PRAIRIE CREEK MINE
RESPONSES TO SECOND ROUND OF INFORMATION REQUESTS

SUBMITTED IN SUPPORT OF:

Environmental Assessment of
Prairie Creek Mine EA0809-002

SUBMITTED TO:

Mackenzie Valley Review Board

SUBMITTED BY:

Canadian Zinc Corporation
Vancouver, BC V6B 4N9

March 2011

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1.0 INTRODUCTION

This document provides responses to the second round of information requests (IR's) received from regulators and the Dehcho First Nations (DCFN) in connection with the environmental assessment (EA) of the Prairie Creek Mine (EA0809-002). Responses are provided to each parties' IR's by section below. A complete copy of the IR's is provided in Appendix A.

2.0 PARKS CANADA IR REPLIES

IR Number: Parks Canada 2-1
Subject: Access Road
Request:

1. *Identify if there is a recognized or typical standard/guide for design, construction, and operation that is utilized in the Northwest Territories for access or haul roads. If this exists, please indicate if CZN proposes to follow this standard for this proposed road.*

Guidelines for winter road construction in the NWT that CZN has reviewed include the following:

- Environmental Guidelines for the Construction, Maintenance and Closure of Winter Roads in the Northwest Territories, prepared for the Department of Transportation, GNWT, by Stanley Associates and Sentar Consultants, October 8, 1993; and,

- Northern Land Use Guidelines, Vol. 5, Access: Roads and Trails, Indian and Northern Affairs Canada, January 2010.

However, the Prairie Creek Mine access road is relatively close to the BC border, and has a greater similarity in terms of terrain, and therefore construction requirements, to the northern BC than to the majority of the NWT. It is predominantly an overland road rather than an ice road. Consequently, CZN has sought the assistance of Kledo Construction, based in Fort Nelson, a company very active with winter access road building in the region. Kledo have 'flown' the Prairie Creek road alignment several times, and have provided advice regarding general constructability and the design/construction of difficult sections. Kledo also prepared a document describing potential water supply requirements for road construction and maintenance (see Appendix B). This document also contains their general approach to road construction which will be adopted by CZN.

2. *Provide typical cross-section diagrams of the access road to depict the various construction situations that are encountered on site, including, but not limited to: construction on well drained and poorly drained soils, ice rich permafrost soils, weaker soils, cut and fill locations, and approaches for stream crossings.*

CZN currently holds land use permit (LUP) MV2003F0028 to construct, maintain and operate a road along the original alignment used by Cadillac Explorations from the mine site to the Liard

Highway at Lindberg Landing. In their ruling in which the road was included in the scope of development for EA 0809-002 (March 5, 2009), the Review Board commented on scope of assessment matters, and stated:

> "conducting an impact assessment of the construction of facilities, including the road, which have been present on the land for over 25 years is not likely to generate any useful information even if it is possible. The Review Board will not be assessing construction impacts of already built structures."

In the Terms of Reference for this EA, the Review Board indicated that they would consider alterations to the road alignment. Therefore, in the responses below, CZN focuses on the proposed road re-alignments. Drawings showing the existing and proposed alignments are provided in Appendix C.

In most cases along the existing road alignment and new alignments, seasonal road construction will consist of blading-off snow, adding a snow-water mix to allow penetration and freezing, followed by replacement and compaction of snow (see Appendix B). Because of different soil types, potential permafrost presence and a need to traverse sloping terrain, certain portions of the new alignments may require different approaches to road bed construction (see Figure 1). These are described below.

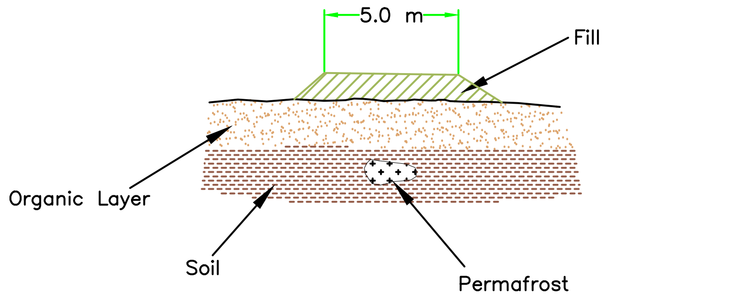
A) Flat terrain, poorly drained, some permafrost: Some flat sections along Km 48-51 of the Polje Creek re-alignment may have soft, poorly drained soils with some permafrost. Aggregate fill (non-organic) placement approximately 0.5 m thick may be required for frost penetration and road bed stability. The fill would not be a continuous berm but would have swales or gaps with snow-fill to ensure that surface drainage is not significantly altered outside of the winter period.

B) Sloping terrain, poorly drained, some permafrost: Some sloping sections along Km 48-50 will require side-hill cuts and may have soft, poorly drained soils with some permafrost. Mineral fill placement approximately 0.5 m thick may be required. Cut material will be used if appropriate, or used elsewhere. The material would not be discarded down-slope, which would cause slope over-steepening and instability.

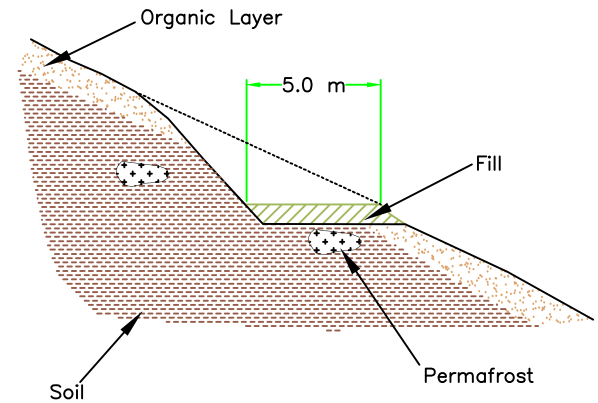
C) Flat terrain, poorly drained, extensive permafrost: Some flat sections along Km 50-52 of the Polje Creek re-alignment may have soft, poorly drained soils with extensive permafrost. Mineral fill would be placed as in A) above, except a non-woven geotextile will be placed first. Kledo's experience is this approach helps to insulate the permafrost and provides a good foundation for the fill.

D) Steep terrain, poorly drained: The section along Km 94-101 where the road climbs to Wolverine Pass in the Silent Hills is quite steep. CZN is proposing to revise the existing switch-backs to reduce grade and make the turns more gradual. Some side-hill cutting will be required in soft, poorly drained soils. Good drainage is seen as important to maintain slope and road bed stability. Drain tile would be installed at the toe of cut slopes to carry drainage beyond the next down-gradient switch-back. Aggregate fill placement approximately 0.5 m thick may be

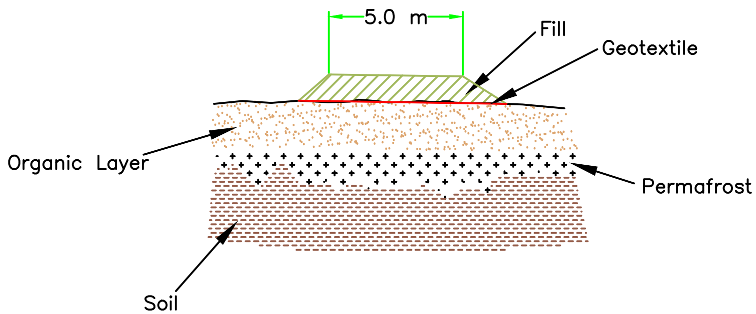
A) Flat Terrain, Poorly Drained, Some Permafrost



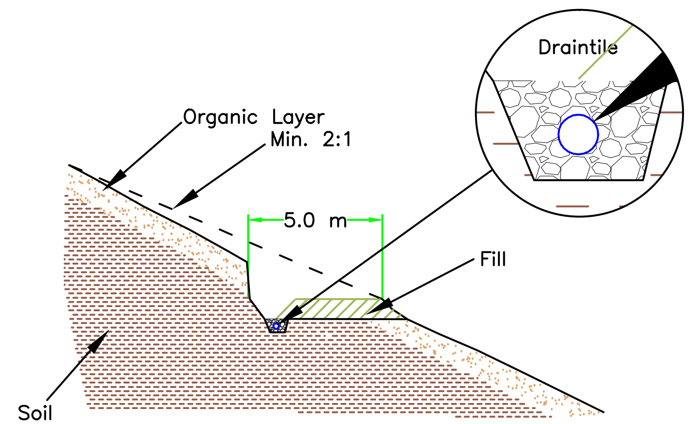
B) Sloping Terrain, Poorly Drained, Some Permafrost



C) Flat Terrain, Poorly Drained, Extensive Permafrost



D) Steep Terrain, Poorly Drained



Not To Scale Vertical Scale Exaggerated

CANADIAN ZINC CORPORATION

PRAIRIE CREEK MINE

Figure 1:

Road Construction Design

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File Name:	Road Construction Design.dwg
Drawn By:	C. Reeves

required. Cut material will be used if appropriate, or used elsewhere, but not discarded down-slope.

The re-alignments east of the Silent Hills are expected to be generally free of permafrost and amenable to typical winter road construction (without fill placement). However, isolated areas of permafrost might occur, over Km 106-109 for example, and if so the approach illustrated in A) would be used.

In terms of stream crossings, bank protection will be determined on a case by case basis, considering factors such as bank type, bank height and stream width. Crossings consisting of low or firm banks, or narrow streams, are considered to be suitable for standard snow-fill without bank protection. Bank protection will be considered for all other crossings, and might consist of water addition to form ice, and/or matting.

CZN is proposing to span Polje Creek with a bridge structure which would remain for the duration of the mine. Figure 2 provides a plan and section view of the proposed span. Bridge abutments would be created well back from the top of bank. Kledo recommends that piles be inserted to support a bridge deck and bin-walls for the abutments. The base of the deck will be at least 1 m above the normal high water mark.

3. *The road may be constructed of snow, ice, granular, or a combination of construction materials depending on the local environmental and physical setting. Provide details on the type of road to be constructed along the length of the route in tabular format, as well as depicted on a map(s).*

Details on the expected bed material during road operations are given in Table 1. The defined road sections are shown in the drawings in Appendix C.

4. *Estimate quarry/borrow material volumes along the length of the road and depict the location of the material source on a map.*

The DAR Addendum indicated that up to 20 km of cut and fill may be required along the proposed road alignment. If the fill thickness is approximately 0.5 m, a road width of 5 m would mean a fill volume of 50,000 m^3. The majority of this volume is expected to be sourced from the cut material. Additional requirements would be provided by borrow sources along the Sundog valley and at the Grainger Gap consisting of talus material above the high water mark. The fill locations were identified in item 3 above. For each fill location, the volume of borrow will depend on cut volumes nearby. Borrow for the Polje Creek re-alignment would likely come from Sundog, while borrow for all fill locations further east would likely come from Grainger Gap.

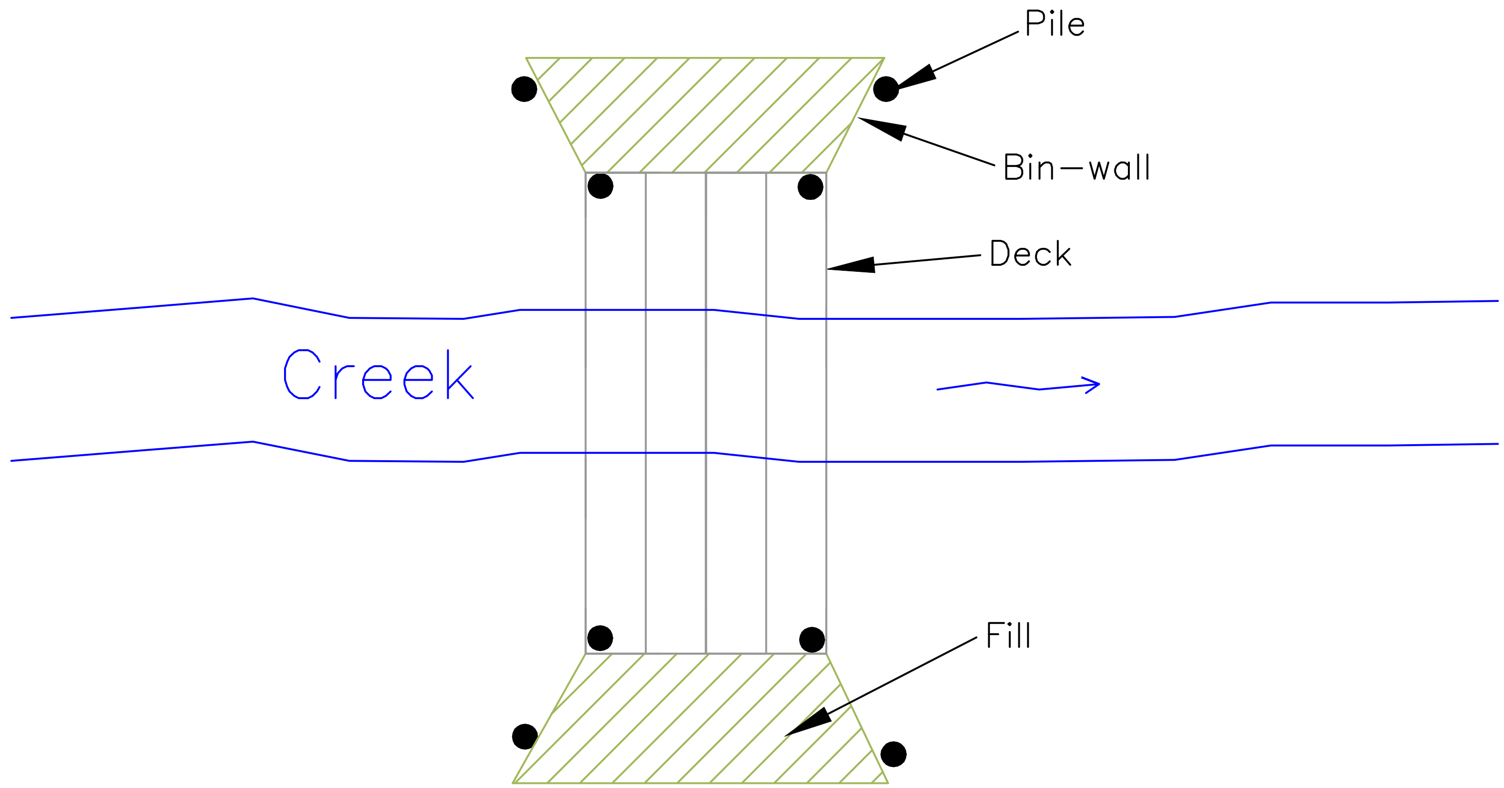
5. *Estimate the snow and water quantity along the length of the road route and depict the location of the water source(s) on a map. PCA recognizes that CZN provided a partial response to this information previously; however, it is requested that an assessment along the length of the route be provided. Our assumption is that the snow and water volumes would be a function of the type of road to be constructed (related to item 3 above).*

TABLE 1: CONSTRUCTIONS MATERIALS FOR ROAD BED

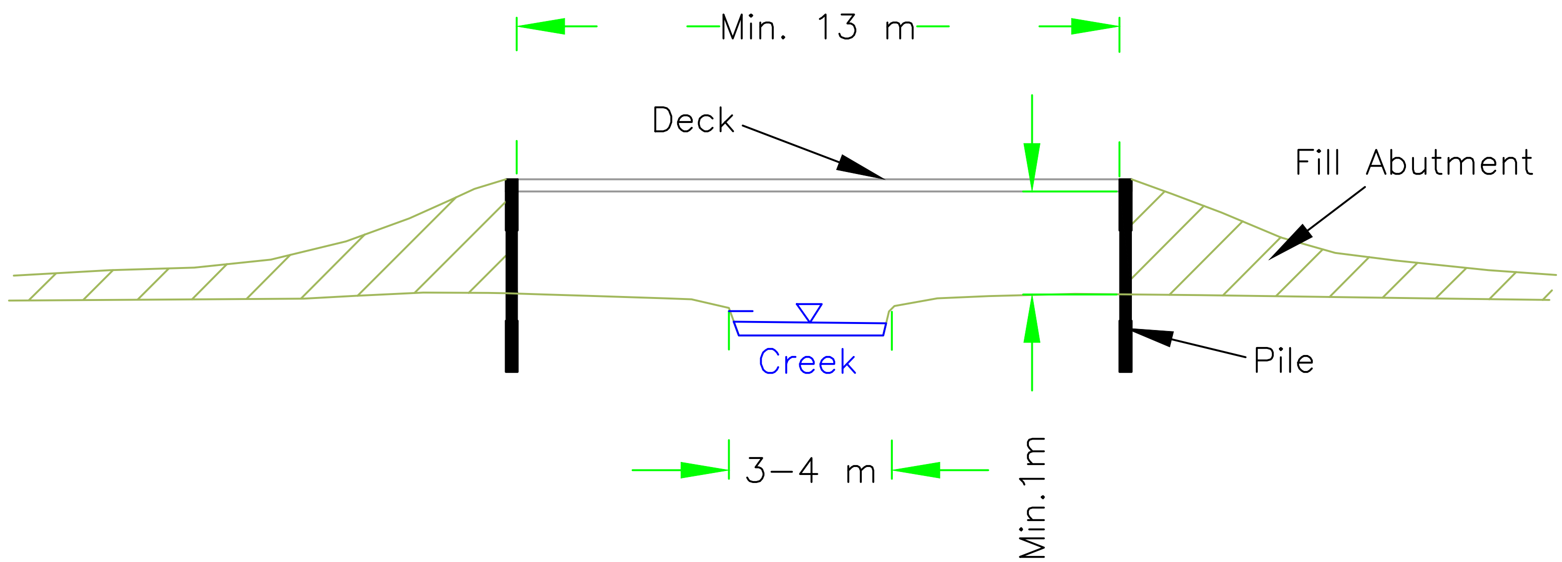
Catchment	Kilometre Marker		Operating Road Bed Material
	From	To	
Prairie	0.0	7.0	All season gravel bed
Funeral	7.0	16.8	All season gravel bed
Sundog	16.8	39.5	Gravel (natural) and snow
	39.5	44.0	Snow and ice
Polje	44.0	48.0	Snow and ice
	48.0	52.5	Snow and ice plus up to 4 km of fill sections, with/without cuts
	52.5	55.0	Snow and ice plus up to 1 km of fill sections, with/without cuts
	55.0	63.0	Snow and ice
Tetcela	63.0	88.5	Snow and ice
Fishtrap	88.5	94.0	Snow and ice
	94.0	101.0	Fill with/without cuts
Un-named	101.0	114.5	Snow and ice plus up to 6 km of fill sections, with/without cuts
Grainger	114.5	140.0	Snow and ice plus up to 5 km of fill sections, with/without cuts
Liard	140.0	156.0	Snow and ice plus up to 1 km of fill sections, with/without cuts

Polje Creek Crossing

Plan View



Long-Section View



CANADIAN ZINC CORPORATION

PRAIRIE CREEK MINE

Figure 2:

Road Construction Design - Polje Creek

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Drawn By:	C. Reeves

An estimate of water requirements for road construction has been prepared by Kledo Construction, and is provided in Appendix B. The estimate is based on winter road construction in the Fort Nelson area for loads of up to 85 tonnes, and for vehicle speeds up to 80 km/hour. The Prairie Creek road is intended for vehicles with a gross vehicle weight (GVW) of less than 60 tonnes travelling at considerably slower speeds. Therefore, the Kledo estimate is very conservative.

Four water sources will be relied on initially for road construction. The four sources are: well water from the mine site; Mosquito Lake at Km 61; Gap Lake at Km 121 (just west of Grainger Gap); and, the Liard River.

Kledo estimated a preferred water demand from Mosquito Lake of approximately 7,800 m^3 (Appendix B). The volume of Mosquito Lake has not yet been defined. However, the lake has a surface area of approximately 435,000 m^2. A drawdown of less than 2 cm would be required to supply the 7,800 m^3. If the lake is given a very conservative average depth of 1.0 metre, this extraction would only represent <2% of the volume. The volume of the lake will be confirmed during the first winter road season (when construction materials and equipment will be brought in) when the road will be built from the east. However, there appears to be a more than adequate supply of water that can be extracted with minimal effect. The possibility of using other water sources in subsequent seasons will also be evaluated at this time, with due consideration of the possible impacts on fish and fish habitat, and approvals from DFO before water extraction.

The availability of snow is not expected to be a limiting factor in road construction. The road will be built from the west in early winter at a time when snow accumulations are available in the mountains. The road has a gravel bed from Km 0 to Km 39, with snow use only for creek crossings. Snow would be used in early winter for road bed between Km 39 and Km 84. The remainder of the road from Km 84 eastwards would only be opened later in the winter, and would make use of snow accumulations from the early winter months.

6. *Provide details of the operation and maintenance activities for the access road.*

Following a request at the Technical Session regarding resources that will be allocated to road maintenance, experienced road engineers at SNC Lavalin provided CZN with equipment and manpower requirements to maintain the access road for the expected haul season. The information can be found in Table 2. Activities would include snow clearing and compaction, and additional snow and water placement to replace ablation and maintain a solid, frozen bed.

7. *If monitoring of the access road occurs during construction and operation, describe the monitoring program. The response is specifically to address: frequency of access road inspection to assess the need for maintenance/repair; items considered in access road inspections (e.g., signs of permafrost degradation).*

Because of the quantity of materials to be hauled, CZN will ensure that the road will be stable and functional at all times during the operating season. Monitoring will occur during both construction and operation. During construction, monitoring will be daily to assess how recently constructed portions are performing, and to determine requirements for portions being

TABLE 2: EQUIPMENT AND MANPOWER FOR ROAD OPERATIONS

Operating Length	165	km
Duration	75	days
Shift Labour	10	hr/day
Shift Equipment	9	hrs/day

Equipment	**Hours**
D8 Dozer	675
Grader 14G Cat(2)	1,350
Grader 14E Cat	675
FEL Cat 950	675
Fuel Truck	750
Snow Plow & Sand Trucks	675
Snow Plow & Sand Trucks	675
Flat Bed Truck	150
Pick up Truck 1	750
Pick up Truck 2	750
Pick up Truck 3	750
Total	**7,875**

Labour	**Hours**
Operators(4)	3,000
Truck Drivers(2)	1,350
Mechanic(1)	750
Service man(1)	750
Foremen(1)	825
Labours (4)	3,000
Total	**9,675**

constructed. During operations, monitoring would initially be daily, with a reduction in frequency as road performance becomes better defined. Problematic areas may be defined which would warrant closer attention and an increased frequency of monitoring, areas of suspected permafrost and cut slopes for example. Road users will be an important source of information. The mine truck fleet will be on the road at all times, and drivers will report on road conditions and any areas of difficulty or requiring repair.

The frequency of monitoring would pick up again later in the season and during periods of warmer temperatures to ensure the integrity of the road bed and creek crossings remain intact until the road is closed.

8. *Conduct a spatial and temporal environmental risk assessment along the length of the road route that considers the impacts of planned activities (unrelated to spills or other accidents and malfunctions) during the following phases of the road: road construction, inclusive of transfer facilities; road operation, inclusive of transfer facilities; and, road post-closure, inclusive of transfer facilities.*

A spatial and temporal environmental risk assessment for the road has been completed containing the requested items, and in the requested format (see Table 3). The assumed criteria and ranks are explained in Table 4. Comments and discussion are given below based on the phase of development. The proposed road south-east of the Liard River has not been included in the assessment because it already exists and is not considered to have any issues of significance. The Liard Transfer Facility is also not included for similar reasons and because of its location in a 'high use' area near the Liard Highway and Nahanni access road.

Construction

Further to the comments made in Item 2 above, CZN has only considered those sections of the road containing proposed new alignments. For the Km 48-56.5 road section, the key issues are considered to be slope stability, permafrost and stream-crossings. The risks of negative consequences for these items will be mitigated by employing appropriate construction techniques (cut slope angle, insulation with fill with/without geotextile) and a span structure for Polje Creek. We believe the mitigated risks are low, but accept that close monitoring and maintenance of key areas will be required to verify that the mitigation employed is effective. Fill placement in local areas is not expected to significantly alter surface drainage patterns because gaps will be left. We note that the risks posed have been assessed independently without consideration of the fact that a section of road would be abandoned which has similar risks if the re-alignment is approved. This re-alignment was requested by Parks Canada to avoid bisecting the karst features (Poljes) to the south.

The road section Km 94-101 (Silent Hills) poses some risk because the slope is steep and the soils may be unstable. The present alignment is not considered to be acceptable because of steep grades and tight turns. CZN intends to reduce the risks posed by revising the alignment. However, this will include side-hill cuts which could be unstable without proper engineering. Kledo has proposed 2:1 slopes with drain-tile installed at the toe, and non-organic fill placement

TABLE 3: ACCESS ROAD ENVIRONMENTAL RISK ASSESSMENT MATRIX

Road Activity	Road KM Marker	Potentially affected component	Predicted Effects	Assessment of unmitigated effects					Proposed Mitigation	Assessment of residual effects		
				Spatial		Temporal		Significance		Influence of mitigation	Significance	Probability
				Magnitude	Extent	Frequency	Duration					
Road and TTF Construction	48-56.5	Topography	Visibility	Medium	Regional	Frequent	Long-term	Medium	None	None	Medium	High
		Slope Stability	Instability	Medium	Local	Intermittant	Long-term	Medium	2:1 angle	Stabilization	Low	Medium
		Permafrost	Thaw	Medium	Local	Intermittant	Long-term	Medium	Fill/cloth	Insulation	Low	Medium
		Groundwater quality and quantity	Impairment	Low	Local	Infrequent	Long-term	Low	None	None	Low	High
		Surface water quality and quantity	Impairment	Low	Local	Infrequent	Long-term	Low	None	None	Low	High
		Surface water drainage patterns	Modification	Low	Local	Frequent	Long-term	Low	Swales, gaps	Same drainage	Low	High
		Stream crossings	Erosion	Medium	Local	Intermittant	Long-term	Low	Span	Bank protection	Low	High
		Sensitive areas	Impairment	Low	Regional	Intermittant	Long-term	Low	None	None	Low	Medium
	TTF	Topography	Visibility	Medium	Local	Frequent	Long-term	Low	None	None	Low	High
		Slope Stability	Instability	Low	Local	Intermittant	Long-term	Low	None	None	Low	High
		Permafrost	Thaw	Medium	Local	Intermittant	Long-term	Medium	Fill	Insulation	Low	High
		Groundwater quality and quantity	Impairment	Low	Local	Infrequent	Long-term	Low	None	None	Low	High
		Surface water quality and quantity	Impairment	Low	Local	Infrequent	Long-term	Low	None	None	Low	High
		Surface water drainage patterns	Modification	Low	Local	Frequent	Long-term	Low	None	None	Low	High
		Stream crossings	Erosion	Low	Local	Intermittant	Long-term	Low	None	None	Low	High
		Sensitive areas	Impairment	Low	Regional	Intermittant	Long-term	Low	None	None	Low	High
	94-101	Topography	Visibility	Medium	Regional	Frequent	Long-term	Medium	None	None	Medium	High
		Slope Stability	Instability	High	Local	Intermittant	Long-term	High	2:1 angle, drain tile	Stabilization	Medium	Medium
		Permafrost	Thaw	Medium	Local	Intermittant	Long-term	Medium	Fill	Insulation	Low	Medium
		Groundwater quality and quantity	Impairment	Low	Local	Infrequent	Long-term	Low	None	None	Low	High
		Surface water quality and quantity	Impairment	Low	Local	Infrequent	Long-term	Low	None	None	Low	High
		Surface water drainage patterns	Modification	Low	Local	Frequent	Long-term	Low	None	None	Low	High
		Stream crossings	Erosion	Low	Local	Intermittant	Long-term	Low	None	None	Low	High
		Sensitive areas	Impairment	Low	Regional	Intermittant	Long-term	Low	None	None	Low	High
	101-156	Topography	Visibility	Medium	Regional	Frequent	Long-term	Low	None	None	Low	High
		Slope Stability	Instability	Low	Local	Intermittant	Long-term	Low	None	None	Low	High
		Permafrost	Thaw	Medium	Local	Intermittant	Long-term	Medium	Fill	Insulation	Low	High
		Groundwater quality and quantity	Impairment	Low	Local	Infrequent	Long-term	Low	None	None	Low	High
		Surface water quality and quantity	Impairment	Low	Local	Infrequent	Long-term	Low	None	None	Low	High
		Surface water drainage patterns	Modification	Low	Local	Frequent	Long-term	Low	None	None	Low	High
		Stream crossings	Erosion	Low	Local	Intermittant	Long-term	Low	None	None	Low	High
		Sensitive areas	Impairment	Low	Regional	Intermittant	Long-term	Low	None	None	Low	High

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Road Activity	Road KM Marker	Potentially affected component	Predicted Effects	Assessment of unmitigated effects					Proposed Mitigation	Assessment of residual effects		
				Spatial		Temporal		Significance		Influence of mitigation	Significance	Probability
				Magnitude	Extent	Frequency	Duration					
Road and TTF Operations	0-48	Topography	Visibility	Medium	Regional	Frequent	Long-term	Medium	None	None	Medium	High
		Slope Stability	Instability	Medium	Local	Intermittant	Long-term	Medium	Maintenance	Stabilization	Low	Medium
		Permafrost	Thaw	Low	Local	Intermittant	Long-term	Low	None	None	Low	High
		Groundwater quality and quantity	Impairment	Low	Local	Infrequent	Long-term	Low	None	None	Low	High
		Surface water quality and quantity	Impairment	Low	Local	Infrequent	Long-term	Low	None	None	Low	High
		Surface water drainage patterns	Modification	Low	Local	Frequent	Long-term	Low	None	None	Low	High
		Stream crossings	Erosion	Medium	Local	Intermittant	Long-term	Medium	Protect banks	No erosion	Low	Medium
		Sensitive areas	Impairment	Medium	Regional	Intermittant	Long-term	Medium	Maintenance	No erosion	Low	Medium
	48-56.5	Topography	Visibility	Medium	Regional	Frequent	Long-term	Medium	None	None	Medium	High
		Slope Stability	Instability	Medium	Local	Intermittant	Long-term	Medium	Maintenance	Stabilization	Low	Medium
		Permafrost	Thaw	Medium	Local	Intermittant	Long-term	Medium	Maintenance	Insulation	Low	Medium
		Groundwater quality and quantity	Impairment	Low	Local	Infrequent	Long-term	Low	None	None	Low	High
		Surface water quality and quantity	Impairment	Low	Local	Infrequent	Long-term	Low	None	None	Low	High
		Surface water drainage patterns	Modification	Low	Local	Frequent	Long-term	Low	Maintenance	Same drainage	Low	High
		Stream crossings	Erosion	Medium	Local	Intermittant	Long-term	Medium	Maintenance	Bank protection	Low	Medium
		Sensitive areas	Impairment	Low	Regional	Intermittant	Long-term	Low	None	None	Low	Medium
	56.5-94	Topography	Visibility	Medium	Regional	Frequent	Long-term	Medium	None	None	Medium	High
		Slope Stability	Instability	Low	Local	Intermittant	Long-term	Low	None	None	Low	High
		Permafrost	Thaw	Medium	Local	Intermittant	Long-term	Medium	Maintenance	Insulation	Low	High
		Groundwater quality and quantity	Impairment	Low	Local	Infrequent	Long-term	Low	None	None	Low	High
		Surface water quality and quantity	Impairment	Low	Local	Infrequent	Long-term	Low	None	None	Low	High
		Surface water drainage patterns	Modification	Low	Local	Frequent	Long-term	Low	Maintenance	Same drainage	Low	High
		Stream crossings	Erosion	Medium	Local	Intermittant	Long-term	Medium	Maintenance	Bank protection	Low	Medium
		Sensitive areas	Impairment	Low	Regional	Intermittant	Long-term	Low	None	None	Low	Medium
	TTF	Topography	Visibility	Low	Local	Frequent	Long-term	Low	None	None	Low	High
		Slope Stability	Instability	Low	Local	Intermittant	Long-term	Low	None	None	Low	High
		Permafrost	Thaw	Medium	Local	Intermittant	Long-term	Medium	Maintenance	Insulation	Low	High
		Groundwater quality and quantity	Impairment	Low	Local	Infrequent	Long-term	Low	None	None	Low	High
		Surface water quality and quantity	Impairment	Low	Local	Infrequent	Long-term	Low	None	None	Low	High
		Surface water drainage patterns	Modification	Low	Local	Frequent	Long-term	Low	None	None	Low	High
		Stream crossings	Erosion	Low	Local	Intermittant	Long-term	Low	None	None	Low	High
		Sensitive areas	Impairment	Low	Regional	Intermittant	Long-term	Low	None	None	Low	High

TABLE 3: ACCESS ROAD ENVIRONMENTAL RISK ASSESSMENT MATRIX

Road Activity	Road KM Marker	Potentially affected component	Predicted Effects	Assessment of unmitigated effects					Proposed Mitigation	Assessment of residual effects		
				Spatial		Temporal		Significance		Influence of mitigation	Significance	Probability
				Magnitude	Extent	Frequency	Duration					
Road and TTF Operations	94-101	Topography	Visibility	Medium	Regional	Frequent	Long-term	Medium	None	None	Medium	High
		Slope Stability	Instability	High	Local	Intermittant	Long-term	High	Maintenance	Stabilization	Medium	Medium
		Permafrost	Thaw	Medium	Local	Intermittant	Long-term	Medium	Maintenance	Insulation	Low	Medium
		Groundwater quality and quantity	Impairment	Low	Local	Infrequent	Long-term	Low	None	None	Low	High
		Surface water quality and quantity	Impairment	Low	Local	Infrequent	Long-term	Low	None	None	Low	High
		Surface water drainage patterns	Modification	Low	Local	Frequent	Long-term	Low	None	None	Low	High
		Stream crossings	Erosion	Low	Local	Intermittant	Long-term	Low	None	None	Low	High
		Sensitive areas	Impairment	Low	Regional	Intermittant	Long-term	Low	None	None	Low	High
	101-156	Topography	Visibility	Medium	Regional	Frequent	Long-term	Low	None	None	Low	High
		Slope Stability	Instability	Low	Local	Intermittant	Long-term	Low	None	None	Low	High
		Permafrost	Thaw	Medium	Local	Intermittant	Long-term	Medium	Maintenance	Insulation	Low	High
		Groundwater quality and quantity	Impairment	Low	Local	Infrequent	Long-term	Low	None	None	Low	High
		Surface water quality and quantity	Impairment	Low	Local	Infrequent	Long-term	Low	None	None	Low	High
		Surface water drainage patterns	Modification	Low	Local	Frequent	Long-term	Low	None	None	Low	High
		Stream crossings	Erosion	Low	Local	Intermittant	Long-term	Low	None	None	Low	High
		Sensitive areas	Impairment	Low	Regional	Intermittant	Long-term	Low	None	None	Low	High

TABLE 4: DEFINITION OF CRITERIA AND RANKS FOR ROAD RISK ASSESSMENT

Assessment of unmitigated effects	Spatial	Magnitude	Low	Effect is unlikely to pose environmental risk
			Medium	Effect may pose environmental risk
			High	Effect is likely to pose environmental risk
		Extent	Local	Effect occurs within a 1 km radius
			Regional	Effect occurs beyond a 1 km radius
	Temporal	Frequency	Infrequent	Effect may occur once every few years
			Intermittent	Effect occurs approximately once a year
			Frequent	Effect occurs several times a year
		Duration	Short-term	Approximately one year
			Medium-term	Over part of the ilfe of the project
			Long-term	Over the ilfe of the project
			Permanent	Beyond the ilfe of the project
	Significance		Low	Un-mitigated effect is unlikely to cause environmental concern
			Medium	Un-mitigated effect may be a cause of environmental concern
			High	Un-mitigated effect is likely to cause environmental concern
Proposed Mitigation				The activity proposed to mitigate effects
Assessment of residual effects	Influence of mitigation			The expected outcome of mitigation
	Significance		Low	Mitigated effect is unlikely to cause environmental concern
			Medium	Mitigated effect may be a cause of environmental concern
			High	Mitigated effect is likely to cause environmental concern
	Probability		Low	Assessment of significance may not be correct
			Medium	Assessment of significance likely to be correct
			High	Assessment of significance expected to be correct

for road bed. The tile will carry drainage laterally beyond the next downstream turn. The need for any additional measures will be evaluated at the time of construction.

Operations

The road section Km 0-48 contains a pre-existing bed adjacent to Funeral Creek, and crosses talus fans in the Sundog valley. The bed adjacent to Funeral Creek is generally stable but is prone to local wash-outs during peak flows. Cadillac also did not armour the slope in proximity to the creek. CZN has been armouring locations prone to erosion, and locally reducing slope angles to promote stability by moving the road alignment into the slope. The more susceptible locations have been addressed, but more work is required in other areas. Passage structures for upslope runoff are also required to avoid wash-outs. The Sundog talus fans will require maintenance to remove any rock ravelling from upslope. Snow accumulations will also need to be monitored to assess the potential for avalanches.

Close monitoring and on-going effective maintenance are seen as important to mitigate the risks posed in more difficult terrain during road operations.

Post-Closure

Post-closure assessment is considered to be applicable to the proposed new alignments. An assessment in a tabular format has not been completed because post-closure issues are considered to be specific to the side-hill cut areas in road sections Km 48-56.5 and Km 94-101. Closure activities for these areas will need to be formulated in detail using the observations and experience gained during the operating period. It is envisaged that material replacement will occur in order to restore a stable natural slope and provide a suitable medium for revegetation. Experience and investigations of the existing road alignment (by EBA Environmental Consultants) have confirmed that natural invasion and revegetation are effective processes in the area. Measures will be incorporated into the restored slopes to maintain stable surfaces until a vegetation cover has been established.

IR Number: Parks Canada 2-2
Subject: Prairie Creek water quality that is protective of aquatic life
Request: *Provide a summary table of water quality parameters and concentrations that are protective of aquatic life in Prairie Creek (i.e. site-specific objectives). Describe the method(s) applied to determine the water quality parameters and concentrations.*

See report from Hatfield Consultants in Appendix D.

IR Number: Parks Canada 2-3
Subject: Prairie Creek water quality – downstream mixing zone
Request:

1. *Provide the full final report, instead of a draft summary, that details the downstream mixing analysis.*

The mixing analysis presented in the first IR round was based on site discharge via a simple culvert outfall. CZN has since proposed to discharge via an exfiltration trench constructed below the bed of Prairie Creek and approximately half way across the creek channel. The preliminary design for this system is provided in Appendix E. As a result, the previous mixing analysis is no longer valid. A new mixing analysis is discussed elsewhere in this document.

2. *Complete the downstream mixing analysis for, but not limited to, the following scenarios:*

   a. Average Prairie Creek flows expected during typical operations.

   b. Worst case Prairie Creek low flows.

   c. Worst case Prairie Creek high flows.

3. *Define the selected typical ranges and worst case conditions.*

4. *Present the concentration contours within the mixing zone.*

5. *Complete the downstream mixing analysis for all water quality parameters that could impact aquatic life.*

6. *Present a summary of the mixing zone dimensions required for water quality to comply with water quality objectives.*

7. *Provide details of an environmental impact analysis to aquatic life within the mixing zone.*

See Appendix D.

IR Number: Parks Canada 2-4
Subject: Prairie Creek water quality predictions and mine site water balance
Request:

1. *Predict in-stream Prairie Creek water quality at Harrison Creek and the Park Boundary for the following scenarios:*

   a. *Average Prairie Creek flows expected during typical operations and monthly average inflows expected during typical operations.*

b. *Average Prairie Creek flows expected during typical operations and worst case high mine inflows (assuming worst case connectivity to the PCAA and HCAA).*

c. *Average Prairie Creek flows expected during typical operations and low mine inflows.*

d. *Worst case Prairie Creek low flows and monthly average inflows expected during typical operations.*

e. *Worst case Prairie Creek low flows and worst case high mine inflows (assuming worst case connectivity to the PCAA and HCAA).*

f. *Worst case Prairie Creek low flows and low mine inflows.*

g. *Worst case Prairie Creek high flows and monthly average inflows expected during typical operations.*

h. *Worst case Prairie Creek high flows and worst case high mine inflows (assuming worst case connectivity to the PCAA and HCAA).*

i. *Worst case Prairie Creek high flows and low mine inflows.*

CZN is to define the selected typical, high, and low flow conditions.

See Appendix F.

2. *For the nine scenarios outlined above, conduct a water balance to demonstrate that mine site water storage capabilities are acceptable. Worst case mine site scenarios should also consider the implications on catchment pond storage capacity and required discharge flow rates due to high or worst case mine inflow volumes occurring in combination with surface flood events, as this combination may require higher discharge volumes.*

CZN is to identify the selected typical ranges and worst case conditions.

See Appendix F. The Catchment Pond has a limited storage capacity. The pond acts as a runoff collection and control point. Discharge can be stopped and water recycled to the Water Storage Pond (WSP) in an emergency. Otherwise, runoff is discharged as it arrives in the pond. Flood events have a very small effect on camp runoff and the Catchment Pond. The catchment for runoff is small, and the camp area is located on permeable floodplain sand and gravel which readily allows percolation of rainfall. Flows in the main camp ditch do not fluctuate greatly. Higher ditch flows would mean a nominally higher (nominal because treated mine water flows will be large by comparison) but more dilute discharge. The Catchment Pond discharge mechanism will include pumps on stand-by which can be activated to ensure sufficient discharge in times when the head difference between the pond and Prairie Creek is insufficient. In addition, there will be a Safety Return line from the Catchment Pond to the Water Storage Pond, with installed pumps that can transfer water if the Catchment Pond is not discharging sufficient quantities to maintain or lower its water level.

Surface flood events will also not significantly affect the WSP and water management strategy. Runoff from upslope of the WSP will be diverted around the pond. Direct precipitation will have a relatively small effect on water levels in the WSP. Mine water and process water will be stored in separate cells in the WSP. Both will feed the Mill based on a 65:35 split. During periods of intense rainfall, if water levels are becoming too high, a greater proportion of process water could be sent back to the Mill (as it would more dilute than usual), and more mine water could be sent to the Water Treatment Plant (WTP), thus maintaining the desired water levels in the cells.

3. *Compare in-stream Prairie Creek water quality predictions to water quality objectives that are based on protection of aquatic life.*

See Appendix D.

IR Number: Parks Canada 2-5
Subject: Potential for bioaccumulation of mercury
Request:

Given that existing data has shown that slimy sculpin downstream of the Prairie Creek contain elevated average levels of mercury in their tissues compared to an upstream site, and that full mining operations are projected to increase loadings of mercury to Prairie Creek,

1. *Provide empirical data to document that the discharge of mercury-rich effluent to Prairie Creek will not jeopardise the health of fish and the entire foods web in Prairie Creek.*

2. *In the absence of these data, ensure that mercury is included in the predictions for downstream concentrations during mine operations, (See EC-2-1; INAC02-1), and that potential environmental effects on biological communities in the system are considered.*

See comments by Hatfield Consultants in Appendix G.

IR Numbers: Parks Canada 2-6
Subject: Adaptive Management of Wildlife Impacts
Request:

1. *Outline the adaptive management process proposed by CZN. Provide sufficient detail on the following key elements of monitoring within the adaptive management framework:*

   a. *Selection of valued ecosystem components that will be monitored with a clear rationale on:*

      i. how they indicate trends for the ecosystem and anthropogenic change

      ii. which areas and seasons within the study area will be addressed by their inclusion *iii. which variable will be monitored (e.g., Dall's sheep recruitment, grizzly bear occupancy)*

- b. *Design of monitoring programs including geographic extent, timing, survey method, personnel requirements, and study controls that will be used to allow development specific change to be detected and mitigated*

- c. *Indicate the thresholds that will be used to determine change, including descriptions of effect size, power, confidence, sample size, and frequency*

- d. *Describe how results from monitoring programs will be integrated into decision making and the process in which mitigations will be determined*

- e. *Comment on the use of additional research and adaptation of monitoring programs to determine efficacy of mitigation measures*

Where CZN believes sufficient information exists (e.g., Dall's sheep) provide a full assessment of data in the context of the above questions to help describe how adaptive management would be applied as proposed.

See comments from Golder Associates in Appendix H.

IR Number: Parks Canada 2-7
Subject: Mitigation of possible impacts to carnivores
Request:

1. *Provide infrastructure design mitigations that will be used to discourage predator and scavenger attraction to the mine site and transfer facilities.*

The camp kitchen and food storage will be inside an enclosed modular building. Workers will be encouraged to eat only in the dining area, except for miners who may take some meals underground. Workers will be made aware as part of site orientation when they start that food, food waste and wrappings are not to be left around the site or in buildings where un-controlled entry is possible (e.g. the shops). Food waste will be collected in the dining area, and will be stored inside and taken to the incinerator daily.

Filtered sewage sludge will be taken to a sludge storage cell in the Solid Waste Area of the Waste Rock Pile. The cell will be bermed and fenced to prevent wildlife entry.

