Parent company of Canadian Zinc

Prairie Creek Project

MINE WATER CONTINGENCY PLAN
FOR WATER LICENCE MV2001L2-0003

April, 2019

Preamble

This *Mine Water Contingency Plan* applies to the underground activities of Canadian Zinc Corporation during exploration at the Prairie Creek Property associated with Water Licence MV2001L2-0003.

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

Canadian Zinc (CZN) constructed a new decline tunnel and underground development in 2006-2007 to permit access for further underground exploration. During permitting, CZN undertook to also manage mine water emanating from the existing workings during the Decline project. CZN has continued to manage this water after completion of the Decline project. 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 <1 L/sec in flow in summer.

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

- collects mine water flows (section 2.1);
- plans to continue to treat mine water under Water Licence MV2001L2-0003 (sections 2.1 to 3.3, and also summarized in section 2 below); and,
- monitor treated water quality (section 3.4).

The ETOP 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 criteria listed in Water Licence MV2001L2-0003, Part D, item 4.

2.0 MINE WATER TREATMENT

CZN treats mine water at the culvert which receives mine water from the 870 portal, with secondary treatment integrated within the culvert stream in a connected delivery line with in-line reaction tanks to the Polishing Pond.

Sodium sulphide is the primary treatment chemical which converts dissolved zinc to a solid sulphide form. The sulphide dose (to be 12 mg/L in 2018) 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 (to be 4 mg/L in 2018) 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 inflows primarily during summer months, the mine water management and treatment system is not affected by surface water flows. 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 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. Most of the past non-compliance incidents can be attributed to the sulphide dose being too low. Previous testing indicated a standard dose during ‘normal’ flow conditions of 7 mg/L as sulphide was required. The most recent testing indicates that 12 mg/L is required.

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 ETOP 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. Recent testing indicates that 4 mg/L iron as ferric sulphate is required as a coagulant followed by flocculant to 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 ETOP dated April 2019, recent testing indicates that settling can be significantly enhanced by using two particular flocculants in tandem. These will be adopted for the 2019 treatment season. In addition, adjustments to the baffles in the Polishing Pond will be made to improve settling. In the unlikely event these measures are not sufficient to produce compliant effluent, additional polishing could be implemented on a trial basis. This could take the form of sand filtration of water leaving the Polishing Pond immediately 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. However, the difficulty has been the replication of conditions on site for this satisfactory settling. CZN is confident that the adoption of different flocculation chemicals and adjustment of the Polishing Pond baffles will result in compliant effluent.

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 Part D, Item 11 of 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 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

Part D Item 12 refers to seepage quality and quantity, and run off. Seepage quality and quantity was addressed above in section 4.1. Run off is assumed to refer to mine drainage. The response framework for treated mine water not meeting discharge criteria was explained above in section 3.2.

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 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, monitoring of this is explained in Section 3.2, including what action is taken to address exceedences.

4.5 CONFORMITY TABLE

A conformity table is provided below that indicates which sections of the plan fulfill which requirements of Part D, condition 12, numbers i-v.

Part D, Condition 12		**Where Addressed**
Item	**Description**	
i	Mine water treatment contingencies re EQC	Section 3.2
ii	Exceeding Polishing Pond freeboard risk	Section 4.1
iii	Collection/management of surface runoff	Sections 3.1 and 4.3
iv	Monitoring, rationale for water management system components	Section 3.2 and ETOP Section 3.4
v	Response framework	Sections 4.1, 4.2 and 4.4

Table 1: Board Directives on Effluent Treatment Options Plan (ETOP)

	Items to be revised in the ETOP	Comment ID	Staff Conformity Check
a)	The Effluent Treatment Operations Plan (ETOP) was required "in order for the Board to remain informed, and to make sound and practical decisions respecting the regulation of effluent treatment. Furthermore, this plan is to outline the effluent treatment options that allow the Licensee to meet the effluent quality requirements set in the License. This condition also stems from Recommended Measure seven (7)(b) in the EA Report approved by the Minister.	Reasons for Decision	
b)	Identify how CZN plans to incorporate the recommended improvements to mixing and the polishing pond retention and identify alternative treatment systems if Applied Water Treatment Inc.'s laboratory treatment dated October 31, 2017 cannot be applied on site.	ECCC-1	Inadequate. Alternative treatment systems have been not identified.
c)	Using real data as evidence, clearly outline how the recommended treatment options (i.e. chemical dosing and filtration) on-site will treat the observed and expected quality and quantity of water to meet EQC.	ENR-5	Adequate for chemical dosing method as demonstrated in section 3.4. Inadequate for sand filtration method. On-site data from sand filtration method have not been illustrated.
d)	The sand filtration method tested by Applied Water Treatment Inc. (October 31, 2017) is not proven to be effective. CZN should seek alternative methods or provide more testing and evidence that the sand filtration will be effective.	ENR-8	Inadequate. Alternative method or additional on-site data have not been provided.
e)	CZN has repeatedly stated that the retention time is not an issue but has not provided evidence to support this claim. If CZN has data showing that effluent water has the retention time of 45 mins as suggested by Applied Water Treatment Inc. (Oct 31, 2017), even during high rainfall events, please provide it to the Board for consideration. If evidence or viable alternative options cannot be provided, then revise the ETOP to address ENR-9.	ENR-9	Adequate.

