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memorandum

To:	Mr. David Harpley, Canadian Zinc	**Date:**	06-Oct-2010
From:	Bill Rozeboom, P.Eng. Gary Van Der Vinne, P.Eng.	**No. Pages:**	7
		Project No.:	16987

Re: **Prairie Creek Mine**
Outfall performance – downstream mixing analysis
DRAFT

This memo is to provide an advance summary of results from a downstream mixing analysis for a proposed outfall from the Canadian Zinc mine at Prairie Creek. Treated process and mine drainage water is proposed to be released from a simple pipe outlet to the bottom of the Prairie Creek channel just upstream of the confluence with Harrison Creek. A more complete description of the mixing analysis methods and assumptions will be documented in a subsequent letter report.

The mixing analysis is based on water quality characteristics of treated effluent water, Prairie Creek receiving water, and instream water quality objectives determined by others on behalf of Canadian Zinc. Relevant concentrations are reproduced in the tables of mixing analysis results. Background studies for the water quality characteristics are presented in Appendices 7, 8, and 10 of the Prairie Creek Mine Developer's Assessment Report submitted in March 2010 by Canadian Zinc to the Mackenzie Valley Review Board. The mixing analysis discussed here is focussed on water quality constituents listed in the previous studies as the main metals, specifically cadmium, copper, lead, selenium, and zinc.

Water Survey of Canada records for Prairie Creek at Cadillac Mine, available for the period October 1974 through December 1990, were reviewed to determine mixing analysis design streamflows for (1) open water and (2) ice cover flow conditions. For each period, design flows were determined that represent (1) mean or average flow conditions; and (2) the 7Q10 discharge indicating a 7-day low flow with a recurrence interval of once in 10 years. For the open water period, the mean flow is 10.7 m^3/s and the 7Q10 flow is 1.3 m^3/s. For ice cover period which typically starts in October and ends in May, the mean flow is 1.1 m^3/s and the 7Q10 flow is 0.05 m^3/s.

The outfall will release treated process water and also mine drainage water. The release of treated process water will be managed on the basis of the flow in Prairie Creek and corresponding dilution capacity to meet the instream targets. Mine drainage water will reflect the groundwater flow into the mine, and the rate of flow is expected to vary both annually and seasonally as a function of antecedent climatic conditions.

It is anticipated that there will be no release of process water during the months of January through March, when flows are usually low. The maximum proposed release of process water is at a rate of 0.02 m^3/s during normal flows for the months of April through August. On average, release flows during September though December would be somewhere between 0.0 and 0.02 m^3/s.

The mine drainage flow rate to be treated and released to Prairie Creek is estimated to range from 0.019 to 0.09 m^3/s. Mine drainage is expected to be the result of seasonally-variable groundwater flows. Prairie Creek streamflows, particularly during the winter months, also reflect groundwater flows. It is considered unlikely that high mine drainage would occur during the winter months, due to low surface recharge. High mine drainage is not expected to coincide with the low groundwater conditions which would produce record low winter streamflows.

The proposed outfall location and stream reach considered in the mixing zone analysis is shown in Photos 1 and 2 below.