The transfer facilities will only be open during the bear hibernation period. However, all workers will be notified of a need to deposit any waste in approved containers in the facilities. The facilities will be closed and free of all attractants outside of the haul season.

CZN has not had a bear attraction issue during its tenure at the site, and has every intention of keeping it that way by continuing to implement appropriate practices.

2. *A good synopsis of food and waste management in terms of disposal has been presented by the developer. Yet insufficient detail is in place on how attractants will be handled on site, and by workers away from the mine site, including along the road or in transfer facilities. All attractants should be stored in animal proof containers; please indicate which types of containers will be used.*

See response to point 1. above. Workers away from the mine site will be required to observe the same policies as those on the mine site in term of management of attractants, and the same as those that have been used for exploration over the last almost two decades. Any attractants stored on site outside of the camp kitchen/diner complex will be stored in suitable animal proof containers.

3. *Describe how other chemical and industrial grease materials will be stored; describe how they will be managed while in use or immediately following use.*

All chemicals and supplies will be stored in an enclosed warehouse structure. Small quantities will be transferred to their point of use (in the Mill or shops) as required. The shops will temporarily store small quantities of lubricating oil and grease in approved containers, as at present. Waste oil and other hazardous waste will be managed as described in the DAR.

4. *Provide details of employee education and management programs to reduce negative encounters and to ensure policies are enforced.*

All workers receive bear awareness orientation when starting on site. This is reinforced during regular safety meetings. Employees also receive a copy of the site Health and Safety Plan (HSP) and are required to read it. The HSP includes bear awareness and response information, and also gives directions on actions and notifications if a bear is spotted in the area. The site environmental officers will be tasked with overseeing the program in terms of enforcement and effectiveness.

5. *Describe how grey water systems will be managed to ensure they remain clean, grease free, and not accessible to wildlife.*

Grey water will be treated the same as sewage. Regular maintenance will ensure water systems remain clean and grease free for functionality and efficiency.

6. *Describe the monitoring programs that will be in place to assess the effectiveness of the above programs and how problems will be dealt with.*

As noted above, the site environmental officers will be tasked with overseeing monitoring programs in terms of enforcement and effectiveness. Issues will be brought to Mine management for resolution.

IR Number: Parks Canada 8
Subject: Road Impacts on wildlife
Request:

1. *Describe the potential impacts on woodland caribou from the road routing and road operation during the winter.*

2. *Describe the associated mitigation for these impacts.*

See Appendix H.

IR Number: Parks_Canada_9
Subject: Assessment of spills and identification of mitigation along the access road and at the mine site
Request:

1. *Conduct a spatial risk assessment along the length of the road, that considers the frequency of spills, the consequence of spills, and the challenges of clean up. The assessment should lead to a fuller assessment of the potential impacts of spills, appropriate mitigation, and their significance. The information requested should include:*

   (a) evaluation of locations where the frequency of potential spills is high, including, without limitation, steep grades, and hairpin turns. Where possible, this should include measurable/numerical limits (e.g. grade);

   (b) evaluation of locations and seasonal conditions where the environmental consequence of a spill is high, including, without limitation, the karst landforms, bull trout spawning areas, trumpeter swan habitat, Polje Creek, and shoulder seasons conditions that may increase movement of contaminants;

   (c) evaluation of locations and seasonal conditions where spill response and/or clean-up is challenging, including, without limitation, difficulties in mobilizing equipment, or containing contaminants;

   (d) identification of the impacts of spilled substances, including all substances that may be transported over the road, including, without limitation, sulphuric acid, ore concentrate, process reagents, and fuel. This may include an evaluation of worst-case scenarios related to the above-noted risk factors.

   (e) identification of mitigation considerations to address these risks, including both design and operational mitigations.

See Appendix I.

3.0 ENVIRONMENT CANADA IR REPLIES

IR Number: EC 2-1
Subject: Effluent quality predictions
Requests:

1. *EC requests that CZN provide predictions for integrated effluent quality for all sources combined (process water, mine water, site runoff, and sewage effluent), with predicted composition to include a full list of parameters (metals, nutrients, major ions). Values should be provided for maximum anticipated concentrations, and for seasonal and annual average concentrations.*

See Appendix F.

2. *EC requests that CZN provide predictions for downstream concentrations of a full suite of parameters. These should include metals, major ions, and nutrients. Predictions should be compared to water quality objectives.*

See Appendix D.

3. *EC requests that information on the camp wastewater be provided, and include system treatment capability, estimated discharge volumes, predicted effluent quality, and annual loadings for nutrients. Parameters of concern include pH, BOD5, TSS, total phosphorus, ammonia (as N), and nitrate (as N).*

As noted in the DAR, the existing Sewage Treatment Plant (STP) was based on an estimated average inflow rate of 30,000 L/day. The plant will be refurbished to treat sewage based on 120 persons producing 270 L/day/person, or 32,400 L/day total. Sewage treatment is based on a biochemical oxygen demand (BOD_5) of 220 to 300 mg/l, and will involve aerobic biological digestion with the addition of air. The design parameters for treated sewage effluent quality are BOD_5 <20 mg/l, and TSS <20mg/l. The use of only non-phosphate based detergents in the camp will be mandatory to reduce nutrients in sewage effluent. Effluent will be pumped to the mine water cell of the WSP. Based on the expected mine water cell water balance ('best guess scenario'), the effluent will comprise 0.9% of the total inflow on an annual basis.

The STP has not operated during CZN's tenure at the site. Camp sewage presently discharges to a pit adjacent to the Administration Building. This is a 'soak-away' with no active treatment, and there is no effluent to sample. The STP was designed by Sanitherm Inc. of Vancouver, B.C. Sanitherm will assist with design of plant upgrades. Sanitherm was asked to provide a laboratory analysis for a typical effluent from a similar extended aeration sewage treatment plant. An analysis for a plant owned by Wendigo Trailer Owners Association Inc. (Winnipeg) was provided (see Appendix F). Results were as follows:

- Ammonia as N <0.050 mg/L; Biochemical Oxygen Demand 6.6 mg/L; TSS 14.0 mg/L

No other parameters requested by Environment Canada were available.

For comparison, Diavik constructed a sewage treatment facility that utilizes advanced biological treatment as well as an alum and filtration system to remove phosphorus. Sewage effluent is sampled once per year. Results from the December 2009 SNP report are as follows:

- Ammonia as N, total 0.0097 mg/L
- Nitrate as N, in water 5.21 mg/L
- BOD Biological Oxygen Demand < 2 mg/L
- pH of Water, field 6.89
- pH of Water, lab 7.25
- Ortho-Phosphate as P in Water < 0.001 mg/L
- Total Dissolved Phosphorus 0.0162 mg/L
- Total Phosphorus 0.0414 mg/L
- Total Suspended Solids (TSS) 12 mg/L

Phosphorous is contained in human excreta, consisting on average of 40-60 grams per person per day. On average, 3-6% consists of phosphorous based components. Conventional extended aeration removes only about 30%. However, a small amount of alum can be added to form a precipitate which will settle as sludge. Alum can be added to the aeration basin or at the inflow of the secondary clarifier, if present. CZN will incorporate alum addition into sewage treatment in order to attain the effluent quality indicated by the Diavik results.

4. *EC requests that CZN fully describe expected environmental changes or impacts associated with the metals, nutrient and major ions parameters.*

See Appendix D.

5. *EC requests that the proponent provides a description of mitigation measures available to prevent impacts, and/or as a contingency in the event concentrations are higher than predicted, or monitoring detects changes which were not predicted.*

The main mitigation initiative to prevent impacts is the water management plan described in Appendix F. Process water will contain higher metal and major ion concentrations. The water will be recycled and re-used as much as possible. Excess process water will be treated using a scheme selected to minimize metal concentrations. The treatment schedule has been designed to treat primarily in the summer, with reduced or no treatment in winter months when the assimilative capacity of Prairie Creek is much less. Nutrient concentrations will be minimized by using emulsion explosives with strict explosive management practices, and by adding alum in sewage treatment to precipitate phosphates.

If discharge concentrations are higher than predicted, or monitoring detects changes which were not predicted, the response will depend on the parameters considered to be causing the problems, and when they occur. A review of water treatment schedule and performance will be undertaken in conjunction with toxicity studies in order to define the source of the variance from predictions. Adaptive management approaches could include a modified treatment schedule, and /or modified or additional treatment steps, either to allow a greater proportion of process water recycling and thus reduce the quantity for treatment and discharge, or to discharge a similar volume of better quality treated water.

IR Number: EC 2-2
Subject: Major ions
Requests: *EC requests that CZN provide test results for major ion constituents, and estimate contributions from process reagents.*

Major ions from the recent metallurgical and water treatment testing are as follows:

Source Quality mg/L	Ca	Mg	Na	SO^4	Chloride	TDS	Total Alk (CaCO3)	Bicarb (HCO3)	Carb (CO3)
Un-treated Mine Water	193	93	1.5	500	410	1000	370	450	<0.5
Treated Mine Water	25	123	1.5	470	310	700	86	78	14
Un-treated Process Water	16	41	2110	1900	0.8	5200	2400	1300	780
Treated Process Water	65	65	1890	4500	1.7	6100	250	230	37

Un-treated mine water was the feed water to metallurgical testing. Sodium and sulphate are the dominant ions that increase in the process due to reagents. Sulphate more than doubles after water treatment. This is due to sodium sulphide and ferric sulphate addition. These chemicals were likely over-dosed to reduce metals concentrations, and their quantities will be less when the doses are optimized.

IR Number: EC 2-3
Subject: Wildlife Monitoring Plan and Technical Advisory Committee
Request:

1. *Specify who they envision as being members of the technical advisory committee;*

See Appendix J.

2. *Provide details of how the technical advisory committee will be involved in the development of the WMP;*

A draft Wildlife Mitigation and Monitoring Plan (WMMP) is provided in Appendix K. This plan will be updated in response to review comments through the EA process, and during the permitting process assuming the project proceeds to this stage. The plan will be considered a 'living' document, and further changes will be considered as necessary during operations, such changes being considered and discussed in the forum of the Technical Advisory Committee.

3. *Provide a draft of the TOR for the technical advisory committee for review by potential members of the committee;*

See Appendix J.

4. *Provide a timeline for the provision of a revised WMP to the technical advisory committee that addresses Section 3.3.6-5 of the Terms of Reference as well as the expected timing of follow-up meetings that would allow members of the committee to review the plan and provide input into the development of the final WMP to be in place prior to the start-up of mine operations and development of the mine access road.*

See Item 2. above.

IR Number: EC 2-4
Subject: Summer road maintenance
Request:

1. *Provide further clarification on the details of road maintenance activities to be carried out during spring and summer, the expected length of the section of the road where these activities will occur, vegetation types or sensitive terrain along this section of the road, equipment and personnel to be used during these activities and the expected timing of activities.*

It is important to note that CZN holds LUP MV2003F0028 for operation of the access road, and that the permit is based on previous LUP N80F249. The latter permit allowed for all season use of the road to Km 39. CZN has undertaken rehabilitation and maintenance of the road up to Km 27 over two recent summer seasons.

CZN also holds LUP MV2004C0030 for exploration drilling. The LUP was issued after EA0405-002. Use of the access road to Km 10 to drill at the Rico Showing was included in the EA, and with no usage restriction based on time of year.

The road from the Mine to Km 39 consists of a gravel bed. Maintenance on the sections along Funeral Creek and upper Sundog Creek are best completed in summer time, and CZN has been doing this sporadically over the last few years. For Mine operations, CZN's intent is to continue this maintenance. Parks Canada noted that the spring and fall could be sensitive times for ungulates should they be in the area. CZN's response was that it did not need to complete the maintenance work in the spring and fall, and that it could voluntarily restrict its' activities to the period July to September to minimize the potential for possible impacts. Activities are related to runoff management control and structures, repairing eroded or potentially erodable areas, slope stability improvement, and in Sundog Creek, removing talus from the road bed where it crosses several talus slopes. Work is confined to the immediate area of the road alignment which has been previously disturbed.

2. *Describe any potential impacts of these spring/summer road maintenance activities on Species at Risk or migratory birds that may be encountered on or adjacent to the access road with specific consideration given to the fact that these activities will occur within the migratory bird nesting season.*

As noted in the DAR, Olive-sided flycatcher's breeding range occurs through the boreal forest of northern Canada where it breeds along forest edges and openings, including the edge of bogs, marshes and ponds. This species was not observed along the access road during 1980, 1981 and 1994 surveys.

The breeding distribution of the common nighthawk is near its northern limits in the Mackenzie Mountains. This species nests in open terrain, generally in areas of gravel beaches, rocky outcrops or in early stages of growth following wildfire of open forests. There is no record of common nighthawks being observed in the Prairie Creek mine area, but there were several observations near ponds along the access road during wetland surveys in 1980. From the Mine, the first wetlands occur in the Fishtrap Creek area from Km 90 onwards.

Therefore, olive-sided flycatcher and common nighthawk have not been observed in proximity to the Mine and western half of the access road. No impacts from summer road maintenance activities are expected.

3. *Describe proposed mitigation to minimize potential impacts and details of any monitoring programs to verify whether mitigation is successful and to identify where adaptive management may be necessary*

Prior to initiating road maintenance work, Mine environmental staff will be sent out to survey for the presence of olive-sided flycatcher, common nighthawk and other birds as a precaution. Common nighthawk is a ‘ground-nester’. Environmental staff will check for the presence of nests in and proximal to the road alignment. Any positive observations will be brought to the attention of the Canadian Wildlife Service, and the need for and form of adaptive management discussed at that time.

4.0 INDIAN AND NORTHERN AFFAIRS IR REPLIES

IR: INAC 2-1
Subject: Effluent Discharge and Receiving Water Quality - Operations
Requests:

1. *In addition to the table(s) on expected effluent quality as requested by Environment Canada during the Technical Session, provide associated rationale and background on how these values were derived.*

See Appendix F.

2. *Provide an assessment of the potential impacts associated with mine effluent, and identify acceptable in-stream parameter concentrations. Provide a rationale for removing all potential contaminants or stressors, present in the mine's effluent, from consideration during the assessment. As an example Table J.6 identifies that arsenic concentrations will increase by 4 times. This increased concentration remains below CCME standards, but the magnitude of the increase may still be significant for Prairie Creek.*

See Appendix D.

3. *Provide additional information on the mixing analysis including: mixing analysis for additional parameters (ammonia and mercury), the model used to generate the predictions, any site specific modifying factors included in the modelling exercise (e.g. attenuation factors) and expected concentration gradients within the plume.*

A mixing analysis (plume model) was completed by Northwest Hydraulics Co. (NHC). The analysis included optimization of the exfiltration trench design (Appendix E), and relationships were generated allowing computation of plume concentrations for any parameter (see Appendix L). In-stream parameter concentrations were determined by Hatfield using the NHC work (Appendix D).

4. *Provide information (i.e. dimensions) for a set mixing/dilution zone that will be applicable to all effluent parameters under all flow conditions. In-stream water quality objectives will be met at the edges of the dilution zone.*

See Appendix D.

5. *Provide a comparative assessment between the use of a simple pipe outfall versus use of a diffuser. Specifically, with respect to the size of the predicted dilution zone and the ability of each option to minimize potential long-term impacts on the receiving environment. In addition, provide an assessment of any increased impacts to the left bank of Prairie Creek during moderate to high flow as a result of the pipe outfall design*

We assume the comparative assessment was requested because CZN proposed a simple outfall instead of a diffuser in the first IR round reply, with an expectation that the outfall would result in a larger dilution zone. As noted elsewhere, CZN proposes to install an exfiltration trench instead of an outfall. Therefore, the request is now considered to be moot.

6. *If in-stream water quality objectives will not be met at the edge of the proposed mixing zone, what mitigation measures will be used to reduce contaminant concentrations to acceptable levels. Any mitigation measures that rely upon decreasing effluent discharge volumes must include calculations demonstrating that the site's water management structures will be capable of storing any un-discharged water under a range of mine inflows including low, expected and high mine flows. The demonstration should also include several scenarios including reducing discharge for consecutive months and over the entire winter.*

The potential difficulties of meeting in-stream water quality objectives at the edge of the proposed mixing zone are associated with treated process water concentrations and the possibility of abnormally low winter flows from December-April. As noted in Appendix F, the treated process water concentrations used in the mixing analysis are considered to be a worst-case, and potentially un-representative. Therefore, the difficulties may in fact not occur.

If difficulties of meeting in-stream water quality objectives arise despite prevailing treated process water quality, then the remedy would be to curtail process water treatment. The water management plan (Appendix F) includes limited process water treatment over the December-April period specifically to avoid water quality impacts. The volume of process water to be treated is approximately 11,000 m^3. The Cell A water balance shows that the cumulative gain in water over the period total approximately 75,000 m^3. The total gain available is approximately 100,000 m^3. Therefore, the cell can easily absorb the un-treated water and defer treatment. In fact, storage capacity is sufficient to defer treatment in November also.

The process water treatment plan has been designed to maintain a consistent quality of water being fed to the Mill (a 65% process water, 35% mine water blend) without interfering with the process, and at the same time minimize the quantity of water being treated and discharged. The objective is to maintain metal and major ion concentrations in feed water below specified levels. Conservatism has been included in the plan. If difficulties of meeting in-stream water quality objectives arise, and for some reason storage capacity was not available in Cell A, process water treatment could still be curtailed by temporarily increasing the proportion of process water being sent to the Mill and lowering the proportion of mine water. This would keep Cell A in balance without other outflows (i.e. treatment). This approach might lead to more mine water needing to be treated if storage was not available in Cell B, but treated mine water concentrations are much less and are unlikely to cause difficulties of meeting in-stream water quality objectives.

IR: INAC 2-2
Subject: Downstream Mixing Analysis
Requests:

1. *Provide a rationalization why the within-period 7Q10 was chosen rather than another combination of low-flow period (the choice of 7-days) and recurrence interval (the choice of 10 years).*

See Appendix L.

2. *Discuss the temporal relevance of the Water Survey of Canada records for Cadillac Creek terminated at 1990 given the period of application is 20 years later.*

See NHC assessment in Appendix M.

IR: INAC 2-3
Subject: Receiving Water Quality – Post Closure
Requests:

1. *Provide predicted in-stream parameter concentrations post-mine closure for 'all' parameters potentially affected by mining operations, including mercury.*

2. *What are predicted in-stream parameter concentrations during early post-closure? How long will the early post-closure conditions last?*

3. *Given that concentrations of several metals are predicted to exceed in-stream objectives after mine closure, identify potential mitigation measures that could be implemented to reduce the concentrations to below in-stream objectives.*

See Robertson Geoconsultants report in Appendix N.

4. *Identify the assessment endpoints that will be used for monitoring post-closure water quality. Identify low, medium and high trigger levels that, when reached, will trigger a response during closure operations. (See INAC 2-8 below)*

After mine closure, once the mine has completely flooded and water levels and water quality have stabilized, the objective will be to ensure water quality in Prairie Creek downstream meets site-specific water quality objectives (SSWQO) for all parameters, except perhaps zinc which is predicted to have had a naturally elevated signature prior to site development.

It is expected that post-closure monitoring will include wells that monitor the mine 'pool' to determine source concentrations, wells that monitor groundwater quality along the flow-path of metal release in bedrock and in the alluvial aquifers (HCAA and PCAA), and stations on Prairie Creek. Trigger levels linked to specified response actions will need to be set for selected monitoring wells, since an 'early warning' of a developing issue is required rather than a later observation of an impact in Prairie Creek. However, most metals are non-conservative and attenuate along the flow-path. Therefore, it is not clear at this stage what concentrations in groundwater at specific locations should be considered as triggers. Concentrations could be considerably higher than the SSWQO but do not cause the SSWQO to be exceeded in Prairie Creek. Further study will be required during the operating period to better quantify the flow-path and attenuation mechanisms, and to establish trigger levels for strategically located wells. During development of the mine, monitoring data from the wells installed recently and surface waters will provide valuable information about how the hydrological system in the mine area responds to pumping from underground, and also how the system will respond after mine closure.

Low and medium trigger levels for the selected wells, if exceeded, would be expected to lead to an increase in the frequency and spatial extent of monitoring. If the high trigger level is exceeded, this would be the signal for starting a response action to lower groundwater concentrations. The most obvious action would be to commence pumping from the mine pool to lower groundwater levels, followed by treatment of the pumped water. However, the exact nature of any action will depend on the form and magnitude of the exceedance, and the risks posed to the receiving environment.

IR: INAC 2-4
Subject: Water Management and Treatment
Requests:

1. *Demonstrate that the proposed water management strategy can handle a range of flow scenarios including consecutive periods of high mine inflows and low Prairie Creek flows requiring a reduction in discharge volumes. Please confirm input parameters and freshet surges to the water balance.*

See Appendix F. Water balances and water management plans for a wide range of mine water flow scenarios have been considered. Because the available storage capacity for mine water is limited, mine water will essentially be treated at a rate comparable to the rate of mine drainage, with some attenuation using the available storage. Water quality assessment shows that this is possible without incurring significant impacts, even if abnormally low winter creek flows occur. A freshet surge will not significantly affect water balance, or intense rainfall events for that matter (see response to Parks Canada IR 2-4, Item 2).

2. *Identify mitigation methods that would be implemented to maintain the site water balance and in-stream water quality objectives during periods when discharge must be reduced.*

See response to INAC IR 2-1, Item 6.

3. *If allowing the mine to re-flood is a proposed mitigation strategy, identify any water quality issues that may arise from re-flooding the mine considering: contact with paste backfill, groundwater outflow from the mine workings/HCAA and PCAA contacts and water quality upon re-starting mine operations.*

Based on the water management plan described in Appendix F, deliberate flooding of the mine during operations is highly unlikely. If this were to occur, a water quality assessment would be completed to determine flooded water quality and water treatment requirements. Significant leaching of the paste backfill is not anticipated, but if it did occur, the flooded water may need to be treated in the process water circuit. During this period, the Mill is unlikely to be operating, and therefore the process water treatment circuit will be idle.

In the unlikely event that the mine was allowed to flood, complete flooding such that the cone of groundwater depression disappears completely would be avoided by pumping and treating water. As such, mine water outflows to the HCAA and PCAA would not occur (note, we do not believe outflows to the PCAA would occur anyway because we do not believe a hydraulic connection exists).

4. *Provide a range of water treatment projections, in conjunction with a range of water balance evaluations, which show the potential range of water treatment and discharge scenarios.*

See Appendix F.

IR: INAC 2-5
Subject: Mining Method – Crown Pillars – Surface Water Inflow to Mine
Request: *Please describe how stability of the ground surface will not be affected by mining, or, how additional flows may affect the water balance and metal flushing from the mine workings.*

The stability of the surface will not be affected since there will be minimal mining activity near the surface. Therefore, it is not expected that mining will result in additional flows that may affect the present water balance. The physical nature of the deposit (a narrow vein structure) will limit the width of mining. The planned mining method, Cut and Fill, will limit the maximum vertical exposure underground to two lifts, each 3 m thick. In addition, the mined out voids will be filled with paste backfill which will further limit the incursion of flows into the mine workings.

IR: INAC 2-6
Subject: Water Storage Pond – Diversion Ditch
Requests: *App. 12 does not provide any details as to the design or constructability of the diversion ditch. Information should be provided that is consistent with the design parameters of the WSP slope stabilization plans.*

The diversion ditch for the WSP will be a relatively simple structure. The upslope area will be excavated to reduce the slope angle as part of the backslope stabilization plan. Some excavation was undertaken in this area previously to obtain borrow material for construction of the Polishing Pond. After the proposed excavation, the backslope will be graded to promote even runoff. The diversion ditch will be located upslope from the access road and will run the length of the WSP. It will be concave in shape and lined with an impervious geotextile, keyed into the upslope bank. Runoff in the ditch will flow both west and east from a high point determined by survey. Specific design details will be determined as part of final design of the WSP.

IR: INAC 2-7
Subject: Hydrogeology – Potential Groundwater Inflows, Minewater Management
Requests:

1. *Identify mitigation measures that are available to handle significantly higher mine in-flows.*

2. *Demonstrate the likelihood of success of any proposed mitigation strategies.*

See Appendix N for a partial response to Item 1, and Appendix F which responds to both items.

IR: INAC 2-8
Subject: Effluent Discharge and Monitoring
Requests:

1. *Identify downstream monitoring points (e.g. assessment boundaries and sample site locations) that will be used to track changes in the receiving environment related to effluent discharges.*
2. *Identify low, medium and high action effects levels for these boundaries that, when reached, will trigger a response. Note that a 'high action level' is generally considered to be a point that should not be reached and requires an immediate halt to discharge.*

See document from Hatfield Consultants in Appendix O.

3. *Identify appropriate adaptive management responses if the moderate level triggers at the most immediate downstream assessment boundary is reached. Include consideration of how proposed responses (reduced discharge volume or load) will impact site operations.*

See response to INAC IR 2-1, Item 6.

4. *Identify a monitoring and reporting strategy that will permit effective enforcement of any water licence conditions respecting variable discharge criteria. Note this strategy will likely require a well defined water discharge strategy (e.g. with flow and concentration numbers that are demonstrated to work with the facility's water balance under a range of scenarios including worst case and be consistent with a defined mixing/dilution zone).*

See Appendix P.

IR: INAC 2-9
Subject: AEMP
Requests:

1. *The proponent should describe the community consultation with respect to measurement endpoints and levels of acceptable changes for the proposed AEMP, which is equivalent to the experimental design outlined in the Spencer et al (2008) study.*

A framework for development of an AEMP was presented in CZN's first IR round reply. The framework has been further developed for this second IR round reply (Appendix O). An actual AEMP would be produced at the permitting stage, assuming the project proceeds to that stage. Appropriate reviews and consultations would occur at that time.

2. *Provide a discussion of the ecological importance of epilithon in the local receiving environment and the sensitivity of the local epilithon to the expected contaminants being discharged.*

See Appendix G.

3. *It is possible that increased water storage capacity can obviate the requirement for seasonally varying effluent quality criteria and the attendant regulatory and monitoring complexity. Provide an assessment of the feasibility of increasing water storage capacity sufficient to use fixed effluent quality criteria prior to considering seasonally varying effluent quality criteria.*

Space for water storage at the Prairie Creek Mine site is limited by the narrowness of valleys. CZN plans to make maximum use of the storage afforded by the existing large pond originally built for tailings storage. This pond will become the WSP. Storage in the WSP will be maximized as part of slope stabilization works, and within the constraints of acceptable factors of safety. Also, see Appendix P.

4. *Section 4.1 suggests that effluent quality criteria should vary with season due to a large range in creek flows. A detailed description of the proposed "different regulatory approach" that would accommodate seasonally varying effluent quality criteria is requested. (See also INAC 2-8)*

See Appendix P.

IR: INAC 2-10
Subject: Effluent Discharge
Requests:

1. *Detail the mitigation measures to minimize the risk of unacceptable discharges due to accident, malfunction or operator error.*

Water management in the event of accidents and malfunctions was described in Section 8.8.5 of the DAR. Regarding water treatment, the operator will always be able to recirculate water internally until the malfunction is rectified, and assumes an appropriate level of monitoring to detect the problem before an unacceptable discharge occurs. A pump-back from the Catchment Pond to the WSP will also be available in an emergency. Also see response to INAC IR 2-11.

2. *Provide a range of water treatment projections, in conjunction with range of water balance evaluations, which show the potential range of water treatment and discharge scenarios (see also INAC 2-3).*

See Appendix F.

3. *Demonstrate that the site's water management system provides sufficient capacity to accommodate site water under a worst case plant malfunction.*

See DAR Section 8.8.5. Also see responses to INAC IR's 2-1 (Item 6) and 2-11.

4. *Please describe the suitability of the preferred treatment strategy for water with elevated arsenic content.*

Both the lime treatment of mine water and sulphide/lime treatment of process water are effective at sufficiently reducing arsenic concentrations in the respective waters. The treatment strategy for each water type has been determined for the respective chemistries, and necessarily focuses on the suite of parameters rather than a single metal.

IR: INAC 2-11
Subject: Spill Control Measures
Requests:

1. *How will gravity flow through the outfall line be stopped if a spill or other on-site contaminants comingle, leach or directly discharge to surface runoff, which according to the current site plan would report to the catchment pond and then Prairie Creek?*

The outfall line will have a valve or gate which can be temporarily closed, if necessary, much like the existing culvert discharge to Harrison Creek. Response actions will depend on the nature and location of any spill. It is entirely likely that a spill affecting the surface runoff system could be intercepted before it extended to the Catchment Pond, thus avoiding a necessity to stop all site discharge.

2. *Describe mitigation measures that would manage surface runoff at the site in the event of a spill or other degradation of on-site surface water quality.*

The WSP water balances have demonstrated that site runoff flows are relatively small compared to mine flows. Observations and monitoring records for the main camp ditch also indicate that these flows are relatively low, even after intense rainfall events. In the event of a spill or other degradation of site surface water quality, any contaminated water could be pumped to the mine water cell of the WSP for storage. The quantity of water would be well within the range of mine flows for which management plans have been determined. In all probability, the duration of such an event would be short and the quantity of water small. A spill in the camp area could likely be isolated before it affected the Catchment Pond, in which case discharge would continue. If the Catchment Pond was affected, the water could be pumped to the WSP, following which discharge would continue.

Discharge of treated water to Prairie Creek during winter will occur via a pipeline from the WTP connected to the outlet culvert in the Catchment Pond. The pond would be isolated from the line to avoid freezing effects. In the event of an on-site spill affecting the Catchment Pond, the winter discharge arrangement can be implemented so that the discharge of treated water could continue.

3. *If potential mitigation measures include restricting flow from the catchment pond or diverting water from the catchment pond back to the WSP, demonstrate that the site water containment structures are capable of containing any water accumulated during restricted discharge, during a spill response or high flow/loading event.*

See Section 8.8.5 of the DAR and response to point 2 above. Also as noted above, the site runoff collection system is not prone to high flows at any time of the year, including during intense rainfall events.

IR: INAC 2-12
Subject: Current Groundwater Conditions
Requests:

1. *The following is stated in the DAR, Appendix 1A: p.6, "Exploration drilling suggests that the Vein Fault strikes along the lower part of Harrison Creek valley and extends into the larger Prairie Creek valley.";p.28, "The Vein Fault is inferred to extend into Harrison Creek valley and crosses the Prairie Creek valley (near MW08-02)." INAC requests that Canadian Zinc confirm the extent of the Vein Fault in the vicinity of Prairie Creek valley and describe the implications of the vein fault being connected to Prairie Creek on flow within the creek itself, and on mine inflows. Under this connection scenario, what would be the required effluent discharge rate and predicted in-stream water quality concentrations?*

Diamond drill exploration for additional Vein hosted material was completed in holes between Zone 4 in Harrison Creek and under Prairie Creek towards the 'discovery' vein showing located on the west side of Prairie Creek in what is termed Zone 5. While the same stratigraphy was intersected there were no significant mineralized veins located in this area. A number of fault like structures were intercepted, which is quite common, but while some contained quartz-carbonate material none of these carried any significant metal mineralization worthy of follow-up. The veins do not line up in a linear fashion and it is anticipated that they are not connected, rather they appear to be en-echelon in style. The lack of mineralization is an indication of the poor development of a host structure.

Comments on hydrogeology are given in Appendix N. The significance of a possible Vein Fault-Prairie Creek connection in terms of water management is addressed in Appendix F.

2. *Provide additional information on the existing dissolved metal groundwater plume(s) throughout the full vertical extent of all of the hydrostratigraphic units, as well as along the width and length of the plume flow paths. Hydrostratigraphic units of concern include Prairie Creek Alluvial Aquifer (>45m, deepest monitoring well is 5.8 m deep), Harrison Creek Alluvial Aquifer (20 m thick, deepest monitoring well is 12.7 m deep), MQV/Vein Fault, and shallow and deep bedrock units. CZN should explain how the characterization of groundwater flow and connectivity within the PCAA and HCAA is determined with confidence given that the existing monitoring wells do not penetrate the full depth of the aquifer.*

3. *Information on any aquifer hydraulic testing within the hydrostratigraphic units of the PCAA, HCAA, MQV/Vein Fault, Shallow Bedrock and Deep Bedrock conducted by CZN. If no information has been collected, describe how groundwater movement in these zones has been predicted and provide the level of confidence that exists in the assessment of groundwater flow rates and plume migration rates.*

4. *Additional information on changes to groundwater seepage rates into Prairie Creek and Harrison Creek during low and high flow conditions.*

For response to Items 2, 3 & 4, see Appendix N.

IR: INAC 2-13
Subject: Groundwater Conditions during Active Mining
Requests:

1. *Assess and describe the potential magnitude of effects on Prairie Creek flows assuming worst case connectivity between Prairie Creek and the MQV/Vein Fault.*

2. *Assess the impacts from the dissolved metal groundwater plume(s) discharging into Harrison Creek and Prairie Creek, using the measured hydraulic and chemical properties of the flow systems and considering the seasonal fluctuations in stream flow rates and effluent discharge.*

See Appendix N.

3. *Assess potential impacts to the minewater discharge strategy and in-stream metals concentrations considering metal loadings to Prairie Creek from the existing dissolved metal plume. Also consider the impacts on the minewater discharge strategy considering a possible reduction in Prairie Creek flows due to mine dewatering. Evaluate any mitigation measures required in response to predicted impacts.*

As mine development progresses and pumping lowers groundwater levels, the sources of recharge to the dissolved metals plume will be removed and the plume will dissipate. Metal concentrations in the plume will reduce in response to removal of the recharge sources, advection/dispersion in the PCAA, and dilution from infiltrating precipitation. Simultaneously, mine water pumped from underground will be treated, but initially at lower rates than those that will occur when the mine is fully developed. The mine water discharge strategy described and assessed elsewhere in this document is based on full mine development. By that stage, the dissolved metal plume will have dissipated. Therefore, no potential impacts to the mine water discharge strategy and predicted in-stream metals concentrations are expected from the existing dissolved metal plume.

Studies have indicated that a significant reduction in Prairie Creek flows due to mine dewatering is unlikely. However, should it occur, mitigation is readily available. It has been demonstrated that the only time in-stream targets might not be met is during the winter low flow months if abnormally low flows occur (Appendix F). This would also be the time when any impacts of creek flow loss from dewatering would also manifest themselves. The primary source of metals in effluent discharge will be treated process water. Treatment of this water can be reduced or stopped over the winter period if necessary. The same mitigation is available regarding possible effects from the dissolved metals plume, although as discussed, is unlikely to be needed.

IR: INAC 2-14
Subject: Post-Closure Groundwater Conditions
Requests:

Re-evaluate predictions of post closure groundwater impacts on Harrison Creek and Prairie Creek by incorporating the following:

- *Worst case scenario assumptions regarding connectivity (i.e. vein fault connects to Prairie Creek), mine water inflows and concentrations.*
- *Re-evaluation using any new additional information regarding the mixing contributions of groundwater from the MQV within the Vein Fault/MQV system. As stated in the Prairie Creek Mine Responses to Information Requests, CZN, 2010, Appendix J, Annex J6, p.3, "At the present time, insufficient data is available to determine the natural zinc load contributing via the Vein Fault/MQV system with a high degree of accuracy. We recommend that our preliminary loading estimates be updated once additional monitoring data become available."*
- *An evaluation of the aquifer's attenuative capacity for metals of concern.*
- *Inclusion of antimony, arsenic, iron, mercury, and silver predictions of in-stream creek concentrations, in addition to cadmium, copper, lead, selenium, zinc, and sulphate.*

See Appendix N.

IR: INAC 2-15
Subject: Mine Waste Management – Tailings and Waste Rock Quantities and Volumes
Requests: *With reference to Table 6-4 Life of Mine (Years 0 – 14) Waste Quantities, provide additional information to address the following:*

- *Mill feed*
    - *Does the tonnage 4,995,000 refer to diluted ore fed to the mill?*
    - *If so, what percentage dilution is assumed?*
    - *What is the in-situ density of the ore and dilution rock*

The tonnage of 4,995,000 refers to diluted ore feed at 15% dilution. The in-situ density of the average ore is 3.25 and the specific gravity of the waste (dilution) rock is 2.8.

- *DMS rock and Flotation Tailings*
    - *What is the bulk density of this material*

The DMS rock specific gravity is <2.8 and the specific gravity of the flotation tailings is 2.84.

- *Concentrates*
    - *What is the bulk density of this material*

The specific gravity of the lead concentrate is 3.5 and the zinc concentrate is 2.2.

- *Voids (stopes & development)*

- *The volume of development waste rock to the Waste Rock Pile is 277,000 m^3 (page 196). Assuming an in-situ specific gravity of 2.7 and swelled specific gravity of 1.9, the volume of development voids in the mine will be approximately 195,000 m^3. If the total volume of voids is 1,799,720 m^3 (as per Table 6-4), this leaves approximately 1,600,000 m^3 of voids in stopes for backfill. Please confirm.*

The total volume of voids, including all stopes and development headings, is 1,799,720 m^3. This is the volume available for backfill. The specific gravity and swelled specific gravity of development rock is has no bearing on the volume of voids after mining or the volume of backfill.

- *Backfilling of overhand cut-and-fill stopes is likely to result in a high percentage of the mined voids being backfilled. That said, 100% backfilling of mined voids is unlikely. What percentage of the voids is assumed to be backfilled in the Prairie Creek mine plan?*

Paste placement strategies can be employed to ensure tight filling of all mine openings. A 99% backfill of voids is projected.

- *Placed Backfill*
  - *The tonnage of backfill is 3,401,470 at a density of 1.89 t/m^3. This gives a backfill volume of 1,800,000 m^3, which is greater than space available underground. Please confirm. (Note: In the CZN DAR Addendum May 2010, the tailings density in the WSP is imputed to be 1.6 t/m^3. If this lower density is achieved in the tailings backfill, then the volume of tailings to be managed is up to 2,177,000 m^3, or 576,000 m^3 more than the available space.)*

The latest test work on the fill has shown the bulk density to be 2.17. The placed backfill of 3,401,470 tonnes at the bulk density of 2.17 will require only 1,567,498 m^3 of space, implying space for more backfill. The 1.89 density figure referred to is a calculated dry density of the fill based on a fill density of 2.24.

The tailings density in the WSP is imputed to be 1.6 t/m^3 because these tailings will contain no DMS, and will consist of a slurry of higher moisture content. The tailings for backfill will be filtered and mixed with DMS in a low moisture content paste.

- *Please confirm that CZN does not intend to develop a surface quarry of sand and gravel for use as a component of tailings backfill or in lieu of tailings backfill altogether.*

CZN does not intend to develop a surface quarry of sand and gravel for use as a component of tailings backfill or in lieu of tailings backfill because this would displace mine waste from underground disposal.

- *Paste backfill is the only tailings management strategy that has been described for the site. Outline and evaluate alternate tailings management strategies that may be utilized if final feasibility and design eliminate the use of paste backfill as a tailings management approach*

Paste backfill has been confirmed as a feasible approach for tailings disposal at Prairie Creek by international experts responsible for the design and implementation of numerous, similar applications elsewhere. Tailings disposal alternatives include slurry deposition in a pond (as originally intended), paste deposition in a pond, and ‘dry stack’ on a pad. Because of the volume of material, all options would have to be located on the Prairie Creek floodplain.

IR: INAC 2-16
Subject: Closure Plan – Waste Rock Storage
Request: *Provide further evaluations to demonstrate that flushing of metals from the Waste Rock Storage Area will not increase in the future.*

The Waste Rock Pile (WRP) final slope angle, cover design and runoff diversion structures will be designed to be stable in perpetuity, and sufficient to limit infiltration to a required amount. Conservatism will be built into the design. This will be based on geochemical monitoring of the waste rock and seepage over the life of the operation, and simulations of cover performance. Note that the waste rock is predicted to be non-acid generating and is likely to be significantly acid consuming with substantial carbonate content. Metal release is predominantly related to soluble metal carbonates (cerrusite and smithsonite primarily) originally derived by re-mobilization of metals from the ore vein into the surrounding host rock by meteoric water circulation. The dissolution of these oxide forms (predominantly carbonates) in the waste rock pile will be driven by contact with infiltrating waters. The majority of the oxides are expected to be ‘flushed-out’ during operations, with collection of the resulting seepage. Placement of a cover during mine closure will significantly reduce further contact with residual oxides, and therefore the mechanism for dissolution.

IR: INAC 2-17
Subject: Closure Plan – Backfilling of Portals
Request: *The proponent should provide objectives for post-closure metal release and an evaluation which suggests that those levels can be achieved.*

See Appendix N.

5.0 FISHERIES AND OCEANS IR REPLIES

IR Number: DFO 2-1
Subject: Nutrient Loading
Request:

1. *As requested in DFO_01, please provide*

   a) *A map of the locations where increases in nutrient levels have been observed downstream from the mine site within Prairie Creek.*

A suitable map showing the INAC/University of Saskatchewan site (High Exposure Site, PN1) where sampling was conducted and implied nutrient enrichment was provided in the first IR round reply (Figure 3.1 from "Review of the Status and Future of Cumulative Effects Monitoring at the Prairie Creek Mine", prepared for INAC by Senes Consultants Limited, March 2009).

To more accurately frame this issue, the following excerpt is included from "Final Report on the 2006 Prairie Creek Monitoring Program", June 5, 2007, Paula Spencer et al:

"Benthic invertebrate results from Prairie Creek suggest reduced invertebrate density when compared with southern systems. The benthic invertebrate community at Prairie Creek did demonstrate community changes between reference and exposure sites, however these changes are not consistent with typical pollution-dependent responses. Stoneflies have been shown to be pollution sensitive in many previous studies while other species such as chironomids are known to be more pollution tolerant. In Prairie Creek, stoneflies increased in density at the high exposure site and chironomids decreased. There is a significant increase in richness at the high exposure site which indicates a slight enrichment may be occurring. In highly oligotrophic ecosystems, very little nutrient input is required to produce a response. It may be the case at Prairie Creek that a small increase in nutrient or mineral inputs can result in a change to benthic communities."

Therefore, the authors speculate that a slight nutrient enrichment **may** have occurred at the high exposure site (one site only) based on an increase in stonefly richness.

   b) *An assessment of the potential impacts on aquatic organisms, including fish and fish habitat, due to potential increases in nutrient loading into the system and provide mitigation measures, where appropriate.*

See Appendix G.

IR Number: DFO_2-2
Subject: Source of Aggregate for road construction and maintenance
Request:

1. *As stated in DFO_02 and the technical sessions, DFO would still require CZN to identify the locations of all aggregate sources in order to determine if additional access roads and/or crossings may be required.*

See reply to Parks Canada IR 2-1, Item 4, above. No additional access roads and/or crossings will be required.

2. *CZN should also update Figure II-4 in Appendix D by removing any borrow sites that are located within the high water mark of any watercourses as well as include any additional access roads and/or crossings that may be required to access the borrow sites. Appropriate sediment and erosion control considerations must be provided, along with the necessary fish and fish habitat assessments for any new spur roads. This is also addressed under DFO_2-5.*

See Item 1 above. The road drawings in Appendix C more accurately depict borrow source locations.

IR Number: DFO_2-3
Subject: Outfall Design
Request:

1. *Provide rationale for why the diffuser outfall option was replaced by a culvert, refer to INAC02-01, including consideration for how the new option will reduce or eliminate downstream impacts.*

See reply to INAC IR 2-1, Item 5.

Once downstream impacts have been considered and the most appropriate outfall option has been selected, DFO will require:

2. *Conceptual designs as well as details on the construction and installation methods for the outfall including consideration for:*

    a. *maintaining stability of the berm;*
    b. *anchoring and footprint of the outfall;*
    c. *area and depth of the trench for installation;*
    d. *disturbance of the banks and riparian area;*
    e. *area isolated (for the installation of the effluent dispersal mechanism).*
    f. *maintenance and subsequent decommissioning of the effluent dispersal mechanism;*
    g. *mitigation measures incorporated to reduce disturbances to substrate and mobilization of sediment; and*
    h. *fish screens (if required)*

A preliminary design for an exfiltration trench by NHC is given in Appendix E. NHC includes measures for isolation of the work area and protection of the creek. These measures will be further developed after a positive EA outcome during detailed design, and to the satisfaction of DFO. At this stage, the information confirms that construction mitigation can be accomplished and impacts minimized. A construction water management plan and spill contingency plan would also be developed at the detailed design stage.

CZN expects that DFO will make a determination based on the information in Appendix E as to whether the exfiltration trench as-built is likely to constitute a loss of equivalent fish habitat. If DFO determines that a loss might occur, design modifications and/or the incorporation of additional elements will be considered as apart of detailed design to avoid habitat loss. If it is determined that habitat loss is unavoidable, a suitable habitat compensation plan will be developed, also at the detailed design stage.

