L graduated cylinder and sample from the top at 15 minutes intervals.

Observations

During settling test the solution settled very quickly within minutes the top of the graduated cylinder was clear. Very little sludge was produced.

2.2 Precipitation Using Sodium Sulphide

The detailed procedure is as follows:

The samples were received by CEMI and kept in cold storage when not being used for testing purposes.

The following samples were prepared and tested:

1) Test 1: 1L of sample water + 24 mg Na_2S + ~5 mg Ferrous Iron
2) Test 2: 1L of sample water + 32 mg Na_2S + ~7 mg Ferrous Iron

3) Test 3: 1L of sample water + 40 mg Na_2S + ~9 mg Ferrous Iron

For each test, start with fresh 1L of sample and add the measured milligrams of NaS and agitate for 20 minutes. After the agitation is complete add the measured amount of $FeSO_4$ and agitate for another 20 minutes. After the ferric iron addition add E10 Floc and transfer to 1L graduated cylinders for settling test. Sample every 15 minutes for 1 hour.

Observations

Throughout the tests each solution (Test 1, Test 2, and Test 3) settled fairly quickly. The solution was clear but still had some suspended solids after 1 hour of settling. Very little sludge was produced.

2.3 Lime Addition

The detailed procedure is as follows:

The samples were received by CEMI and kept in cold storage when not being used for testing purposes.

The following samples were prepared and tested:

1) 1L of Sample Water

With sample water add lime solution until pH 9.2, record lime used and repeat for pH 9.7.

3.0 RESULTS

3.*1 Precipitation Using Lime*

3.1.1 Lime Consumption

Lime Consumption up to target pH for 2.5 L sample

Desired pH	Lime (CaO) Consumption kg/m3	Measured pH
8.0	0.145	8.46
8.5	0.182	8.56
9.0	0.661	9.06
9.5	0.849	9.44
10.0	1.185	9.98

Although the lime precipitation removed the zinc to required concentration suitable for discharge to the environment, the lime consumption for an already alkali solution is very high due to buffering capacity of the solution. The transportation of such large quantities of material makes it difficult to treat using lime solution. In addition this treatment also produces a higher level of sludge which will make sludge handling/management more difficult. The table below shows the results at various pH values.

3.1.2 Solution Analysis

DISSOLVED METALS		FEED	ID 8	ID 8.5	ID 9	ID 9.5	ID 10	ID 15M	ID 30M	ID 45M
Aluminum (Al)	mg/L	0.282	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Antimony (Sb)	mg/L	<0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Arsenic (As)	mg/L	<0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Barium (Ba)	mg/L	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02
Beryllium (Be)	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Bismuth (Bi)	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron (B)	mg/L	0.73	0.56	0.57	0.57	0.55	0.54	0.57	0.58	0.55
Cadmium (Cd)	mg/L	0.0196	0.0022	0.001	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Calcium (Ca)	mg/L	468	635	630	645	651	822	678	662	686
Chromium (Cr)	mg/L	<0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cobalt (Co)	mg/L	0.437	0.007	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Copper (Cu)	mg/L	0.284	0.038	0.08	0.043	0.058	0.007	0.02	0.032	0.03
Iron (Fe)	mg/L	145	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead (Pb)	mg/L	0.0038	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Lithium (Li)	mg/L	0.139	0.128	0.123	0.118	0.123	0.12	0.119	0.12	0.119
Magnesium (Mg)	mg/L	223	206	206	201	201	84.9	201	197	192
Manganese (Mn)	mg/L	8.46	5.19	3.08	0.72	0.27	0.01	0.41	0.35	0.09
Molybdenum (Mo)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel (Ni)	mg/L	0.24	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Phosphorus (P)	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1
Potassium (K)	mg/L	34	28	36	34	34	35	35	35	35
Selenium (Se)	mg/L	<0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Silicon (Si)	mg/L	8.2	1.3	1.2	0.8	0.7	0.6	0.6	0.6	0.5
Silver (Ag)	mg/L	<0.0001	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Sodium (Na)	mg/L	174	170	170	169	171	170	174	172	174
Strontium (Sr)	mg/L	3.1	3.27	3.3	3.24	3.3	3.42	3.66	3.6	3.64
Sulphur (S)	mg/L	750	712	708	707	718	695	731	714	724
Thallium (Tl)	mg/L	0.0001	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Tin (Sn)	mg/L	<0.2	<0.2	<0.2	<0.2	2.9	<0.2	<0.2	<0.2	<0.2
Titanium (Ti)	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Uranium (U)	mg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Vanadium (V)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc (Zn)	**mg/L**	**100**	**0.24**	**0.13**	**<0.05**	**<0.05**	**<0.05**	**<0.05**	**<0.05**	**<0.05**
Zirconium (Zr)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
HARDNESS (CALCULATED AS CACO3)										
Hardness (CaCO3)	mg/L	2090	2440	2420	2440	2450	2400	2520	2460	2500

* For the table above the Zinc content was below 0.1 mg/L after solution reached a pH of 9.

The solutions tested were the initial sample water (FEED) , a sample after each target pH was achieved (ID 8, ID 8.5, ID 9, ID 9.5, ID 10) and samples taken from the top of graduated cylinder during settling test at 15 minutes (ID 15M), 30 minutes (ID 30M), and 45 minutes (ID 45M).

3.2 Precipitation Using Sodium Sulphide

The following table contains the zinc concentration in the effluent at 15 minute intervals after being treated with sodium sulphide. All samples were taken from the top of the graduated cylinder.

Zinc total (mg/L) At Specified Time Intervals	Test 1	Test 2	Test 3
15 mins	0.67	0.14	0.07
30 mins	0.08	0.05	0.06
45 mins	<0.05	<0.05	<0.05
60 mins	<0.05	<0.05	<0.05

The above table indicates that sodium sulphide treatment is very effective and the settling rate is extremely fast with a small amount of iron addition during the settling stage. Further optimization of sulphide addition may reduce the sulphide requirements and 5 to 10 mg/L of iron appears to enhance settling rate. Within 15 to 30 minutes a clear clean solution with zinc concentration of less than 0.08 was obtained. This treatment option is already in place and it only needs some refinements to optimize precipitation and settling.

4.0 RECOMMENDATIONS

We recommend CZN continue using sodium sulphide to treat the mine water. Follow-up testing is recommended to refine sulphide dosage and the ferric sulphate/flocculant settling aids. Testing should also be performed on the decline water separately to ensure the selected treatment scheme is appropriate for winter conditions.