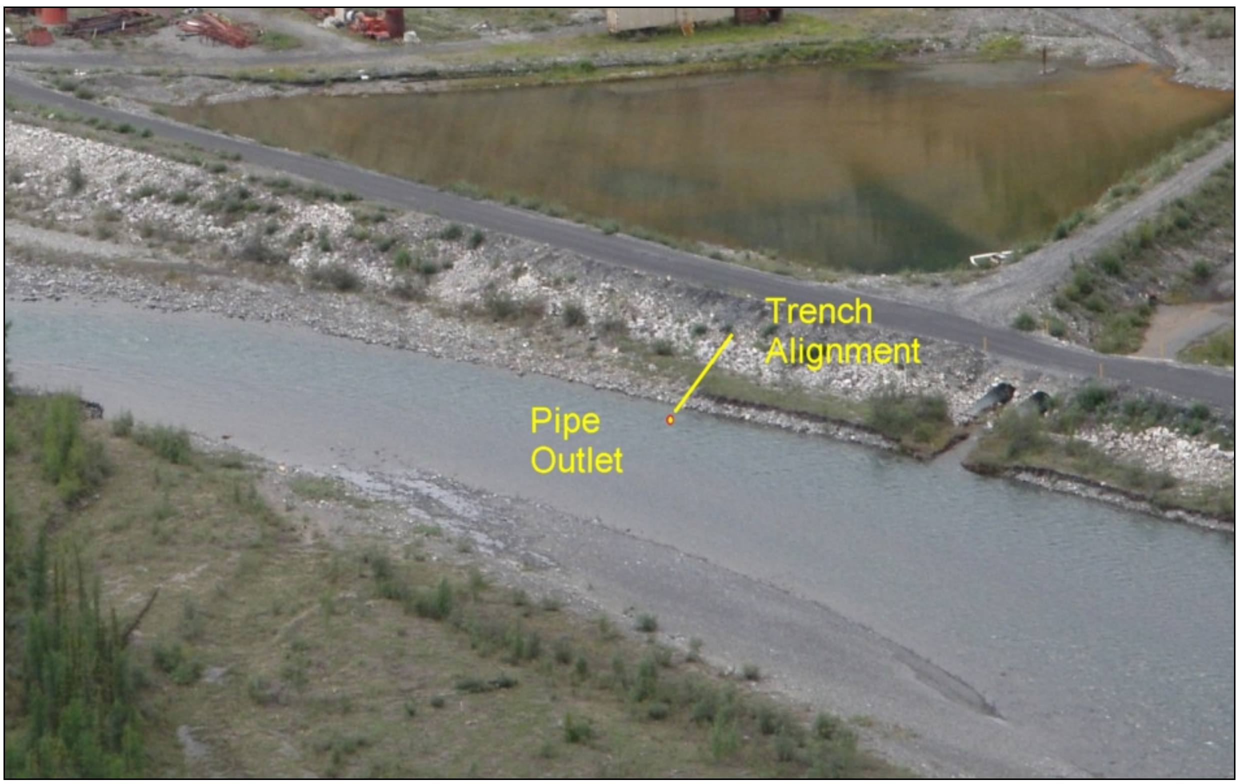

Photo 1. Proposed location of pipe outlet from catchment pond to Praiarie Creek. Flow is left to right.

Photo 2. View downstream to Prairie Creek mixing zone reach. Stream length seen in photo is about two kilometres. The outlet end of the catchment pond is visible at the lower edge of photo.

Table 1 presents mixing analysis results for the Prairie Creek open water mean flow, 10.7 m^3/s, with treated process water being released at the maximum rate of 0.02 m^3/s. Scenarios were run with both low and high estimates of mine drainage, but the mine drainage rate was found to not have a significant effect on the results. Detailed results to be documented in a subsequent report will show how the plume is progressively diluted as mixing occurs across the width of channel. The cross section maximum concentrations of water quality constituents occur along the left bank, downstream from the outfall location. The downstream mixing length required for the cross section maximum concentration to meet the instream water quality objective varies from about 625 m to 1370 m, depending on the constituent. The longest mixing length is for selenium.

Table 2 presents mixing analysis results for the Prairie Creek open water 7Q10 flow, 1.3 m^3/s, with treated process water being released at 0.003 m^3/s. The process water release rate is as assumed in previous work for this amount of streamflow. Scenarios were run with both low and high estimates of mine drainage but the mine drainage rate was again found to not have a significant effect on the results. The downstream mixing length required for the cross section maximum concentration to meet the instream water quality objective varies from about 65 m to 750 m, depending on the constituent. The longest mixing length is for selenium.

Table 1
Mixing Analysis for Prairie Creek Open Water Mean Flow, 10.7 m^3/s

Initial Concentrations and Targets

MAIN METALS		Treated Water		Prairie	Instream
		Process	Mine	Creek	Objective
Cadmium	mg/L	0.00262	0.00001	0.000048	0.000172
Copper	mg/L	0.0021	0.0072	0.00057	0.00253
Lead	mg/L	0.0932	0.0001	0.00023	0.00113
Selenium	mg/L	0.0392	0.0033	0.00116	0.00216
Zinc	mg/L	0.039	0.017	0.00714	0.02265

Outfall Releases: Treated Process Flow 0.02 m^3/s; Low Mine Drainage 0.019 m^3/s

Constituent	Mixing Length* (m)
Cadmium	625
Copper	420
Lead	710
Selenium	1370
Zinc	645

Outfall Releases: Treated Process Flow 0.02 m^3/s; High Mine Drainage 0.090 m^3/s

Constituent	Mixing Length* (m)
Cadmium	625
Copper	480
Lead	710
Selenium	1380
Zinc	650

*Mixing lengths represent the downstream distance at which the cross section maximum concentration meets the instream objective.