The approach to decommissioning of the exfiltration trench will be determined in consultation with DFO. If the system proves to be inherently stable during operations, one option might be to leave it in-place to avoid possible impacts from removal. If removal is to occur, a similar approach to area isolation and construction mitigation as described in Appendix E can be implemented.

3. *Specifics on fish use and type of habitat within the area of influence (including the mixing zone) from the construction and operation of the outfall option are required.*

See Appendix P.

IR Number: DFO_2-4
Subject: Construction of Winter Road - Water withdrawal
Request:

1. *DFO still requires specific locations and annual volumes (per source) of water for the construction and maintenance of the road and crossings. This should also consider any additional spur roads needed to access aggregate sources (see DFO_2-2). All data should be site and seasonally specific, including bathymetric survey results as well as the calculation of the total available water volume (lakes) or flow (streams) under ice for each source.*

See Appendix B and the reply to Parks Canada IR 2-1, Item 5. At this time, CZN will rely on the Mine well, Mosquito Lake, Gap Lake and the Liard River as water sources. The amount of water required is relatively small and will not have a significant effect on the bodies of water that it is being drawn from. Extraction from Mosquito Lake and Gap Lake will be based on "DFO Protocol for Winter Water Withdrawal from Ice-Covered Waterbodies in the NWT". A short spur road to Mosquito Lake already exists at approximately Km 61.3. This will be utilized. The existing road alignment follows the shore of Gap Lake. There are also other possibilities for lake water extraction if required. There are small lakes at Km 139 and 141 just off the road alignment that would require only short spur roads. These lakes could be quantified and water extracted based on the protocol.

2. *Provide an assessment of potential impacts from water withdrawals at each watercourse locations, including potential effects on over-wintering and spawning habitat for all the fish species found in those watercourses. CZN should also discuss potential changes to water temperatures, flow regimes, reduction in quantity and quality of over-wintering habitat, depletion of available oxygen, changes in ice formation and possibility of fish kills.*

The above noted water sources will be used in the absence of any other suitable sources. The availability of other sources will be evaluated at a later date, and as noted, DFO will be consulted on investigation information before another source is used. For example, Sundog Creek upstream of the crossing at Km 22.5 may represent a source, but may not be required. CZN is not currently planning to extract water from other creeks along the route. If this changes, CZN will collect the information requested and consult DFO on the findings before water extraction.

3. *Provide water source alternatives or other road construction options in order to reduce water requirements (i.e. more clear span bridges), in the event that the current water source options do not have sufficient flow to protect fish and fish habitat.*

CZN is confident that the presently defined water sources, which do not include creeks, will have sufficient capacity for needs. Future investigations would seek to define additional, suitable sources to reduce distances of water hauling. The main water use is expected to be for road bed construction, not creek crossings which would be primarily by snowfill. Clear span structures will be considered if conditions vary from those expected, and temporary spans may be used in any event to facilitate crossings.

IR Number: DFO_2-5
Subject: Access road – Erosion, Runoff and Extreme Events
Request:

See reply to Parks Canada IR 2-1, Item 2, regarding the Review Board's comments that they will not be assessing structures already built, including the road. Therefore, the comments below focus on the new alignments, although details of approaches and changes proposed for the existing road are also given.

1. *Provide conceptual design plans for representative sections of the road and crossings, with special consideration for Funeral Creek, and any other area of the road that may be vulnerable to such things as extreme events, permafrost slumping, and erosion.*

CZN will not be introducing any physical footprints within the high water mark of crossings, other than snow and ice. The latter would be for bank protection as necessary. Another alternative is to use matting which would be removed on seasonal road closure. The proposed re-alignments will reduce creek crossing issues because the new alignments cross creeks near their headwaters where flows in spring are considerably less, and thus the channels are narrower and less incised. As noted, a span structure is proposed for Polje Creek. Funeral Creek is crossed in one location near its headwaters. The channel is narrow and incised. A permanent span structure will be built with abutments above the high water mark and outside of the channel. The road along Funeral Creek has been in existence for nearly 30 years. CZN began rehabilitating the road several years ago. Some sections were eroded during floods in 2006 and 2007. The worst sections have been repaired, but some areas remain where slope angle reduction and armouring is required. Erosion of the road bed also occurred along Prairie Creek. However, all of the eroded sections have been repaired.

a) List mitigation measures appropriate to those representative sections and/or vulnerable locations and how they will mitigate impacts to fish and fish habitat.

The armouring of eroded sections along Funeral Creek has been noted above, as well as the intention to place a span structure at Km 13.1. A proposed span across Polje Creek will avoid any impacts on the creek and banks. The other creek crossings on the existing road alignment have been relatively stable and not prone to erosion since their last use in 1982. As noted above, apart from Polje Creek, creek crossings on the re-alignments are mostly small, headwater streams that can be protected and crossed with simple snow-fills. Erosion and sediment production in the spring can be avoided.

b) Clearly identify where sediment and erosion control prevention techniques have been incorporated into the road and crossing designs.

Comments are made here specific to new crossings and the new alignments. The new span at Km 13.1 will avoid disruption of the creek channel. The Polje re-alignment avoids three crossings of Polje Creek over Km 48-49 in favour of three crossings of smaller tributaries. Fill placement along this re-alignment will leave gaps/swales so natural runoff flow directions are not significantly modified. If there is potential for new runoff channels to be formed, the channel outlets will be directed to areas where runoff can dissipate and sediment can settle out. The Polje Creek span has been noted. The switch-backs climbing to Wolverine Pass are to be revised, and this will include provision for upslope drainage collection and diversion to stilling areas. Erosion control prevention techniques are not expected to be specifically required for crossings of the other re-alignments because they are small headwater streams in well vegetated areas.

2. *Describe monitoring activities for the road to ensure that it will not be a sediment source to the adjacent watercourses during the construction, operation, temporary closure in the summer and during extreme events.*

Road construction and operation will occur in late fall and winter when any precipitation will be snow. Construction and maintenance activities will be continually overseen by supervisors who will ensure appropriate techniques are used such that sediment will not be produced during periods of thaw. This will also apply to seasonal road closure activities, including snow-fill removal.

A potential for erosion and sediment production may exist during spring freshet and extreme rainfall events. After the first year of construction, and following extreme rainfall events at any time, the re-alignments will need to be checked for areas of instability, specifically the creek crossings, areas of fill placement, and the switch-backs in the Silent Hills. Over-flights of these areas are initially proposed to allow for inspection. If problem areas are suspected, follow-up inspections will be made by helicopter, and will include set-downs and the use of small tools (e.g. shovels) and readily transportable materials (e.g. silt fence), as necessary. More significant remedial work would be undertaken during construction in the subsequent road season.

IR Number: DFO_2-6
Subject: Groundwater Discharge to Prairie Creek
Request:

1. *Provide predicted impacts of the removal or reduction of groundwater flow to Harrison and Prairie Creek from mine dewatering and operation on the fish (i.e. Bull Trout and arctic grayling during their various life stages) and their habitat.*

As noted in CZN's reply to DFO IR 6, Item 2, no sites of groundwater up-wellings have been noted in Prairie Creek near the mine site. Only low numbers of adult bull trout have been recorded along this reach of the creek, and habitat has been classified as migratory only. No spawning activity or juvenile fish have been recorded. Also, during all of Cadillac's and CZN's fisheries studies, and the work undertaken by DFO, the University of Saskatchewan and Parks Canada recently, no arctic grayling have been found above the mouth of Prairie Creek.

Regarding Harrison Creek, the following was extracted from the Golder Associates document contained in Appendix 24 of the DAR:

"The rock at the culvert outfalls close to Prairie Creek is likely a barrier to fish passage under most flow conditions, except perhaps under exceptionally high flow conditions. The stream was examined on 30 July 2009, the morning after an intense rain storm. Despite the heavy rain, which increased stream flows, the majority of the channel remained very shallow and provided little habitat for fish. Habitat suitable for juvenile fish extended for approximately 30 m upstream of the culverts, created primarily by flows from the Prairie Creek Mine site discharge, which is a combination of site run-off and treated mine water. Upstream of this point, the stream bifurcates into several narrow channels. A significant proportion of the flows appear to be interstitial in this section based on the higher surface flows in the upper reaches and the water visibly seeping out of the gravel into the pool immediately upstream of the culverts. The available habitat would not permit fish movements or residency into the upper part of the watershed. In summary, based on the observations made in 2008 and again in 2009, Harrison Creek does not provide useable fish habitat. The presence of very low flows, even after a heavy rain event, suggests that the stream could not support fish (with the possible exception of 30 m of channel upstream of the existing road culverts), assuming that fish are able to pass the culverts."

The 30 m of the Harrison Creek channel upstream of the existing road culverts crosses part of the Prairie Creek Alluvial Aquifer (PCAA). Groundwater studies by Robertson Geoconsultants, and geological data from drill holes, both indicate a low potential for hydraulic connection between the rock mass where mining will occur and the PCAA. Therefore, no impacts on fish are expected from the removal or reduction of groundwater flow to Harrison Creek from mine dewatering, and the dewatering is not expected to significantly alter flows in Prairie Creek.

2. *Provide mitigation measures to reduce or eliminate impacts to fish.*

No mitigation measures are deemed necessary because no impacts are expected.

IR Number: DFO_2-7
Subject: Access Road - Fish Habitat Assessment
Request:

1. *Photos were provided in Appendix E of the IR response, but location of the crossing and specific kilometre markers were not clearly identified. These should be provided.*

The photos from Appendix E of the first round IR response where the locations of road crossings were not clear are reproduced in Appendix R. The crossing locations are shown, and the kilometre markers appear in the captions.

2. *Please provide an updated table E1 to ensure that all water course crossings. This includes all watercourse crossings for any new crossings to access borrow sources.*

No new crossings will be required to access borrow sources. All sources can be accessed from the proposed alignment without additional creek crossings. Therefore, Table E1 does not need to be updated to reflect new crossings to access borrow.

IR Number: DFO_2-8
Subject: Closure and Reclamation Plan
Requests:

1. *What other methods will be used, during decommissioning, to provide long term stability, prevent mobilization of sediment and to reduce erosion along Funeral Creek? As an example, a description of timing windows for decommissioning of the road, consideration of bioengineering solutions, details on re-vegetation (or a commitment to developing a long term sediment and erosion control plan), etc. should also be provided.*

2. *How will CZN ensure the effectiveness of the proposed mitigation measures during and after closure? And what adaptive management options have CZN considered?*

The road bed along Funeral Creek already exists. Per our reply to Parks Canada IR 2-1, Item 2, and the Review Board’s comments, CZN believes the approach to decommissioning of the road along Funeral Creek is not a subject for consideration in the EA. CZN provided a reasoned reply to DFO IR 9 as a courtesy. CZN will be happy to review the approach to road decommissioning with DFO at a later date, and is open to considering bio-engineering solutions, timing windows and other approaches to minimize potential impacts. As with any closure activity, there would be a period of monitoring after decommissioning works have been undertaken to ensure they are effective and to allow any necessary adjustments to be made. Monitoring would continue until conditions are observed to be demonstrably stable.

IR Number: DFO_2-9
Subject: Impact Assessment - Fish and fish habitat
Request:

1. *In the revised version of Table 5, water quality post-closure was identified as having a "low" impacts to fish and fish habitat even though the criteria in the matrix was characterized as follows:*

    a. *Geographic Extent – **Moderate** (Portion of Prairie Creek)*
    b. *Duration – **High** (Perpetuity)*
    c. *Frequency – **High** (Perpetually continuous)*
    d. *Variance – **Moderate** (flow variation)*
    e. *Reversibility – **High** (hard to resolve)*

Considering that all of the criteria ranked either high (3 out of 5) or moderate (2 out of 5), it is not clear why the impacts were characterized as "low". CZN should provide a rational for this conclusion as well as a description of acceptable mitigation measures in order to minimize impacts to fish and fish habitat.

There was an error in the table presented in the IR reply. The title of the third column, 'Magnitude', was missing. The correct table appears below:

Parameter		Magnitude	Geographic Extent	Duration	Frequency	Variance	Reversibility
Water quality, operations	Rank	Moderate	Moderate	Moderate	High	Moderate	Low
	Basis	Above baseline, below SSC	Portion of Prairie Ck	Mine Life	Continuous over mine life	Discharge & flow variation	Quickly resolved
Water quality, post-closure	Rank	Low	Moderate	High	High	Moderate	High
	Basis	Near baseline	Portion of Prairie Ck	Perpetuity	Perpetually continuous	Flow variation	Hard to resolve
Sediment	Rank	Low	Moderate	Low	Low	Moderate	Low
	Basis	History	Mine/Road	Stable in few years	Occur <monthly	Intense rainfall	Quickly resolved
Habitat alteration	Rank	Low	Moderate	Moderate	Low	Low	Low
	Basis	Very little	Mine/Road	Mine Life	Minor in winter	Stable footprint	Little to begin with
Accidents and malfunctions – mine	Rank	Low	Low	Moderate	Low	Moderate	Low
	Basis	Oversight	Mine	Mine Life	Awareness & precautions	If performance poor	Rapid clean-up
Accidents and malfunctions – access road	Rank	Moderate	Moderate	Low	Low	Moderate	Low
	Basis	Limited quantities	Road	No sources	Awareness & precautions	If performance poor	Rapid clean-up

Note: SSC = Site-Specific Criteria

Note that for water quality, post-closure (and all of the other parameters for that matter), no overall significance was assigned. However, despite the fact that 3 out of 5 criteria were ranked high, 2 out of 5 moderate, and 1 low, a low to moderate overall significance is assigned for the following reasons:

- A much higher weighting is given to the criterion ‘Magnitude’ because it is considered the most significant in terms of the potential for impacts. If the magnitude of the parameter is low, which it is, the ranks of all subsequent criteria are considered less significant;
- The criterion ‘Frequency’ could be given a moderate rank because post-closure water quality impact issues likely only arise during periods of abnormally low creek flows in late winter months, an infrequent occurrence; and,
- The Prairie Creek Mine area is naturally mineralized, and the true nature of baseline water quality has been obscured by previous mine development. Post-closure water quality is expected to be roughly equal to that of the true baseline.

6.0 NATURAL RESOURCES CANADA IR REPLIES

IR Number: NRCan 2-1
Subject: Terrain Conditions along the Access Road
Request:

(i) Please confirm if detailed geotechnical investigations (borehole drilling, installation of temperature cables) will be conducted as recommended by Golder in App. D for the proposed re-routed sections of the access road such as that to the east of Silent Hills to better characterize subsurface conditions including ground ice conditions where there is a potential for ice-rich soils. Please also describe how the results of these investigations will be utilized in route selection and associated mitigation and environmental management plans.

The completion of shallow borings, with and without temperature measurements, is expected to occur along the Polje re-alignment, specifically west of Polje Creek, and on the western slope of the Silent Hills where the switch-backs climbing to Wolverine Pass are to be revised. These areas are considered the main locations for further investigation of possible permafrost presence and possible unstable ground, respectively. While localized permafrost may exist east of the Silent Hills, and in other places, CZN's approach to road construction (see reply to Parks Canada IR 2-1, Item 2) is expected to satisfactorily address these occurrences. However, we will defer to the advice of our geotechnical consultant, Golder Associates, at the time of the investigation regarding the nature, scope and extent of the investigation. Investigation results are unlikely to mean a modification of the road alignment, rather construction techniques and/or road bed design may be altered somewhat. The intent will be to ensure a stable road bed and adjacent ground, and avoidance of permafrost melting.

(ii) Please provide any further information on any analysis conducted to determine the most probable period for construction and operation of the access road.

CZN and its consultants have researched extensively the probable period for construction and operation of the access road. Additional information on road construction techniques (reply to Parks Canada IR 2-1, Item 2, and Appendix C) have served to increase our confidence in the plans previously presented.

(iii) Please describe any plans to ensure that impacts to the ground surface (including damage to the organic layer) are minimized during periods of thin snow cover conditions.

The construction methods explained in Appendix C (initial snow clearing followed by watering and 'freezing-in' a solid base before spreading a snow-water mix) effectively reduces the reliance on significant snow accumulations for road construction. As noted, the availability of snow is not expected to be a limiting factor for early road construction, and the specific intent is to preserve the organic layer.

IR Number: NRCan 2-2
Subject: Stability of the Water Storage Pond (WSP)
Request:

(i) *Please indicate how information acquired from ongoing monitoring of piezometers and slope inclinometers will be utilized to determine when mitigation will be required to deal with potential instabilities of the north slope, including definition of criteria for intervention and for selection of mitigation options.*

See Appendix R.

(ii) *Please provide any further information on the design values with respect to extreme events (rainfall, snow melt) utilized for stability analysis and design of diversion structures.*

The frequency and magnitude of extreme events (rainfall, snowmelt) in terms of stability analysis and design of diversions will be considered further as part of detailed design before construction. Such events are not expected to significantly affect slope stability, given that after construction, the backslope will consist of a smooth, even grade promoting runoff to diversions structures.

IR Number: NRCan 2-3
Subject: Design values (flood data, climate data) for mine components
Request:

(i) *Please provide any additional information regarding how incorporation of more recent data including the 2006 event may affect the design values for project components (e.g. design flood for flood protection dyke) and how this information may be incorporated into final design of project components.*

In a letter from Hayco dated March 10, 2004 (DAR Addendum, Appendix C), a maximum flood profile was calculated using a discharge of 549 m3/sec, generated using recent and historical data. The profile was compared to that used to design the height of the flood protection berm. The height of the profile was found to be less. NHC indicated that the 2006 flood likely had a discharge in the range 200-400 m3/sec. Therefore, the 2006 flood is within the range of design values assumed for project components, which in terms of flood protection already exist.

(ii) *Please clarify if any analysis has been conducted to determine whether there is a significant trend in daily maximum discharge, magnitude of extreme rainfall events and if there are significant trends, comment on the implications of increasing values over the project life for project design and operation.*

See Appendix M.

IR Number: NRCan 2-4
Subject: Waste Rock Management
Request:

(i) *Prior to placement of the waste rock and other solid wastes in WRP, would the exposed WRP bedrock pad be cleaned and any major cracks sealed to minimize seepage loss to the Harrison Creek Alluvial Aquifer (HCAA) below?*

No, because the limited amount of seepage not reporting to the Seepage Collection Pond will infiltrate through the rock mass to the underground workings and be collected with other inflows. On closure, seepage will be effectively limited by the cover placed over the pile.

(ii) *In the WRP cover model simulations for closeout (DAR Appendix #22), two cover systems consisting of a 2 m granular till and a combination of 0.5 m compacted clayey till and 1.5 m granular till were evaluated. The cover systems reduced the annual net percolation through the pile by approximately 34% – 40% and by 42 - 50%, respectively, with both ponding of water on the cover layer and without in comparison to the bare waste rock as cover. In the conceptual closeout scenario (DAR Appendix #27) placing of only a 20 cm soil amendment layer as a suitable growth media is considered. This discrepancy needs to be resolved in terms of cover selection criteria and the anticipated benefits in terms of overall improvement in the drainage water quality from WRP upon closure.*

The 20 cm soil amendment layer would be **in addition** to the underlying till layer.

(iii) *Consideration should also be given to the predictive modelling of post closure drainage water quality from WRP in terms of both short term (5-10 y) and long term (10 y +) time frame and the need for collection and treatment of the WRP drainage, if any.*

This has been done in conjunction with assessment of cover type and performance, and results demonstrate that infiltration and seepage can be effectively limited. CZN's plan is to collect representative geochemical data for waste rock during operations, and to re-assess closure seepage potential, and therefore closure requirements, well before actual closure. The intent of this work is to define a suitably conservative cover design (in terms of seepage) such that collection and treatment of drainage is not necessary.

IR Number: NRCan 2-5
Subject: Paste Backfill
Request:

(i) *Certain operational information was explained during the technical sessions in discussions between consultants to the proponent and consultants to the parties. Among the points of interest to NRCan, we are interested in the following areas: whether the proposed paste backfill cement content provides the required trafficability / load bearing strength for equipment mobility within a reasonable time; if the solid content would permit pumping of the paste to the desired locations; and, whether booster pumps, back-*

up units or lowering of the solids content would be needed to meet pumping requirements.

The trafficability/load bearing strength paste layer will not only have a 3% cement content, but will consist of a 50:50 tailings:DMS mix. This is expected to be suitable for traffic in a short time.

Paste backfill can be prepared at varying strengths and varying densities to meet a wide range of mining needs. This includes bulk lower strength fill in cut and fill mining, or higher strength fill for trafficability. It may also require lower densities to reduce pumping pressures and pump maintenance, however with a resulting increase in binder costs. All measures are available. In addition, it is not necessary to place high strength paste on the floor for trafficability, since a bed of aggregate can provide good bearing pressure and rapid turnaround time, if so needed. These are day to day economic and operational decisions that would also include the effect of strength on cycle time and dilution from backfill, in addition to costs incurred.

Trucking from the mill to the underground has been proposed to make use of returning trucks and to reduce or eliminate the need for expensive pumps in the paste backfill plant as well as booster pumps. Coupling trucks with mobile concrete-type paste pumps reduces the trucking of paste on ramps and levels, further improving the overall efficiency. Paste slump can be altered to suit the exact backfill needs. There are sufficient measures to provide adequate strength of backfill while maintaining control of costs.

(ii) "Appendix 1" to Appendix I was not included in the CZN IR responses.

Appendix 1 is the information appended to the memorandum in Appendix I of the first IR round response.

IR Numbers: NRCan 2-6
Subject: Effluent Treatment and Post Closure Water Quality
Request:

Are these concentrations expected to remain elevated through both operational and closure periods or better treatment technologies, if any, would be implemented to lower them to meet the stated water quality objectives?

Operational Se concentrations are addressed in Appendix D. Closure Se concentrations are addressed in Appendix N.

(i) What is the expected time frame for these elevated Zn levels to continue and the anticipated treatment requirements, if any?

pHase Geochemistry/Robertson Geoconsultants have indicated that the source term concentrations are considered to be applicable to the early mine closure period, and that they will reduce with time. However, since zinc is a conservative metal, an elevated concentration might persist for an extended period. An assessment of water quality after mine closure has indicated that the magnitude of the sources (WRP, Vein Fault, backfilled mine) is unlikely to lead to zinc concentrations in Prairie Creek higher than those predicted to have occurred before any site development. Therefore, a need for water treatment is not expected. The intent of post-closure monitoring would be to confirm this, with appropriately selected triggers for response actions if conditions are not as expected (see reply to INAC IR 2-3, point 4).

(ii) *What are the management and disposal plans for the effluent treatment sludge generated during both operational and post closure phases?*

During operations, water treatment sludge will be combined with the backfill mix and taken underground. Water treatment is not expected to be required after mine closure. All mine openings will be backfilled. In the unlikely event that monitoring and assessments during operations indicate that a period of water treatment needs to continue after mine closure, any sludge will be stabilized with cement and taken to a suitable disposal location. This might be a mine portal that has not been completely backfilled in order to accommodate the sludge, or part of the Waste Rock Pile before cover placement.

(iii) *CZN is proposing a different regulatory approach for the water license to include the expected water quality exceedences during both operational and post closure phases? What is the expected timeframe for post closure collection and treatment of effluents from all sources, and the cut-off water quality requirements for no further treatment?*

The regulatory approach proposed for the Water Licence is explained in Appendix P. This applies to the operating period and mine decommissioning period. It is expected that water treatment will cease soon after, if not before, mine closure. Mine voids will have been backfilled. Closure activities will include backfilling of the access tunnels, starting with the lowest elevations. Water treatment would continue while pumping from underground is required, but at some stage, pumping will stop and so will water treatment. Post-closure monitoring will then continue until conditions have reached an equilibrium and stabilized, and it has been conclusively determined that no further closure activities are required (see reply to INAC IR 2-3, point 4).

(iv) *Zn and Cd levels in the Prairie Creek are reported to be further reduced by the natural attenuation processes in the creek. Have these natural attenuation processes/compartments been identified and what are the expected overall and seasonal removal efficiencies? Any supporting documents or test results to these effects should be provided.*

The attenuation of metals in the natural environment by a range of processes is a well established geochemical fact (for example, put ‘natural metal attenuation’ into Google and review results). Overall and seasonal removal efficiencies have not been quantified because they are not being relied on. However, there is no question that attenuation will occur, although to different degrees depending on the parameter.

7.0 TRANSPORT CANADA IR REPLIES

IR Number: TC 2-1
Subject: Outfall Design
Request:

1) *Provide additional background information for effluent culvert as an alternative to the diffuser outfall option. Describe how the effluent culvert will better "avoid icing and minimize other possible impacts" and be a better management practice to the diffuser outfall option.*

2) *Provide construction designs and installation details of the effluent culvert. Include information such as the plans showing all project features and dimensions, a cross section view of the material site showing current land and water elevations and bank slopes and final excavation grades and slopes; and indicate the time of year when project construction will occur.*

As noted above, effluent discharge is now proposed to be via an exfiltration trench. See Appendix E for details. Construction would occur in the July 15 – August 15 allowable in-stream works window.

IR Number: TC 2-2
Subject: Road Maintenance
Request: *Provide additional details describing the activities associated with the summer road maintenance of the access road. Include information such as the sections of the road which will require general summer maintenance, equipment to be used during these activities, any in-stream works required, any stream–crossings to be included in the maintenance program, and the time of year when these activities will take place.*

See reply to Environment Canada IR 2-4. The work may involve use of hoes, dozers and graders, as at present. No in-stream works are expected, but if this is required and DFO approval has been given, it would occur in the July 15 – August 15 allowable in-stream works window. Crossings of potentially fish-bearing streams are generally not permitted, unless this occurs using clear spans, or to install clear spans.

IR Number: TC 2-3
Subject: Water Body Usage
Request: *Provide historical information on the traditional and recreational usage of affected water bodies, including the types of vessels that frequent the water bodies. The NWPP Office will require more specific information once water crossings have been determined and finalized, and this would have to be reflected in a proponent's NWPA Application.*

CZN holds an LUP to operate the existing access road, and there are no permanent crossing structures in place. CZN is currently proposing to install only one permanent structure, a bridge span of Polje Creek. This location is inside the expanded NNPR. To our knowledge, there has been no historical traditional or recreational use of this creek for navigation, and none is likely in future.

8.0 DCFN IR REPLIES

IR Number: DFN-1
Subject: Use of Initial Dilution Zones (IDZs)
Request:

1. *Please explain how the switch from the use of a diffuser with end-of-pipe discharge limits to a simple discharge pipe with extremely long IDZs can be considered more protective of water quality and aquatic life? If it is not, what is the basis for the switch? Is it just about saving money for CZN?*

See reply to Transport Canada IR 2-1.

2. *Has CZN had any meetings or correspondence with the MVLWB to discuss the use of IDZs in Prairie Creek? Please provide details such as meeting notes, letters and e-mails. Please explain what the MVLWB's reaction has been to CZN's proposed use of IDZs in Prairie Creek. Has it been positive or negative?*

See letter from MVLWB dated November 29, 2010.

3. *If CZN has not held any discussions with the MVLWB, on what basis is CZN assuming that the MVLWB would favourably review a proposal for IDZs in Prairie Creek? Is the single line noted above in the draft LWB document the sole piece of information that CZN is relying upon in assuming that the MVLWB would approve of IDZs at Prairie Creek?*

See Item 2 above.

IR Number: DFN-2
Subject: Where can IDZ's be used?
Request: *Please explain the basis for CZN assuming that IDZs would be approved for continuous use in Prairie Creek given that the most direct guidance available suggests that the use of IDZs would be restricted to larger surface water bodies or periodic discharges in smaller water bodies.*

See Appendix G.

IR Number: DFN-3
Subject: Design standards for the use of IDZs
Request:

Please provide evidence and explanations as to how CZN has met the requirements of each of these 16 criteria in its proposed use of IDZs in Prairie Creek.

The 16 criteria in the Saskatchewan Environment document are intended for Saskatchewan, and are not necessarily relevant to, and have not been adopted by, the NWT. As the MVLWB have stated, "following any decision of the Review Board, the MVLWB would use the findings and conclusions of the environmental assessments as well as evidence collected during its own regulatory process to determine the specific approach to regulating effluent discharge”.

In particular, please ensure that this evidence includes (1) an analysis of the flows, width and cross-sectional flow areas of the plumes as compared to Prairie Creek as a whole for each contaminant and under each flow condition

See Appendices D and L.

2. *an explanation as to how the use of a simple pipe instead of a diffuser would satisfy Criteria #3.*

An exfiltration trench is proposed.

IR Number: DFN-5
Subject: Parks Canada and Environment Canada IRs
Request:

1. *For the Parks Canada IRs, please ensure that the answers provided are for the Prairie Creek Mine as a whole including all mine activities and impacts regardless of whether or not those activities and impacts occur inside or outside of the boundaries of Nahanni National Park Reserve.*
2. *For IRs related to water quality, water balances and chemical loadings to Prairie Creek, please ensure that exfiltration from both mine workings and the surface water ditches and subsequent movement to Prairie Creek through groundwater flows are included in all calculations and analysis.*

This submission meets these requests.

APPENDIX A

Information Requests

Second Round

IR Number: **Parks_Canada _2-1**
Source: **Parks Canada Agency (PCA)**
To: **Canadian Zinc Corporation (CZN)**
Subject: **Access Road**
Reference: **Technical Meeting Day 2; Undertakings 12, 17**

Preamble:

CZN's response to the first round information request, Parks_Canada_10, items(c-i)and (l) , did not fully address questions regarding the access road. During the Technical Meetings, CZN provided part of the outstanding information. The responses, however, lacked detail. As such, CZN committed to providing additional information related to operations and maintenance, as well as design aspects of the access road. Although Parks Canada only needs this information within Nahanni National Park Reserve of Canada (NNPR), we assume it would be useful for others with interests outside the park). For the sake of clarity and completeness, PCA outlines our understanding of this commitment in the request below (See Numbers 1-7).

Additional information is also requested to fully understand the spatial and temporal aspects of environmental impacts resulting from the road during construction, operation, and post-closure. PCA recognizes that information presented to date by CZN may partially address some items requested in the environmental risk assessment; however, a complete consolidation of all considerations, that includes consideration of significance and environmental impacts of the road, will assist parties in understanding determining significance of potential adverse environmental effects of the road. Additionally, PCA notes that environmental impacts local to the road bed are of particular interest. The localized details will likely compliment the larger spatial scale information that was the major focus of the access road information presented to date by CZN. (This information request is identified as Number 8)

Request: (See also DFO_2-2; 2-4; 2-5; NRCan-1)

With consideration given to information provided by CZN to date, PCA provides the following detailed requests.

1. Identify if there is a recognized or typical standard/guide for design, construction, and operation that is utilized in the Northwest Territories for access or haul roads. If this exists, please indicate if CZN proposes to follow this standard for this proposed road.
2. Provide typical cross-section diagrams of the access road to depict the various construction situations that are encountered on site, including, but not limited to: construction on well drained and poorly drained soils, ice rich permafrost soils, weaker soils, cut and fill locations, and approaches for stream crossings.
3. The road may be constructed of snow, ice, granular, or a combination of construction materials depending on the local environmental and physical setting. Provide details on the type of road to be constructed along the length of the route in tabular format, as well as depicted on a map(s).
4. Estimate quarry/borrow material volumes along the length of the road and depict the location of the material source on a map.

5. Estimate the snow and water quantity along the length of the road route and depict the location of the water source(s) on a map. PCA recognizes that CZN provided a partial response to this information previously; however, it is requested that an assessment along the length of the route be provided. Our assumption is that the snow and water volumes would be a function of the type of road to be constructed (related to item 3 above).
6. Provide details of the operation and maintenance activities for the access road.
7. If monitoring of the access road occurs during construction and operation, describe the monitoring program. The response is specifically to address: frequency of access road inspection to assess the need for maintenance/repair; items considered in access road inspections (e.g., signs of permafrost degradation).
8. Conduct a spatial and temporal environmental risk assessment along the length of the road route that considers the impacts of planned activities (unrelated to spills or other accidents and malfunctions) during the following phases of the road:
    - Road construction, inclusive of transfer facilities
    - Road operation, inclusive of transfer facilities
    - Road post-closure, inclusive of transfer facilities

Include, but do not limit, a consideration of impacts on the following:

- Topography
- Slope stability
- Permafrost
- Groundwater quality and quantity
- Surface water drainage patterns
- Sensitive areas

If applicable, the environmental risk assessment is to consider:

- Assessment of unmitigated effects
- Spatial boundaries – magnitude (i.e., low, medium, high) and extent (i.e., regional and local)
- Temporal boundaries – frequency (i.e., frequent, intermittent, infrequent), duration (i.e., permanent, long-term, medium term, short term), significance (i.e., low, medium, high)
- Proposed mitigation
- Assessment of residual effects
- Residual effects/influence of mitigation
- Significance of residual impacts
- Probability

The environmental risk assessment could be consolidated in tabular format. The table below is provided for consideration.

CZN is to define the criteria and level/ranks for the criteria used in the risk assessment, as well as significance. A comparison of the unmitigated effects with the residual effects is to illustrate and quantify the effectiveness of mitigation.

Road Activity	Road Section	Potentially affected component	Predicted Effects	Assessment of unmitigated effects					Proposed Mitigation	Assessment of residual effects		
				Spatial		Temporal				Residual effects/ influence of mitigation	Significance of residual impacts	Probability
				Magnitude	Spatial extent	Frequency	Duration	Significance of effects				
Road Construction	Section x	Topography										
		Slope Stability										
		Permafrost										
		Groundwater quality and quantity										
		Surface water quality and quantity										
		Surface water drainage patterns										
		Stream crossings										
		Sensitive areas										

IR Number: Parks_Canada_2-2
Source: Parks Canada Agency (PCA)
To: Canadian Zinc Corporation (CZN)
Subject: Prairie Creek water quality that is protective of aquatic life
Reference: Technical Meeting Day 2; Undertaking 10

Preamble:

The Developer's Assessment Report (DAR) provided an initial screen of water quality parameters that require further consideration in terms of applicable water quality objectives (refer to DAR Table 8-7: Generic Water Quality Objectives). Select analysis provided in the DAR does not consider Prairie Creek background water quality in its screening analysis for water quality objectives. PCA notes that the water quality in Prairie Creek downstream of the mine, is a function of treated process water, treated mine water, as well as, Prairie Creek water quality and quantity. In general, the water quality parameters identified in the DAR (Tables 8-7 and 8-8) were considered by CZN to be parameters that form the basis of the water quality objectives to be achieved in Prairie Creek. CZN water quality objectives appear to be based on the concept that the Prairie Creek water quality will protect all types of aquatic life for all life stages. PCA supports this position.

Appendix J of the CZN Response to IRs provided predicted water quality in Prairie Creek and comparison to water quality objectives for a broader range of parameters than the range that was presented in the DAR. During the Technical Meetings it was noted that CZN was not intending to consider all of the water quality objectives presented in Appendix J in determining acceptable in-stream Prairie Creek water quality. This resulted in uncertainty in the water quality parameters that CZN would consider when determining mine water discharge quality and quantity. To address this uncertainty, PCA requested during the Technical Meeting a summary table of water quality parameters and concentrations that are protective of aquatic life in Prairie Creek. CZN took this request under consideration.

For clarity, the request is identified below.

Request:

Provide a summary table of water quality parameters and concentrations that are protective of aquatic life in Prairie Creek (i.e. site-specific objectives). Describe the method(s) applied to determine the water quality parameters and concentrations.

IR Number: **Parks_Canada_2-3**
Source: **Parks Canada Agency (PCA)**
To: **Canadian Zinc Corporation (CZN)**
Subject: **Prairie Creek water quality – downstream mixing zone**
Reference: **Technical Meeting Day 2; Downstream Mixing Analysis (NHC 2010)**

Preamble:

The Developer's Assessment Report (DAR) provided limited information regarding the method of mine water discharge to Prairie Creek and the associated aspects of water quality mixing within Prairie Creek. CZN's Response to Information Request (IR) document (September, 2010) and discussion during the Technical Meeting demonstrated that mixing of mine water and Prairie Creek water is to occur within an initial dilution zone downstream of the discharge location. A summary report for the downstream mixing analysis was distributed during the Technical Meeting (*Prairie Creek Mine outfall performance – downstream mixing analysis* DRAFT (NHC 2010). It was not possible to review the summary report during the Technical Meeting, and therefore limited inquiries/comments have been provided on the downstream mixing zone results to date.

Upon review of the downstream mixing analysis report, it is understood that it is a draft document that provided only a summary of results, with limited to no methods of analysis. The analysis considered a limited range of discharge conditions, and a limited number of water quality parameters.

Request: (see also INAC02-01)

1. Provide the full final report, instead of a draft summary, that details the downstream mixing analysis.
2. Complete the downstream mixing analysis for, but not limited to, the following scenarios:
   a. Average Prairie Creek flows expected during typical operations.
   b. Worst case Prairie Creek low flows.
   c. Worst case Prairie Creek high flows.
3. Define the selected typical ranges and worst case conditions.
4. Present the concentration contours within the mixing zone.
5. Complete the downstream mixing analysis for all water quality parameters that could impact aquatic life.
6. Present a summary of the mixing zone dimensions required for water quality to comply with water quality objectives.
7. Provide details of an environmental impact analysis to aquatic life within the mixing zone.

IR Number: **Parks_Canada_2-4**
Source: **Parks Canada Agency (PCA)**
To: **Canadian Zinc Corporation (CZN)**
Subject: **Prairie Creek water quality predictions and mine site water balance**
Reference: **Technical Meeting Day 2; Undertakings 3, 5, 7, 10,**

Preamble:

The Developer's Assessment Report (DAR) and Response to Information Request (IR) (Appendix J) provided by CZN predicted concentrations of parameters of concern in Prairie Creek for select mine water discharge as well as Prairie Creek flow rate conditions. The results of the analysis were discussed in detail during the Technical Meeting. The following was noted:

- In-stream predicted concentrations are a function of the end of pipe water quality and quantity discharged to Prairie Creek, as well as, Prairie Creek flow rate and water quality.
- After complete mixing of the mine discharge water with Prairie Creek, the predicted concentrations can be compared to Prairie Creek water quality objectives to assess if the discharge scenario is acceptable with respect to Prairie Creek water quality. The water quality parameters and objectives were uncertain at the time of the Technical Meeting (This is the subject of Parks_Canada_2-2 above).
- There is no water balance calculation for each condition analyzed to demonstrate that the mine water discharge rate adopted in the analysis will not compromise on site water storage.

Request: (see also INAC02-03)

1. Predict in-stream Prairie Creek water quality at Harrison Creek and the Park Boundary for the following scenarios:
   a. Average Prairie Creek flows expected during typical operations and monthly average inflows expected during typical operations.
   b. Average Prairie Creek flows expected during typical operations and worst case high mine inflows (assuming worst case connectivity to the PCAA and HCAA).
   c. Average Prairie Creek flows expected during typical operations and low mine inflows.
   d. Worst case Prairie Creek low flows and monthly average inflows expected during typical operations.
   e. Worst case Prairie Creek low flows and worst case high mine inflows (assuming worst case connectivity to the PCAA and HCAA).
   f. Worst case Prairie Creek low flows and low mine inflows.
   g. Worst case Prairie Creek high flows and monthly average inflows expected during typical operations.
   h. Worst case Prairie Creek high flows and worst case high mine inflows (assuming worst case connectivity to the PCAA and HCAA).
   i. Worst case Prairie Creek high flows and low mine inflows.

CZN is to define the selected typical, high, and low flow conditions.

2. For the nine scenarios outlined above, conduct a water balance to demonstrate that mine site water storage capabilities are acceptable. Worst case mine site scenarios should also consider the implications on catchment pond storage capacity and required discharge flow rates due to high or worst case mine inflow volumes occurring in combination with surface flood events, as this combination may require higher discharge volumes.

   CZN is to identify the selected typical ranges and worst case conditions.

3. Compare in-stream Prairie Creek water quality predictions to water quality objectives that are based on protection of aquatic life.

IR Number: Parks_Canada_2-5
Source: Parks Canada Agency (PCA)
To: Canadian Zinc Corporation (CZN)
Subject: Potential for bioaccumulation of mercury
Reference: IR response to Parks_Canada_33
Technical Meeting – Undertakings 3, 8, 10

Preamble:

The Developer's Assessment Report (DAR) submission indicated that concentrations of mercury in treated waste-water discharged to Prairie Creek will exceed natural levels of mercury in the river. Therefore, if the mine becomes operational, it will result in increased loadings of mercury to Prairie Creek and the potential for bioaccumulation of mercury in aquatic food webs.

A peer reviewed scientific article authored by Spencer et al. (2008) (Integrated Environmental Assessment and Management, 4: 327-343) documented elevated levels of mercury in slimy sculpin body tissues immediately downstream of the Prairie Creek mine. The data reflected a 2.4 and 2.8 fold increases in mercury levels in fish tissues between the upstream reference site and downstream exposed sites.

Analyses of these data showed that statistical differences in concentrations of mercury in sculpin at the upstream (non-exposed site) compared to the downstream near-field site and the far-field downstream site are close to being statistically significant ($P = 0.07$) but not statistically significant at probability of 0.05). Given low sample sizes inherent to the study by Spencer et al (2008), the lack of a statistical difference in concentrations of mercury in sculpin tissues among the upstream site, and the two downstream sites exposed to mining effluent from the Prairie Creek mine, is not surprising and likely reflects a sampling design used by Spencer et al (2008) that was not overly powerful. Nevertheless, differences in levels of mercury in sculpin among these 3 sites is statistically significant at a probability of 0.10, which in many studies, is used to assess statistical significance if a study design is known to be only moderately powerful. Moreover, the lack of statistical significance does not change the fact that average levels of mercury downstream of the mine were between 2.4 and 2.8 times higher than that above the mine, and does not preclude the possibility that these elevated levels are biologically significant, and are of potential concern as the mine transitions to full operation.

Based on potential concerns related to mercury contamination of Prairie Creek due to the discharge of mercury from the Prairie Creek Mine to Prairie Creek, Parks Canada requested (Parks_Canada_33) that CZN clarify why details of their assessment of contaminant loads did not include an evaluation of a potential increase in loadings of mercury, and an evaluation of their potential environmental effects on biological communities in this system.

The reply from CZN did not address this concern and re-iterated that differences in mean levels of mercury among the three sites were not "statistically significant" at a probability of 0.05. Parks Canada was aware of the lack of the statistical differences, measured at the restrictive probability of 0.05, and this was not the central issue of Parks_Canada_33.

Request:

Given that existing data has shown that slimy sculpin downstream of the Prairie Creek contain elevated average levels of mercury in their tissues compared to an upstream site, and that full mining operations are projected to increase loadings of mercury to Prairie Creek,

1. Provide empirical data to document that the discharge of mercury-rich effluent to Prairie Creek will not jeopardise the health of fish and the entire foods web in Prairie Creek.

2. In the absence of these data, ensure that mercury is included in the predictions for downstream concentrations during mine operations, (See EC-2-1; INAC02-1), and that potential environmental effects on biological communities in the system are considered.

IR Number: **Parks_Canada_2-6**
Source: **Parks Canada Agency (PCA)**
To: **Canadian Zinc Corporation (CZN)**
Subject: **Adaptive management of wildlife impacts**
Reference: **Technical Meeting Day 2; Undertaking No. 23**

Preamble:

In their Developer's Assessment Report (DAR), CZN states that an adaptive management framework be implemented to manage impacts of their development on wildlife populations. Monitoring and adaptive management are important to ensure anticipated or unanticipated effects on wildlife are mitigated and the ecological integrity of Nahanni National Park Reserve is unaffected. Canadian Zinc's response to Parks_Canada_05 provided little information on how the monitoring program and associated adaptive management will occur. Discussion on Day 2 of the Technical Meeting provided minimal additional information and resulted in Undertaking No. 23. To clarify our requests related to Undertaking No. 23, PCA is providing the following request.

Request:

1. Outline the adaptive management process proposed by CZN. Provide sufficient detail on the following key elements of monitoring within the adaptive management framework:
    a. Selection of valued ecosystem components that will be monitored with a clear rationale on:
        i. how they indicate trends for the ecosystem and anthropogenic change
        ii. which areas and seasons within the study area will be addressed by their inclusion
        iii. which variable will be monitored (e.g., Dall's sheep recruitment, grizzly bear occupancy)
    b. Design of monitoring programs including geographic extent, timing, survey method, personnel requirements, and study controls that will be used to allow development specific change to be detected and mitigated
    c. Indicate the thresholds that will be used to determine change, including descriptions of effect size, power, confidence, sample size, and frequency
    d. Describe how results from monitoring programs will be integrated into decision making and the process in which mitigations will be determined
    e. Comment on the use of additional research and adaptation of monitoring programs to determine efficacy of mitigation measures

    Where CZN believes sufficient information exists (e.g., Dall's sheep) provide a full assessment of data in the context of the above questions to help describe how adaptive management would be applied as proposed.