Table 2: Board Directives on Minewater Treatment Contingency Plan (MTCP)

	Items to be revised in the MTCP	Reference/ Comment ID	Staff conformity check
a)	Concern was raised during the drafting of the License about the volume of minewater produced possibly exceeding the combined storage capacity and water treatment rates of the treatment system located within the mill and the polishing pond. In a letter dated August 21, 2003 from the Licensee to the Board, the Licensee states that in the event that a " ... catastrophic inrush [of water] takes place ... " and the volume of minewater exceeds the capacity of the treatment system inside the mill and the polishing pond, equipment will be removed from the underground decline and it will be allowed to flood. To encourage the Licensee to undertake contingency planning and to consider all available options to mitigate this type of event, the Board requires the Licensee to submit a Minewater Treatment Contingency Plan.	Reasons for Decision	See item f below.
b)	Contingencies for the treatment of Minewater in the event it does not meet discharge criteria	Part D, condition 12(i)	Adequate.
c)	A description of the risk of the Minewater exceeding the Polishing Pond freeboard limit.	Part D, condition 12(ii)	Adequate
d)	The process and facilities for the collection and management of surface runoff generated on site;	Part D, condition 12(iii)	Adequate
e)	Details of monitoring, including a rationale for each component of the Water management system;	Part D, condition 12(iv)	Adequate
f)	A description of the Response Framework that will be implemented by the Licensee to link the results of monitoring to those corrective actions necessary to ensure that the objectives listed in Part D Item 11 are met including: (1) definitions, with rationale for Action Levels applicable to the performance of the Polishing Pond with respect to geotechnical stability, thermal characteristics, seepage quality and quantity, and run off; and (2) for each action level, a description of how exceedances of the Action Level will be assessed and what actions may be taken if the Action Level is exceeded.	Part D, condition 12(v)	Conformity table -adequate. Geotechnical stability: please clarify the thresholds or trigger for action. For example, list the parameters used to visually inspect each component (liner, outlet pipe, etc.) of the polishing pond and clearly define “worsening of the dyke condition”. Detail all the observations that would trigger the response action i.e. consultation of a geotechnical engineer. The 2006 Golder Technical Memo includes the outlet pipe. Please include monitoring frequency, action level and response action for the outline pipe.

			Thermal characteristics: Board staff notes CZN has included thermal considerations of the polishing pond. Please provide a response framework if the thermal condition causes the polishing pond to malfunction. For examples, how often is the outlet and air bubblers monitored? What is the action level for these components (e.g. if air bubbler) stop working because of the cold? What is the response action if the action levels are exceeded? Seepage quality and quantity- see item i below. Runoff: Board staff acknowledges that CZN has reported that surface runoff has not been an issue since treatment started in 2006. However, purpose of the Mine Water Contingency Plan is in case of a " ... catastrophic inrush [of water] takes place ... " and the volume of minewater exceeds the capacity of the treatment system inside the mill and the polishing pond as pointed out in item a. Please provide response actions for the catastrophic situations.
g)	MTCP is a separate condition of the Licence and has a different intent then the ETOP, as discussed in ECCC-2. Two separate documents (ETOP and MTCP) shall be updated and submitted for Board approval.	ECCC-2	Adequate
h)	In order to illustrate to reviewers and the Board that the Plan meets these specific Licence requirements, Board Staff recommend that the MTCP be resubmitted for Board approval with the inclusion of a conformity table in the plan that clearly indicates which sections of the plan fulfill which requirements of Part D, condition 12, numbers i-v. In doing so, the updated MTCP should address ENR's comments that the plan: (1) Provide adequate and viable contingencies; and (2) Provide thresholds or triggers for action in the response framework.	ENR-6	See item f above.
i)	The contingencies and response framework require improvement beyond adjusting dosage, as per the requirements of Part D, Condition 12 of MV2001L2-0003. If holding water is not a viable option, please	ENR-7	Inadequate Board staff acknowledges that CZN proposes to further evaluate

	investigate alternative options that is viable that will prevent the release of effluent that does not meet EQC. This update shall be reflected in the next version of the Minewater Treatment Contingency Plan.		polishing options using water treatment engineers, including additional or different chemicals, and the use of tertiary filtration. However, this proposal still does not satisfy review comment ENR-7. Please investigate and elaborate on how these alternative options may be viable in preventing releasing effluent that do not meet EQC.