Table 2
Mixing Analysis for Prairie Creek Open Water 7Q10 Flow, 1.3 m^3/s

Initial Concentrations and Targets

MAIN METALS		Treated Water		Prairie	Instream
		Process	Mine	Creek	Objective
Cadmium	mg/L	0.00262	0.00001	0.000048	0.000172
Copper	mg/L	0.0021	0.0072	0.00057	0.00253
Lead	mg/L	0.0932	0.0001	0.00023	0.00113
Selenium	mg/L	0.0392	0.0033	0.00116	0.00216
Zinc	mg/L	0.039	0.017	0.00714	0.02265

Outfall Releases: Treated Process Flow 0.003 m^3/s; Low Mine Drainage 0.019 m^3/s

Constituent	Mixing Length* (m)
Cadmium	120
Copper	70
Lead	65
Selenium	750
Zinc	160

Outfall Releases: Treated Process Flow 0.003 m^3/s; High Mine Drainage 0.090 m^3/s

Constituent	Mixing Length* (m)
Cadmium	120
Copper	90
Lead	65
Selenium	750
Zinc	170

*Mixing lengths represent the downstream distance at which the cross section maximum concentration meets the instream objective.

7Q10 flow refers to the 7-day low flow having a recurrence interval of one in ten years.

Table 3
Mixing Analysis for Prairie Creek Ice Cover Mean Flow, 1.1 m^3/s

Initial Concentrations and Targets

MAIN METALS		Treated Water		Prairie	Instream
		Process	Mine	Creek	Objective
Cadmium	mg/L	0.00262	0.00001	0.000048	0.000172
Copper	mg/L	0.0021	0.0072	0.00057	0.00253
Lead	mg/L	0.0932	0.0001	0.00023	0.00113
Selenium	mg/L	0.0392	0.0033	0.00116	0.00216
Zinc	mg/L	0.039	0.017	0.00714	0.02265

Outfall Releases: Treated Process Flow 0.0025 m^3/s; Low Mine Drainage 0.019 m^3/s

Constituent	Mixing Length* (m)
Cadmium	46
Copper	38
Lead	58
Selenium	123
Zinc	50

Outfall Releases: Treated Process Flow 0.0025 m^3/s; High Mine Drainage 0.090 m^3/s

Constituent	Mixing Length* (m)
Cadmium	44
Copper	62
Lead	56
Selenium	540
Zinc	54

*Mixing lengths represent the downstream distance at which the cross section maximum concentration meets the instream objective.

Table 3 presents mixing analysis results for the Prairie Creek ice cover mean flow, 1.1 m^3/s, with treated process water being released at 0.0025 m^3/s. The process water release rate is as assumed in previous work for this amount of streamflow. Scenarios were run with both low and high estimates of mine drainage; the mine drainage rate was found to be inconsequential except on the results for selenium. As with the open water analysis, the cross section maximum concentration of water quality constituent occurs along the left bank, downstream from the outfall location. The downstream mixing length required for the cross section maximum concentration to meet the instream water quality objective varies from about 38 m to 62 m, for cadmium, copper, lead, and zinc. The required mixing length for the remaining constituent, selenium, ranged from about 123 m for a low mine drainage scenario to 540 m for high mine drainage. As noted above, it is considered unlikely that high mine drainage conditions would actually occur during winter low flows.

The mixing zone model used to produce the above results was unstable for the winter 7Q10 scenario due to the very small depths for a flow of 0.05 m^3/s in Prairie Creek. An alternative simplified approach is planned to analyze the mixing for this flow scenario, but this work could not be completed in the timeline required for this memo of initial results. However, it should be noted that the available results show that mixing occurs more quickly at low flows than at high flows because of the relatively narrow width of channel. At the 7Q10 low winter discharge, there will be no release of process water, and mixing of the mine drainage water will likely occur more rapidly than in the ice cover mean flow scenario because of the reduced channel width.

Respectfully submitted,

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review draft

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