IR Number: **Parks_Canada_2-7**
Source: **Parks Canada Agency (PCA)**
To: **Canadian Zinc Corporation (CZN)**
Subject: **Mitigation of possible impacts to carnivores**
Reference: **Technical Meeting, Day 2**

Preamble:
Carnivores are a valued ecosystem component of the Greater Nahanni Ecosystem and integral to the ecological integrity of Nahanni National Park Reserve. They present special challenges to development as attraction to sites often leads to conflict and in many instances increased mortality rates. Most carnivores (e.g., grizzly bears and wolverines) have very low reproductive rates and have large home ranges. Even slight increases in mortality can have significant effects on populations, as evidenced by the ban on grizzly bear hunting in the Mackenzie Mountains. This is particularly important with the Prairie Creek mine as grizzly density in the area is considered very high (Weaver 2008). However, effective management of attractants, appropriate placement and design of infrastructure, strong education efforts with staff, and monitoring combined with adaptive management approaches can adequately mitigate impacts. In response to IR 1 Parks_Canada_04 7a, Canadian Zinc provided a paragraph of high level information. During the Technical Meetings, Canadian Zinc committed to several of these approaches in principle (Day 2 – page 273-278). Further clarification is now asked for to ensure mitigations will be appropriate and adequate.

Request:

1. Provide infrastructure design mitigations that will be used to discourage predator and scavenger attraction to the mine site and transfer facilities.
2. A good synopsis of food and waste management in terms of disposal has been presented by the developer. Yet insufficient detail is in place on how attractants will be handled on site, and by workers away from the mine site, including along the road or in transfer facilities. All attractants should be stored in animal proof containers; please indicate which types of containers will be used.
3. Describe how other chemical and industrial grease materials will be stored; describe how they will be managed while in use or immediately following use.
4. Provide details of employee education and management programs to reduce negative encounters and to ensure policies are enforced.
5. Describe how grey water systems will be managed to ensure they remain clean, grease free, and not accessible to wildlife.
6. Describe the monitoring programs that will be in place to assess the effectiveness of the above programs and how problems will be dealt with.

IR Number: **Parks_Canada_2-8**
Source: **Parks Canada Agency (PCA)**
To: **Canadian Zinc Corporation (CZN)**
Subject: **Road Impacts on wildlife**
Reference: **Technical Meeting Day 2 Undertakings #19, 21, 22**

Preamble:
Woodland caribou are a valued component of the Greater Nahanni Ecosystem. Further, woodland caribou (boreal and northern mountain ecotypes) are a species listed under Schedule 1 of the *Species at Risk Act* (SARA) that use habitat within the environmental assessment study area. Any species listed under Schedule 1 of the SARA must be identified, and any adverse impacts of the development on them thoroughly assessed and mitigated, regardless of whether the impact(s) are deemed "significant." If the project is carried out, the assessment must ensure that measures are taken to avoid or lessen those effects, and to monitor them.

As has been previously noted in the review process, PCA has insufficient information to determine the impact of the road on wildlife, and in particular, on woodland caribou, or to determine appropriate mitigation and monitoring programs (IR Round 1 Parks_Canada_3 and technical meetings day 2). During the Technical Meetings, CZN made commitments to meet these information requirements by proposing mitigations to avoid wildlife impacts (e.g. avoiding road work during calving/lambing season or during animal migration).

To address further information deficiencies during winter operation of the road, CZN committed (Undertaking #18) to undertaking three winter surveys for caribou and other wildlife (Tentative: November 2010; February to March 2011). In lieu of providing the full information from these surveys before preparation of technical reports, CZN proposed to assume a number of different outcomes from the February and March surveys, committing to appropriate mitigation requirements for a variety of outcomes to caribou that may result from the later surveys.

As discussed at the Technical Meeting, PCA has significant reservations that the approach outlined in this commitment will provide adequate information. However, we are reiterating our information request to allow the proponent an opportunity to demonstrate that its approach will provide the required information. If a review of the response to this Information Request shows the information is not adequate, then we will consider submitting a request for ruling regarding this issue.

Request:
1. Describe the potential impacts on woodland caribou from the road routing and road operation during the winter.
2. Describe the associated mitigation for these impacts.

IR Number: Parks_Canada_2-9
Source: Parks Canada Agency/Environment Canada
To: Canadian Zinc Corporation
Subject: Assessment of spills and identification of mitigation along the access road and at the mine site
References: Information Request Response – Appendix F: Spill Contingency Planning
Technical Meeting – Day 2 – Undertakings # 13, 14, 15

Preamble:
In its response to first round Information Requests on spill contingency planning, Canadian Zinc (CZN) noted its intent to focus on the "assessment of the risks of spills occurring and mitigation considerations." The adequacy of the response was discussed during the Technical Meeting, particularly by Environment Canada (EC) and Parks Canada Agency (PCA), and CZN made a commitment to provide more information and rigour to this assessment. The discussion included a request to clarify some of the examples in CZN's response including: sulphuric acid spills, sensitive areas, an assessment of the impacts, clean up challenges, and a consideration of this information along the full length of the road. PCA has a mandated interest in this assessment in areas where spills could occur along the length of road within Nahanni National Park Reserve (NNPR), or in areas where a spill could have an impact on valued components within NNPR. EC's interest extends to the entire length of the road, and to the mine site as well.

The initial IR response included some examples of high risk areas (steep grades), environmentally sensitive areas (karst) and spilled substances (sulphuric acid). Both PCA and EC require a more comprehensive evaluation. For instance, in addition to the karst, other sensitive areas would also include areas near bull trout spawning habitat, or key terrestrial habitat for migratory birds. Note that the existing access road and sections of the proposed Silent Hills re-alignment cross a site which supports roughly 8% of the Canadian breeding population of Trumpeter Swans. The Tetcela River and Fishtrap Creek feature the most extensive wetlands in the southeastern Mackenzie Mountains. [i]

The requested assessment information would be consistent with that provided in other project reviews considered by the Board, including, for instance, the review of the DeBeers Snap Lake Diamond project. In that review, the proponent followed a risk assessment approach to assess impacts of accidents and malfunctions. The assessment considered frequency, and consequence of a number of spill risk scenarios.

PCA and EC acknowledge CZN's commitments within the technical meeting to provide this information. This information is required for Responsible Ministers to consider significance and potential mitigation before the end of the environmental assessment process. For the sake of clarity and completeness, PCA and EC reiterate the request as follows:

Request:

1. Conduct a spatial risk assessment along the length of the road, that considers the frequency of spills, the consequence of spills, and the challenges of clean up. The assessment should lead to a fuller assessment of the potential impacts of spills, appropriate mitigation, and their significance. The information requested should include:

(a) evaluation of locations where the frequency of potential spills is high, including, without limitation, steep grades, and hairpin turns. Where possible, this should include measurable/numerical limits (e.g. grade);

(b) evaluation of locations and seasonal conditions where the environmental consequence of a spill is high, including, without limitation, the karst landforms, bull trout spawning areas, trumpeter swan habitat, Polje Creek, and shoulder seasons conditions that may increase movement of contaminants;

(c) evaluation of locations and seasonal conditions where spill response and/or clean-up is challenging, including, without limitation, difficulties in mobilizing equipment, or containing contaminants;

(d) identification of the impacts of spilled substances, including all substances that may be transported over the road, including, without limitation, sulphuric acid, ore concentrate, process reagents, and fuel. This may include an evaluation of worst-case scenarios related to the above-noted risk factors.

(e) identification of mitigation considerations to address these risks, including both design and operational mitigations.

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[i] Latour, P.B., J. Leger, J.E. Hines, M.L. Mallory, D.L. Mulders, H.G. Gilchrist, P.A. Smith and D.L. Dickson. 2008. Key migratory bird terrestrial habitat sites in the Northwest Territories and Nunavut. 3rd edition. Canadian Wildlife Service Occasional Paper No. 114. Available at http://www.ec.gc.ca/Publications/default.asp?lang=En&xml=4625F589-01A1-4A7B-BBCE-C8E36573B657

IR Number: EC-2-1
Source: Environment Canada
To: Canadian Zinc Corp. (CZN)
Subject: Effluent quality predictions
References: IR Response – EC-16 (in part)
Technical Sessions – Undertakings #3, 4, 6, 7, and 8.

Preamble:
Water quality predictions are a key element needed for evaluating the effects of a development. It is necessary to have a clear understanding of the changes which can be expected to occur during the construction, operation, and closure of the mine. To assess the effects associated with changes to water quality, effluent and non-point sources of elements must be well characterized. Predicted concentrations for the full suite of parameters contained in the effluent should be provided for maximum values, as well as for seasonal and annual averages.

With this information, the proponent can quantify the extent and magnitude of potential changes which may occur in the receiving environment. To this end, information must be presented on the extent of alteration which can occur in the receiving waters, for the full suite of parameters. This will require an understanding of effluent behaviour in the stream, including the effects of any modifying factors (such as pH, hardness, dissolved oxygen etc.) on the fate and effects of individual contaminants. Knowledge of the biological receptors will also be needed, in order to assess the effects of the discharge. The area of chronic toxicity caused by the discharge must be minimized, and there must be no acute toxicity of undiluted effluent at end of pipe. Potential contaminant-associated changes to the ecosystem should be described and quantified.

In addition to the effects of parameters which act as contaminants, there can be adverse effects or changes associated with the addition of nutrients. Prairie Creek is a phosphorus-limited oligotrophic stream, with median total phosphorus concentrations of 0.005 mg/L. Phosphorus in runoff can increase due to surface disturbance, and mine water can contribute a less-available form of phosphorus. Camp wastewater will be the biggest source of biologically available phosphorus, as well as nitrogen, and may cause increases in biological productivity. Predictions should be made of nutrient concentrations and loadings, and there should be a discussion of potential effects on the downstream ecosystem.

When developing predictions, it is expected that these will take into account all available mitigation measures. For example, the in-stream concentration predictions should be based on the optimum discharge configuration that can be used for minimizing creation of a discrete effluent plume, and maximizing dispersion. Realistic treatment capabilities should underlie effluent quality estimates. Where alternatives or contingencies may be needed, it is expected that these will be identified and enough detail provided to assure reviewers that the risk of poor quality effluent can be addressed.

Requests:

1. EC requests that CZN provide predictions for integrated effluent quality for all sources combined (process water, mine water, site runoff, and sewage effluent), with predicted composition to include a full list of parameters (metals, nutrients,

major ions). Values should be provided for maximum anticipated concentrations, and for seasonal and annual average concentrations.

2. EC requests that CZN provide predictions for downstream concentrations of a full suite of parameters. These should include metals, major ions, and nutrients. Predictions should be compared to water quality objectives.

3. EC requests that information on the camp wastewater be provided, and include system treatment capability, estimated discharge volumes, predicted effluent quality, and annual loadings for nutrients. Parameters of concern include pH, BOD5, TSS, total phosphorus, ammonia (as N), and nitrate (as N).

4. EC requests that CZN fully describe expected environmental changes or impacts associated with the metals, nutrient and major ions parameters.

5. EC requests that the proponent provide a description of mitigation measures available to prevent impacts, and/or as a contingency in the event concentrations are higher than predicted, or monitoring detects changes which were not predicted.

IR Number: EC-2-2
Source: Environment Canada
To: Canadian Zinc Corp.
Subject: Major ions
References: IR Response – EC-14
DAR Appendix 5

Preamble:
Changes in receiving water TDS can occur in connection with effluent discharges, due to elevated concentrations of the major ions (cations calcium, magnesium, sodium and potassium, and anions carbonate-bicarbonate, chloride and sulphate). CZN did predict that the magnitude of the TDS loads would be similar to the predictions made for sulphate (approximately 50 tonnes annually), but effluent quality predictions do not cover individual constituents. Source term predictions have been provided for pH and a list of metals (DAR Appendix 5), but not for the major ions, nor the nutrients.

In the technical meetings, CZN stated they would investigate the testing of existing samples for major ions to provide a better estimate of effluent quality for TDS.

Requests:

1. EC requests that CZN provide test results for major ion constituents, and estimate contributions from process reagents.

IR Number: EC 2-3
Source: Environment Canada
To: Canadian Zinc Corporation
Subject: Wildlife Monitoring Plan and Technical Advisory Committee
Reference: Technical Sessions – Undertaking #28

Preamble:
At the end of the Oct.6-8 technical meetings there was discussion surrounding the formation of a technical advisory committee to handle outstanding issues relating to mitigation and monitoring during operation of the mine and to provide oversight and input into monitoring programs and adaptive management.

This technical advisory committee should be involved in discussions surrounding the development of the Wildlife Monitoring Plan (WMP). In response to EC's first round IR (IR Number EC-10) requesting an updated draft of the WMP, CZN proposed that a formal WMP was not necessary at the environmental assessment stage, but accepted that it was important to have an appropriate WMP in place before operations commence, and committed to producing such a plan. During the technical hearings CZN envisioned that the technical advisory committee would be "a body that is both focused towards management and review of technical information, and also a vehicle for public engagement and interaction, including community engagement". From the technical hearings, Undertaking no. 28 requested that Canadian Zinc draw up the terms of reference for the technical advisory committee as well as suggest the parties to that committee and possible involvements, and that it be sent out for review. CZN committed to preparing such a draft. During their closing comments at the technical hearings, EC expressed their interest in having a representative from the Canadian Wildlife Service participate in the committee to address outstanding wildlife concerns with respect to the WMP.

Request:
For Canadian Zinc Corporation to:

1. Specify who they envision as being members of the technical advisory committee;
2. Provide details of how the technical advisory committee will be involved in the development of the WMP;
3. Provide a draft of the TOR for the technical advisory committee for review by potential members of the committee;
4. Provide a timeline for the provision of a revised WMP to the technical advisory committee that addresses Section 3.3.6-5 of the Terms of Reference as well as the expected timing of follow-up meetings that would allow members of the committee to review the plan and provide input into the development of the final WMP to be in place prior to the start-up of mine operations and development of the mine access road.

   The revised WMP should be a stand alone document, and should therefore consolidate existing information relevant to mitigation, monitoring and adaptive management for all wildlife VECs that is currently provided in the DAR and associated appendices as well as any new information provided in response to first and second round IRs. The revised WMP should also highlight steps that are being undertaken to fulfill requirements of Section 3.3.6-5 of the Terms of

Reference that are not currently addressed, as well as how existing plans will be modified in order to be appropriate for full-scale mining covering all activities occurring at the mine site and along the transportation corridor.

IR Number: EC2-4
Source: Environment Canada
To: Canadian Zinc Corporation
Subject: Summer road maintenance
Reference: Technical Sessions – Day 2

Preamble: During the technical sessions it was revealed that summertime road maintenance will take place along the upper portions of the access road from the Mine site towards Sundog Creek. The length of this section of the access road appears to be constrained by the first point at which CZN is unable to cross a fish bearing stream. These summer maintenance activities were not described in the DAR or in 1st round IRs. EC has concerns about the potential impact of these activities on migratory birds, given that these activities will occur within the nesting season for migratory birds in boreal regions of the NWT (migratory birds may be found incubating eggs from May 7 until July 21, and young birds can be present in the nest until August 10).

Request:
For Canadian Zinc Corporation to:

1. Provide further clarification on the details of road maintenance activities to be carried out during spring and summer, the expected length of the section of the road where these activities will occur, vegetation types or sensitive terrain along this section of the road, equipment and personnel to be used during these activities and the expected timing of activities;
2. Describe any potential impacts of these spring/summer road maintenance activities on Species at Risk or migratory birds that may be encountered on or adjacent to the access road with specific consideration given to the fact that these activities will occur within the migratory bird nesting season.

   CZN should note that Olive-sided Flycatcher, and Common Nighthawk are now listed on Schedule 1 of the federal *Species at Risk Act* (SARA) as threatened. Section 79(2) of SARA requires that during an environmental assessment, potential adverse affects on listed wildlife species and their critical habitat must be identified, measures must be taken to avoid or lessen those adverse effects and to monitor them, and any such measures must be consistent with any applicable recovery strategies or action plans;
3. Describe proposed mitigation to minimize potential impacts and details of any monitoring programs to verify whether mitigation is successful and to identify where adaptive management may be necessary.

IR: INAC02-01

Subject: Effluent Discharge and Receiving Water Quality - Operations

Linkage: INAC-07, INAC-08, INAC-09, INAC-10, EC-14, EC-16, DFO-01, PC-39, PC-44, PC-45, Technical Session Day 1 and Day 2.

References:

DAR, CZN, March 2010.

Responses to Information Requests, Appendix J, CZN, September 2010.

Responses to Information Requests, Appendix K, CZN, September 2010.

Prairie Creek Mine, Outfall Designs – Preliminary Construction Details, Draft, Northwest Hydraulic Consultants, October 5, 2010.

Prairie Creek Mine, Outfall Performance – Downstream Mixing Analysis, Draft, Northwest Hydraulic Consultants, October 6, 2010.

Preamble:

Canadian Zinc's (CZN's) DAR identified five metals (cadmium, copper, lead, selenium and zinc) in their treated effluent that are considered likely to impact receiving water quality. Section 8.5 of the DAR identifies that chemicals of potential concern were identified by comparing information on treated minewater and process water against CCME, BC AQ and USEPA water quality guidelines, summarized in Table 8.7. Note that nutrient data was not included in the original assessment.

Additional parameters (antimony, arsenic, iron, mercury, silver, ammonia, nitrate, nitrite, phosphorous, sulphate and conductivity) were requested in IRs, and Appendix J of CZN's IR response document provides updated predictions of in-stream water quality concentrations for the following scenarios: mine drainage flows of 29 L/sec and 100 L/sec, at both average and high Prairie Creek flows, at both Harrison Creek and the Nahanni National Park Boundary.

The DAR and IR response did not include a comprehensive characterization of expected effluent quality including: metals, major ions and nutrients. CZN has indicated they will provide this information in response to a request from Environment Canada at the Technical Session.

Appendix K of CZN's IR response identifies that a diffuser (as proposed in the DAR) is no longer proposed, and effluent discharge to Prairie Creek will be through a simple pipe outlet. A draft report providing a mixing analysis was provided on Oct 7, during the Technical Session. The mixing analysis considered cadmium, copper, lead, selenium and zinc under the following scenarios: high and low mine flows, and 7Q10, open water mean and ice covered mean Prairie Creek flows. CZN indicated at the Technical Session that they would include mercury and ammonia in an updated mixing analysis.

In-stream water quality predictions provided in Appendix J exceed proposed site specific water quality objectives for copper, lead, selenium, antimony, arsenic, mercury, ammonia, nitrate, phosphorous and sulphate under one or more prediction scenarios during site operations. The draft mixing analysis identifies parameter specific mixing zones ranging from 38 m to 1380 m in length, but does not provide information on plume size, concentration gradients within the plume or a comparison of the size of dilution zone achieved using the simple pipe outfall against what could be achieved with a diffuser.

While much information has been presented, uncertainty remains regarding the extent of potential receiving water impacts resulting from effluent discharges at Prairie Creek, and INAC requires additional information to assess potential impacts.

Note: Any assessment of a range of conditions should include all combinations of the following flow scenarios as a minimum: the average Prairie Creek flows expected during typical operations, worst case Prairie Creek low flows and worst case Prairie Creek high flows; the monthly average inflows expected during typical operations and worst case high mine inflows (assuming worst case connectivity to the PCAA and HCAA). Worst case mine site scenarios should also consider the implications on catchment pond storage capacity and required discharge flow rates due to high or worst case mine inflow volumes occurring in combination with surface flood events, as this combination may require higher discharge volumes. CZN is to identify the selected typical ranges and worst case conditions.

Requests:

1. In addition to the table(s) on expected effluent quality as requested by Environment Canada during the Technical Session, provide associated rationale and background on how these values were derived.
2. Provide an assessment of the potential impacts associated with mine effluent, and identify acceptable in-stream parameter concentrations. Provide a rationale for removing all potential contaminants or stressors, present in the mine's effluent, from consideration during the assessment. As an example Table J.6 identifies that arsenic concentrations will increase by 4 times. This increased concentration remains below CCME standards, but the magnitude of the increase may still be significant for Prairie Creek.

3. Provide additional information on the mixing analysis including: mixing analysis for additional parameters (ammonia and mercury), the model used to generate the predictions, any site specific modifying factors included in the modelling exercise (e.g. attenuation factors) and expected concentration gradients within the plume.
4. Provide information (i.e. dimensions) for a set mixing/dilution zone that will be applicable to all effluent parameters under all flow conditions. In-stream water quality objectives will be met at the edges of the dilution zone.
5. Provide a comparative assessment between the use of a simple pipe outfall versus use of a diffuser. Specifically, with respect to the size of the predicted dilution zone and the ability of each option to minimize potential long-term impacts on the receiving environment. In addition, provide an assessment of any increased impacts to the left bank of Prairie Creek during moderate to high flow as a result of the pipe outfall design.
6. If in-stream water quality objectives will not be met at the edge of the proposed mixing zone, what mitigation measures will be used to reduce contaminant concentrations to acceptable levels. Any mitigation measures that rely upon decreasing effluent discharge volumes must include calculations demonstrating that the site's water management structures will be capable of storing any un-discharged water under a range of mine inflows including low, expected and high mine flows. The demonstration should also include several scenarios including reducing discharge for consecutive months and over the entire winter.

IR: INAC02-02

Subject: Downstream Mixing Analysis

Linkage: INAC -06, Technical Session Day 1 and 2.

References:

Prairie Creek Mine, Outfall Performance – Downstream Mixing Analysis, Draft, Northwest Hydraulic Consultants, October 6, 2010.

Preamble:

Mixing analysis was conducted using information collected at the Cadillac mine using data from 1974 to 1990. Mixing analysis is important from an environmental monitoring program perspective because it sets the geographic scale for measuring concentration–related, but not necessarily loading-related, possible effects. It is important to understand extreme conditions so that monitoring locations may be situated such that the agreed upon mixing zone, nearfield and farfield areas may be adequately monitored.

Typically in the NWT, the edge of the "mixing zone" or end of pipe measurements comprise stations that fall within the SNP (Surveillance Network Program) whereas other stations falling outside this area comprise AEMP (Aquatic Effects Monitoring Program) stations.

Adaptive management actions are driven by triggers that usually differ between SNP and AEMP locations. Thus it is important that the demarcation between the two areas be well estimated. INAC requests the following information to assess the downstream mixing analysis as provided by the proponent.

Requests:

1. Provide a rationalization why the within-period 7Q10 was chosen rather than another combination of low-flow period (the choice of 7-days) and recurrence interval (the choice of 10 years).
    - The recurrence interval (10 years) should reflect some fraction of the expected mine operating life that is greater than 1 to ensure a conservative temporal scale. The current choice of 7-days may reflect weekly patterns in mine operations but is not reflective of any natural temporal scales.

2. Discuss the temporal relevance of the Water Survey of Canada records for Cadillac Creek terminated at 1990 given the period of application is 20 years later.
    - Given that climate change is affecting precipitation patterns and timing of critical water-flow events such as freshet and ice-up; the relevance of a water quality record terminated 20 years ago should be discussed.

IR: INAC02-03

Subject: Receiving Water Quality – Post Closure

Linkage: PC 21, PC 22, PC 23, Technical Session Day 3

References:

DAR, CZN, March 2010.

Responses to Information Requests, Appendix J, CZN, September 2010.

Site Hydrogeology Report, Prairie Creek Mine Site, Northwest Territories, Canada – Rev 0, Robertson GeoConsultants Inc., February 2010.

Preamble:

Tables J13 and J14 in CZN's IR response Appendix J identify concentrations of cadmium, lead and zinc in excess of in-stream objectives in Prairie Creek both at Harrison Creek and at the NNPR boundary post closure. The tables identify that the estimated zinc concentrations will be of the same order as naturally occurring zinc concentrations under pre-mining conditions. However, post-closure cadmium concentration estimates are approximately three times higher than pre-mining cadmium concentration estimates and post-closure lead concentration estimates are approximately double pre-mining lead concentration estimates. Note, mercury concentration estimates are not provided in Tables J13 and J14.

Sections 5.3.4 and 5.3.5 of Robertson GeoConsultants Inc. February 2010 Site Hydrogeology report predict that early post-closure metals concentrations will be higher than long term post closure metals concentrations. Tables J13 and J14 do not indicate whether the predicted in-stream concentrations are for early or late post-closure conditions, but are assumed to be for long-term post closure.

Given the potential for exceedances of in-stream objectives, INAC requires additional information regarding post-closure water quality in Prairie Creek to assess potential long-term impacts from this operation.

Requests:

1. Provide predicted in-stream parameter concentrations post-mine closure for 'all' parameters potentially affected by mining operations, including mercury.
2. What are predicted in-stream parameter concentrations during early post-closure? How long will the early post-closure conditions last?
3. Given that concentrations of several metals are predicted to exceed in-stream objectives after mine closure, identify potential mitigation measures that could be implemented to reduce the concentrations to below in-stream objectives.
4. Identify the assessment endpoints that will be used for monitoring post-closure water quality. Identify low, medium and high trigger levels that, when reached, will trigger a response during closure operations. (See INAC02-08 below)

IR: INAC02-04

Subject: Water Management and Treatment

Linkage: INAC 02, PC 40, PC 41, Technical Session Day 1 and 2.

References:

DAR, CZN, March 2010.

Responses to Information Requests, Appendix J, CZN, September 2010.

Table A9-1 Water Storage Pond Water Balance – corrected, October 8 2010.

Preamble:

Canadian Zinc will discharge a combination of treated minewater and process water to Prairie Creek. The proposed discharge strategy identifies that the final effluent composition will be determined by blending the treated process water and treated minewater streams in the Reactor Clarifier, prior to discharging to the Catchment Pond. The final blend will be modified as required to meet regulated limits. Canadian Zinc has identified that flow volumes in Prairie Creek will largely determine the effluent blend and flow volume. Treated process water will not be discharged during periods of low flow, i.e. winter, but will be discharged at a maximum rate of 0.020 m^3/s during higher flow periods, i.e. the summer months.

Tables in Appendix J identify that in-stream guidelines for metals and nutrients may be exceeded under several scenarios, but primarily during periods of low flow in Prairie Creek. CZN has indicated that effluent discharges will be reduced during periods of low Prairie Creek flow in order to meet in-stream objectives.

INAC is concerned that the ability of the site's water management system to handle consecutive months of low flow conditions in Prairie Creek has not been fully demonstrated. For example, assuming high mine inflows and low Prairie Creek flows as shown in Table J2, effluent discharge may have to be reduced by ½ in order to meet in-stream copper objectives for several consecutive months. Each month of reduced discharge will result in an extra 117,000 m^3 of water that must be managed. Two consecutive months of reduced discharge would require all the available operating storage capacity (not including free-board) in the WSP, assuming that maximum operating capacity was available when low Prairie Creek flows were first encountered.

Further, water inflows to the mine have been estimated to rise to 100 lps as a mean annual flow, (RGC report, referenced DAR page 211). The project water balance in App. 9 uses only 50 lps as the mean annual flow. Peak flows during snowmelt (DAR page 210 – CZN observations) may yield temporary flows which are much greater than 100 lps. During this period it will be necessary to have sufficient freeboard in the WSP to contain the water until it can be treated and discharged.

INAC is concerned that the water management strategy for the site must be flexible enough to handle the entire range of scenarios that could occur over the life-of-mine, therefore INAC requires additional information to evaluate the proposed water management strategy and to assess its ability to mitigate potential impacts. It is apparent from the tables and information presented in the DAR and IR responses to date that the receiving environment conditions will restrict and dictate effluent discharge and quality which in turn will influence the on-site water balance and management. Appropriate contingencies and storage capacity is required to handle the potential volumes of water from operations.

Note: Any assessment of a range of conditions should include all combinations of the following flow scenarios as a minimum: the average Prairie Creek flows expected during typical operations, worst case Prairie Creek low flows and worst case Prairie Creek high flows; the monthly average inflows expected during typical operations and worst case high mine inflows (assuming worst case connectivity to the PCAA and HCAA). Worst case mine site scenarios should also consider the implications on catchment pond storage capacity and required discharge flow rates due to high or worst case mine inflow volumes occurring in combination with surface flood events, as this combination may require higher discharge volumes. CZN is to identify the selected typical ranges and worst case conditions.

Requests:

1. Demonstrate that the proposed water management strategy can handle a range of flow scenarios including consecutive periods of high mine inflows and low Prairie Creek flows requiring a reduction in discharge volumes. Please confirm input parameters and freshet surges to the water balance.
2. Identify mitigation methods that would be implemented to maintain the site water balance and in-stream water quality objectives during periods when discharge must be reduced.
3. If allowing the mine to re-flood is a proposed mitigation strategy, identify any water quality issues that may arise from re-flooding the mine considering: contact with paste backfill, groundwater outflow from the mine workings/HCAA and PCAA contacts and water quality upon re-starting mine operations.
4. Provide a range of water treatment projections, in conjunction with range of water balance evaluations, which show the potential range of water treatment and discharge scenarios.

IR: INAC02-05

Subject: Mining Method – Crown Pillars – Surface Water Inflow to Mine

Linkage: INAC02-07

References:

DAR, CZN, March 2010.

Preamble:

Mining of ore zone near to, or through to, ground surface has the potential to intercept surface runoff and route it through the mine workings. This could result in a significant increase in flow through mine during operations and after closure. INAC requests the following information to assess potential impacts associated with additional flows through the mine workings.

Request:

1. Please describe how stability of the ground surface will not be affected by mining, or, how additional flows may affect the water balance and metal flushing from the mine workings.

IR: INAC02-06

Subject: Water Storage Pond – Diversion Ditch

Linkage: Technical Session Day 2

References:

DAR, CZN, March 2010.

Preamble:

Diversion of water around the Water Storage Pond is indicated as necessary for operation of the pond (page 210), and is purportedly described in more detail in App 12. The slope above the WSP is relatively steep, composed in part of clayey soils and there has been slope instability in this area. INAC requests the following information to better understand the mine development plan which will aid in the assessment of potential impacts.

Requests:

1. App. 12 does not provide any details as to the design or constructability of the diversion ditch. Information should be provided that is consistent with the design parameters of the WSP slope stabilization plans.

IR: INAC02-07

Subject: Hydrogeology – Potential Groundwater Inflows, Minewater Management

Linkage: INAC 01, INAC 03, Technical Session Day 1

References:

Site Hydrogeology Report, Prairie Creek Mine Site, Northwest Territories, Canada – Rev 0, Robertson GeoConsultants Inc., February 2010.

Preamble:

Section 4.4.3 of Robertson GeoConsultants Hydrogeology report identifies that the Vein Fault may intersect the Prairie Creek Valley, and could transmit significant quantities of groundwater flow to the deeper mine workings. Mine inflows could reach as high as 200 L/s if the MQV/Vein fault extends under Prairie Creek. At this point exploration drilling has not identified the presence of the MQV/Vein Fault under Prairie Creek, but the possibility of significantly higher mine in-flows remains.

CZN has indicated that higher flow rates will be managed by increasing treatment capacity and discharging more effluent. As noted in INAC02-04, the ability to increase effluent discharges may be limited by conditions in Prairie Creek (i.e. instream objectives, mixing zone characteristics and Prairie Creek flow conditions). INAC requests the following information to assess potential impacts of increased minewater flows.

Requests:

1. Identify mitigation measures that are available to handle significantly higher mine in-flows.
2. Demonstrate the likelihood of success of any proposed mitigation strategies.

IR: INAC02-08

Subject: Effluent Discharge and Monitoring

Linkage: INAC 06, INAC 11, Technical Session Day 2

References:

DAR, CZN, March 2010.

Responses to Information Requests, Appendix L, CZN, September 2010.

Aquatic Effects Monitoring Final Plan Canadian Zinc, Pugsley/Dube Consulting Inc., June 2, 2010.

Preamble:

CZN has proposed a variable discharge strategy whereby effluent discharge volumes and effluent contaminant concentrations would increase during periods of high flow in Prairie Creek. Impacts to Prairie Creek resulting from effluent discharges will be monitored using a combination of SNP, AEMP and MMER programs. A potential near field monitoring point located approximately 200 m downstream of Harrison Creek was identified in response to Parks Canada IR 39, but was not finalized pending receipt of an effluent mixing analysis. Appendix L in CZN's IR response document provides a general description of a monitoring program for the site, but includes few details regarding assessment locations, action trigger levels or response actions.

During the Technical Session CZN referred to the US EPA's use of total maximum daily loadings as a strategy for regulating discharges. This procedure is typically used when technology based effluent criteria have not been successful at protecting receiving water, and additional controls are required to provide an opportunity for the degraded receiving water to recover. However, Water Quality Based Effluent Limits are used in USEPA permits. Compliance with water licence conditions in the NWT is typically assessed using a combination of grab samples and 4 sample running averages (i.e. Maximum Average Concentration). Variable discharges and variable loadings will affect the ability of enforcement personnel to quickly and definitively assess whether effluent is in compliance with water licence conditions which may prove problematic for CZN as well as enforcement personnel.

INAC requires additional information to assess the proposed discharge and monitoring strategy.

Requests:

1. Identify downstream monitoring points (e.g. assessment boundaries and sample site locations) that will be used to track changes in the receiving environment related to effluent discharges.
2. Identify low, medium and high action effects levels for these boundaries that, when reached, will trigger a response. Note that a 'high action level' is generally considered to be a point that should not be reached and requires an immediate halt to discharge.
3. Identify appropriate adaptive management responses if the moderate level triggers at the most immediate downstream assessment boundary is reached. Include consideration of how proposed responses (reduced discharge volume or load) will impact site operations.
4. Identify a monitoring and reporting strategy that will permit effective enforcement of any water licence conditions respecting variable discharge criteria. Note this strategy will likely require a well defined water discharge

strategy (e.g. with flow and concentration numbers that are demonstrated to work with the facility's water balance under a range of scenarios including worst case and be consistent with a defined mixing/dilution zone).

IR: INAC02-09

Subject: AEMP

Linkage: INAC 06, INAC 11, Technical Session Day 2

References:

Aquatic Effects Monitoring Final Plan Canadian Zinc, Pugsley/Dube Consulting Inc., June 2, 2010.

Preamble:

In the NWT a tenet of the INAC (2009) AEMP guidance document is community consultation to develop monitoring questions and acceptable levels of change.

The AEMP functions as a "safety net" with respect to those concerns addressed through consultation, because even with discrete discharge limits based on a combination of concentrations and/or loadings in place, synergistic and unanticipated effects may occur. In order to perform this role, from an ecological perspective, the measurement endpoints should be sensitive to the contaminants being released and with a known relationship between observed changes and cascading effects in the ecosystem of the receiving environment. Note that other pragmatic considerations such as impact of sampling in a low-productivity system, etc. also apply.

In order to function as a "safety net", from a practical perspective the AEMP and particularly SNP decision points should actionable in a timely manner. INAC requests the following information to assess the appropriateness of the AEMP as provided by the proponent to identify potential downstream effects.

Requests:

1. The proponent should describe the community consultation with respect to measurement endpoints and levels of acceptable changes for the proposed AEMP, which is equivalent to the experimental design outlined in the Spencer et al (2008) study.
2. Provide a discussion of the ecological importance of epilithon in the local receiving environment and the sensitivity of the local epilithon to the expected contaminants being discharged.

3. It is possible that increased water storage capacity can obviate the requirement for seasonally varying effluent quality criteria and the attendant regulatory and monitoring complexity. Provide an assessment of the feasibility of increasing water storage capacity sufficient to use fixed effluent quality criteria prior to considering seasonally varying effluent quality criteria.
4. Section 4.1 suggests that effluent quality criteria should vary with season due to a large range in creek flows. A detailed description of the proposed "different regulatory approach" that would accommodate seasonally varying effluent quality criteria is requested. (See also INAC02-08.)

IR: INAC02-10

Subject: Effluent Discharge

Linkage: INAC 07, Technical Session Day 1 and 2.

References:

Responses to Information Requests, Appendix L, CZN, September 2010.

Preamble:

Appendix L describes a proposed discharge strategy whereby continuous flow monitoring data would be collected for Prairie Creek, and used in conjunction with background concentrations to calculate allowable discharge loads. Simultaneously, water treatment plant rates and recent treated water quality data would be used to calculate treated water loads. Treated loads would be adjusted by varying the volumes of mine and mill water entering the treatment plant. The calculations could be automated.

Although it is common to optimize and automate water treatment systems, it is not that common that the water treatment scheme and discharge strategy would change based on instantaneous conditions in the receiving environment. The potential exists for accidents, malfunctions and/or operator error resulting in discharges of unacceptable quality. Potential operational issues that may affect treated water quality include:

- fluctuations in influent water quality (as may occur from metallurgical process),
- process rate fluctuations (as may be needed to match discharge volume in Prairie Creek),
- regular sludge removal from the clarifier and process rate being too high for continuous effective settling of fine flocculent (in a plant operated without a large polishing pond)

- seasonal temperature effects (as it pertains to speed &/or efficiency of chemical reactions in the treatment plant).

Table 6-7 DAR has WQ data, which suggests that arsenic may be in the range of 0.10 mg/l (dissolved) and 0.75 mg/l total in the process water depending upon the ore source. Based upon the water balance schematics (provided in CZN DAR Addendum May 2010), 50% of the mine water becomes process water on an annual basis. The treatability testing in App. 2, was done on influent of 0.0009 mg/l, or about 1/10th the potential concentration of the average combined mine water and process water.

INAC requires additional information and detail to assess the ability of the proposed treatment and discharge strategy to mitigate potential environmental impacts.

Requests:

1. Detail the mitigation measures to minimize the risk of unacceptable discharges due to accident, malfunction or operator error.
2. Provide a range of water treatment projections, in conjunction with range of water balance evaluations, which show the potential range of water treatment and discharge scenarios (see also INAC02-03).
3. Demonstrate that the site's water management system provides sufficient capacity to accommodate site water under a worst case plant malfunction.
4. Please describe the suitability of the preferred treatment strategy for water with elevated arsenic content.

IR: INAC02-11

Subject: Spill Control Measures

Linkage: INAC 04 – IR response, Technical Session

References:

DAR, CZN, March 2010.

DAR, Appendix 28, CZN, March 2010.

Responses to Information Requests, INAC04, CZN, September 2010.

Outfall Design – Preliminary Construction Details, Northwest Hydraulic Consultants, Oct 5, 2010.

Preamble:

CZN's response to IR INAC 04 identifies that the surface water run-off ditch system on site is expected to only contain clean run-off. However, the Fuel Spill Contingency Plan identifies the main site drainage channel as a secondary control point for spills from several locations on site. The site surface drainage system discharges to the catchment pond. Traditionally, surface water is managed on site just as any other water, such as process water and mine water, as there is a potential for leaching and contamination of surface runoff as a result of operations at the mine (fuel spills, chemical spills, runoff and leaching from laydown areas, general contamination from construction areas or industrial operations, etc.).

Preliminary outfall design calls for a gravity outflow from the Catchment Pond to Prairie Creek. Figures 6-18 and 6-19 in the DAR identify a Catchment Pond Safety Return linking the Catchment Pond with the Water Storage Pond.

It appears that spills on the site could enter the Catchment Pond through the surface water drainage system, and then enter Prairie Creek. INAC requires additional information on spill control at the site to fully assess potential impacts.

Requests:

1. How will gravity flow through the outfall line be stopped if a spill or other on-site contaminants comingle, leach or directly discharge to surface runoff, which according to the current site plan would report to the catchment pond and then Prairie Creek?
2. Describe mitigation measures that would manage surface runoff at the site in the event of a spill or other degradation of on-site surface water quality.
3. If potential mitigation measures include restricting flow from the catchment pond or diverting water from the catchment pond back to the WSP, demonstrate that the site water containment structures are capable of containing any water accumulated during restricted discharge, during a spill response or high flow/loading event.

IR: INAC02-12

Subject: Current Groundwater Conditions

Linkage: Technical Session Day 3

References:

Site Hydrogeology Report, Prairie Creek Mine Site, Northwest Territories, Canada – Rev 0, Robertson GeoConsultants Inc., February 2010.

Preamble:

One or more dissolved metal groundwater plumes exist as a result of mining activities that occurred pre-2007. The plume(s) extend from the mine workings to Harrison Creek and to Prairie Creek.

Metals concentrations (including cadmium, zinc and/or lead) exceeding the proposed in-stream criteria by several times have been identified in site groundwater (MW08-01, July 2009, DAR Appendix 1A, Table 3-5), Harrison Creek (HC3, July 2009, DAR Appendix 1A, Table 3-5) and Prairie Creek (PC-2, Sept. 2008, DAR, Appendix 1A, Table 3-4).

Currently, the following items are unknown: the southern extent of the MQV/Vein Fault in the vicinity of the Prairie Creek valley, the delineation of the plume(s) throughout the full depth and width of the PCAA and HCAA along the entire flow paths, the migration characteristics of the plume(s), and the potential long term impacts the plume(s) will have on water quality in Prairie Creek and in Harrison Creek.

INAC requests the following information to assess the current and future conditions and impacts from the existing groundwater plumes' discharge to Prairie Creek and Harrison Creek.

Requests:

1. The following is stated in the DAR, Appendix 1A: p.6, "Exploration drilling suggests that the Vein Fault strikes along the lower part of Harrison Creek valley and extends into the larger Prairie Creek valley.";p.28, "The Vein Fault is inferred to extend into Harrison Creek valley and crosses the Prairie Creek valley (near MW08-02)." INAC requests that Canadian Zinc confirm the extent of the Vein Fault in the vicinity of Prairie Creek valley and describe the implications of the vein fault being connected to Prairie Creek on flow within the creek itself, and on mine inflows. Under this connection scenario, what would be the required effluent discharge rate and predicted in-stream water quality concentrations?
2. Provide additional information on the existing dissolved metal groundwater plume(s) throughout the full vertical extent of all of the hydrostratigraphic units, as well as along the width and length of the plume flow paths. Hydrostratigraphic units of concern include Prairie Creek Alluvial Aquifer (>45m, deepest monitoring well is 5.8 m deep), Harrison Creek Alluvial Aquifer (20 m thick, deepest monitoring well is 12.7 m deep), MQV/Vein Fault, and shallow and deep bedrock units. CZN should explain how the characterization of groundwater flow and connectivity within the PCAA and HCAA is determined with confidence given that the existing monitoring wells do not

penetrate the full depth of the aquifer.

3. Information on any aquifer hydraulic testing within the hydrostratigraphic units of the PCAA, HCAA, MQV/Vein Fault, Shallow Bedrock and Deep Bedrock conducted by CZN. If no information has been collected, describe how groundwater movement in these zones has been predicted and provide the level of confidence that exists in the assessment of groundwater flow rates and plume migration rates.
4. Additional information on changes to groundwater seepage rates into Prairie Creek and Harrison Creek during low and high flow conditions.

IR: INAC02-13

Subject: Groundwater Conditions during Active Mining

Linkage: Technical Session Day 3

References:

Site Hydrogeology Report, Prairie Creek Mine Site, Northwest Territories, Canada – Rev 0, Robertson GeoConsultants Inc., February 2010.

Preamble:

The presence of impacted groundwater adjacent to Prairie Creek and impacted surface water in Prairie Creek suggests that Prairie Creek Alluvial Aquifer (PCAA) and Prairie Creek are hydraulically connected to the underground mining area and specifically the MQV/Vein Fault directly or through the Harrison Creek Alluvial Aquifer (HCAA).

When mine dewatering occurs, groundwater flow directions will reverse and groundwater from the HCAA, Harrison Creek, the PCAA, and possibly from Prairie Creek will be captured and flow toward the mine openings to eventually become mine inflows. The measured hydraulic conductivities of the hydrostratigraphic units and the extent of the Vein Fault that daylights beneath HCAA and possibly beneath PCAA greatly influence the capture zone created by mine dewatering.

If the capture zone reaches Prairie Creek, stream flow rates will be reduced. If the capture zone does not include Prairie Creek, the existing dissolved metal groundwater plume adjacent to Prairie Creek will continue to discharge into the creek. If Prairie Creek stream flow rates decrease or, alternatively, if the existing dissolved metal plume continues to discharge into Prairie Creek during active mining, then the allowable amount of effluent discharged to Prairie Creek will need to be further reduced, possibly halted, to control loadings into Prairie Creek so that the in-stream concentration criteria are met.

INAC requests the following information to assess potential impacts to Prairie Creek and Harrison Creek.

Requests:

1. Assess and describe the potential magnitude of effects on Prairie Creek flows assuming worst case connectivity between Prairie Creek and the MQV/Vein Fault.
2. Assess the impacts from the dissolved metal groundwater plume(s) discharging into Harrison Creek and Prairie Creek, using the measured hydraulic and chemical properties of the flow systems and considering the seasonal fluctuations in stream flow rates and effluent discharge.
3. Assess potential impacts to the minewater discharge strategy and in-stream metals concentrations considering metal loadings to Prairie Creek from the existing dissolved metal plume, Also consider the impacts on the minewater discharge strategy considering a possible reduction in Prairie Creek flows due to mine dewatering. Evaluate any mitigation measures required in response to predicted impacts.

IR: INAC02-14

Subject: Post-Closure Groundwater Conditions

Linkage: Technical Session Day 3

References:

Site Hydrogeology Report, Prairie Creek Mine Site, Northwest Territories, Canada – Rev 0, Robertson GeoConsultants Inc., February 2010.

Responses to Information Requests, Appendix J, CZN, September 2010.

Preamble:

The level of groundwater characterization at the mine site presented in the DAR is insufficient to determine with certainty the source of the existing dissolved metal groundwater plume(s). The DAR states that the plume may have originated from either of the two following sources or both:

1. Mine water by-passing collection and treatment at the 870-level portal
2. Groundwater discharges from the Vein Fault into Harrison Creek Alluvial Aquifer and/or Prairie Creek Alluvial Aquifer

If the existing dissolved metal groundwater plume originates from the MQV/Vein Fault flow path, then the impacts from this existing plume will indicate what impacts might be expected post-closure.

In CZN's Responses to Information Requests, September 2010, in Appendix J, the following is stated:

"Revised predictions of pre-mine and post-closure main metals (in Prairie Creek) at Harrison Creek are contained in Table J13, and at the Park Boundary in Table J14. No site-specific criteria are exceeded during average flows. At low flows, cadmium, lead and zinc criteria are exceeded February to April. The cadmium and lead exceedances are marginal. Note that the predictions of in-stream water quality are arithmetic, and do *(not?)* include consideration of attenuation effects. While zinc is a relatively conservative metal, cadmium and lead are prone to attenuation, and therefore concentrations of these metals are likely to be well below the predicted values, and therefore impacts are not expected. The predicted zinc concentrations post-closure are less than pre-mine concentrations. "(INAC assumes that attenuation effects were "not" considered based on the wording of this paragraph. If this is not the case, INAC will revise this IR accordingly).

The data in Tables 3-4 and 3-5 of the DAR indicate:

1. Table 3-4 (Water Quality Data Sept/Oct 2008) shows in stream Zn concentrations of 27 ug/L in two samples collected in September 2008 from water sampling station PC-1, located in Prairie Creek downstream of the mill. The Zn concentrations of 27 ug/L are above the proposed site specific criteria of 22.65 ug/L. They are over two times the predicted pre-mine Zn concentration of 8.4 ug/L (Table J13 in Appendix J of CZN IR Replies). They are approximately three times the predicted post closure Zn concentration of 7.66 ug/L (Table J13 in Appendix J of CZN IR Replies). The samples were collected in September when the creek flow rate is moderate (6.4 m3/L), and not during low flow conditions, from February to April, when flows are typically less than 0.5 m^3/L.

2. Table 3-5 (Water Quality Data July 2009) shows the cadmium concentration being over four times the site specific criteria in monitoring well MW-08-01, located downgradient from Harrison Creek and adjacent to Prairie Creek. The presence of elevated cadmium in groundwater adjacent to Prairie Creek does not support CZN's position that natural attenuation will reduce cadmium concentrations to acceptable levels.

Due to the many hydrogeological uncertainties associated with the predictions of post-closure impacts to Prairie Creek presented in the DAR (i.e. aquifer hydraulic conductivities, percentage of groundwater flow provided by the MQV in the Vein Fault/MQV system, groundwater seepage rates into streams, extent of the Vein Fault, effect of existing groundwater plume), INAC requests the following information to assess post-closure impacts from the re-development of the mine.

Requests:

1. Re-evaluate predictions of post closure groundwater impacts on Harrison Creek and Prairie Creek by incorporating the following:
   - Worst case scenario assumptions regarding connectivity (i.e. vein fault connects to Prairie Creek), mine water inflows and concentrations.
   - Re-evaluation using any new additional information regarding the mixing contributions of groundwater from the MQV within the Vein Fault/MQV system. As stated in the Prairie Creek Mine Responses to Information Requests, CZN, 2010, Appendix J, Annex J6, p.3, "At the present time, insufficient data is available to determine the natural zinc load contributing via the Vein Fault/MQV system with a high degree of accuracy. We recommend that our preliminary loading estimates be updated once additional monitoring data become available."
   - An evaluation of the aquifer's attenuative capacity for metals of concern.
   - Inclusion of antimony, arsenic, iron, mercury, and silver predictions of in-stream creek concentrations, in addition to cadmium, copper, lead, selenium, zinc, and sulphate.

IR: INAC02-15

Subject: Mine Waste Management – Tailings and Waste Rock Quantities and Volumes

Linkage: Technical Session Day 2 and Day 3

References:

DAR, CZN, March 2010.

Preamble:

The mine development plan for the Prairie Creek mine is to "have no tailings on surface after mine closure" (ref. Section 6.11, page 191). This objective forces a linkage between ore mined (in-situ density, volume of voids for backfilling), concentrate removed (% of ore, density, volume extracted from ore), swell factor from ore to tailings. INAC requests the following information to better understand the mine development plan which will aid in the assessment of potential impacts.

Requests:

1. With reference to Table 6-4 Life of Mine (Years 0 – 14) Waste Quantities, provide additional information to address the following:

   - Mill feed
     - Does the tonnage 4,995,000 refer to diluted ore fed to the mill?
     - If so, what percentage dilution is assumed?
     - What is the in-situ density of the ore and dilution rock

   - DMS rock
     - What is the bulk density of this material

   - Flotation tailings
     - What is the bulk density of this material

   - Concentrates
     - What is the bulk density of this material

   - Voids (stopes & development)
     - The volume of development waste rock to the Waste Rock Pile is 277,000 m^3 (page 196). Assuming an in-situ specific gravity of 2.7 and swelled specific gravity of 1.9, the volume of development voids in the mine will be approximately 195,000 m^3. If the total volume of voids is 1,799,720 m^3 (as per Table 6-4), this leaves approximately 1,600,000 m^3 of voids in stopes for backfill. Please confirm.
     - Backfilling of overhand cut-and-fill stopes is likely to result in a high percentage of the mined voids being backfilled. That said, 100% backfilling of mined voids is unlikely. What percentage of the voids is assumed to be backfilled in the Prairie Creek mine plan?

   - Placed Backfill
     - The tonnage of backfill is 3,401,470 at a density of 1.89 t/m^3. This gives a backfill volume of 1,800,000 m^3, which is greater than space available underground. Please confirm. (Note: In the CZN DAR Addendum May 2010, the tailings density in the WSP is imputed to be 1.6 t/m^3. If this lower density is achieved in the tailings backfill, then the volume of tailings to be managed is up to 2,177,000 m^3, or 576,000 m^3 more than the available space.)
     - Please confirm that CZN does not intend to develop a surface quarry of sand and gravel for use as a component of tailings backfill or in lieu of tailings backfill altogether.
     - Paste backfill is the only tailings management strategy that has been described for the site. Outline and evaluate alternate tailings management strategies that may be utilized if final feasibility and design eliminate the use of paste backfill as a tailings management approach.

IR: INAC02-16

Subject: Closure Plan – Waste Rock Storage

Linkage: Technical Session Day 3

References:

DAR, CZN, March 2010.

Preamble:

The Waste Rock Storage is designed for an outer slope of 2H:1V. This surface is to be covered, although cover details are not provided. It is intended that the cover will restrict infiltration as a means to limit flushing of metals. In general, it is difficult to conduct earthworks, such as cover construction, on a 2H:1V slope, and, such a steep slope is prone to erosion.

The proposed location of the Waste Rock Storage with lateral diversions is near the lower end of a tributary (likely ephemeral, but none-the-less subject to runoff during extreme precipitation events and freshet snow melt). After closure the diversions may fail and the creek flow will pass either through the rock pile (as a flow-through rock drain) or over top. In either case, the stability of the pile or the cover may be affected, resulting in increased flushing of metals. INAC requests the following information to assess potential post-closure impacts.

Request:

1. Provide further evaluations to demonstrate that flushing of metals from the Waste Rock Storage Area will not increase in the future.

IR: INAC02-17

Subject: Closure Plan – Backfilling of Portals

Linkage: Technical Session Day 3

References:

DAR, CZN, March 2010.

Preamble:

Backfilling of mine workings and portals is proposed as a means to restrict groundwater flow through any voids. Whereas it is correct that this will restrict groundwater flow, the extent to which it will is uncertain. No objectives for post-closure levels (concentration and/or load) of metal release are proposed. INAC requests the following information to assess potential post-closure impacts.

Request:

1. The proponent should provide objectives for post-closure metal release and an evaluation which suggests that those levels can be achieved.

Canadian Zinc Corporation
Prairie Creek Mine

Fisheries and Oceans Canada - Information Request
Round Two

IR Number: **DFO_2-1**
Related IRs: **DFO_01; EC-2-1; PCA 2-2**
Source: **Fisheries and Oceans Canada**
To: **Canadian Zinc Corporation**
Subject: **Nutrient Loading**
References:

- **Section 4.7.4 of the DAR;**
- **IR Response to DFO_01 - Appendix J.**
- **Technical Session - Undertakings #2, 3, 4, 7, 8 and 10**

Preamble:
In our first round of IRs (DFO_01) and based on information in the DAR, DFO requested that Canadian Zinc Corporation (CZN) provide a map of the locations where increases in nutrient levels have been previously observed downstream from the mine site and to assess the potential impacts on aquatic organisms, including fish and fish habitat, due to increases in nutrient loading into the downstream system. CZN was also asked to provide mitigation measures, where appropriate, for all predicted impacts.
In CZN's written response to DFO_01, information was provided about water quality objectives and a map of sampling sites; however this information did not address our initial request. DFO still has outstanding concerns related to possible increases in productivity that may have effects on the fish and the habitat within Prairie Creek, which includes potential effects to all life stages of fish, changes in fish behaviour, and changes of habitat use by all resident fish species. Prairie Creek is a naturally oligotrophic stream (having low productivity) and could be sensitive to any additional loading of nutrient into the system. DFO has concerns that the potential impacts have not been adequately assessed.

This IR relates to Environment Canada's Information request: EC-2-1

Request:

1) As requested in DFO_01, please provide
   a) A map of the locations where increases in nutrient levels have been observed downstream from the mine site within Prairie Creek.
   b) An assessment of the potential impacts on aquatic organisms, including fish and fish habitat, due to potential increases in nutrient loading into the system and provide mitigation measures, where appropriate.

IR Number: DFO_2-2
Related IRs: DFO_02; DFO_2-5; PCA 2-1
Source: Fisheries and Oceans Canada
To: Canadian Zinc Corporation
Subject: Source of Aggregate for road construction and maintenance
References:

- **Section 6.13 DAR (p. 200);**
- **Section 5 DAR Addendum (p.5-6);**
- **IR Response to DFO_02;**
- **Technical Session**

Preamble:
In CZN's written response to DFO_02, it was stated that "sources of aggregate will not be situated in river beds or within the high water mark of alluvial fans" for the construction and maintenance of the road. CZN also clearly re-iterated this point during the technical sessions. DFO appreciates CZN's commitment to not using watercourse materials as an aggregate source, however, it is still unclear what sources of materials will be used for the construction and maintenance of the road. In Appendix D of the CZN's written IR response submission, borrow sites were identified on a map (Figure II-4) including locations that were either within or near watercourses.

As mentioned during the technical sessions, DFO also noticed that some of the borrow sites identified on the map in Appendix D were located off the main road right of way and that additional spur roads and/or crossings may be required to access these materials.

Request:

1) As stated in DFO_02 and the technical sessions, DFO would still require CZN to identify the locations of all aggregate sources in order to determine if additional access roads and/or crossings may be required.
2) CZN should also update Figure II-4 in Appendix D by removing any borrow sites that are located within the high water mark of any watercourses as well as include any additional access roads and/or crossings that may be required to access the borrow sites. Appropriate sediment and erosion control considerations must be provided, along with the necessary fish and fish habitat assessments for any new spur roads. This is also addressed under DFO_2-5.

IR Number: **DFO_2-3**
Related IRs: **DFO_03; EC-2-1; INAC 02-01**
Source: **Fisheries and Oceans Canada**
To: **Canadian Zinc Corporation**
Subject: **Outfall Design**
References:

- **Section 6.16 (p. 208, p. 216-217); Section 8 (p.257); Section 10.2.5 (p.307) DAR;**
- **IR Response to DFO_03**
- **Technical Session – Undertaking #3, 4**
- **Prairie Creek Mine, Outfall Designs – Preliminary Construction Details, Draft, Northwest Hydraulic Consultants, October 5, 2010.**
- **Prairie Creek Mine, Outfall Performance – Downstream Mixing Analysis, Draft, Northwest Hydraulic Consultants, October 6, 2010.**

Preamble:
CNZ proposed in the DAR to use a diffuser to discharge wastewater into Prairie Creek indicating that this option was chosen in order to "avoid icing and minimize other possible impacts" (p. 257) and to "ensure complete mixing with receiving water" (p.307). CNZ also described the use of a diffuser as a best management practice, in Section 10.2.5 of the DAR, to "promote complete mixing with receiving water and avoid impacts associated with non-mixed, 'neat' solutions". During the technical sessions, CZN announced that the diffuser option would be replaced by an effluent culvert into Prairie Creek and provided a two page preliminary outfall design report.

Canadian Zinc should be aware that DFO will not consider authorizing an outfall design option until the downstream impacts have been adequately addressed. CZN should refer to IRs by other parties, notably INAC02-01 and EC-2-1.

Request:

1) Provide rational for why the diffuser outfall option was replaced by a culvert, refer to INAC02-01, including consideration for how the new option will reduce or eliminate downstream impacts.

Once downstream impacts have been considered and the most appropriate outfall option has been selected, DFO will require:

2) Conceptual designs as well as details on the construction and installation methods for the outfall including consideration for:
   a. maintaining stability of the berm;
   b. anchoring and footprint of the outfall;
   c. area and depth of the trench for installation;
   d. disturbance of the banks and riparian area;
   e. area isolated (for the installation of the effluent dispersal mechanism).

    f. maintenance and subsequent decommissioning of the effluent dispersal mechanism;
    g. mitigation measures incorporated to reduce disturbances to substrate and mobilization of sediment; and
    h. fish screens (if required)

3) Specifics on fish use and type of habitat within the area of influence (including the mixing zone) from the construction and operation of the outfall option are required.

IR Number: **DFO_2-4**
Related IRs: **DFO_04; PCA 2-1**
Source: **Fisheries and Oceans Canada**
To: **Canadian Zinc Corporation**
Subject: **Construction of Winter Road - Water withdrawal**
References:

- **Section 6.22 (p. 230) DAR;**
- **IR Response to DFO_04;**
- **Technical Session - Undertakings # 16**

Preamble:
In Canadian Zinc's initial response to our information request (DFO_04), one waterbody (Mosquito Lake) and several watercourses were identified as potential water sources for the construction and maintenance of the winter road and crossings. Most of the water sources being considered by CZN are or potentially may be fish-bearing.

CZN also mentioned the use of the "*DFO Protocol for Winter Water Withdrawal from Ice-covered Waterbodies in the Northwest Territories and Nunavut*", but was advised in previous meetings as well as during the technical sessions that the protocol does not apply to watercourses. This protocol was developed by DFO in conjunction with industry and other regulators to provide standardized guidance to water users on protective water withdrawal volumes for lakes (DFO, 2010). This protocol clearly identifies criteria and information that must be collected in order for the protocol to apply and includes water source identification, bathymetric survey results and volume calculations. These details have not yet been provided by CZN. As per undertaking #16 from the technical session, CZN has committed to providing that information to DFO for Mosquito Lake prior to using it as a water source.

DFO also stated, during the technical sessions, that site-specific information is required for all watercourse withdrawals during the environmental assessment. DFO is concerned with water withdrawals in these river systems as they are known to be fish bearing and sensitive Bull Trout habitat. Impacts of water withdrawals from rivers, streams and creeks are difficult to predict without site-specific information and may lead to impacts on water temperatures, flow regimes, quantity and quality of over-wintering habitat, available oxygen levels, ice formation and fish survival.

In CZN's response to DFO_04 in Appendix E, groundwater upwelling or groundwater fed systems were also identified as potential water sources, specifically from Sundog Creek and Polje Creek. CZN also recognized that there is a potential for over-wintering fish in those areas and that DFO should be consulted before extraction occurs. Though we agree that consultation with DFO should occur, this does not address the need to collect baseline information, as part of the environmental assessment, in order to predict and mitigate any potential impacts.

Please also refer to PCA 2-1.

Request:

1) DFO still requires specific locations and annual volumes (per source) of water for the construction and maintenance of the road and crossings. This should also consider any additional spur roads needed to access aggregate sources (see DFO_2-2). All data should be site and seasonally specific, including bathymetric survey results as well as the calculation of the total available water volume (lakes) or flow (streams) under ice for each source.
2) Provide an assessment of potential impacts from water withdrawals at each watercourse locations, including potential effects on overwintering and spawning habitat for all the fish species found in those watercourses. CZN should also discuss potential changes to water temperatures, flow regimes, reduction in quantity and quality of over-wintering habitat, depletion of available oxygen, changes in ice formation and possibility of fish kills.
3) Provide water source alternatives or other road construction options in order to reduce water requirements (i.e more clear span bridges), in the event that the current water source options do not have insufficient flow to protect fish and fish habitat.

IR Number: **DFO_2-5**
Related IRs: **DFO_05; PCA 2-1**
Source: **Fisheries and Oceans Canada**
To: **Canadian Zinc Corporation**
Subject: **Access road – Erosion, Runoff and Extreme Events**
References:

- **Section 4.4.1 (p. 81), Section 9.3.2 (p. 292), 10.1.2 (p. 300-301) 10.2.5 (p. 307) DAR, CZN, March 2010**
- **IR Response to DFO_05**
- **Technical Session - Undertakings # 11 and 17**

Preamble:
During the technical sessions, CZN committed to developing a sediment and erosion control plan for the road (Undertaking #11). Though this commitment was supported by DFO, CZN must also provide details on how sediment and erosion prevention techniques have been incorporated into the overall design of the road and crossings. DFO also asked that CZN provide typical design plans for the road and crossing, including details on any physical footprints within the high water mark of crossings (i.e bank stabilization, abutments, etc). DFO requires this information during the environmental assessment in order to determine whether any of these works will require an authorization under the *Fisheries Act*.

Request:

1) Provide conceptual design plans for representative sections of the road and crossings, with special consideration for Funeral Creek, and any other area of the road that may be vulnerable to such things as extreme events, permafrost slumping, and erosion.
    a. list mitigation measures appropriate to those representative section and/or vulnerable locations and how they will mitigate impacts to fish and fish habitat.
    b. Clearly identify where sediment and erosion control prevention techniques have been incorporated into the road and crossing designs.
2) Describe monitoring activities for the road to ensure that it will not be a sediment source to the adjacent watercourses during the construction, operation, temporary closure in the summer and during extreme events.

IR Number: DFO_2-6
Related IRs: DFO_06; DFO_04; INAC 03; PCA 13
Source: Fisheries and Oceans Canada
To: Canadian Zinc Corporation
Subject: Groundwater Discharge to Prairie Creek
References:

- **Section 8.3 and Appendix 1, DAR;**
- **IR Response - Appendix E & H**

Preamble:
CZN has identified that a cone of groundwater depression around the Mine will occur as a result of mine dewatering and operations. In CZN's response to INAC03, it was indicated that this area of reduced groundwater would impact a segment of Harrison Creek, greatly reducing or eliminating surface flow.

Bull Trout have a strong association with groundwater discharge, often spawning in areas of groundwater upwellings. These areas are important for incubation of eggs, emergence and survival of juveniles as well as overwintering habitat.

Concern exists that the removal of groundwater may have an impact on the distribution and volume of groundwater upwellings in nearby streams, including Harrison and Prairie Creek. This may also impact the volume of surface water available and induce impacts on the direct and indirect fish habitat present around the mine site.
In order to predict potential impacts of a reduction in groundwater discharge to the system and impacts on direct and indirect habitat, DFO would require more information.

Request:

1) Provide predicted impacts of the removal or reduction of groundwater flow to Harrison and Prairie Creek from mine dewatering and operation on the fish (i.e. Bull Trout and arctic grayling during their various life stages) and their habitat.
2) Provide mitigation measures to reduce or eliminate impacts to fish.

IR Number: DFO_2-7
Related IRs: DFO_08, DFO_2-2; PCA 2-1
Source: Fisheries and Oceans Canada
To: Canadian Zinc Corporation
Subject: Access Road - Fish Habitat Assessment
References:

- **Section 9.3.2 (p. 292); Appendix 14 DAR, CZN, March 2010**
- **Response to IR DFO_08**
- **CZN Responses to Information Requests, Appendix E**
- **Technical Session – Undertakings # 12**

Preamble:
DFO requested as part of DFO_08 that CZN provide additional details on each water crossing including crossing locations, crossing structures and size, where DFO Operational Statements will be used, methods for installation and mitigation measures to reduce or eliminate impacts to fish and fish habitat. CZN provided Table E1 in Appendix E of the IR response showing information about each of the 48 crossings. As noted in DFO_2-2, DFO noticed that additional roads may be needed to access aggregate sources and may require new watercourse crossings. These should be included in table E1.

Additionally in CZN response to our IR, they committed to ensuring that the channel, bed and banks of the stream, for all crossings and abutments, are protected. For completely frozen conditions, simple snowfill should be adequate most of the time; however, stream banks may still require protection. If stream banks are not completely frozen, additional protection may be required to support the weight of trucks and heavy equipment.

Request:

1) Photos were provided in Appendix E of the IR response, but location of the crossing and specific kilometre markers were not clearly identified. These should be provided.

2) Please provide an updated table E1 to ensure that all water course crossings. This includes all watercourse crossings for any new crossings to access borrow sources.

IR Number: **DFO_2-8**
Related IRs: **DFO_09**
Source: **Fisheries and Oceans Canada**
To: **Canadian Zinc Corporation**
Subject: **Closure and Reclamation Plan**
References:

- **Appendix 27 DAR, CZN, March 2010**
- **Response to IR DFO_09**
- **CZN Responses to Information Requests, p.58**
- **Linked to Technical Session – Undertaking #11 & 18**

Preamble:
As part of our review of the DAR and Appendix 27, DFO noticed that some activities related to closure and reclamation may potentially impact fish and fish habitat, particularly those related to the reclamation of portions of the access road along Funeral Creek, and may require an Authorization under the *Fisheries Act*. DFO had asked CZN (IR DFO_09) to describe measures to prevent sediment from entering the creek, methods for road bed and culvert removal as well as how fish (i.e. Bull Trout) and their habitat would not be impacted by these activities.

In the responses to this information request , CZN proposed to the following measures:

- Coarse or/and organic materials would be place adjacent to the creek to prevent sediment discharge until vegetation has established;
- re-contouring of the road bed to create natural slopes, and may include armouring or silt fencing to control sediment ;
- where a road bed crosses a channel, the road bed would be removed.

Requests:

1) What other methods will be used, during decommissioning, to provide long term stability, prevent mobilization of sediment and to reduce erosion along Funeral Creek? As an example, a description of timing windows for decommissioning of the road, consideration of bioengineering solutions, details on re-vegetation (or a commitment to developing a long term sediment and erosion control plan), etc. should also be provided.
2) How will CZN ensure the effectiveness of the proposed mitigation measures during and after closure? And what adaptive management options have CZN considered?

IR Number: **DFO_2-9**
Related IRs: **DFO_11**
Source: **Fisheries and Oceans Canada**
To: **Canadian Zinc Corporation**
Subject: **Impact Assessment - Fish and fish habitat**
References:

- **Section 10.2 (p.302) DAR, CZN, March 2010**
- **Section 7.0 of the Addendum**
- **IR Response to DFO_11 , p. 59-60**
- **Technical Session – Undertaking # 18**

Preamble:
In CZN response to DFO_11, they provided a revised version of Table 5 from the DAR which summarized the potential for significant impacts to fish and fish habitat.

Request:

1) In the revised version of Table 5, water quality post-closure was identified as having a "low" impacts to fish and fish habitat even though the criteria in the matrix was characterized as follows:
    a. Geographic Extent **– Moderate** (Portion of Prairie Creek)
    b. Duration **– High** (Perpetuity)
    c. Frequency **– High** (Perpetually continuous)
    d. Variance – **Moderate** (flow variation)
    e. Reversibility **– High** (hard to resolve)

Considering that all of the criteria ranked either high (3 out of 5) or moderate (2 out of 5), it is not clear why the impacts were characterized as "low". CZN should provide a rational for this conclusion as well as a description of acceptable mitigation measures in order to minimize impacts to fish and fish habitat.

IR Number: NRCan 2-1

Source: Natural Resources Canada – Earth Science Sector

To: Canadian Zinc Corporation (CZN)

Subject: Terrain Conditions along the Access Road

References:
TOR: 3.2.4, 3.3.1, 3.3.7, 3.3.3
Project Description Report Appendix B
DAR: Main Report section 4.12.3, 4.12.4, 9.2, 9.4.2, 10.4.2, Appendix 16, DAR Addendum sections 5.4, 6, and 7.4
Response to NRCan IR 1-11, Parks Canada IR 1-8,1-10, and 1-12, Transport Canada IR 1-3 and 1-5, Proponent's Response Appendix D
Transcripts Technical Meeting Oct. 7 2010 pg 140-221

Preamble:
In response to NRCan IR 1-11 (and IRs from other parties), the Proponent provided additional information regarding the terrain conditions along the access road, including the results of investigations carried out in August 2010. The additional maps and information provided have been helpful in providing a better understanding of the terrain stability along the road corridor. Investigations conducted to date have largely consisted of desk top studies and field and air reconnaissance and no field investigations have been conducted to determine the geotechnical properties of subsurface materials. The report provided by Golder (App. D) indicates that further investigations are proposed for final design after receipt of regulatory approval. The proposed investigations may include ground surveying and possibly drilling to confirm ground conditions. Instrumentation to measure ground temperatures may also be installed at selected locations. NRCan is supportive of the proposed investigations but it was unclear from the written material whether the Proponent is committed to conducting these more detailed investigations. During the technical session NRCan requested further details regarding plans for future geotechnical investigations. The Proponent indicated that further investigations would be done that would include borehole drilling and temperature cable installation where permafrost could affect for example design and construction of permanent bridge abutments.

The Proponent has provided additional information regarding the techniques that will be utilized to mitigate potential road construction and operation impacts such as ground instability and erosion. The Proponent has identified sections of the road that are most vulnerable and described design features to limit impacts. NRCan suggests that the results of the future proposed geotechnical investigations may result in revisions to proposed alignment routing, mitigation plans or identify other sections of the road that may also be vulnerable to erosion etc. According to the updated maps provided (App. D fig.11-4), portions of the proposed re-routing east of Silent Hills will cross terrain that may be ice-rich. Vegetation clearance may result in changes to the ground thermal regime due for example, to loss of shade resulting in increased summer heating of the ground. Loss of surface protection and increased thaw penetration could result in ground instabilities, alterations in drainage and increased erosion. Disturbance to the organic layer would exacerbate these effects. There are also a number of water crossings in this section of the road and these potential instabilities may have implications for water crossing design and mitigation of environmental effects. Clarification is required regarding whether the Proponent will conduct further geotechnical investigations including borehole drilling and temperature cable installation to better characterize the sensitivity of the terrain in this section of the proposed route to determine the final alignment and also to develop mitigation and environmental management plans.

NRCan also requested a description of monitoring plans to determine if ground conditions are adequate for activities associated with the road to occur. Parks Canada (IR 1-12) also requested information on the criteria to determine opening and closing of the road. The Proponent has indicated that the road will be advanced east of km38 when the ground is sufficiently frozen to support the machinery without rutting and remain open until the ground is not sufficiently frozen. The Proponent indicated during the Technical Sessions and in their responses to IR requests (e.g. Transport Canada IR 1-3) that activities for the winter road would start in November working from the mine to the intermediate transfer facility with hauling from the mine to the Liard crossing to start Dec. 1 and continue to March 31 with potential shoulder periods depending on prevailing conditions. There was some discussion during the technical session regarding realistic operating periods for the winter road opening and closing. The Proponent indicated that based on the temperature profiles they have examined (pg 149, Oct. 7 transcript) the winter road will operate until April 15. Some clarification however is required on the analysis done by the proponent to determine the most likely operating period of the road as this may change from year to year due to climate variability and perhaps progressively decrease if climate warms over the project life (as acknowledged by the Proponent in response to Parks Canada IR 1-10, App. D). This variability including extreme warm years can lead to later freeze-up and earlier onset of thaw and result in a shorter operating season.

Temperature conditions will be a factor determining when suitable conditions exist for winter road operation as this will determine when active layer freeze-back is complete in permafrost terrain or where seasonal frost has penetrated sufficiently in other areas. Snow cover will provide protection for the ground and this could also be a limiting factor for road construction and operation. With thin snow cover conditions, it may be difficult to provide a level surface and protect the organic layer from damage (which as mentioned above could lead to alterations in the ground thermal regime). It is not clear from the IR responses and the discussions at the technical sessions how the Proponent will ensure that damage to the ground surface will be minimized under thin snow cover conditions which could periodically occur.

Request:

(i) Please confirm if detailed geotechnical investigations (borehole drilling, installation of temperature cables) will be conducted as recommended by Golder in App. D for the proposed re-routed sections of the access road such as that to the east of Silent Hills to better characterize subsurface conditions including ground ice conditions where there is a potential for ice-rich soils. Please also describe how the results of these investigations will be utilized in route selection and associated mitigation and environmental management plans.

(ii) Please provide any further information on any analysis conducted to determine the most probable period for construction and operation of the access road.

(iii) Please describe any plans to ensure that impacts to the ground surface (including damage to the organic layer) are minimized during periods of thin snow cover conditions.

See also DFO IR 2-5 and Parks Canada 2-1

IR Number: NRCan 2-2

Source: Natural Resources Canada – Earth Science Sector

To: Canadian Zinc Corporation (CZN)

Subject: Stability of the Water Storage Pond (WSP)

References:
TOR: 3.2.4, 3.2.5, 3.3.1, 3.3.2, 3.3.7

DAR: Main Report section 4.12.3, 4.12.4, 6.3.7, 6.16, 6.17, 8.7, 8.8.1, 8.8.3, 9.2, Appendices 12 and 16, DAR Addendum sections 3 and 7.3, Addendum Appendix B
Response to NRCan IR 1-12, INAC IR 1-2, Environment Canada IR 1-13, Parks Canada IR 1-41, Proponent's Response Appendix D, Transcripts Technical Meeting Oct 8 pg 21-29

Preamble:
The Proponent has provided (App. D) a report by BGC (1995) which includes additional information on subsurface conditions in the vicinity of the WSP including the north slope and an assessment of slope stability conditions. This report has addressed NRCan's request for further information and has been useful in providing a better understanding of the terrain stability conditions at the project site. This report indicates that the slopes have performed poorly in the past and instability in the back slope resulted in distortion and tearing of the synthetic liner. Heavy precipitation and melting of a deeper than average snow pack led to continuous shallow failures upstream of the perimeter dyke in 1982. Data collected for a short period following inclinometer casing installation in 1994 indicates movement of several millimetres per year with significant deformation of the casings occurring following those measurements making it impossible for the probe to penetrate the entire length. Limited measurements from new inclinometer casings installed recently also appear to indicate similar movements. The information provided would seem to indicate that significant deformation of the north slope is possible and that further monitoring would be recommended. During the technical meeting the Proponent indicated that further investigations (including borehole drilling) of the north slope would be done prior to final design to better determine the extent of the clay layer. NRCan suggests that these investigations will also allow the Proponent to determine whether permafrost still exists at the site and whether degrading permafrost may still be a factor at some locations as it has been in the past resulting in failures observed in the backslope (BGC 1995). The Proponent has also indicated that additional piezometers and slope inclinometers will be installed prior to final design. The information acquired through ongoing monitoring of this instrumentation will be useful in determining whether slope movements are increasing and for planning mitigation. It would be useful if the Proponent could indicate how this information will be utilized to determine when mitigation will be required including the criteria for intervention.

NRCan also requested information regarding how extreme events such as high rainfall or excessive snow melt have been incorporated in the stability analysis and design of the WSP (including stability of north slope). From the information in the BGC (1995) report it appears that high rainfall and excessive snow melt in the past have been a factor in the poor performance of the slopes. The proponent has indicated that extreme events have been incorporated into the stability analysis. They have provided some information on design features and also on a monitoring plan. The proposed design appears to be reasonable, however it is not clear how design values with respect to extreme events have been determined.

Request:
(i) Please indicate how information acquired from ongoing monitoring of piezometers and slope inclinometers will be utilized to determine when mitigation will be required to deal with potential instabilities of the north slope, including definition of criteria for intervention and for selection of mitigation options.

(ii) Please provide any further information on the design values with respect to extreme events (rainfall, snow melt) utilized for stability analysis and design of diversion structures.

IR Number: NRCan 2-3

Source: Natural Resources Canada – Earth Science Sector

To: Canadian Zinc Corporation (CZN)

Subject: Design values (flood data, climate data) for mine components

References:
TOR: 3.2.4, 3.3.2, 3.3.7
Project Description Report: Sections 3.1 and 4.8.3 and Appendix B
DAR: Main Report section 4.3, 4.4, 8.7 and 8.8; DAR Appendices 9, 11,12, 16 18, 20, 22
DAR Addendum: Sections 2 and 3
Response to NRCan IR 1-10, INAC IR 1-2, Parks IR 1-40, 1-42, Environment Canada IR 1-13, MVRB IR 1-3, 1-4, Proponent's Response Appendices D and Q
Transcripts Technical Meeting Oct. 8 pg 18-79

Preamble:
NRCan requested (NRCan IR 1-10) further information regarding the climate data utilized for design of project components such as the water storage pond, water diversion and retention structures. NRCan also requested information regarding how climate variability and extreme events were included in the design of project components. The Proponent provided additional information in its response to NRCan IR 1-10, as well as responses to IRs from other parties, and there was further discussion of these issues during the technical session on Oct 8.

NRCan agrees with the Proponent that records for project site climate data are generally short for most resource development projects which is the reason that the site climatology must be developed from records from regional stations. In its request NRCan was seeking a better understanding of the data sources utilized and the analysis performed to develop the site climatology that the Proponent utilized in the impact assessment and design of project components. The Proponent has indicated that a detailed analysis of site climatology was not required as design of diversion structures for the Waste Rock Pile (WRP) and the Water Supply Pond (WSP) and the water balance for the WSP are relatively insensitive to climate. The Proponent acknowledges that it has made assumptions regarding climatic variables and that these have been conservative. The 16 year record of monthly flows recorded for Prairie Creek has been used in the impact assessment of proposed discharges, and in the design of water management plans. The Proponent has indicated that no significant issues have been noted in 20 years of performance observations of structures.

NRCan is in some agreement with the Proponent that some components may be less sensitive to climate and that utilization of conservative assumptions can ensure that structures are designed to maintain their integrity and minimize impacts. There have however been some reports of the impact of extreme events on project components. In their report (provided in App. D) on Tailings Pond Design, Bruce Geotechnical Consultants (1996) commented that continuous shallow failures upstream of the perimeter dyke in 1982 were likely due to heavy rain and melting of thicker than average snow pack. In response for MVRB IR 4 on the subject of the flood protection dyke, NHC (App. Q) indicates that a flood in July 2006 was responsible for rip rap displacement along the berm. This event followed a heavy 24 hour rainfall and the flood was the largest flow in 30 years (since 1978) and was likely comparable to the peak flow recorded in 1977. Both examples show the importance of having adequate knowledge of climate variability and for accounting for uncertainties especially where only short records exist which may not adequately capture the range in conditions that may occur. Difficulties also arise in the determination of design floods including Probable Maximum Flood because the calculation of flows of a return period of 100 years or longer requires extrapolation of a much shorter data record. The July 2006 event for example, was not included in the analysis conducted to determine whether the height of the flood protection dyke is adequate. It would be useful to incorporate more recent data into the analysis to determine whether there would be any significant change in the magnitude of the design flood for the flood protection dyke.

The Proponent provided to NRCan (Oct. 19) further information on data records utilized in analysis which included two graphs showing normalized maximum daily discharge and annual runoff for 4 locations. It is not clear whether there is any significant trend in the daily maximum discharge record that could be related to for example, increases in the magnitude of extreme rainfall events. Continuation of an upward trend may mean that higher flows occur more frequently over time which could have implications for performance of mine components, such as the flood protection dyke, over the intended project life.

Request:

(i) Please provide any additional information regarding how incorporation of more recent data including the 2006 event may affect the design values for project components (e.g. design flood for flood protection dyke) and how this information may be incorporated into final design of project components.

(ii) Please clarify if any analysis has been conducted to determine whether there is a significant trend in daily maximum discharge, magnitude of extreme rainfall events and if there are significant trends, comment on the implications of increasing values over the project life for project design and operation.

IR Number: NRCan 2-4

Source: Natural Resources Canada – Minerals and Metals Sector

To: Canadian Zinc Corporation (CZN)

Subject: Waste Rock Management

References: DAR Appendices 22 and 27, Response to Parks Canada IR 1-42

Preamble:
The waste rock would be deposited in a designed waste rock pile (WRP) on the north slope of the Harrison Creek valley, approximately 400 m north of the 930 portal. The organic soil cover and overburden from the designated WRP area would be stripped to bedrock. Part of the overburden material would be used for construction of a lined seepage collection pond and berms for collecting drainages from the waste rock pile. At closure, the pile would be covered with a suitable cover material to minimize precipitation infiltration and, hence, drainage from the site. Response from the proponent is sought on the following items

Request:

(i) Prior to placement of the waste rock and other solid wastes in WRP, would the exposed WRP bedrock pad be cleaned and any major cracks sealed to minimize seepage loss to the Harrison Creek Alluvial Aquifer (HCAA) below?

(ii) In the WRP cover model simulations for closeout (DAR Appendix #22), two cover systems consisting of a 2 m granular till and a combination of 0.5 m compacted clayey till and 1.5 m granular till were evaluated. The cover systems reduced the annual net percolation through the pile by approximately 34% – 40% and by 42 - 50%, respectively, with both ponding of water on the cover layer and without in comparison to the bare waste rock as cover. In the conceptual closeout scenario (DAR Appendix #27) placing of only a 20 cm soil amendment layer as a suitable growth media is considered.This discrepancy needs to be resolved in terms of cover selection criteria and the anticipated benefits in terms of overall improvement in the drainage water quality from WRP upon closure.

(iii) Consideration should also be given to the predictive modelling of post closure drainage water quality from WRP in terms of both short term (5-10 y) and long term (10 y +) time frame and the need for collection and treatment of the WRP drainage, if any.

IR Number: NRCan 2-5

Source: Natural Resources Canada – Minerals and Metals Sector

To: Canadian Zinc Corporation (CZN)

Subject: Paste Backfill

References: Response to Parks Canada IR 1-19, 1-21, 1-28, 1-35 and NRCan IR 1-2(8); Appendix I to the CZN IR Response; Technical Meeting Day 3 Transcript, pp. 48-61

Preamble:

The mill tailings, as produced, together with approximately 75% of the DMS float rock, as aggregates, and mixed with 1-3% cement would be placed back underground as paste backfill in mined out stopes. The paste backfill placement would use a combination of haul trucks and pumping methods to fill the available void space with appropriate bulkheads for retention of the fill.

Request:

(i) Certain operational information was explained during the technical sessions in discussions between consultants to the proponent and consultants to the parties. Among the points of interest to NRCan, we are interested in the following areas: whether the proposed paste backfill cement content provides the required trafficability / load bearing strength for equipment mobility within a reasonable time; if the solid content would permit pumping of the paste to the desired locations; and, whether booster pumps, back-up units or lowering of the solids content would be needed to meet pumping requirements.

(ii) “Appendix 1” to Appendix I was not included in the CZN IR responses.

IR Number: NRCan 2-6

Source: Natural Resources Canada – Minerals and Metals Sector

To: Canadian Zinc Corporation (CZN)

Subject: Effluent Treatment and Post Closure Water Quality

References: Responses to Parks Canada IR 1-21, 1-22, 1-23, 1-25, 1-26, 1-45 , 1-46, and 1-47 and INAC IR 1-07, 1-08, and 1-09

Preamble:

The expected Se concentration in the treated process water is reported to be high at approximately 0.039 mg/L in comparison to both CCME and site specific SRC water quality objectives.

Request:
Are these concentrations expected to remain elevated through both operational and closure periods or better treatment technologies, if any, would be implemented to lower them to meet the stated water quality objectives?

Preamble:
Post closure drainages from WRP, vein fault zones and backfilled mine are expected to have elevated Zn concentrations of ~ 30,000 µg/L, 1,185 µg/L and 1,300 µg/L, respectively, with estimated average discharge flow rates of ~ 0.14 L/s, 2.9 L/s and 2.1 L/s.

Requests:

(i) What is the expected time frame for these elevated Zn levels to continue and the anticipated treatment requirements, if any?

(ii) What are the management and disposal plans for the effluent treatment sludge generated during both operational and post closure phases?

(iii) CZN is proposing a different regulatory approach for the water license to include the expected water quality exceedences during both operational and post closure phases? What is the expected timeframe for post closure collection and treatment of effluents from all sources, and the cut-off water quality requirements for no further treatment?

(iv) Zn and Cd levels in the Prairie Creek are reported to be further reduced by the natural attenuation processes in the creek. Have these natural attenuation processes/compartments been identified and what are the expected overall and seasonal removal efficiencies? Any supporting documents or test results to these effects should be provided.

Transport Canada   Transports Canada

IR Number: **TC -1**
Source: **Transport Canada**
To: **Canadian Zinc Corporation**
Subject: **Outfall Design**
References:

- **Prairie Creek Mine, Outfall Designs: Preliminary Construction Details, October 5, 2010.**

Preamble:
CZN has opted to remove the option of a diffuser for the discharge of effluent into Prairie Creek and as an alternative CZN plans to install an effluent culvert. CZN has provided details on the effluent culvert in the preliminary outfall design report.

Request:

1) Provide additional background information for effluent culvert as an alternative to the diffuser outfall option. Describe how the effluent culvert will better “avoid icing and minimize other possible impacts” and be a better management practice to the diffuser outfall option.
2) Provide construction designs and installation details of the effluent culvert. Include information such as the plans showing all project features and dimensions, a cross section view of the material site showing current land and water elevations and bank slopes and final excavation grades and slopes; and indicate the time of year when project construction will occur.

Canada

IR Number: **TC -2**
Source: **Transport Canada**
To: **Canadian Zinc Corporation**
Subject: **Road Maintenance**
References:

- **Technical Meeting Oct 26, 2010**

Preamble:
CZN identified that the portions of the access road from the Mine Site to Sundog Creek will require summer road maintenance. Summer road maintenance activities were not identified in the Developer's Assessment Report provided by CZN.

Request:

1) Provide additional details describing the activities associated with the summer road maintenance of the access road. Include information such as the sections of the road which will require general summer maintenance, equipment to be used during these activities, any in-stream works required, any stream–crossings to be included in the maintenance program, and the time of year when these activities will take place.

Transport Canada   Transports Canada

IR Number: **TC -3**
Source: **Transport Canada**
To: **Canadian Zinc Corporation**
Subject: **Water Body Usage**
References:

- **Technical Meeting Oct 26, 2010**

Preamble:
CZN has not provided the historical usage of affected water bodies and it was not identified in the Developer's Assessment Report. This information is required for Navigational assessment purposes and determining requirements under the Navigable Waters Protection Act (NWPA). CZN is encouraged to make a formal NWPA application to Transport Canada's Navigable Waters Protection Program (NWPP) Office – Edmonton. Program information and an application form are available on Transport Canada's web page:
http://www.tc.gc.ca/eng/marinesafety/oep-nwpp-menu-1978.htm.

Request:
1) Provide historical information on the traditional and recreational usage of affected water bodies, including the types of vessels that frequent the water bodies. The NWPP Office will require more specific information once water crossings have been determined and finalized, and this would have to be reflected in a proponent's NWPA Application.

Canada

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October 29, 2010

Chuck Hubert
Environmental Assessment Officer
Mackenzie Valley Environmental Impact Review Board
Via E-mail: chubert@reviewboard.ca

Re: Canadian Zinc EA – Information Requests

These information requests (IRs) are being submitted on behalf of Dehcho First Nations (DFN).

IR Number: DFN-1

Source: Dehcho First Nations

To: Canadian Zinc

Subject: Use of Initial Dilution Zones (IDZs)

Preamble: Canadian Zinc Corporation (CZN) had originally proposed the use of a diffuser for the discharge of wastewater into Prairie Creek. CZN is now proposing a simple pipe for discharge of mine wastewater into Prairie Creek with the use of downstream mixing to meet receiving water quality objectives.

As was explained at the recent technical session, the basis for this change in CZN's water treatment plan is a document released on April 29, 2010 by the Land and Water Boards (LWBs). The document, titled *Water & Effluent Quality Management Policy – FINAL DRAFT*, has already been posted to the public registry for this EA.

With regards to the use of IDZs, the LWB document states the following:

> "Note that the establishment of an *initial dilution zone* (*IDZ*) will be considered by the *Boards* on a case-by-case basis such that the water quality standards for the *receiving environment* will need to be met outside of the *IDZ*. Guidelines respecting *IDZ*s will be developed as noted in Appendix A."

Request: (1) Please explain how the switch from the use of a diffuser with end-of-pipe discharge limits to a simple discharge pipe with extremely long IDZs can be considered more protective of water quality and aquatic life? If it is not, what is the basis for the switch? Is it just about saving money for CZN?

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(2) Has CZN had any meetings or correspondence with the MVLWB to discuss the use of IDZs in Prairie Creek? Please provide details such as meeting notes, letters and e-mails. Please explain what the MVLWB's reaction has been to CZN's proposed use of IDZs in Prairie Creek. Has it been positive or negative?

(3) If CZN has not held any discussions with the MVLWB, on what basis is CZN assuming that the MVLWB would favourably review a proposal for IDZs in Prairie Creek? Is the single line noted above in the draft LWB document the sole piece of information that CZN is relying upon in assuming that the MVLWB would approve of IDZs at Prairie Creek?

IR Number: DFN-2

Source: Dehcho First Nations

To: Canadian Zinc

Subject: Where can IDZs be used?

Preamble: The impetus for the LWBs document was a 2006 Indian and Northern Affairs Canada (INAC) document titled *Towards the Development of Northern Water Standards: Review and Evaluation of Approaches for Managing Water Use in Northern Canada*. With regards to the use of effluent mixing zones, the INAC paper in turn relies on a publication titled *Surface Water Quality Objectives* dated 1997 by Saskatchewan Environment. That 1997 publication was updated in 2006.

The LWB document provides no guidance however as to the criteria that would be used when deciding whether or not to approve the use of an IDZ. The INAC document also does not provide any criteria but does state the following:

> "*Guidelines for initial dilution zones* - As IDZs are likely to be integrated into the framework for managing water quality in the north, development of guidelines for IDZs represents an important near-term priority. Such guidelines already exist in certain other Canadian jurisdictions (e.g., SEPS 1997) and can be used as a basis for developing such guidelines for the Mackenzie Valley. The guidelines should specify the procedures for determining the extent of IDZs and the general provisions that need to met within the IDZs;"

Going then to the Saskatchewan Environment document does provide some guidance on this issue. That document states:

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> "The effluent mixing zone guidelines are intended for application to larger surface waterbodies. However, they also have limited application to some intermittent streams and small lakes that have sufficient flow or volume of water, at least seasonally, to adequately assimilate periodic discharges of treated wastewater effluent."

Request: Please explain the basis for CZN assuming that IDZs would be approved for continuous use in Prairie Creek given that the most direct guidance available suggests that the use of IDZs would be restricted to larger surface water bodies or periodic discharges in smaller water bodies.

IR Number: DFN-3

Source: Dehcho First Nations

To: Canadian Zinc

Subject: Design standards for the use of IDZs

Preamble: If approval for IDZs were given to CZN, the IDZs would need to meet specific design criteria such as the extent of the IDZs in relation to Prairie Creek as whole. Following are some examples of these criteria from Saskatchewan.

1. At the outer edge of the mixing zone the water quality should not be appreciably different from the water quality prior to the discharge of the effluent.
2. The size of the mixing zone will be influenced by the difference in water quality between the effluent and the receiving waterbody and the volume of effluent relative to the receiving waterbody.
3. The mixing zone should be as small as practicable and should not be of such size or shape as to cause or contribute to the impairment of existing or likely water uses.
4. The existing General Objectives for Effluent Discharges (Section 3.1) should be achieved at all sites within the limited use zone.
5. The limited use zone in streams and rivers should be apportioned no more than 25 percent of the cross-sectional area or volume of flow, nor more than one-third of the river width at any transect in the receiving water during all flow regimes which equal or exceed the 7Q10 flow for the area.
6. Surface water quality objectives **applicable to the area** must be achieved at all points along a transect at a distance downstream of the effluent outfall to be determined on a case-by-case basis.
7. The mixing zone should be designed to allow an adequate zone of passage for the movement or drift of all stages of aquatic life; specific portions of a cross-section of flow or volume may be arbitrarily allocated for this purpose.

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8. Mixing zones should not interfere with the migratory routes, natural movements, survival, reproduction, growth, or increase the vulnerability to predation, of any representative aquatic species, or endangered species.
9. Mixing zones should not interfere with fish spawning and nursery areas.
10. When two or more mixing zones are in close proximity, they should be so defined that a continuous passageway for aquatic life is available.
11. When two or more mixing zones overlap the combination of the effluent plumes should not result in unacceptable synergistic or antagonistic effects on aquatic life or other water uses downstream of the mixing zone(s).
12. Mixing zones should not cause an irreversible organism response or attract fish or other organisms and thereby increase their exposure period within the zone;
13. The 96 hr LC50 toxicity criteria, for indigenous fish species and other important aquatic species should not be exceeded at any point in the mixing zones;
14. Mixing zones should not result in contamination of natural sediments so as to cause or contribute to excursions of the water quality objectives outside the mixing zone.
15. Specific numerical water quality objectives may be established for such variables or constituents thought to be of significance within the effluent mixing zone.
16. Defining the effluent mixing zone may need to be done on a case-by-case basis, particularly where effluent is discharged into smaller waterbodies (i.e. streams and small lakes).

Request: Please provide evidence and explanations as to how CZN has met the requirements of each of these 16 criteria in its proposed use of IDZs in Prairie Creek. In particular, please ensure that this evidence includes (1) an analysis of the flows, width and cross-sectional flow areas of the plumes as compared to Prairie Creek as a whole for each contaminant and under each flow condition and (2) an explanation as to how the use of a simple pipe instead of a diffuser would satisfy Criteria #3.

IR Number: DFN-4

Source: Dehcho First Nations

To: Mackenzie Valley Land and Water Board

Subject: Use of Initial Dilution Zones (IDZs)

Preamble: Canadian Zinc Corporation (CZN) had originally proposed the use of a diffuser for the discharge of wastewater into Prairie Creek. CZN is now proposing a simple pipe for discharge of mine wastewater into Prairie Creek with the use of downstream mixing to meet receiving water quality objectives.

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As was explained at the recent technical session, the basis for this change in CZN's water treatment plan is a document released on April 29, 2010 by the Land and Water Boards (LWBs). The document, titled *Water & Effluent Quality Management Policy – FINAL DRAFT*, has already been posted to the public registry for this EA.

With regards to the use of IDZs, the LWB document states the following:

> "Note that the establishment of an *initial dilution zone* (*IDZ*) will be considered by the *Boards* on a case-by-case basis such that the water quality standards for the *receiving environment* will need to be met outside of the *IDZ*. Guidelines respecting *IDZ*s will be developed as noted in Appendix A."

Request: (1) Has the MVLWB had any meetings or correspondence with CZN to discuss the use of IDZs in Prairie Creek? Please provide details such as meeting notes, letters and e-mails. Please explain what the MVLWB's reaction has been to CZN's proposed use of IDZs in Prairie Creek. Has it been positive or negative?

(2) Does the MVLWB have any additional guidance available on where and under what criteria it would approve the use of IDZs? Please provide this information.

(3) Please review IRs DFN-1 to DFN-3 which were directed to CZN. If the MVLWB has any information to offer with regards to these IRs, please do so.

IR Number: DFN-5

Source: Dehcho First Nations

To: Canadian Zinc

Subject: Parks Canada and Environment Canada IRs

Preamble: DFN has had the benefit of quickly reviewing the IRs that were submitted earlier today by Parks Canada and Environment Canada.

Request: (1) For the Parks Canada IRs, please ensure that the answers provided are for the Prairie Creek Mine as a whole including all mine activities and impacts regardless of whether or not those activities and impacts occur inside or outside of the boundaries of Nahanni National Park Reserve.

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(2) For IRs related to water quality, water balances and chemical loadings to Prairie Creek, please ensure that exfiltration from both mine workings and the surface water ditches and subsequent movement to Prairie Creek through groundwater flows are included in all calculations and analysis.

If you have any questions, please contact me.

Sincerely,

Joe Acorn

APPENDIX B

Preliminary Estimate of Water Consumption for the Construction and Maintenance of the Prairie Creek Mine Access Road

Preliminary Estimate of Water Consumption for the Construction & Maintenance of the Prairie Creek Mine Access Road

Prepared by Paul Davidson

Kledo Construction Ltd.

Fort Nelson, BC

December 31, 2010

Introduction

Kledo Construction Ltd. has been involved in the construction of industrial winter roads for many years in the Fort Nelson, BC area. Typically the roads are built for heavy loads up to 85,000 kg for use by the forest or oil and gas industries. Since the Prairie Creek Mine road is intended for considerably lighter loads (~40,000 kg), construction requirements in terms of water needs may be commensurately considerably less. Therefore, the estimates given here should be considered as conservative maxima. Information provided in this report is based on local empirical knowledge and experience as there have been no known studies regarding water consumption for local road construction.

A related report *Ice Road Construction in Fort Nelson, BC* (see appendix) describes the water consumption for road construction at 130 m^3 per kilometre and for seasonal maintenance at 120 m^3 per kilometre. For construction, muskeg may require more water while overland forested areas may require less water. Typically, the water trucks used in our area can haul 10-12 m^3 of water per load.

The first process in constructing a winter road is to remove the snow from the right of way using snow cats or light dozers. The snow is plowed to the edge of the right of way to allow frost penetration of the opened right of way. Next comes watering and freezing in of the road base. *The volume of water used for the base is estimated at **30 m^3 per km**, but it is variable due to dry muskeg conditions that may be encountered.*

When the road base is firm, water trucks and a grader will complete the task of building the constructed travel surface, mixing snow and water capable of supporting the loaded traffic. The volume of water used for the road surface construction is estimated at **100 m^3 per km.**

Regular daily maintenance of the road surface is required. This may include the sealing of cracks and fissures and snow fills at creek crossings to maintain the safety and integrity of the road and for adequate haul speeds. The volume of water estimated for this activity is **120 m^3 per km**.

Calculation of Estimated Water Consumption for Construction and Maintenance of Road

Road information for this report is taken from Figure 6-20: Prairie Creek Mine Access Road (with Inset Figures) from the CZN Developer's Assessment Report (DAR).

1. Section A: Mine to Tetcela Transfer Facility (84 km)
    - The existing road alignment is already permitted with the exception of the 8.8 km of the proposed Polje Re-alignment.
    - This report does not calculate water requirements for this road section because the bed from Km 0 to Km 39 is considered to be of all season condition, the re-alignment will require fill placement due to expected permafrost presence, and the remaining road portions mostly traverse a well drained plateau.. Any water needs would be sourced from a supply well at the mine site as annual construction of this road section would occur using equipment captive at the mine site.

2. Section B: Tetcela Transfer Facility to Liard River Ice Bridge (71 km)
    - This section of road is permitted from Km 84-90 and Km 116-120. The remainder consists of proposed re-alignments.
    - It is understood that presently, there are two confirmed water sources available, Mosquito Lake at Km 65 and the Liard River at Km 155.
    - It is understood that in the first year, the road will be opened and constructed beginning from the Liard Highway #7, so the water for the road base structure will come from the Liard River. The volume for the construction of the road base is calculated at 30m^3 per km times 71 km = 2,130 m^3.
    - The volume for the construction of the road surface is calculated at 100m^3 per km times 71 km = 7,100 m^3 sourced from the Liard River and Mosquito Lake.
    - The volume for the seasonal maintenance of the road surface is calculated as 120m^3 per km times 71 km = 8,520 m^3 sourced from the Liard River and Mosquito Lake.

3. Section C: Liard River Ice Bridge to Liard Highway #7 (24km)
    - This section of road iconsists of the Old Nahanni Logging Road and part of the Nahanni Butte access road. It can be opened from the Liard Highway #7 to the Liard River.
    - Winter road construction will draw water from the Liard River.
    - The volume for the construction of the road base and road surface is calculated as 130m^3 per km times 24 km = 3,120 m^3 .
    - The volume for the seasonal maintenance of the road surface is calculated as 120m^3 per km times 24 km = 2,880 m^3 .

4. Table 1: Summary of Water Consumption for Prairie Creek Mine Winter Road

Road Segment	Source	Construction	Maintenance	Total
0-84 km		Not estimated	Not estimated	
84-155 km	Liard River	2130 3550	4260	9940
	Lake at km 65	3550	4260	7810
155-Liard Hwy	Liard River	3120	2880	6000
Totals (m^3)		**12,350**	**11,400**	**23,750**

Note: The volume of the lake at Km 65 has not yet been quantified, therefore it is not known how much water the lake can supply. Any reduction in lake supply would be replaced by the mine and Liard river sources.

5. Summary

Information regarding water consumption is based on empirical experience for high capacity roads (loads and speeds) from the Fort Nelson area. Only with operational experience in this location for the required road capacity will we be better able to reliably forecast water volumes required for winter road construction.

Appendix 1:

Winter Road Construction

in Fort Nelson, BC

Paul Davidson,

Kledo Construction Ltd.

August 18, 2010

Winter Road Construction in Fort Nelson, BC

For many years, the forest industry based in Fort Nelson, B.C. constructed winter roads and ice bridges as the predominant access structures for transportation of manufactured logs to the mills. These winter access structures were designed for heavy industrial use and loaded 5-8 axle log haulers could typically reach loads of 85,000 KG. The roads were constructed in November and December, but daily maintenance was required to strengthen and repair the surface through to breakup in late March. Drivers were not permitted to use tire chains except on designated grades. The area generally does not contain significant areas of permafrost.

The knowledge and expertise developed by local contractors remains available, but fewer contractors are building roads and bridges. Typically, the forest industry roads followed seismic roads and trails where the vegetation had already been removed from the right of way. Low ground pressure dozers (typically a Caterpillar D5 or 6, and more recently a blade equipped Snowcat) would enter onto the right of way in early November to plow the snowfall from the cleared right of way to the edges, maximizing the area available to construct the road. The snow would be stored in windrows at the edge of the road for later use. Skilled equipment operators removed all the snow and herbaceous vegetation cover without removing the root mat or damaging the moss covering.

After the exposed ground was exposed to night time freezing temperatures typically -15^{o} Celsius for 2-3 nights, road construction would begin. Any significant delay beyond 3 days due to warm or cold weather or operational delays could sometimes affect the success of the next phase.

In the second phase, water tank trucks with a capacity of $10m^3$ (10,000 litres) were used to carry fresh water from approved borrow pits, ponds and lakes to the road surface. Typically the first loads were ½ the full volume to protect the trucks from breaking through the thin frozen upper layer of root mat and soils. In the first pass, up to 6 loads of water would be applied per kilometre. Usually this first pass was about 11/2 lanes wide for a one way off-highway road with pullouts. One measure of a good road builder and the longevity and strength of his road was how well he could have the water penetrate into the soils. Good absorption and deep penetration of water provided a sound base to build the road surface. *Volume of water used in this phase on average may accumulate to 30 m^3 per kilometre, but can be highly variable depending on ground conditions. Muskeg may require more water while overland forested conditions may require less water.*

Once the base was built, for the third phase, usually one road grader and two water trucks would work together constructing an ice surface. The water truck would apply water and the grader would sweep snow from the plowed windrow onto the freshly watered surface. Mixing of the snow and water would be used to fill in voids and smooth out the road. Typically, day time temperatures of -25^o Celsius made for good freezing conditions and maximizing construction. *Volume of water used in this phase on average may accumulate to 100 m^3, or about 10 full truck loads per kilometre.*

Regular daily maintenance of the surface is required to seal cracks and fissures and to maintain a smooth travelling surface. Specialized equipment was designed and installed on water trucks whereby a remote controlled blade was attached to the frame to enable drivers to direct snow to these road defects and apply water in the same pass. Then road traffic compacted the snow and water to repair the surface. Regular application of water and snow throughout the season was required to maintain the strength of the surface. *Volume of water used in this phase on average may accumulate to 10 m^3, or about 1 full truck load per kilometre per week over 12 weeks. Total volume of water for road maintenance could amount to 120 m3 per season per kilometre. This estimate is highly variable, depending on seasonal conditions and traffic.*

Total annual water consumption per kilometre:

Phase 1: building the subsurface = 30 m^3

Phase 2: building the ice surface = 100 m^3

Phase 3: seasonal maintenance = 120 m^3

Total water use for all three phases is about 250 m^3 per kilometre. This is an estimate given for the average conditions observed and worked in the Fort Nelson area for heavy industrial use with traffic flows averaging 100 loaded trucks per day at 85,000 kg per truck. Average loaded speed was variable from 50-60 kmph.

Typically, the NWT Department of Transportation designs and maintains snow roads for 64,000 kg loads with an average rate of speed at 35 kmph. Ice bridges are designed for 64,000 kg with a speed limit of 20 kmph. Water is used sparingly, only for snow fills, very rough road sections and ice bridges.

The author acknowledges the expertise, information and assistance provided by Gordie Smith and his employees from G&C Products, a long term road construction contractor in the forestry and oil and gas industry in Fort Nelson.

Paul Davidson, RFT

Health and Safety Coordinator

Kledo Construction, Fort Nelson, BC

APPENDIX C

Road Alignment Drawings

NOTES:

1) TOPOGRAPHIC DATA PREPARED BY CANADIAN ZINC.

PROFILE 1 – ACCESS ROAD
SCALE: H: 1:50,000
V: 1:10,000

SNC·LAVALIN

CANADIAN ZINC CORPORATION

Surveyed by:	Date:	DWG. No.	Description	Rev.	Date:	Description	Signature
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Designed by: A.R. WACHMANN	2006-08-31			PB	06-09-18	FOR INFORMATION	TW
				PC	06-10-12	FOR INFORMATION	TW
Drawn by: N. SCHWAB/CHL	2006-09-07						
Checked by: L. PIUS	2006-09-07						
Approved by: A.R. WACHMANN	2006-09-08	REFERENCE DRAWING		REVISIONS			

Title:

PRAIRIE CREEK MINE
PROPOSED ACCESS ROAD

PLAN & PROFILE
STA. 0+000 TO STA. 72+000

Scale: 1:50,000

Project No.: 017145-0000-41DK-0002

PE

CANCEL PRINTS BEARING LETTER PREVIOUS TO

PROFILE – MODIFIED PROPOSED ACCESS ROAD
SCALE: H: 1:50,000
V: 1:10,000

PRELIMINARY
FOR INFORMATION ONLY
2010-12-10

SNC·LAVALIN

CANADIAN ZINC CORPORATION

		Date	DWG. No.	Description	Rev.	Date	Description	Signature
Surveyed by:			Winter_Road.dwg	TOPOGRAPHIC DATA PREPARED BY CANADIAN ZINC	PA	06-09-08	FOR INFORMATION	TW
Designed by:	A.R. WACHMANN	2006-08-31			PB	06-09-18	FOR INFORMATION	TW
					PC	06-12-12	FOR INFORMATION	TW
Drawn by:	N. SCHWAB/CHL	2006-09-07						
Checked by:	L. PIUS	2006-09-07						
Approved by:	A.R. WACHMANN	2006-09-08	REFERENCE DRAWING		REVISIONS			

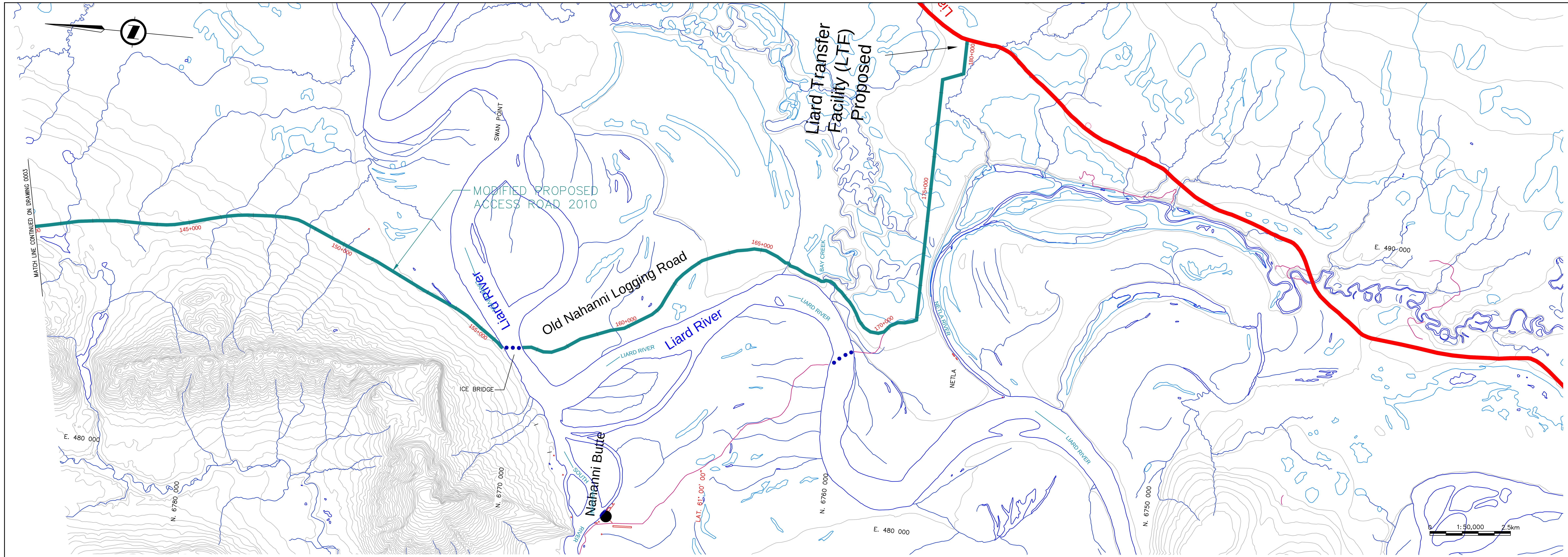
Title: PRAIRIE CREEK MINE
PROPOSED ACCESS ROAD

PLAN & PROFILE
STA. 72+000 TO STA. 136+000

Scale: 1:100

Project No.: 017145-0000-41DK-0003 PE

CANCEL PRINTS BEARING LETTER PREVIOUS TO

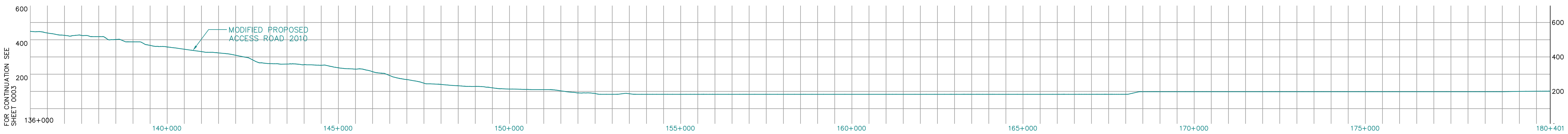


NOTES:

1) TOPOGRAPHIC DATA PREPARED BY CANADIAN ZINC.

LEGEND

- PROPOSED ACCESS ROAD 2010
- WINTER ROAD WHERE IT VARIES FROM THE PROPOSED ROAD
- ICE BRIDGE
- TRAIL
- WATERCOURSES
- WETLAND



539.24	525.40	525.05	518.16	500.91	487.68	467.17	457.68	445.05	431.02	423.40	409.98	382.40	361.27	358.53	355.06	351.46	337.09	329.39	314.08	292.00	268.38	247.63	240.31	232.57	228.68	220.84	213.36	211.43	210.20

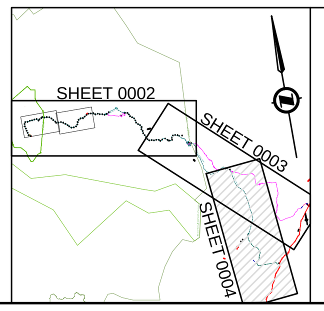
202.98	191.37	187.78	182.88	186.24	182.88	182.88	182.88	182.88	182.88	182.88	182.88	182.88	182.88	182.88	182.88	182.88	182.88	182.88	182.88	182.88	182.88	182.88	182.88	182.88	182.88	182.88	182.88	182.88	182.88

182.88	182.88	182.88	182.88	182.88	182.88	198.12	198.12	198.12	198.12	198.12	198.12	198.12	198.12	198.12	198.12	198.12	198.12	198.12	198.12	198.12	198.12	198.12	198.12	198.12	198.12	200.00	201.23	201.63

PROFILE – MODIFIED PROPOSED ACCESS ROAD

SCALE: H: 1:50,000
V: 1:10,000

PRELIMINARY
FOR INFORMATION ONLY
2010-12-10



SNC·LAVALIN

CANADIAN ZINC CORPORATION

		Date
Surveyed by:		
Designed by:	A.R. WACHMANN	2006-08-31
Drawn by:	N. SCHWAB/CHL	2006-09-07
Checked by:	L. PIUS	2006-09-07
Approved by:	A.R. WACHMANN	2006-09-08

REFERENCE DRAWING

DWG. No.	Description
Winter_Road.dwg	TOPOGRAPHIC DATA PREPARED BY CANADIAN ZINC

REVISIONS

Rev.	Date:	Description	Signature
PA	06-09-08	FOR INFORMATION	TW
PB	06-09-18	FOR INFORMATION	TW
PC	06-12-12	FOR INFORMATION	TW

Title:

PRAIRIE CREEK MINE
PROPOSED ACCESS ROAD

PLAN & PROFILE
STA. 136+000 TO STA. 176+113

Scale: 1:50,000

Project No.: 017145-0000-41DK-0004 PE

CANCEL PRINTS BEARING LETTER PREVIOUS TO

APPENDIX D

Discharge Toxicity and Impact Assessment

Hatfield Consultants

MEMO

Date: March 2, 2011 **HCP Ref No.:** CZN1682

From: John Wilcockson and Martin Davies

To: David Harpley, CZN

Subject: Prairie Creek Mine – Water Quality Benchmarks and Assessment of Potential Aquatic Effects.

This memo addresses several related subjects pertaining to effluent discharge from Canadian Zinc Corp.'s Prairie Creek Mine to Prairie Creek, NWT. These subjects include:

- Development of proposed site-specific water quality objectives (SSWQO);
- Definition of an initial dilution zone (IDZ, also called a mixing zone) in Prairie Creek;
- Development of proposed Effluent Quality Criteria (EQC); and
- An assessment of potential for aquatic effects once the mine becomes operational.

A summary of results contained within this memo is presented in Section 6.0.

1.0 METHODS FOR DERIVING SSWQO

Proposed SSWQO derived for the Prairie Creek Mine using the Canadian Council of Ministers of the Environment (CCME) Reference-Condition Approach (RCA) (CCME 1991) were previously reported by the Saskatchewan Research Council in the following documents:

- The report, Development of Site-Specific Water Quality Guidelines for Prairie Creek, NWT, March 2010 (Dubé and Harwood 2010), which provided a full rationale for the derivation process and proposed objectives for chloride, total cadmium, total copper, total lead, total mercury, total selenium and total zinc;
- The memo, Site-Specific Water Quality Objectives for Prairie Creek, NWT, September 2010 (Harwood 2010a), which proposed SSWQO for some additional analytes of concern requested by regulators in Information Requests, namely total iron, arsenic, silver, and antimony, dissolved sulphate, total ammonia-N, nitrate-N, nitrite-N, total phosphorus and total dissolved solids (TDS); and

- The memo, Site-Specific Water Quality Objective for Zinc in Prairie Creek, NWT, September 2010 (Harwood 2010b), which proposed a revised SSWQO for zinc.

In this document we refer to these proposed SSWQOs as "RCA-derived benchmarks". The RCA-derived benchmarks represent the upper limit of natural background concentrations of various analytes of concern (AOC). Subsequently, Hatfield Consultants outlined an iterative SSWQO derivation approach (Attachment 1, Hatfield 2010). In this iterative approach, the use of RCA-based benchmarks was proposed as a first step, paired with consideration of other published guidelines and direct toxicity testing. Other guidelines were considered because the RCA-derived values are based on upstream conditions only, rather than toxicological information, and therefore do not necessarily provide realistic thresholds for potential effects in the aquatic receiving environment. Guidelines published by the CCME are based on toxicity testing data and provide a more scientifically defensible threshold for assessing the potential for toxic effects, although they are considered by some to be insufficiently protective for Northern lakes and rivers, particularly for nutrients (i.e., nitrogen and phosphorus), which may naturally be present in very low concentrations, and dissolved metals in Northern water bodies with very low natural hardness.

The December 2010 memo outlined a scientific approach for evaluating and possibly adopting CCME guidelines as SSWQO, which also considered the results of whole effluent toxicity testing. Conceptually, this approach first assesses whether Prairie Creek water quality downstream of the mine would not change measurably from upstream conditions (i.e., would remain within the natural range of upstream variability, defined using the RCA approach) during mine operations. If this is predicted to be the case, then the RCA-based benchmarks would be adopted as water quality objectives for Prairie Creek downstream of the mine. However, if water quality modelling predicted a measurable change in specific water quality variable(s) downstream of the mine relative to upstream, then a second-tier assessment of potential effect would be undertaken to determine whether predicted changes in water quality would cause negative (acutely or chronically toxic) effects downstream. This second-tier assessment would be done using the CCME guideline (or equivalent provincial guidelines, where CCME guidelines do not exist).

1.1 BENCHMARKS AND GUIDELINES CONSIDERED

RCA-derived benchmarks, existing CCME guidelines, proposed CCME guidelines and other guidelines are presented in Table 1 below.

CCME environmental quality guidelines are routinely updated. Revised CCME water quality guidelines have recently been proposed for cadmium and zinc (Roe 2009). We have considered these new proposed guidelines in this analysis.

In addition to CCME guidelines, we also have provided alternative environmental quality benchmarks where CCME does not provide a guideline.

Table 1 Considered site-specific water quality objectives for Prairie Creek downstream of the Prairie Creek Mine, including those derived using Reference-Condition Approach, and published benchmarks from CCME other sources.

	units	RCA-derived Benchmarks	Current CCME	CCME Proposed	Alternative
Cd	μg/L	0.172	0.017	**0.38**[2]	-
Cu	μg/L	2.53	4	-	-
Pb	μg/L	1.13	7	-	-
Se	μg/L	2.16	1	-	-
Zn	μg/L	22.65	30	**35**[3]	-
Sb	μg/L	0.606	-	-	20[4]
As	μg/L	0.56	5	-	-
Fe	μg/L	229	300	-	-
Hg	μg/L	0.034	0.026	-	-
Ag	μg/L	0.103	0.1	-	-
NH_3-N	mg/L	0.013	0.239	-	-
NO_3-N	mg/L	0.230	2.900	-	-
NO_2-N	mg/L	1.030	0.060	-	-
Total P	mg/L	0.016	0.004 / <50%[1]	-	-
SO_4	mg/L	119.3	-	-	100[5] / 200[6]
TDS	mg/L	413.0	-	-	-

[1] Vale of 4 ≥g/L CCME Total Phosphorus "trigger range" in ultra-oligotrophic waters for further investigations (not a toxicological threshold). CCME guideline also recommends <50% increase from background conditions to be environmentally acceptable.

[2] Revised, hardness-based Cd guideline (Roe 2009), assuming a hardness of 210 mg/L.

[3] Revised, hardness-based Zn guideline is hardness-based (Roe 2009) assuming a hardness of 200 mg/L.

[4] Ontario Working Guideline for antimony (Fletcher *et al*. 1996).

[5] British Columbia Interim Guideline for sulphate (BCMoE 2000).

[6] Proposed objective for sulphate, based on recent research (Elphick *et al*. 2010). Hardness of 200 mg/L was assumed.

Of the various analytes of concern (AOC), copper, lead, zinc, arsenic, iron, ammonia, and nitrate have CCME water quality guidelines with concentrations greater than their respective SSWQO. CCME guidelines for cadmium and zinc are currently in the process of being updated to reflect new knowledge; proposed new guidelines were presented by Environment Canada at a Society of Environmental Toxicology and Chemistry (SETAC) conference in June 2009 (presentation provided in Attachment 2).

There is currently no CCME water quality guideline for antimony. However, Ontario's Ministry of Environment provides a working guideline of 20 μg/L.

Similarly, no CCME guideline for sulphate exists. British Columbia uses an interim water quality guideline for sulphate of 100 mg/L, but has acknowledged that this value may be overly conservative because it does not consider the ameliorating effect of water hardness (Nagpal 2006). BC is in the process of developing a new, hardness-dependent guideline. Recently published sulphate-toxicity data indicate a strong attenuating influence of hardness on sulphate toxicity. Based on hardness dependant species sensitivity curves developed by Elphick *et al*. (2010) for various aquatic species, the relatively high hardness of Prairie Creek water (mean 256 mg/L) should mitigate any potential acute or sub-lethal toxicity of sulphate at concentrations predicted in the creek. Unfortunately, no information is currently available about the revised BC guideline.

Data presented in the Elphick *et al.* (2010) paper indicate that at a hardness of 256 mg/L (i.e., mean hardness of Prairie Creek), chronic effects would not be observed on sensitive aquatic organisms (i.e., cladocerans) below sulphate concentrations of approximately 1,000 mg/L. The lowest mean concentration resulting in a chronic effect at a similar hardness (160 mg/L), was 678 mg/L sulphate (range 258-1,059 mg/L). We have proposed a water quality objective of 200 mg/L based on the species sensitivity curve provided in Elphick *et al.* (2010). This value represents a conservative interpretation of the results of Elphick *et al*. (2010).

As discussed in the whole-effluent toxicity testing section below, preliminary results suggest that the CCME guidelines (or other proposed toxicity-based benchmarks above) would be sufficiently protective of aquatic organisms living in Prairie Creek. This is not unexpected, given the CCME guidelines are based on peer-reviewed toxicity data to which a margin of safety has been applied.

1.2 WHOLE-EFFLUENT TOXICITY TESTING

In this assessment approach, the proposed application of the CCME (or equivalent) published guideline is supported by on-going, whole-effluent toxicity testing. These tests involve exposing a variety of aquatic species (fish and invertebrates) to whole effluent (using simulated treated mine and mill process effluents). Essentially, if a CCME (or equivalent) published guideline is greater than the corresponding RCA-derived benchmarks for a given analyte, the published guideline can be adopted as the SSWQO if the same analyte in the whole effluent is at a higher concentration than both the RCA benchmarks and CCME guideline, and does not cause toxicity (acute or sub-lethal) at environmentally relevant concentrations.

Toxicity testing of simulated effluents is still on-going; a brief summary of results to February 24, 2011 appears in Attachment 3. Results so far have indicated no acute toxicity of 100% effluent to rainbow trout, and no sub-lethal toxicity to duckweed (*Lemna minor*). However, acute toxicity to *Daphnia* has been observed inconsistently (in some tests) at effluent concentrations ≥40% of release (i.e., concentrations not expected to be observed in downstream Prairie Creek), and sub-lethal toxicity to *Ceriodaphnia* at concentrations of ≥10% of release.

No toxicity was observed in a 5%v/v dilution sample of treated process water. Concentrations in this sample were calculated assuming little contribution of contaminants from the dilution water, which was primarily Perrier water. Concentrations of several AOC exceeded both the RCA-derived benchmarks and the CCME or alternative benchmark. These were cadmium (3.2-times the proposed revised CCME), lead (2.2-times the existing CCME guideline), zinc (1.3-times the proposed revised CCME), and sulphate (1.8-times the proposed toxicity benchmark based on a hardness-dependant species sensitivity curve, as per Elphick *et al*., 2011). We anticipate that the selection of the CCME (or other proposed toxicity-based benchmarks), as SSWQOs will be further supported by ongoing toxicity testing.

Iterative toxicity identification evaluations (TIEs) are on-going, and focused on determining the likely cause of the observed toxicity to these waterflea species. TIE results to date have indicated that treated process (mill) effluent, rather than treated mine water (i.e., seepage from within the mine, which will comprise the majority of total effluent discharged) is the source of toxicity. Results also suggest that metals are not the primary source of observed toxicity in any samples, given effluent from which divalent metals have been removed using an EDTA column showed similar toxicity to waterfleas as effluent containing these metals.

Currently, the laboratory suspects that the effect may be due to sulphate (which exhibits concentrations in undiluted effluent above thresholds known to affect waterfleas), or flocculants used during treatment (both were elevated in the simulated effluent). The elevated concentrations of sulphate and flocculant may be a result of insufficient aging of the pre-treated mine and mill process effluent (see Appendix F, Addendum F3), which is not representative of actual mine operations. Sufficient retention time for aging of pre-treated mine and mill process effluent in the Water Storage Pond will not be an issue once the mill is operational.

1.3 PROPOSED SITE-SPECIFIC WATER QUALITY OBJECTIVES

Following the derivation methodology outlined earlier in this document, and considering results of water quality modelling (See Section 3), the following SSWQO are recommended for the Prairie Creek Mine (Table 2). The list of recommended objectives, below, will be sufficiently protective of the aquatic environment downstream of the Prairie Creek Mine. Many are based on RCA-benchmarks and therefore represent similarity to the upstream concentrations. The remainder is based on sound science, including suitable margins of safety.

It should be noted that receiving-water objectives and guidelines are targets for use in interpretation of environmental quality, rather than firm, regulatory end-points, such as Effluent Quality Criteria. However, mine environmental performance relative to these objectives should be an important factor in ongoing, adaptive management in the Prairie Creek watershed.

Table 2 Proposed site-specific water quality objectives for Prairie Creek downstream of the Prairie Creek Mine.

Analyte of Concern	Proposed SSWQO	Derivation/Rationale
Metals		
Antimony (Sb)	20 µg/L	Ontario guideline
Arsenic (As)	5 µg/L	CCME (existing guideline)
Cadmium (Cd)	0.38 µg/L	CCME (proposed guideline)
Copper (Cu)	4 µg/L	CCME (existing guideline)
Iron (Fe)	300 µg/L	CCME (existing guideline)
Lead (Pb)	7.0 µg/L	CCME (existing guideline)
Mercury (Hg)	0.034 µg/L	RCA-derived benchmark
Selenium (Se)	2.16 µg/L	RCA-derived benchmark
Silver (Ag)	0.10 µg/L	RCA-derived benchmark
Zinc (Zn)	35 µg/L	CCME (proposed guideline)
Nutrients[1]		
Ammonia	0.24 mg/L	CCME (existing guideline)
Nitrate	2.9 mg/L	CCME (existing guideline)
Nitrite	1.03 mg/L	CCME (existing guideline)
Total phosphorus	0.016 mg/L	RCA-derived benchmark
Ions		
Sulphate	200 mg/L	Based on hardness-based, dose-response relationships published in Elphick *et al.* (2010)
Total Dissolved Solids (TDS)	413 mg/L	RCA-derived benchmark

[1] See discussion below.

Specific Note Regarding Nutrients

Because of several factors—including the naturally low-nutrient environment of Prairie Creek, interactions and dependencies between specific nutrients with respect to their effects on primary productivity, and confounding effects of climate and ice cover on algal production—it is important to consider nutrient concentrations in Prairie Creek differently than one would assess other analytes such as metals, where more precise, toxicological thresholds exist.

Although water quality objectives for nutrients have been proposed in this section, effects of nutrient discharges on Prairie Creek will require site-specific assessment and monitoring. Section 5.0 discusses potential for enrichment effects in Prairie Creek specifically.

2.0 PROPOSED INITIAL DILUTION ZONE (IDZ)

An Initial Dilution Zone (IDZ), also called a "mixing zone", was defined as "an area adjacent to the effluent outfall within which waste is discharged and first mixes with water in the receiving environment" by the Mackenzie Valley Land and Water Board (MVLWB) in *The Final Draft Water and Effluent Quality Management Policy* (MVLWB *et al*. 2010).

In that document, MVLWB does not provide any guidance on defining IDZs, but states that "…establishment of an initial dilution zone (IDZ) will be considered by the Boards on a case-by-case basis such that the water quality standards for the receiving environment will need to be met outside of the IDZ."

CCME (2003) define an IDZ as "the area contiguous with a point source (effluent) where the effluent mixes with ambient water and where concentrations of some substances may not comply with water quality guidelines or objectives."

CCME also provides 14 factors that should be considered while setting an IDZ, as follows:

- The dimensions of an IDZ should be restricted to avoid adverse effects on the designated uses of the receiving water system (i.e., the IDZ should be as small as possible);
- Conditions outside the IDZ should be sufficient to support all of the designated uses of the receiving water system (i.e., there should be no environmental impact, meaning no guideline/objective excursions or sublethal toxicity);
- Conditions within the IDZ should not cause acute or short-term chronic toxicity to aquatic organisms;
- The IDZ should not impinge on critical fish or wildlife habitats (e.g., spawning or rearing areas for fish; over-wintering habitats for migratory waterfowl);
- Wastewaters that are discharged to the receiving water system must not be acutely toxic to aquatic organisms;
- Conditions within an IDZ should not result in bio-concentration of contaminants of potential concern (COPC) to levels that are harmful to the organism, aquatic-dependent wildlife or human health;
- A zone of passage for migrating aquatic organisms must be maintained;
- Placement of mixing zones must not block migration into tributaries;
- Mixing zones for adjacent wastewater discharges should not overlap with each other;
- Mixing zones should not unduly attract aquatic life or wildlife, thereby causing increased exposure to COPC;
- Mixing zones should not be used as an alternative to reasonable and practical pollution prevention, including wastewater treatment (pollution prevention principle);
- Mixing zones must not be established such that drinking water intakes are contained therein;

- Accumulation of toxic substances in water or sediment to toxic levels should not occur in the mixing zone; and

- Adverse effects on the aesthetic qualities of the receiving water system (e.g., odour, colour, scum, oil, floating debris,) should be avoided.

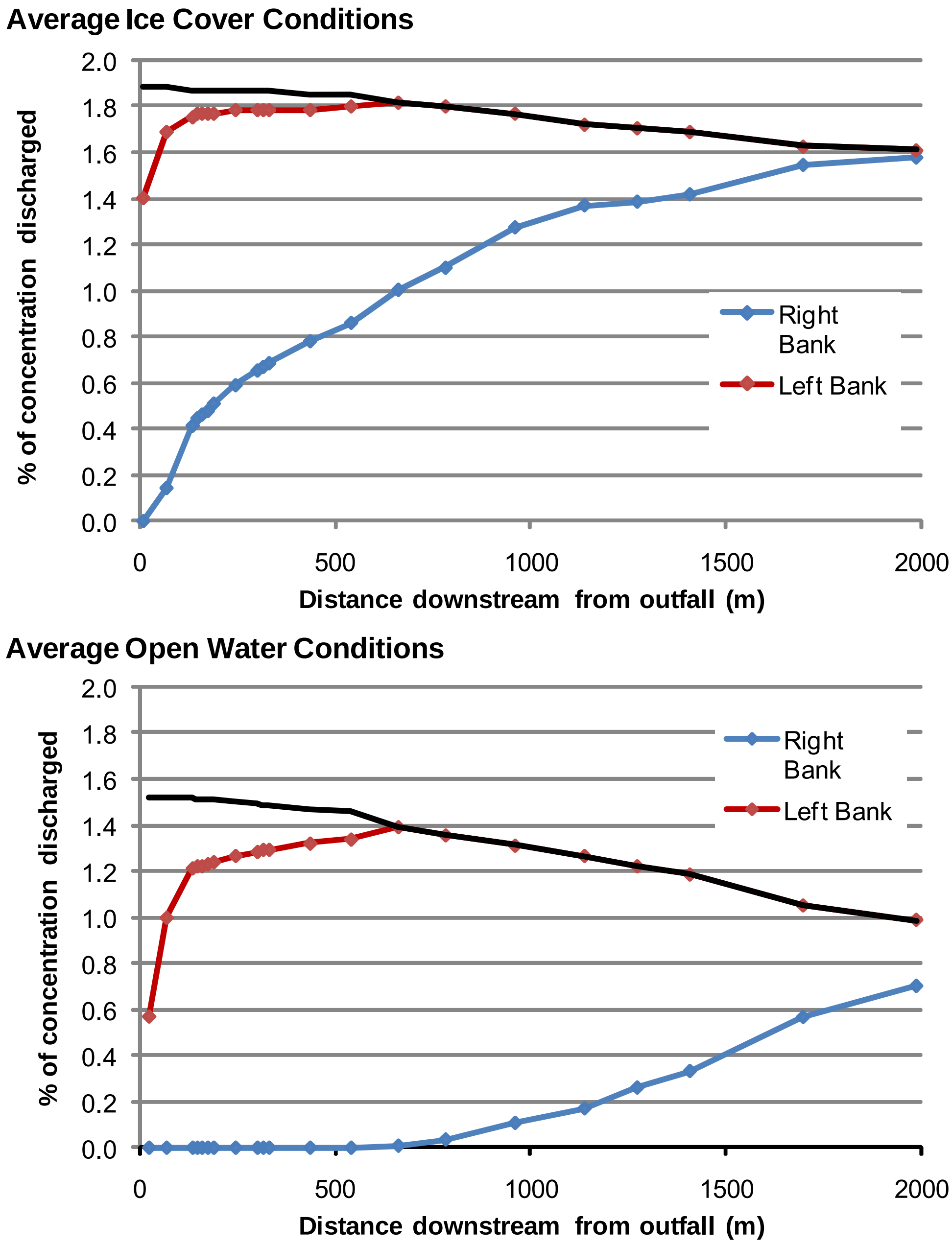
Other jurisdictions also provide their own guidance on how IDZ's should be established. British Columbia guidance, for instance, stipulates that the downstream end of the initial dilution zones should be located approximately 100 m downstream of the outfall, or four times channel width (Government of BC 2010), while Saskatchewan guidance appears to be consistent with CCME (Government of Saskachewan 2006).

The treated effluent discharge from the Prairie Creek Mine will be discharged to Prairie Creek via a buried exfiltration trench (see Northwest Hydraulics Co. [NHC], December 22, 2010 and February 11, 2011). Use of this trench, rather than a simple pipe discharge, will result in very rapid mixing of effluent into Prairie Creek, so that effluent concentrations are typically less than 2% of release within tens of metres downstream of the discharge point (Figure 1). Most effluent mixing will occur in this small zone of vertical mixing, immediately downstream of the discharge point. Effluent concentrations at complete vertical mixing will be similar to those occurring further downstream at complete, transverse (cross-channel) mixing.

Following CCME guidance on IDZ definition, the IDZ should extend from the discharge point to a downstream location between the exfiltration trench and somewhere shortly downstream of the point of complete vertical mixing. Based on plume modelling, the point of complete vertical mixing can be anywhere from 1.6 m to 31 m downstream of the exfiltration trench. Given compliance water quality sampling in Prairie Creek should occur at the downstream edge of the IDZ, logistical considerations are also important in defining the IDZ.

We propose that the IDZ extend approximately 100 m downstream of the exfiltration trench. At this location, the creek enters a narrower, unbraided riffle zone which is shallow and therefore convenient and safe to access and sample year round. It will also allow the sampler to avoid any possible confounding influences of sampling directly downstream of the confluence with Harrison Creek. Modelling suggests that the difference in effluent concentrations between the downstream point of vertical mixing and 100 m will be small; concentrations downstream of the outfall during mean open ice cover and open water conditions are shown in Figure 1.

Figure 1 Estimated effluent-concentration profiles in Prairie Creek downstream of effluent discharge, during average ice-covered conditions (left) and open water conditions (right) (after NHC, February 11, 2011).



Sampling to assess compliance with water quality guidelines/benchmarks at 100 m downstream should occur along the left (mine-side) bank of the creek, with samples collected a short distance from the shore, both to ensure maximum cross-channel concentrations are assessed and to ensure sampler safety.

3.0 ASSESSMENT OF POTENTIAL AQUATIC EFFECTS

The potential for aquatic effects resulting from mine effluent discharges has been assessed in three ways:

1. Screening of predicted downstream concentrations against SSWQO;
2. Using results of whole-effluent toxicity testing; and
3. For potential effects of nutrients associated with enrichment rather than toxicity, comparison of concentrations of bio-available phosphorus and nitrogen with published thresholds associated with primary productivity.

Whole-effluent toxicity testing is currently on-going; complete results will be presented as an addendum to this submission. Screening of predicted creek concentrations at the downstream edge of the IDZ against the SSWQO is done here.

Potential SSWQO provided in Table 1 were screened against predicted water quality downstream of the proposed IDZ (complete vertical mixing) and also at complete mixing (i.e., vertical and transverse). Four effluent discharge scenarios were modelled and discussed by NHC *(Mixing analysis for exfiltration trench outfall to Prairie Creek – DRAFT*, February 11, 2011).

3.1 EFFLUENT DISCHARGE CHARACTERISTICS

3.1.1 Components of Final Effluent

Briefly, discharged effluent will be comprised primarily of two treated effluent streams, and two secondary streams, as follows:

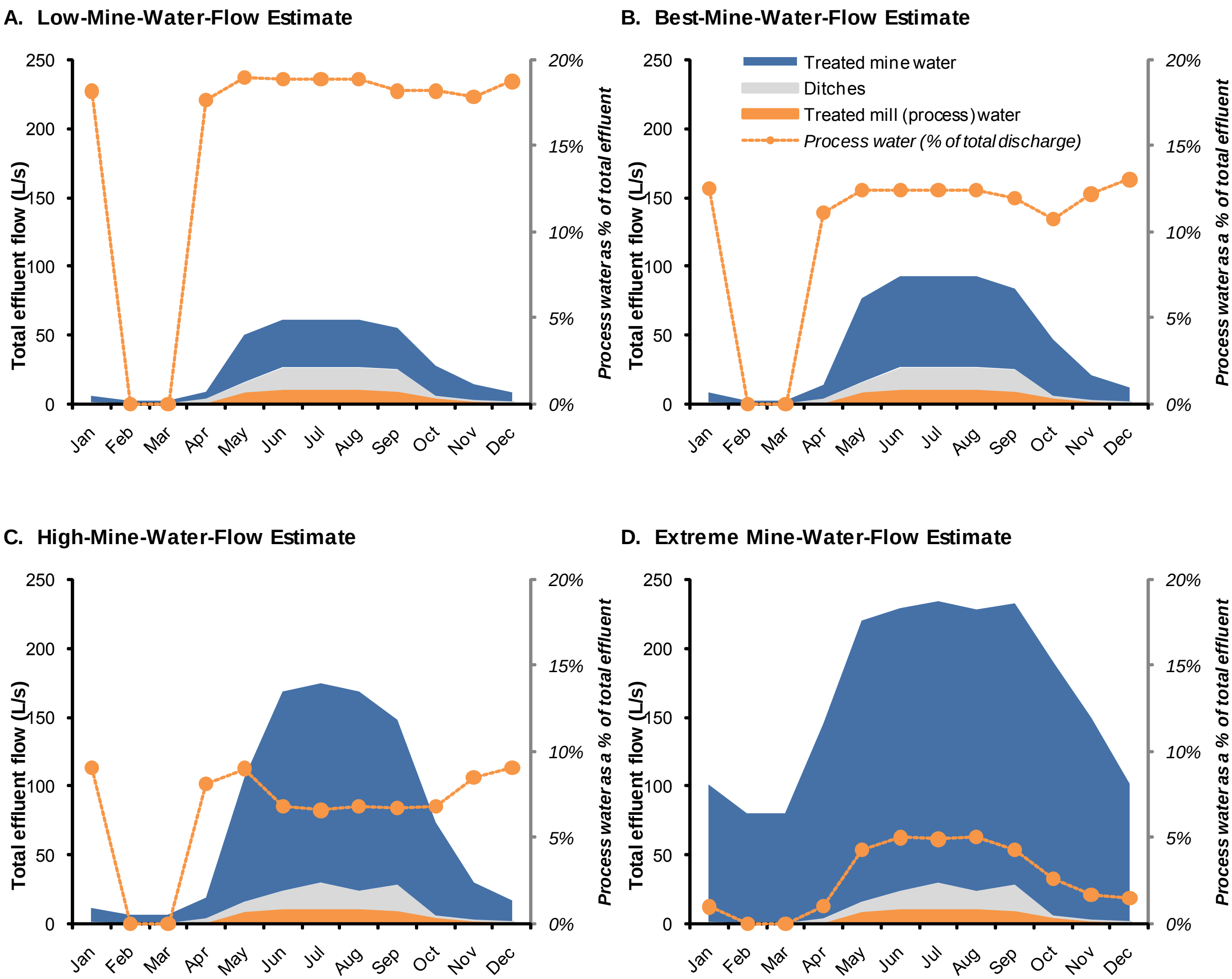
- process (mill) water, generated by the milling process;
- mine water (seepage water removed from the mine itself);
- site runoff water (ditch water); and
- treated camp sewage effluent.

The process water produced will be highly regulated, predictable (flows are known and do not change), and not dependant on external factors. The volume of mine water, however, will depend on the spatial development of the mine, permeability of the rock mass, and seasonal changes in infiltration, and therefore will be more variable. Therefore, the mine has developed four different volume management scenarios for consideration in predictions, representing low, best-estimate, high, and extreme mine-water discharge scenarios. As stated in a CZN memo (Appendix F of the second round Information Request [IR] reply, *Water Balance and Water Quality*), "the first three estimates are based on different hydraulic conductivities (K) from the Vein Fault…" and "the last estimate assumes a hydraulic connection between the Vein Fault and the Prairie Creek Alluvial Aquifer (PCAA)." The extreme mine-water flow scenario is considered unlikely (5% possibility, Robertson Geoconsultants, February 2011).

Predicted monthly discharges of total treated effluent, and its composition, appear in Figure 2. In all months and all scenarios, mine water is predicted to be the primary constituent of final effluent. No process effluent is planned to be discharged in February and March. In other months, process effluent is predicted to comprise 18-19% of total treated effluent discharge under the Low Mine Water scenario, 11-13% in the Best Estimate case, 7-9% in the High case, and 1-5% in the Extreme case. This has important implications to final effluent quality, water quality modelling, and establishment of Effluent Quality Criteria, given concentrations of most analytes of concern are much higher in treated process effluent than treated mine water, which exhibits quality that is more similar to that of upstream Prairie Creek water (see next section).

Sewage water will be stored with mine water in the large Water Storage Pond for several months. Both ditch water and sewage effluent will have some residence time in the final site pond (Catchment Pond) before being discharged. This will reduce concerns of impacts related to biochemical oxygen demand (BOD) and ammonia.

Figure 2 Predicted monthly total effluent discharges from the Prairie Creek Mine, under different mine-seepage water scenarios.



3.1.2 Predicted Final Effluent Quality

With regard to quality, treated mine water exhibits concentrations of some analytes that are similar to, or even below, concentrations found in Prairie Creek upstream of the mine. Similarly, ditch water has been analyzed and has been shown to have lower concentrations of the AOC relative to both treated mine and treated process water, and for some analytes, not substantially different than upstream Prairie Creek waters.

Concentrations of AOC in the different discharge streams and upstream Prairie Creek, as used in water quality modelling described in Section 3.2, appear below. Generally, treated process water exhibited high concentrations of metals, ions, and hardness relative to the other streams and upstream Prairie Creek water.

Table 3 Concentrations used in model calculations.

	Units	Treated Mine Water[1]	Treated Process Water[1]	Camp Ditch	Upstream Prairie Creek	Diavik U/G Drainage (for nitrogen estimates only)
Ag	µg/L	0.01	0.7	0.05	0.029	-
As	µg/L	2.8	9	0.8	0.24	-
Cd	µg/L	0.04	24.3	0.35	0.048	-
Cu	µg/L	7.2	71	2.2	0.57	-
Fe	µg/L	21	5,400	44	48.6	-
Hg	µg/L	0.01	2.04	0.028	0.02	-
Pb	µg/L	1.7	304	23.2	0.23	-
Sb	µg/L	25.3	119	2.2	0.244	-
Se	µg/L	3.3	39.2	2.4	1.16	-
Zn	µg/L	17	1,350	53	7.14	-
NH_4 N	mg/L	0.043	0.29	0.054	0.005	0.69
NO_3 N	mg/L	<1	<1	0.42	0.14	5.354
NO_2 N	mg/L	<0.25	<0.25	<0.001	0.08	0.013
Total P	mg/L	0.0033	0.23	0.005	0.007	-
Ortho-P	mg/L	0.0025	0.025	0.0025	0.0012	-
SO_4	mg/L	470	4,500	110	67.8	-
TDS	mg/L	700	6,100	380	274	-
TSS	mg/L	2	26	2	-	-
Hardness	mg/L	576	470	378	250	-

[1] Highest value of two measurements of simulated, treated effluent chemistry in 2010 and 2011, as described in Section 3.2.

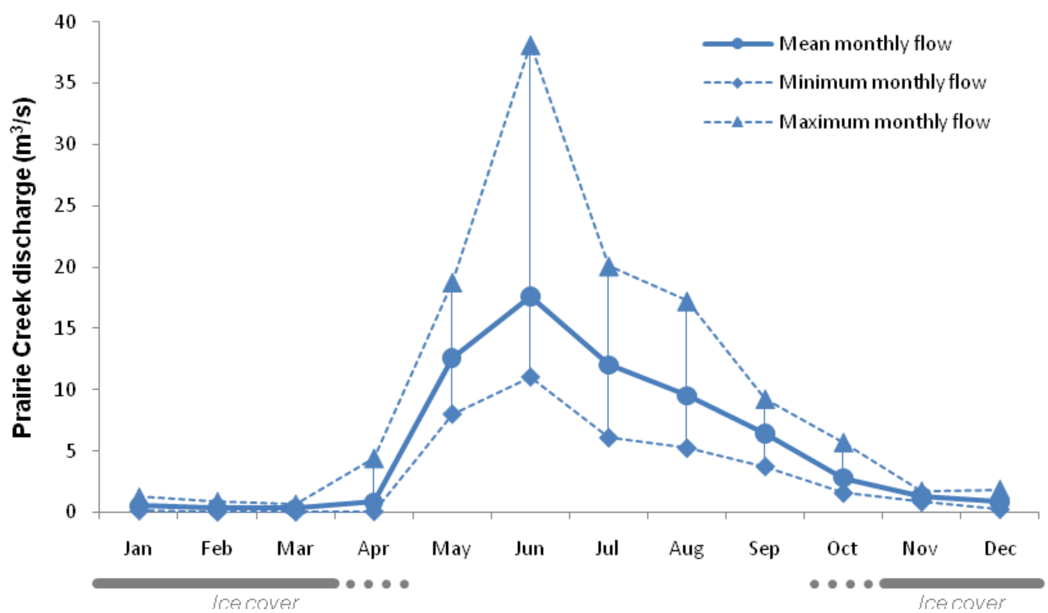
3.2 PRAIRIE CREEK WATER QUALITY PREDICTIONS

3.2.1 Near-field Dilution Model

NHC modelled dispersion and dilution of effluent from the Prairie Creek Mine under various seasonal conditions and mine-seepage scenarios (i.e., Low, Best-Estimate, High, and Extreme), as described in detail in NHC (February 11, 2011).

The dilution model considered seasonal variation, given Prairie Creek flow decreases significantly during winter, reducing the creek's assimilative capacity. The seasonal hydrograph for Prairie Creek (Figure 3) is typical of a smaller, northern stream, with high flows over a short, spring-to-fall period, peaking in June, and low flows through winter, under ice.

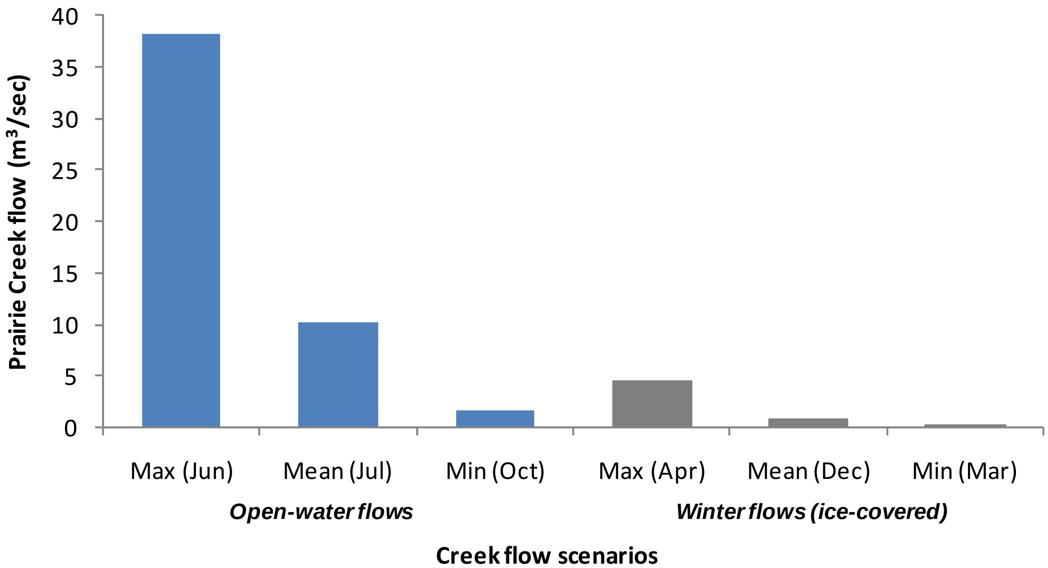
Figure 3 Range of mean monthly flows observed in Prairie Creek at Harrison Creek, 1976 to 1990.



The treated process water has higher concentrations of most AOC, and therefore greater potential to cause toxicity. Given this, the process-water flow will be reduced significantly in winter. Various Prairie Creek discharge scenarios were modelled by NHC, including maximum, minimum and mean creek flows, in both open water and ice-covered conditions (Figure 4). These scenarios would most likely occur in the following months:

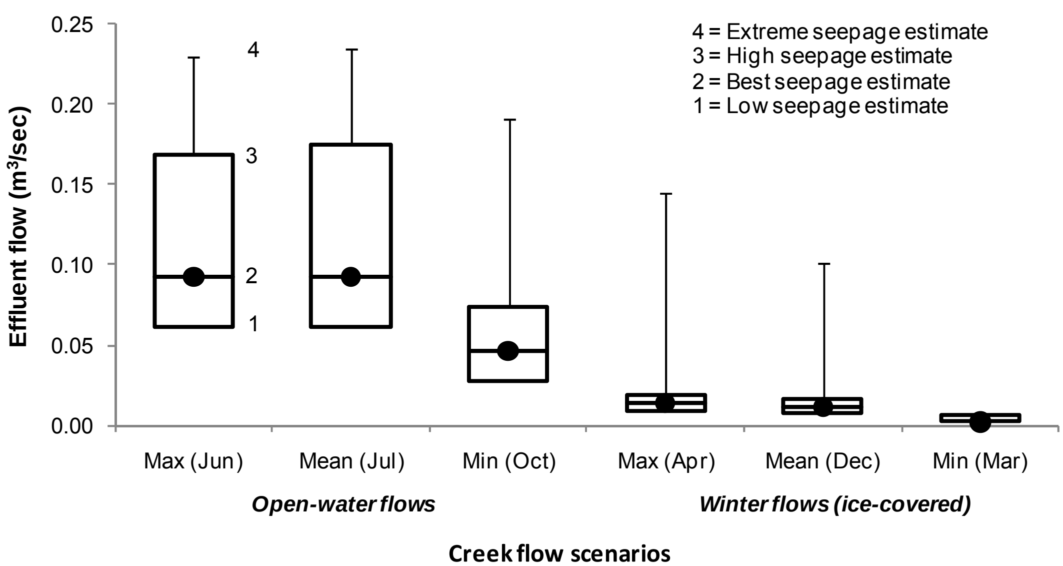
- Maximum open water – June (38.2 m3/s);
- Mean open water – July (10.2 m3/s);
- Minimum open water – October (1.57 m3/s);
- Maximum ice cover – April (4.43 m3/s);
- Mean ice cover – December (0.71 m3/s); and
- Minimum ice cover – March (0.039 m3/s).

Figure 4 Range of Prairie Creek flows used for effluent-dispersion modelling.



NHC conducted their simulations using flows of mine effluent discharged to the creek via the exfiltration trench, under different creek flows (Figure 5). Model outputs included scalar dilution factors (i.e., descriptions of the ratio of effluent to upstream creek water, or vice-versa) at points of complete vertical mixing, and complete transverse mixing.

Figure 5 Effluent-volume scenarios modelled, incorporating potential mine-seepage flows.



3.2.2 Prediction of Downstream Concentrations of Analytes of Concern

Hatfield combined available effluent and creek chemistry data with the plume-modelling results to calculate AOC concentrations along the plume centre-line at both complete vertical mixing (i.e., shortly downstream of discharge) and at complete vertical and transverse mixing. The model used to estimate creek concentrations at the downstream edge of the IDZ was as follows:

$$[AOC]_{ds} = ([AOC]_{eff} \text{ x } P_{eff}) + ([AOC]_{us} \text{ x } (1-P_{eff}))$$

Where:

$[AOC]_{ds}$ is the concentration of a given analyte in Prairie Creek downstream of discharge.

$[AOC]_{eff}$ is the concentration of a given analyte in treated effluent. Concentrations were based on chemical analysis of simulated, treated process and mine water. Two simulated treated effluents were generated for CZN by SGS in September 2010 and January 2011 (SGS 2010, 2011); we selected the highest concentrations of individual analytes between the two simulations (Table 4). Complete chemistry for simulated treated mine water, simulated treated process water, upstream Prairie Creek water and mine ditch water at the time that water was collected for the second simulated effluent batch trial (SGS 2011) is provided in Attachment 4.

$[AOC]_{us}$ is the concentration of a given analyte in Prairie Creek upstream of the outfall. Concentrations used in the model were average creek concentrations as provided in the RCA-derived benchmark derivation documents.

P_{eff} is the proportion of downstream creek flow comprised of effluent water. This is the inverse of the dilution factors provided by NHC.

Table 4 Metal concentrations in simulated effluent, 2010 and 2011 trials (higher number, in bold, was used for modeling).

	Total Metals (µg/L)									
	Ag	As	Cd	Cu	Fe	Hg	Pb	Sb	Se	Zn
Treated Mine Water										
Jan-2011	**0.01**	0.20	**0.04**	0.70	**21**	**0.01**	**1.7**	**25.3**	2.8	2.5
Sep-2010	**0.01**	**2.8**	0.01	**7.2**	2.5	**0.01**	0.10	22.9	**3.3**	**17**
Treated Process Water										
Jan-2011	**0.7**	**9.0**	**24.3**	**71.0**	**5,400**	1.90	**304**	**119**	10.0	**1,350**
Sep-2010	0.04	1.8	2.62	2.10	43.0	**2.04**	93.2	11.2	**39.2**	39

Bold numbers are the larger concentrations of the two created effluent simulations.

Non-metal AOC were not assessed in September 2010. January 2011 concentrations are provided in Attachment 4.

3.2.3 Model Outputs

Concentrations of effluent in downstream Prairie Creek water, modelled by NHC under various seasonal and mine-water-release scenarios, appear below. In all seasons and mine-water-release scenarios except Extreme, effluent concentrations are predicted to fall below 3% of release under typical flow conditions, after complete vertical mixing. Complete vertical mixing is predicted to occur between 1.6 and 31 m downstream of the outfall, depending on the scenario and season. In historical low flow conditions (in both late fall and winter under ice), concentrations of effluent in the creek after vertical mixing are less than 5%.

In the case of "extreme" mine-seepage flows, concentrations of effluent may be comparably higher in the creek at the edge of the IDZ (i.e., at complete vertical mixing), with concentrations up to 17% predicted at historical-low flows under ice in late winter. However, it should be noted that this Extreme case is considered unlikely (by RGC), and that, if it does occur, the relatively benign quality of treated mine water would serve to reduce concentrations of analytes of concern present in higher concentrations in treated process water.

Predicted concentrations of effluent in Prairie Creek following complete, transverse mixing are only slightly lower than those predicted following vertical mixing, because most effluent mixing has already occurred by the time effluent has mixed vertically into Prairie Creek. This illustrates the efficacy of the exfiltration trench system to ensure rapid mixing of effluent into the creek.

Table 5 Predicted concentrations of proportion of downstream flow comprised of effluent in each of the modelled scenarios.

	Ice Cover (winter)			Open Water		
	Monthly max flow (Apr)	Monthly mean flow (Dec)	Monthly min flow (Mar)	Monthly max flow (Jun)	Monthly mean flow (Jul)	Monthly min flow (Oct)
After vertical mixing						
Low Mine-Water Estimate	0.31%	1.32%	4.95%	0.37%	1.01%	2.10%
Best Mine-Water Estimate	0.49%	1.89%	4.95%	0.56%	1.53%	3.51%
High Mine-Water Estimate	0.66%	2.69%	13.51%	1.02%	2.87%	5.46%
Extreme Mine-Water Estimate	5.08%	14.71%	17.24%	1.39%	3.83%	13.16%
After transverse (complete) mixing						
Low Mine-Water Estimate	0.19%	1.11%	4.88%	0.16%	0.59%	1.72%
Best Mine-Water Estimate	0.30%	1.59%	4.88%	0.24%	0.90%	2.87%
High Mine-Water Estimate	0.42%	2.27%	13.33%	0.44%	1.68%	4.46%
Extreme Mine-Water Estimate	3.18%	12.50%	16.95%	0.60%	2.25%	10.87%

Predicted concentrations of analytes of concern in Prairie Creek downstream of the discharge, based on these modelled concentrations, appear in Table 6. In all cases, the predicted concentrations are less than the proposed SSWQOs. Furthermore, in nearly all scenarios, predicted concentrations of these various metals and ions at complete vertical mixing fall within the range of background concentrations (i.e., the upstream, RCA-derived benchmarks, particularly using the best estimate of expected mine water seepage.

Modelling results indicated little difference in downstream water quality in the creek at the point of full vertical mixing and the point of full transverse mixing, indicating that stable downstream water quality will occur nearly immediately downstream of the discharge. Results also indicted that excursions from the range of background concentrations generally only occur under extreme conditions, that is, very low creek flows combined with very high effluent flow.

Table 6 Predicted concentrations of analytes of concern in Prairie Creek, downstream of the IDZ, screened against RCA-derived benchmarks and CCME guidelines.

Water Quality Variable	Objective/ Guideline	Mine Seepage Scenario	Winter Creek Flows (Ice-Covered) Max (Apr)	Mean (Dec)	Min (Mar)	Open-Water Creek Flows Max (Jun)	Mean (Jul)	Min (Oct)
Prairie Creek flows used in model (m^3/s)			4.43	0.71	0.039	38.2	10.2	1.57
A. Predicted concentrations in Prairie Creek after vertical mixing (IDZ)								
Total Cadmium (µg/L)	RCA	Low	0.058	0.112	0.065	0.066	0.097	0.147
	0.172	**Best**	**0.059**	**0.113**	**0.065**	**0.067**	**0.099**	**0.151**
	Proposed CCME	High	0.059	0.116	0.096	0.068	0.103	0.156
	0.38	Extreme	0.078	0.152	0.109	0.069	0.106	*0.177*
Total Copper (µg/L)	RCA	Low	0.611	0.815	0.898	0.634	0.747	0.951
	2.53	**Best**	**0.622**	**0.852**	**0.898**	**0.647**	**0.781**	**1.041**
	CCME	High	0.659	1.070	1.466	0.747	1.069	1.561
	4	Extreme	0.936	1.684	1.713	0.702	0.929	*1.661*
Total Lead (µg/L)	RCA	Low	0.367	0.996	0.303	0.466	0.876	*1.424*
	1.13	**Best**	**0.366**	**1.002**	**0.303**	**0.468**	**0.881**	***1.430***
	CCME	High	0.367	1.008	0.429	0.471	0.907	*1.442*
	7	Extreme	0.478	1.103	0.483	0.476	0.918	*1.475*
Total Selenium (µg/L)	RCA	Low	1.180	1.277	1.266	1.192	1.248	1.342
	2.16	**Best**	**1.183**	**1.289**	**1.266**	**1.196**	**1.259**	**1.370**
	CCME	High	1.187	1.305	1.449	1.206	1.286	1.410
	1	Extreme	1.287	1.553	1.529	1.214	1.307	*1.565*
Total Zinc (µg/L)	RCA	Low	7.708	10.563	7.628	8.138	9.876	12.453
	22.65	**Best**	**7.713**	**10.607**	**7.628**	**8.156**	**9.918**	**12.529**
	Proposed CCME	High	7.724	10.663	8.472	8.193	10.046	12.647
	35	Extreme	8.363	11.487	8.840	8.228	10.128	13.053
B. Predicted concentrations in Prairie Creek after transverse (complete) mixing								
Total Cadmium (µg/L)	RCA	Low	0.054	0.102	0.065	0.056	0.077	0.129
	0.172	**Best**	**0.055**	**0.103**	**0.065**	**0.056**	**0.077**	**0.132**
	Proposed CCME	High	0.055	0.105	0.095	0.056	0.080	0.136
	0.38	Extreme	0.066	0.135	0.108	0.057	0.081	*0.153*
Total Copper (µg/L)	RCA-	Low	0.595	0.776	0.893	0.597	0.671	0.880
	2.53	**Best**	**0.602**	**0.807**	**0.893**	**0.601**	**0.690**	**0.952**
	CCME	High	0.609	0.850	1.453	0.613	0.737	1.053
	4	Extreme	0.789	1.504	1.692	0.623	0.772	*1.458*
Total Lead (µg/L)	RCA	Low	0.315	0.877	0.302	0.331	0.608	*1.207*
	1.13	**Best**	**0.315**	**0.882**	**0.302**	**0.332**	**0.611**	***1.211***
	CCME	High	0.315	0.887	0.426	0.332	0.624	*1.218*
	7	Extreme	0.381	0.967	0.478	0.334	0.630	*1.253*
Total Selenium (µg/L)	RCA	Low	1.171	1.256	1.264	1.171	1.207	1.304
	2.16	**Best**	**1.172**	**1.265**	**1.264**	**1.172**	**1.211**	**1.325**
	CCME	High	1.174	1.278	1.443	1.173	1.220	1.353
	1	Extreme	1.218	1.468	1.519	1.174	1.228	*1.468*
Total Zinc (µg/L)	RCA	Low	7.487	10.019	7.616	7.555	8.715	11.465
	22.65	**Best**	**7.485**	**10.049**	**7.616**	**7.555**	**8.725**	**11.508**
	Proposed CCME	High	7.488	10.089	8.442	7.553	8.760	11.568
	35	Extreme	7.772	10.677	8.790	7.553	8.780	11.862

Highlighted cell represents excursion of the recommended objective; italicizing/underlining represents a value greater than the RCA-derived benchmark.

Table 6 (Cont'd.)

Water Quality Variable	Objective/ Guideline	Mine Seepage Scenario	Winter Creek Flows (Ice-Covered) Max (Apr)	Mean (Dec)	Min (Mar)	Open-Water Creek Flows Max (Jun)	Mean (Jul)	Min (Oct)
Prairie Creek flows used in model (m^3/s)			4.43	0.71	0.039	38.2	10.2	1.57
A. Predicted concentrations in Prairie Creek after vertical mixing (IDZ)								
Total Silver (µg/L)	RCA	Low	0.029	0.030	0.028	0.029	0.030	0.031
	0.103	**Best**	**0.029**	**0.030**	**0.028**	**0.029**	**0.030**	**0.031**
	CCME	High	0.029	0.030	0.026	0.029	0.030	0.031
	0.1	Extreme	0.028	0.028	0.026	0.029	0.030	0.029
Total Arsenic (µg/L)	RCA	Low	0.249	0.289	0.367	0.252	0.273	0.317
	0.56	**Best**	**0.253**	**0.304**	**0.367**	**0.257**	**0.286**	**0.352**
	CCME	High	0.258	0.324	*0.586*	0.269	0.319	0.402
	5	Extreme	0.372	*0.630*	*0.681*	0.278	0.344	*0.598*
Total Iron (µg/L)	RCA	Low	50.591	61.524	47.234	52.268	58.652	68.575
	229	**Best**	**50.492**	**61.317**	**47.234**	**52.213**	**58.476**	**67.935**
	CCME	High	50.419	61.003	44.870	52.074	58.034	67.096
	300	Extreme	50.030	56.231	43.841	51.968	57.717	63.553
Total Mercury (µg/L)	RCA	Low	0.021	0.025	0.020	0.021	0.024	0.028
	0.034	**Best**	**0.021**	**0.025**	**0.020**	**0.021**	**0.024**	**0.027**
	CCME	High	0.021	0.025	0.019	0.021	0.024	0.027
	0.026	Extreme	0.021	0.023	0.018	0.021	0.023	0.026
Total Antimony (µg/L)	RCA	Low	0.337	*0.806*	*1.484*	0.379	*0.614*	*1.119*
	0.605	Best	**0.382**	***0.947***	***1.484***	**0.427**	***0.743***	***1.467***
	Ontario	High	0.426	*1.147*	*3.630*	0.546	*1.064*	*1.952*
	20	Extreme	*1.547*	*4.132*	*4.564*	*0.638*	*1.306*	*3.856*
B. Predicted concentrations in Prairie Creek after transverse (complete) mixing								
Total Silver (µg/L)	RCA	Low	0.029	0.030	0.028	0.029	0.030	0.031
	0.103	**Best**	**0.029**	**0.030**	**0.028**	**0.029**	**0.030**	**0.031**
	CCME	High	0.029	0.030	0.026	0.029	0.030	0.030
	0.1	Extreme	0.029	0.028	0.026	0.029	0.029	0.029
Total Arsenic (µg/L)	RCA	Low	0.245	0.281	0.365	0.245	0.259	0.303
	0.56	**Best**	**0.248**	**0.294**	**0.365**	**0.247**	**0.267**	**0.332**
	CCME	High	0.251	0.311	*0.581*	0.252	0.286	0.373
	5	Extreme	0.323	*0.571*	*0.674*	0.257	0.301	0.535
Total Iron (µg/L)	RCA	Low	49.846	59.524	47.254	50.182	54.499	64.965
	229	**Best**	**49.784**	**59.350**	**47.254**	**50.158**	**54.394**	**64.434**
	CCME	High	49.738	59.086	44.920	50.098	54.134	63.710
	300	Extreme	49.497	55.087	43.922	50.052	53.947	60.952
Total Mercury (µg/L)	RCA	Low	0.020	0.024	0.020	0.021	0.022	0.026
	0.034	**Best**	**0.020**	**0.024**	**0.020**	**0.021**	**0.022**	**0.026**
	CCME	High	0.020	0.024	0.019	0.021	0.022	0.026
	0.026	Extreme	0.020	0.023	0.018	0.021	0.022	0.025
Total Antimony (µg/L)	RCA	Low	0.302	*0.719*	*1.466*	0.302	0.461	*0.961*
	0.605	**Best**	**0.330**	***0.839***	***1.466***	**0.323**	**0.537**	***1.246***
	Ontario	High	0.358	*1.007*	*3.585*	0.374	*0.725*	*1.639*
	20	Extreme	*1.062*	*3.549*	*4.491*	0.414	*0.867*	*3.228*

Highlighted cell represents excursion of the recommended objective; italicizing/underlining represents a value greater than the RCA-derived benchmark.

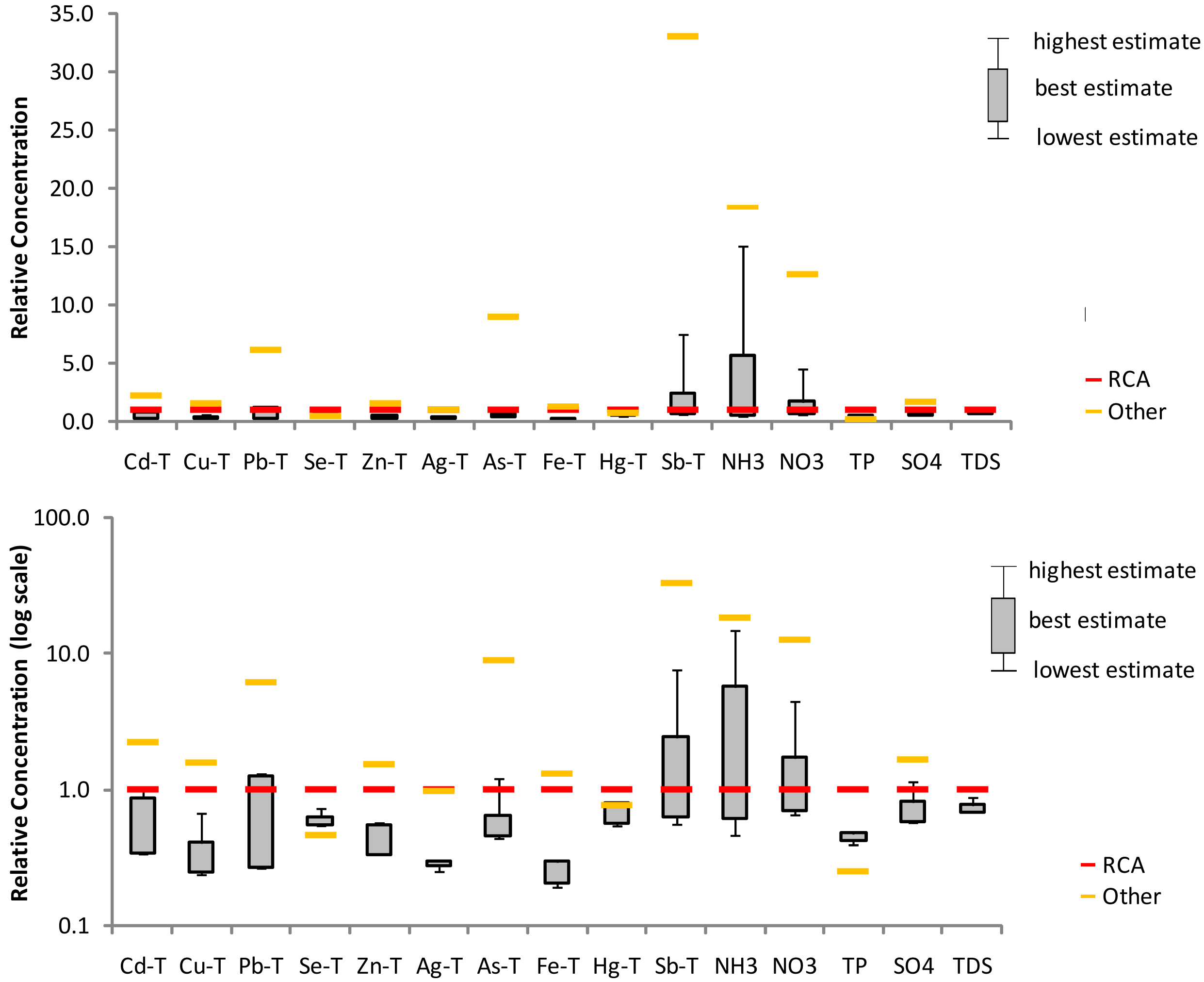
Table 6 (Cont'd.)

Water Quality Variable	Objective/ Guideline	Mine Seepage Scenario	Winter Creek Flows (Ice-Covered) Max (Apr)	Winter Creek Flows (Ice-Covered) Mean (Dec)	Winter Creek Flows (Ice-Covered) Min (Mar)	Open-Water Creek Flows Max (Jun)	Open-Water Creek Flows Mean (Jul)	Open-Water Creek Flows Min (Oct)
Prairie Creek flows used in model (m^3/s)			4.43	0.71	0.039	38.2	10.2	1.57
A. Predicted concentrations in Prairie Creek after vertical mixing (IDZ)								
Ammonia (mg/L)	RCA	Low	0.006	0.013	*0.039*	0.007	*0.047*	*0.018*
	0.013	**Best**	**0.008**	***0.017***	***0.039***	**0.008**	***0.075***	***0.027***
	CCME	High	0.009	*0.022*	*0.098*	0.011	*0.144*	*0.041*
	0.24	Extreme	*0.039*	*0.105*	*0.123*	*0.014*	*0.195*	*0.094*
Nitrate (mg/L)	RCA	Low	0.152	0.209	*0.398*	0.155	0.181	*0.248*
	0.23	Best	**0.161**	***0.238***	***0.398***	**0.165**	**0.208**	***0.321***
	CCME	High	0.171	*0.280*	*0.845*	0.190	*0.275*	*0.423*
	2.90	Extreme	*0.401*	*0.907*	*1.039*	0.209	*0.325*	*0.824*
Total Phosphorous (mg/L)	RCA	Low	0.007	0.008	0.007	0.007	0.007	0.008
	0.016	**Best**	**0.007**	**0.007**	**0.007**	**0.007**	**0.007**	**0.008**
	CCME	High	0.007	0.007	0.007	0.007	0.007	0.008
	0.004	Extreme	0.007	0.007	0.006	0.007	0.007	0.007
Sulphate (mg/L)	RCA	Low	70.949	83.055	87.711	71.768	78.676	91.506
	119.3	**Best**	**69.461**	**85.307**	**87.711**	**72.533**	**80.738**	**96.981**
	Other	High	72.385	88.460	*122.151*	74.436	85.870	104.625
	200	Extreme	90.074	*135.705*	*137.145*	75.907	89.723	*134.514*
TDS (mg/L)	RCA	Low	277.990	292.953	295.089	279.047	287.833	303.454
	400	Best	**275.809**	**295.327**	**295.089**	**279.857**	**290.010**	**309.200**
	-	High	279.510	298.648	331.568	281.859	295.457	317.233
		Extreme	298.227	348.383	347.448	283.416	299.527	348.591
B. Predicted concentrations in Prairie Creek after transverse (complete) mixing								
Ammonia (mg/L)	RCA	Low	0.006	0.012	*0.038*	0.006	0.008	*0.015*
	0.013	**Best**	**0.007**	***0.015***	***0.038***	**0.006**	**0.010**	***0.023***
	CCME	High	0.007	*0.020*	*0.096*	0.008	*0.015*	*0.034*
	0.24	Extreme	*0.026*	*0.090*	*0.121*	0.009	*0.019*	*0.078*
Nitrate (mg/L)	RCA	Low	0.148	0.198	*0.394*	0.146	0.164	0.228
	0	**Best**	**0.153**	**0.223**	***0.394***	**0.151**	**0.180**	***0.288***
	CCME	High	0.159	*0.258*	*0.835*	0.161	0.219	*0.371*
	2.90	Extreme	*0.304*	*0.792*	*1.024*	0.170	*0.249*	*0.705*
Total Phosphorous (mg/L)	RCA	Low	0.007	0.007	0.007	0.007	0.007	0.008
	0.016	**Best**	**0.007**	**0.007**	**0.007**	**0.007**	**0.007**	**0.008**
	CCME	High	0.007	0.007	0.007	0.007	0.007	0.008
	0.004	Extreme	0.007	0.007	0.006	0.007	0.007	0.007
Sulphate (mg/L)	RCA	Low	69.770	80.693	87.420	69.511	74.182	87.221
	119.3	**Best**	**68.840**	**82.598**	**87.420**	**69.841**	**75.391**	**91.698**
	Other	High	70.669	85.267	*121.427*	70.662	78.399	97.885
	200	Extreme	81.774	*125.520*	*135.969*	71.297	80.658	*122.912*
TDS (mg/L)	RCA	Low	276.496	290.019	294.780	276.177	282.117	298.131
	400	**Best**	**275.132**	**292.028**	**294.780**	**276.525**	**283.393**	**302.828**
	-	High	277.448	294.839	330.800	277.389	286.586	309.320
		Extreme	289.200	337.225	346.203	278.061	288.972	335.619

Highlighted cell represents excursion of the recommended objective; italicizing/underlining represents a value greater than the RCA-derived benchmark.

Figure 6 graphically compares predicted concentrations of these analytes in Prairie Creek downstream of the mine discharge (at complete vertical mixing) to RCA-derived benchmark (red bar) and other, published guidelines (yellow bar). Predicted concentrations have been normalized to the RCA-derived benchmarks, to allow comparison of all analytes on a single graph, and presented on both normal and log scales to assist interpretation of absolute and relative relationships between these values.

Figure 6 Predicted downstream concentrations of AOC in Prairie Creek, normalized to the RCA-derived benchmarks and published guidelines (presented on normal and logarithmic axes).



"Other" category includes CCME, proposed CCME, guidelines from other jurisdictions and an objective based on scientific literature reviews.

All AOCs had predicted downstream concentrations less than their respective proposed SSWQO and most also had downstream concentrations less than the upper range of background concentrations (as per the RCA-derived benchmarks; Table 6). Specific AOC predicted to exceed the upper range of background concentrations at full vertical mixing were as follows:

- Total cadmium slightly exceeded the RCA-derived benchmark of 0.172 µg/L by 1.03 times, under extreme effluent flow and open-water minimum creek flow;
- Total lead exceeded the RCA-derived benchmark of 1.13 µg/L by up to 1.3 times during open-water minimum creek flows, under all effluent-flow scenarios during abnormally low creek flows in October.;

- Total arsenic exceeded the RCA-derived benchmark of 0.56 µg/L by up to 1.2 times under high effluent flow and ice-covered minimum creek flows, and for extreme effluent flow under ice-covered minimum and mean, and open-water minimum, creek flows;
- Total antimony exceeded the RCA-derived benchmark, 0.605 µg/L for most scenarios, except monthly maximum creek flows and best/high effluent flows. Excursions were as high as 7.5-times the RCA-derived benchmark;
- Ammonia exceeded the RCA-derived benchmark of 0.013 mg/L for all of the scenarios. Excursions were as high as 9.5-times the RCA-derived benchmark;
- Nitrate exceeded the RCA-derived benchmark of 0.23 mg/L in most scenarios. Excursions were as high as 4.5-times the RCA-derived benchmark;
- Total phosphorus fell within the RCA-derived benchmark, but exceeded the CCME "trigger range for further investigation" for ultra-oligotrophic waters; and
- Sulphate exceeded the RCA-derived benchmark of 119 mg/L by up to 1.2 times under high effluent flow and ice-covered minimum creek flow, and for extreme effluent flow under ice-covered minimum and mean, and open-water minimum, creek flows.

4.0 PROPOSED EFFLUENT QUALITY CRITERIA

Canadian Zinc has proposed effluent quality criteria (EQC) for inclusion in a Water License to regulate the final effluent discharge (Table 7). These proposed criteria are well below previous EQCs governing previous mine discharge to Prairie Creek and Canada-wide MMER requirements, often by over an order of magnitude.

These maximum permitted concentrations (maximum average) were input into the same dilution model used to assess the simulated effluent sample (Section 3.0). Predicted downstream concentrations (at Harrison Creek, equivalent to the edge of the IDZ) were compared against the proposed SSWQO (Table 8). Of the water quality variables, cadmium, mercury, copper and zinc exceeded their respective proposed SSWQO. Cadmium only exceeded its proposed SSWQO during winter and during minimum flow scenarios. The highest exceedance for cadmium was 3.6-times the SSWQO. Copper, zinc, ammonia, total phosphorous and TDS exceeded their proposed SSWQO during April only, by 1.7-times (copper) 1.3-times (zinc), 1.1-times (ammonia), 1.2-times (total phosphourous) and 1.3-times (TDS) respectively for minimum flow scenarios. Mercury exceeded its proposed SSWQO for all months but May and June for minimum flow scenarios. There were also mercury exceedances in October and November for mean river flow scenarios. The highest mercury exceedance was 4.4-times the SSWQO.

Table 7 Existing and proposed effluent quality criteria (EQCs) for the Prairie Creek Mine (mg/L).

Water Quality Variable	Existing Prairie Creek License		MMER			Proposed Prairie Creek License	
	Max. Average	Max. Grab	Monthly	Composite	Grab	Max. Average	Max. Grab
Ammonia N	5	10	-	-	-	2	4
Nitrate N	-	-	-	-	-	10	20
Total Arsenic	0.5	1	0.5	0.75	1.0	0.01	0.02
Total Cadmium	0.005	0.01	-	-	-	0.01	0.02
Total Copper	0.1	0.2	0.3	0.45	0.6	0.03	0.06
Total Lead	0.15	0.3	0.2	0.3	0.4	0.1	0.2
Total Mercury	0.02	0.04				0.001	0.002
Total Zinc	0.3	0.6	0.5	0.75	1.0	0.5	1.0
Total Suspended Solids	15	30	15	22.5	30	15	30
Total Petroleum Hydrocarbons	5	10	-	-	-	5	10
Total Phosphorous	-	-	-	-	-	0.1	0.2
TDS	-	-	-	-	-	2000	3000
pH	6-9.5		6-9.5			6-9.5	

The mean upstream concentration of mercury in Prairie Creek is 0.026 µg/L, compared to the SSWQO of 0.034 µg/L and therefore it takes little incremental input from the mine to result in an exceedance. The mercury SSWQO was derived using the RCA-benchmark derivation approach. The concern of mercury contamination is not toxicological effects due to direct exposure of aquatic organisms, but rather the consumption of aquatic organisms that have accumulated methylated mercury. Therefore a better way of regulating/managing mercury in water is via monitoring tissue residue concentrations, as proposed in the aquatic monitoring program (Hatfield 2011).

April tended to have the highest predicted excursions of SSWQO. This is due to an inconsistency in the model between predicted mine flows, which are assumed to increase in spring starting in April, and the historical water flow record for Prairie Creek, which shows that higher flows do typically start in April but that low, winter flows have persisted into April in some years. In reality, this scenario--of spring conditions on the mine site, but winter conditions in the creek--would not occur.

Generally, objective excursions occurred during winter, when the mine can reduce the flow of treated process water (the component of the final effluent contributing most of the AOC mass). As such, modelled results present a conservative (worst case) estimate of downstream concentrations. CZN has undertaken to voluntarily reduce treated process water discharge during abnormally low winter flows to avoid exceeding SSWQO. Their approach and commitment would be verified in SNP results.

Best-estimate mine-seepage flows were used in this assessment (Table 8). At high or extreme mine-seepage flows, effluent volumes discharged are much higher, and, using the maximum permitted concentrations in the table above, result in more frequent excursions of downstream water-quality objectives. However, such a scenario is not realistic, because the presence of large amounts of mine-seepage water in final effluent would serve to substantially reduce actual concentrations of all of these analytes in effluent, relative to the low or best-estimate flow scenarios. In addition, nearly all the exceedances are during minimum flows when treated process water discharge could be reduced.

It is challenging to derive a single set of EQC that will not result in occasional downstream excursions of SSWQO, without creating EQC that are so small (conservative) that they are regularly triggered but falsely predict contaminant-related effects when none exist. The main goal of the EQC is to ensure that effluent is not acutely toxic and anticipate when effluent discharged might be capable of causing downstream effects. Water quality and biological monitoring of the receiving environment, particularly in the first years of mine operations and discharges, will provide rapid feedback regarding the performance of EQC and any need for them to be revisited to ensure good environmental quality. In a companion document (proposed environmental monitoring plan), we have proposed a tiered, trigger mechanism for adaptive environmental management and monitoring.

Table 8 **Predicted seasonal, downstream concentrations of analytes of concern, if effluent (best estimate) were discharged with maximum (monthly average) permitted concentrations.**

Regulated Variable	Creek Flows	Permit max (µg/L)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			Prairie Creek at Harrison Creek											
Total Arsenic (µg/L)	Mean	10	0.36	0.29	0.30	0.38	0.30	0.29	0.31	0.33	0.36	0.40	0.39	0.37
	Min		0.68	0.62	0.72	1.52	0.33	0.32	0.39	0.41	0.45	0.52	0.47	0.65
	Max		0.29	0.26	0.27	0.27	0.28	0.26	0.28	0.29	0.33	0.32	0.35	0.30
Total Cadmium (µg/L)	Mean	10	0.175	0.099	0.111	0.189	0.109	0.101	0.124	0.144	0.175	0.210	0.200	0.180
	Min		0.498	0.438	0.536	1.352	0.143	0.132	0.197	0.221	0.266	0.334	0.284	0.471
	Max		0.103	0.070	0.077	0.075	0.089	0.072	0.094	0.101	0.137	0.128	0.163	0.109
Total Copper (µg/L)	Mean	30	0.95	0.72	0.76	0.99	0.75	0.73	0.79	0.85	0.95	1.05	1.02	0.96
	Min		1.90	1.72	2.01	4.43	0.85	0.82	1.01	1.08	1.21	1.42	1.27	1.82
	Max		0.73	0.64	0.66	0.65	0.69	0.64	0.70	0.73	0.83	0.81	0.91	0.75
Total Mercury (µg/L)	Mean	1	0.033	0.025	0.026	0.034	0.026	0.025	0.027	0.029	0.033	0.036	0.035	0.033
	Min		0.064	0.058	0.068	0.148	0.029	0.028	0.035	0.037	0.041	0.048	0.043	0.062
	Max		0.025	0.022	0.023	0.023	0.024	0.022	0.024	0.025	0.029	0.028	0.031	0.026
Total Lead (µg/L)	Mean	100	1.51	0.74	0.86	1.64	0.84	0.76	0.99	1.19	1.51	1.85	1.76	1.55
	Min		4.74	4.14	5.12	13.30	1.19	1.07	1.72	1.97	2.41	3.10	2.59	4.47
	Max		0.78	0.45	0.52	0.50	0.64	0.47	0.69	0.76	1.12	1.03	1.38	0.84
Total Zinc (µg/L)	Mean	500	13.4	9.7	10.3	14.1	10.2	9.7	10.9	11.9	13.4	15.1	14.7	13.7
	Min		29.4	26.5	31.3	71.7	11.9	11.3	14.5	15.7	17.9	21.3	18.8	28.1
	Max		9.9	8.3	8.6	8.5	9.2	8.3	9.4	9.8	11.5	11.1	12.8	10.1
			Prairie Creek at Park Boundary											
Total Arsenic (µg/L)	Mean	10	0.35	0.28	0.30	0.36	0.29	0.29	0.31	0.32	0.35	0.38	0.37	0.36
	Min		0.64	0.59	0.67	1.40	0.32	0.31	0.37	0.39	0.43	0.49	0.45	0.61
	Max		0.29	0.26	0.27	0.26	0.28	0.26	0.28	0.29	0.32	0.31	0.34	0.29
Total Cadmium (µg/L)	Mean	10	0.162	0.094	0.104	0.175	0.103	0.095	0.116	0.134	0.162	0.193	0.185	0.167
	Min		0.454	0.400	0.489	1.235	0.134	0.123	0.182	0.204	0.244	0.306	0.260	0.429
	Max		0.098	0.068	0.074	0.072	0.085	0.070	0.089	0.096	0.128	0.120	0.151	0.102
Total Copper (µg/L)	Mean	30	0.91	0.71	0.74	0.94	0.73	0.71	0.77	0.82	0.91	1.00	0.97	0.92
	Min		1.77	1.61	1.87	4.08	0.82	0.79	0.97	1.03	1.15	1.33	1.20	1.70
	Max		0.72	0.63	0.65	0.64	0.68	0.63	0.69	0.71	0.81	0.78	0.88	0.73
Total Mercury (µg/L)	Mean	1	0.031	0.025	0.026	0.032	0.025	0.025	0.027	0.028	0.031	0.034	0.033	0.032
	Min		0.060	0.055	0.063	0.137	0.028	0.027	0.033	0.035	0.039	0.045	0.041	0.058
	Max		0.025	0.022	0.023	0.022	0.024	0.022	0.024	0.025	0.028	0.027	0.030	0.025
Total Lead (µg/L)	Mean	100	1.38	0.69	0.80	1.50	0.78	0.70	0.91	1.09	1.38	1.69	1.60	1.42
	Min		4.30	3.76	4.65	12.13	1.09	0.98	1.57	1.79	2.19	2.81	2.36	4.05
	Max		0.73	0.43	0.49	0.47	0.60	0.45	0.64	0.71	1.03	0.95	1.27	0.78
Total Zinc (µg/L)	Mean	500	12.8	9.4	9.9	13.4	9.8	9.5	10.5	11.4	12.8	14.3	13.9	13.0
	Min		27.2	24.6	29.0	65.9	11.4	10.9	13.8	14.9	16.8	19.9	17.7	26.0
	Max		9.6	8.1	8.4	8.3	9.0	8.2	9.2	9.5	11.1	10.7	12.3	9.8

Table 8 (Cont'd.)

Regulated Variable	Creek Flows	Permit max (mg/L)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Prairie Creek at Harrison Creek														
Ammonia (mg/L)	**Mean**	**2**	**0.03**	**0.02**	**0.02**	**0.03**	**0.02**	**0.02**	**0.02**	**0.02**	**0.03**	**0.04**	**0.04**	**0.03**
	Min		0.10	0.08	0.10	0.27	0.02	0.02	0.03	0.04	0.05	0.06	0.05	0.09
	Max		0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.02
Nitrate (mg/L)	**Mean**	**10**	**0.27**	**0.19**	**0.20**	**0.28**	**0.20**	**0.19**	**0.22**	**0.23**	**0.27**	**0.30**	**0.29**	**0.27**
	Min		0.59	0.53	0.62	1.43	0.23	0.22	0.29	0.31	0.36	0.42	0.37	0.56
	Max		0.19	0.16	0.17	0.17	0.18	0.16	0.19	0.19	0.23	0.22	0.25	0.20
Total Phosphorous(mg/L)	**Mean**	**0.1**	**0.008**	**0.007**	**0.008**	**0.008**	**0.008**	**0.007**	**0.008**	**0.008**	**0.008**	**0.009**	**0.008**	**0.008**
	Min		0.011	0.011	0.012	0.019	0.008	0.008	0.008	0.009	0.009	0.010	0.009	0.011
	Max		0.008	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008
TDS (mg/L)	**Mean**	**2000**	**296**	**283**	**285**	**298**	**284**	**283**	**287**	**291**	**296**	**302**	**300**	**297**
	Min		352	342	359	500	290	288	300	304	312	324	315	347
	Max		284	278	279	279	281	278	282	283	289	288	294	285
Prairie Creek at Park Boundary														
Ammonia (mg/L)	**Mean**	**2**	**0.03**	**0.01**	**0.02**	**0.03**	**0.02**	**0.01**	**0.02**	**0.02**	**0.03**	**0.03**	**0.03**	**0.03**
	Min		0.09	0.08	0.09	0.24	0.02	0.02	0.03	0.04	0.04	0.06	0.05	0.08
	Max		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.02
Nitrate (mg/L)	**Mean**	**10**	**0.25**	**0.19**	**0.20**	**0.27**	**0.19**	**0.19**	**0.21**	**0.23**	**0.25**	**0.28**	**0.28**	**0.26**
	Min		0.54	0.49	0.58	1.32	0.22	0.21	0.27	0.29	0.33	0.40	0.35	0.52
	Max		0.19	0.16	0.17	0.16	0.18	0.16	0.18	0.19	0.22	0.21	0.24	0.19
Total Phosphorous (mg/L)	**Mean**	**0.1**	**0.008**	**0.007**	**0.008**	**0.008**	**0.008**	**0.007**	**0.008**	**0.008**	**0.008**	**0.008**	**0.008**	**0.008**
	Min		0.011	0.010	0.011	0.018	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.011
	Max		0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008
TDS (mg/L)	**Mean**	**2000**	**294**	**282**	**284**	**296**	**283**	**282**	**286**	**289**	**294**	**299**	**298**	**295**
	Min		344	335	350	480	289	287	297	301	308	319	311	340
	Max		283	277	279	278	280	278	281	282	288	287	292	283

Highlighted cells represent predicted concentrations that exceed their respective proposed SSWQOs.

5.0 POTENTIAL FOR ENRICHMENT EFFECTS

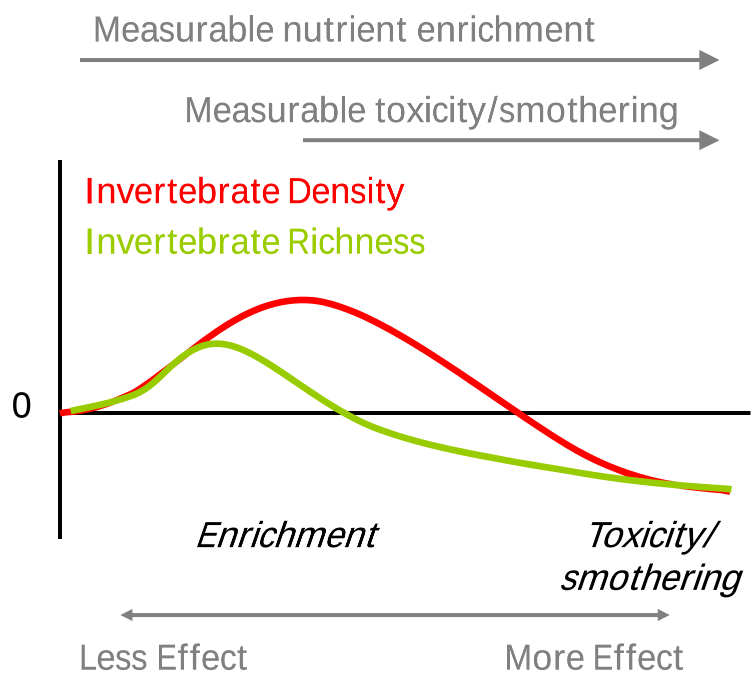
In freshwater, inorganic nitrogen exists in various forms, including nitrite (NO_2), nitrate (NO_3), or ammonium (NH_4), with nitrate being the dominant form (McClain *et al.* 1998), and ammonia being the most bio-available (although both nitrate and ammonia are bio-available). Once taken up by biota, nitrogen is converted to an organic form. When an organism decomposes or produces waste, ammonia or ammonium is produced. This process releases inorganic nitrogen for uptake, completing the cycle (McClain *et al.* 1998). The bio-available fraction of nitrogen is expressed as dissolved inorganic nitrogen (DIN), which represents the sum of nitrate and ammonium present in a water sample.

Phosphorus is an essential element found in water, rock, and in all living organisms; however, unlike nitrogen, phosphorus is one of the least abundant elements that is required by organisms for nutrition or structural support (Wetzel 2001). As a result, it can often be a limiting factor for biological productivity. In rivers, the dominant form of phosphorus is particulate phosphorus, which occurs when phosphate binds to particles or substrates, is taken up by biota, or is released from rocks by weathering; particulate forms of phosphorus are not readily bio-available. Dissolved phosphorus exists in water in organic (i.e., phosphate bound to organic molecules) and inorganic (orthophosphate, PO_4) forms. Once taken up by biota, phosphorus forms organic complexes until it is released through decomposition or excretion as orthophosphate, which completes the cycle. Orthophosphate also can adsorb onto iron and aluminum oxides and clay minerals, rendering it unavailable for biological uptake (McClain *et al*. 1998). The most bio-available fraction of phosphorous is orthophosphates (OP), which represents the dissolved inorganic forms of phosphorus. OP is generally considered to be an equivalent measure to soluble reactive phosphorus (SRP) (Pote and Daniel 2000).

Nutrients, including nitrogen, and phosphorus, are essential elements for plant and animal growth. In both terrestrial and aquatic systems, low concentrations of either phosphorus or nitrogen can limit plant growth. In freshwaters, P is typically the limiting nutrient (Howarth 1988, Vollenweider 1992 as cited in Chambers 2001). In these cases, it is said that the system is phosphorous-limited. Small incremental increases of phosphorus to these systems can have pronounced effects on algal growth. If concentrations of either bioavailable nitrogen or phosphorus are limiting in a river, even a surplus of the other nutrient will not substantially affect primary productivity.

Studies of the effects of nutrient addition to river systems generally indicate that moderate enrichment will increase the primary and secondary productivity of a river, often without loss of species (Figure 7). Further increases in nutrient concentrations will first cause a reduction in species richness, followed by a reduction in species abundance (Chambers *et al.* 2000, 2001). Even further increases in enrichment may result in the excessive production of algae (i.e., algal blooms) that can clog waterways, reduce oxygen levels, increase pH, which can adversely affect fish and other biota, as well as affecting the odour, appearance, and taste of drinking water, and affecting recreational users (USDA 1999).

Figure 7 Pearson-Rosenberg curve demonstrating the effect of increasing nutrients on benthic invertebrates.



Given that a eutrophic system is highly biologically productive, eutrophication can have positive effects in some systems by providing nutrients that can help local fisheries flourish; in some water bodies, nutrients are actually added to increase aquatic productivity and fish production (e.g., see Fisheries and Oceans Canada [DFO]'s Lake Enrichment Program: www-heb.pac.dfo-mpo.gc.ca/facilities/lep_e.htm). However, such enrichment, particularly in a naturally low-nutrient (oligotrophic) system, represents a change in its natural character.

Criteria have been established to classify lakes as eutrophic systems, which involve a measure of primary production and nutrient concentrations (Wetzel 2001, Dodds and Welch 2000); however, these criteria are less easily applied to streams and rivers, where relationships between nutrients and periphyton biomass in streams are more complex due to the effects of flooding, turbidity, and grazing (Dodds and Welch 2000).

The type of nutrient limitation that occurs in a river will influence which nutrient will have the greatest effects on periphyton biomass; generally, systems may be limited by nitrogen or phosphorus, or co-limited by both nutrients. The form of the nutrient input also will influence the intensity and extent of eutrophication; inputs comprised of dissolved, bioavailable forms of nutrients will tend to cause more dramatic and localized effects (Dodds and Welch 2000). Many other factors influence periphyton growth, including flows, light, temperature, depth, turbidity, and the extent of grazing by benthic invertebrates. At the Prairie Creek Mine site, the highest predicted nutrient concentrations downstream of the mine discharge would occur under ice, at a time when periphyton growth is inhibited due to low light and temperature.

Growth saturation of periphyton occurs at very low concentrations. In oligotrophic, cold-water rivers, algal cell division switches from being nutrient-limited to nutrient-saturated at between 1 and 5 µg/L OP, and 2,000-3,000 µg/L (2-3 mg/L) DIN (Chambers *et al.* 2000, 2001, and references therein).

Background (upstream) concentrations of nutrients in Prairie Creek generally are low, with average OP of 1.2 µg/L (range <0. 5 to 1.8 µg/L) and DIN of approximately 150 µg/L measured. Modelled concentrations downstream of the Prairie Creek Mine indicate an increase in DIN in all scenarios, particularly during low creek flows. However, only during the low creek flows and high effluent discharge scenarios do OP concentrations increase notably relative to background concentrations, although they remain under 1.5 µg/L in all scenarios (Table 9).

Given bio-available-nutrient benchmarks mentioned above, OP concentrations at the downstream edge of the IDZ may be sufficient to cause mild eutrophication. Predicted DIN concentrations are below the respective growth-saturation benchmark, but increase more greatly than phosphorus downstream, which remains below growth-saturation threshold. As such, bio-available phosphorus in Prairie Creek is likely the nutrient of greatest importance from an enrichment perspective.

It should be noted that the DIN and OP concentrations used in the model do not incorporate any attenuation of these substances during treatment, or near-field uptake and bio-transformation in the creek. DIN concentrations have been derived from untreated mine drainage concentrations for Diavik mine. DIN from sewage was not included because the anticipated input relative to mine water is small. It is anticipated that DIN and OP concentrations will be reduced while waste water resides in the on-site water-storage ponds. Phosphorus from sewage will also be precipitated via the use of alum.

Table 9 Predicted concentrations of bio-available nutrients downstream of the Prairie Creek Mine.

Nutrient	Mine Seepage Scenario	Winter Creek Flows (Ice-Covered) Max (Apr)	Mean (Dec)	Min (Mar)	Open-Water Creek Flows Max (Jun)	Mean (Jul)	Min (Oct)
Prairie Creek flows (m^3/s)		4.43	0.71	0.039	38.2	10.2	1.57
A. Predicted concentrations in Prairie Creek after vertical mixing (IDZ)							
DIN (µg/L)	Low	239	304	525	242	271	349
	Best	**250**	**339**	**525**	**253**	**303**	**434**
	High	261	387	1045	282	381	553
	Extreme	529	1117	1271	305	440	1020
Ortho-P (µg/L)	Low	1.21	1.26	1.26	1.21	1.23	1.29
	Best	**1.20**	**1.27**	**1.26**	**1.21**	**1.24**	**1.31**
	High	1.21	1.28	1.37	1.21	1.25	1.33
	Extreme	1.25	1.40	1.42	1.21	1.25	1.41
B. Predicted concentrations in Prairie Creek after transverse (complete) mixing							
DIN (µg/L)	Low	234	292	521	232	252	326
	Best	**240**	**321**	**521**	**237**	**271**	**396**
	High	247	362	1034	250	316	493
	Extreme	416	983	1254	259	351	882
Ortho-P (µg/L)	Low	1.22	1.27	1.26	1.22	1.26	1.31
	Best	**1.21**	**1.28**	**1.26**	**1.22**	**1.26**	**1.33**
	High	1.22	1.29	1.38	1.23	1.28	1.35
	Extreme	1.28	1.44	1.42	1.23	1.29	1.45

6.0 SUMMARY

The following bullets summarize the findings of this memo:

1. CZN is proposing discharge to Prairie Creek via an exfiltration trench, which will result in rapid vertical and transverse mixing of effluent into Prairie Creek, particularly relative to a single-pipe-discharge configuration. Complete vertical mixing is expected to occur between 1.6 and 31 m downstream of the outfall.

2. An initial dilution zone (IDZ) of 100 m downstream of the exfiltration trench is proposed. Although this is longer than the vertical-mixing zone, the creek at this point is a narrow, unbraided, and safe to routinely sample. Additional dilution further downstream (to complete, transverse mixing) is minimal.

3. Toxicity testing using simulated whole effluents is ongoing. Results to date indicate no toxicity to fish or plants, but some acute or sub-lethal toxicity to waterfleas (*Ceriodaphnia*) at concentrations not expected to occur in the receiving environment. An ongoing Toxicity Identification Evaluation (TIE) suggests that metals are not the cause of the observed toxicity. There were no effects on *Ceriodaphnia* in a 5%v/v dilution of treated process water; this result was used as the basis for selecting the recommended SSWQO (see below).

4. For the AOC we have recommended the following toxicity benchmarks as SSWQO:

    - **Selenium, mercury, silver, nitrite, total phosphorous and TDS:** adopt the RCA-derived water quality benchmarks;
    - **Cadmium and zinc:** adopt proposed, revised CCME guideline;
    - **Copper, lead, arsenic, iron, ammonia and nitrate:** adopt existing CCME guidelines;
    - **Antimony:** adopt interim Ontario guideline; and
    - **Sulphate:** Adopt a hardness-adjusted benchmark, using dose-response data provided by Elphick *et al.* (2010).

    Selection of toxicity-based benchmarks over the RCA-based (background concentration) benchmarks was based on preliminary toxicity testing results that indicated no toxicity at concentrations of several metals greater than both the CCME and RCA-derived benchmarks. It is anticipated that the final toxicity testing results will support the selection of the higher of the CCME and RCA-derived objectives as the SSWQO in all instances.

5. Predicted concentrations at the downstream edge of the initial dilution zone were screened against the recommended SSWQO. There were no exceedances, thus indicating a predicted absence of aquatic impacts related to effluent toxicity.

6. Effluent Quality Criteria are proposed which will result in the downstream water quality meeting SSWQO for most AOC under all conditions. Although some excursions of SSWQO could occur during abnormally low creek flows in winter, retention of process water in winter will allow mine operators to reduce concentrations of AOC in effluent and assist in meeting downstream water quality targets. Predicted mercury concentrations exceeded more often than the other AOCs. This was largely due to background concentrations in Prairie Creek that were already near the CCME guideline. The Aquatic Monitoring Program recommends the monitoring of mercury in the tissue of aquatic organisms to confirm negative ecological effects do not occur due to increases in mercury in water in Prairie Creek.

7. A review of estimated nutrient contentions downstream of the mine outfall, indicates that the mine discharge may result in a small amount of enrichment, but that phosphorus concentrations in Prairie Creek will remain low and limiting to algal growth.

A trigger-based, adaptive monitoring program (proposed in a companion memo) will ensure that the mine, once operational, does not cause ecological impacts, and that any effects that may occur outside the normal course of events are quickly identified and addressed.

7.0 REFERENCES

BCMoE (BC Ministry of Environment). 2000. Ambient Water Quality Guideline for Sulphate, Overview Report. Prepared pursuant to Section 2(e) of the Environmental Management Act, 1981. November, 2000.

CCME (Canadian Council of Ministers of the Environment). 1991. A protocol for the derivation of water quality guidelines for the protection of aquatic life. *In:* Canadian Water Quality Guidelines: Appendix IX. Prepared by the Task Force on Water Quality Guidelines of the Canadian Council of Ministers of the Environment. Water Quality Branch, Environment Canada, Ottawa, ON. 24pp.

CCME. 2003. Guidance on the Site-Specific Application of Water Quality Guidelines in Canada: Procedures for Deriving Numerical Water Quality Objectives.

Chambers, P.A., A.R. Dale, G.J. Scrimgeour, and M.L. Bothwell. 2000. Nutrient enrichment of northern rivers in response to pulp mill and municipal discharges. *J. Aquat. Ecosystem Stress and Recovery* 8:53-66.

Chambers, P.A., M. Guy, E.S. Roberts, M.N. Charlton, R. Kent, C. Gagnon, G. Grove, and N. Foster. 2001. Nutrients and their impact on the Canadian environment. Agriculture and Agri-Food Canada, Environment Canada, Fisheries and Oceans Canada, Health Canada and Natural Resources Canada. 241 p.

Dodds, W.K. and E.B. Welch. 2000. Establishing nutrient criteria in streams. J. N. Am. Benthological Society. 19(1):186-196.

Dubé, M. and A. Harwood. 2010. Development of Site-Specific Water Quality Guidelines for Prairie Creek, NWT. Saskatchewan Research Council, Environment and Forestry. SRC Publication No. 10432-1E10.

Elphick, J.R., M. Davies, G. Gilron, E.C. Canaria, B. Lo, and H.C. Bailey. 2011. An Aquatic Toxicological Evaluaation of Sulfate: the case for considering hardness as a modifying factor in setting water quality guidelines. Environ Tox and Chem, 30:247-253.

Fletcher, T., G.L. Stephenson, J. Wang, C.D. Wren, and B.W. Muncaster. 1996. Scientific criteria document for the development of a provincial water quality guideline for antimony. Ontario Ministry of Environment and Energy. ISBN 0-7778-4619-5. 32p.

Government of British Columbia, 2010. *Municipal Sewage Regulation, Environmental Management Act*, includes amendments up to B.C. Reg. 4/2010, January 14, 2010. BCReg 129/99, O.C. 507/99.

Harwood, A. 2010a. Update to Site-Specific Water Quality Objective for Zinc in Prairie Creek, NWT. Saskatchewan Research Council (SRC). Memo issued on September 1, 2010.

Harwood, A. 2010b. Additional Site-Specific Water Quality Objectives for Prairie Creek, NWT. Saskatchewan Research Council (SRC). Memo issued on September 1, 2010.

Hatfield (Hatfield Consultants). 2010. Assessment of potential aquatic effects, Prairie Creek. Hatfield Consultants. Memo issued on December 2nd, 2010.

Hatfield. 2011. Prairie Creek Mine - Proposed Aquatic Monitoring Framework for CZN's Prairie Creek Mine. Hatfield Consultants. Memo issued on February 28th, 2011.

McClain, M.E., R.E. Bilby and F.J. Triska. 1998. Biogeochemistry of N, P, and S in Northwest rivers: Natural distributions and responses to disturbance. *In:* River Ecology and Management: Lessons from the Pacific Coastal Ecoregion. R.J. Naiman and R.E. Bilby (Eds). Springer-Verlag, New York. pp. 347-372.

MVLWB (Mackenzie Valley Land and Water Board, Gwich'in Land and Water Board, Sahtu Land and Water Board and Wek'eezhii Land and Water Board). 2010. *Final Draft - Water and Effluent Quality Management Policy,* April 29, 2010

Nagpal, N. 2006. A case study on application of generic water quality guidelines and problems. Platform presentation at the 33rd Aquatic Toxicity Workshop, Jasper, Alberta, October 1-4, 2006.

NHC (Northwest Hydraulic Consultants). 2011. Re:Mixing analysis for exfiltration trench outfall to Prairie Creek – DRAFT. Memo from W Rozeboom and G. VanDerVinne to D. Harpley, Canadian Zinc Corp., February 11, 2011.

Pote, D.H. and T.C. Daniel. 2000. Analyzing for dissolved reactive phosphorus in water samples. *In:* Methods of Phosphorus Analysis for Soils, Sediments, Residuals, and Waters. G.M. Pierzynski (Ed). Southern Cooperative Series Bulletin No. #396. North Carolina State University. pp. 91 - 93

Roe, S. 2009. Federal water quality guidelines for the protection of aquatic life for cadmium, uranium and zinc developed under the Chemicals Management Plan, Power Point presentation given by S. Roe, National Guidelines and Standards Office at the SETAC Laurentian Annual Meeting, Ottawa, June 19th, 2009.

Saskatchewan Environment. 2006. Surface Water Quality Objectives Interim Edition EPB356, July, 2006. Accessed at: http://www.saskh20.ca/DWBinder/EPB356SurfaceWaterQualityObjectives.pdf

SGS (Société Générale de Surveillance). 2010. Prairie Creek Water Treatment Testing, Project: CEMI-0896. Report prepared for Canadian Zinc Corporation, Vancouver, August 2010. 0896-0210R01-2.

SGS. 2011. RE: Large Batch Treatment for Toxicity, Project: CEMI-1102. Memorandum from S. Basra and P. Bhatia to D. Harpley, Canadian Zinc, Vancouver, February 9, 2011.

USDA (US Department of Agriculture). 1999. A Procedure to Estimate the Response of Aquatic Systems to Changes in Phosphorus and Nitrogen Inputs. National Water and Climate Centre.

Wetzel, R.G. 2001. Limnology: Lake and River Ecosystems 3rd Ed. Elsevier Academic Press, San Diego, CA.

APPENDICES

Appendix A1

Iterative SSWQO Derivation Approach and Whole Effluent Toxicity Testing - Proposal

MEMO

Date: December 2nd, 2010 **HCP Ref No.:** CZN1682

From: John Wilcockson

To: David Harpley, CZN

Subject: Assessment of potential aquatic effects, Prairie Creek.

This memo outlines a proposed approach to assessing potential aquatic effects to the aquatic environment resulting from the discharge of effluent from the Prairie Creek Mine.

1.0 OVERVIEW

Proposed site-specific water quality objectives (SSWQOs) have already been developed using CCME's Reference Condition Approach (RCA). Using this approach, the natural distribution of receiving water concentrations (in this case Prairie Creek), is used to calculate Mean+2SD concentrations for each analyte of concern.

Preliminary desktop testing, combined with plume modeling were used to predict river concentrations of various analytes. These predicted concentrations were compared against the CCME guidelines as a first screen to identify the contaminants of interest. Metals of interest included cadmium, copper, lead, mercury, selenium and zinc.

Of these, cadmium, mercury and selenium had calculated RCA-derived objectives greater than their CCME water quality guidelines. Conversely, copper, lead and zinc had calculated RCA derived objectives less than the CCME water quality guidelines, resulting in SSWQOs that were more protective than the CCME water quality guidelines. Based on a review of existing Prairie Creek chemistry under modeled discharge scenarios, regulators have proposed additional analytes of interest.

Testing with simulated effluents to date has indicated that, under low river flows, concentrations of some metals or ions can exceed the derived SSWQOs (SGS-CEMI 2010). Predicted copper, lead, selenium, antimony, ammonia and nitrate concentrations exceed at mine drainage flows of 29 L/sec, while these plus arsenic, lead, phosphorous and sulphate exceed at mine drainage flows of 100 L/sec.

Toxicity testing was done with both mine water and simulated process water. Results generally indicated low toxicity of mine water. There were no acute mortalities and subchronic effects were only seen at concentrations as low as 68.1% mine water (*Ceriodaphnia dubia* reproduction). Simulated process water resulted in greater toxicity. The rainbow trout LC50 was 70.71 %v/v, while the *Daphnia magna* LC50 was <10%v/v. LC50 is the concentration of test water diluted in lab water that results in the death of 50% of the test population within a specified amount of time.

Based on our understanding there are three primary questions that will needed to be answered prior to the issuance of a discharge permit:

1) **Potential toxicity of whole effluent** - Is the predicted final effluent going to be toxic to organisms living in Prairie Creek?

2) **Derive appropriate Water Quality Objectives** – What are appropriate site-specific water quality objectives (SSWQOs) for Prairie Creek downstream of an initial dilution zone?

3) **Aquatic monitoring when mine is operational -** What aquatic monitoring activities should the mine undertake once it becomes operational? What are appropriate frequencies of measurement, triggers and management/monitoring actions?

A proposed work plan is outlined below intended to address the first two questions. Aquatic monitoring will be addressed in an additional work plan. The proposed approach includes additional plume modeling, whole effluent toxicity testing and CCME recommended approaches for developing site-specific water quality objectives (Attachment 1). The result will be: the definition of an initial dilution zone (IDZ), derivation of final site-specific water quality objectives (SSWQOs), and a check on the existing EQCs in context of the IDZ and SSWQOs (Attachment 1).

2.0 POTENTIAL TOXICITY OF WHOLE EFFLUENT

To answer (1) above, we suggest using a tiered toxicity testing program, conducting only as many tests as needed (Attachment 2). The proposed approach is as follows:

a) Conduct acute toxicity testing on simulated final effluent using rainbow trout and the waterflea *Daphnia magna*. All tests will use Prairie Creek water for dilutions. Previous toxicity testing was conducted using laboratory water for effluent dilutions, however, carbonates of calcium and magnesium (water hardness) provide protection to aquatic organisms from the effects of exposure to metals. The hardness in Prairie Creek water is quite high (250 mg/L). Therefore, repeating toxicity tests using Prairie Creek water may result in lower toxicity of simulated process water. If acute toxicity is observed go to (b) below, if no acute toxicity is observed, got to (c).

b) Conduct a Toxicity Identification Evaluation (TIE) on the simulated effluent sample using acute toxicity tests. TIEs involve physico-chemical manipulations of a sample before it is tested for toxicity. Manipulations generally involve chemically removing individual or groups of analytes, followed by performing toxicity tests; removal of toxicity by a particular treatment provides an indication of the cause of toxicity, which can then be determined definitively using a series of follow-up steps. This type of testing is usually done in a tiered manner, initially focusing on analytes that are most likely to be a cause of toxicity (e.g., metals, ammonia, process chemicals). Once the primary cause of toxicity is understood, Canadian Zinc may be able to adjust the effluent treatment process slightly and significantly reduce the predicted toxicity of effluent. Alternatively, the cause of toxicity observed in this simulated effluent may not be relevant to anticipated conditions once the mine is operating. This will become clear once the identity of the toxicant is known. Once the cause of the acute toxicity has been mitigated, additional toxicity testing should be conducted on effluents to confirm the absence of acute toxicity and to determine if there is any chronic toxicity. After process adjustments have been made, go back to (a) above.

c) Conduct chronic (sublethal) toxicity testing on simulated final effluent. Chronic tests would use *Ceriodaphnia dubia* (a reproduction test using a freshwater crustacean) and *Pseudokirchneriella subcapitata* (a growth test using a freshwater alga). These tests are required under the Metal Mining Effluent Regulations; consequently, these data will help to provide an assessment of the toxicity of the effluent under relevant conditions (i.e., in the receiving environment), related to relevant compliance benchmarks that the mine will need to meet during operations. If chronic toxicity is observed, go to (d) below, if no chronic toxicity is observed go to (e).

d) Assess whether the observed chronic toxicity indicates a real ecological risk. If so, conduct a Toxicity Identification Evaluation on the simulated effluent sample using chronic toxicity tests. See (b) above for a description and purpose of a TIE. Once the cause of the chronic toxicity has been determined, assess the magnitude of predicted effect and consider the range of potential management and treatment options. If any actions have been taken to mitigate the causative factor, conduct additional chronic testing after process adjustments have been made, go back to (c) above.

e) No more toxicity testing is warranted. However, it will be prudent to demonstrate that the treated effluent is unlikely to become more toxic once active mining begins.

We also recommend modeling the predicted effluent plume in Prairie Creek. If, as discussed, Canadian Zinc decides to build an ex-filtration trench in Prairie Creek, dilution of the effluent plume should be rapid and predicted effects, if any, would be isolated to a small zone immediately adjacent to the outfall. This information will support the results of any toxicity testing conducted, and be directly relevant to ongoing discussions between the mine and stakeholders regarding definition of an Initial Dilution Zone.

The toxicity work will be conducted by the Nautilus Environmental laboratory, Burnaby, BC (www.nautilusenvironmental.com).

3.0 DERIVATION OF SITE-SPECIFIC WATER QUALITY OBJECTIVES (SSWQO)

SSWQOs derived using the RCA approach, are most likely unnecessarily overly protective of aquatic organisms in Prairie Creek. The application of RCA is based on the concept of no net change to water quality of a receiving environment and is not based on a scientific assessment of potential effects. However, we acknowledge the concern of NWT regulators that the CCME water quality objectives are generic and do not consider the uniqueness/sensitivity of water bodies in the far north and therefore may not be sufficiently protective. Consequently the project team has provided the following approach to modify the existing SSWQOs (derived using RCA):

a) New simulated effluent and Prairie Creek water will be submitted for analytical chemistry. Analysis will include a wider range of chemical variables than were assessed previously. The results will be incorporated into plume dispersion models allowing the prediction of analytes in Prairie Creek downstream of the outfall under a number of scenarios. The predicted concentrations will be used to select new analytes of concern, using several approaches: (1) exceedance of existing generic CCME guidelines; (2) significant increases relative to typical background concentrations; and (3) regulator suggestions based on typical mining-related contaminants of concern.

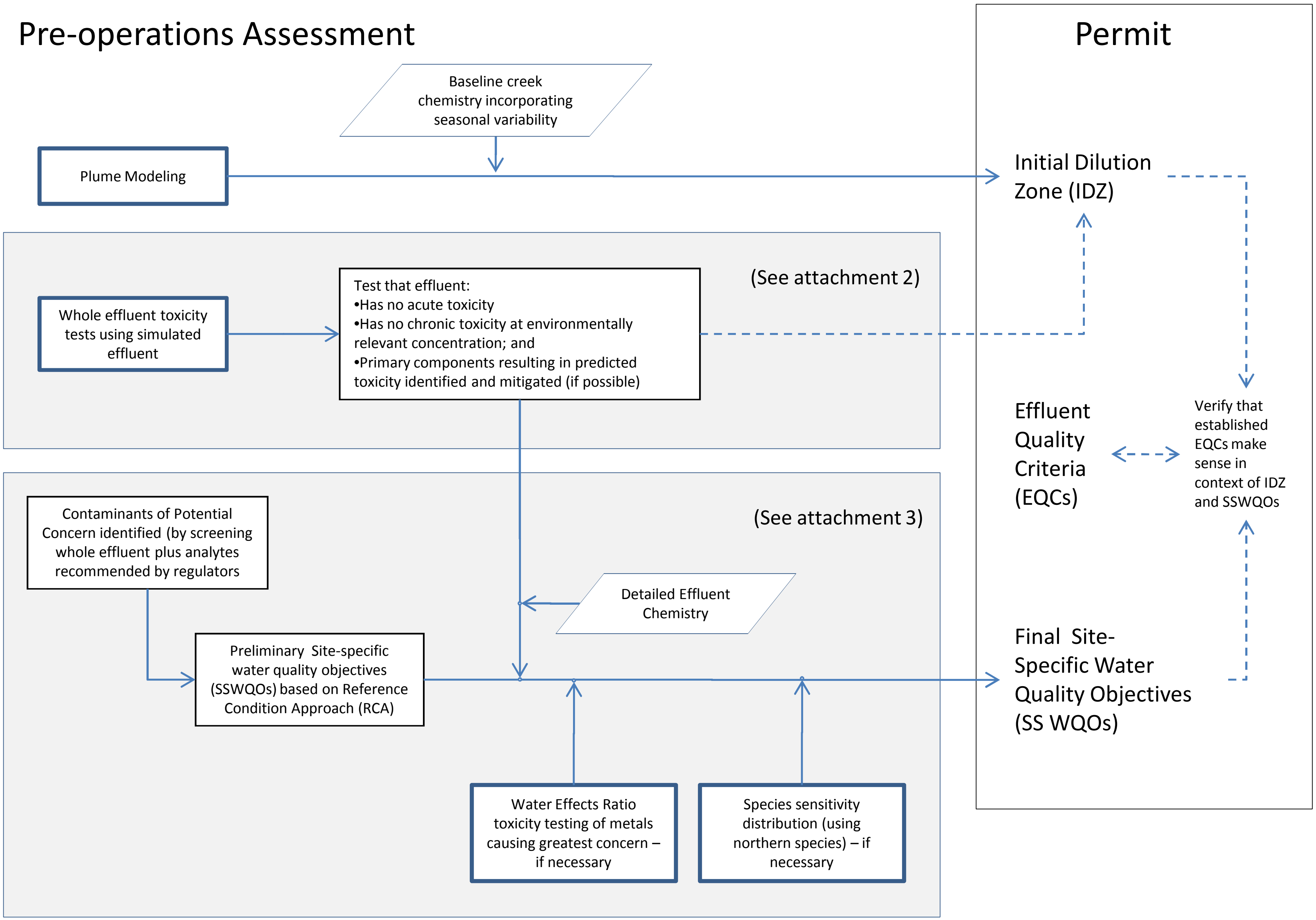
b) As done previously, the reference condition approach (RCA) will be applied to derive preliminary objectives for all the selected analytes of concern.

c) Review the results of toxicity tests, especially the results of chronic toxicity tests. Review the concentrations of all selected analytes in the highest test concentration tested that did not result in any observed toxicity. If the concentrations in this test sample are higher than both the CCME guidelines and the RCA derived objectives, it indicates that the higher of the CCME guidelines or RCA derived objectives is sufficiently protective. Therefore adopt the higher of the two. If the concentration in this sample are not higher than both the CCME guidelines and RCA derived objective, then keep the RCA-derived objective.

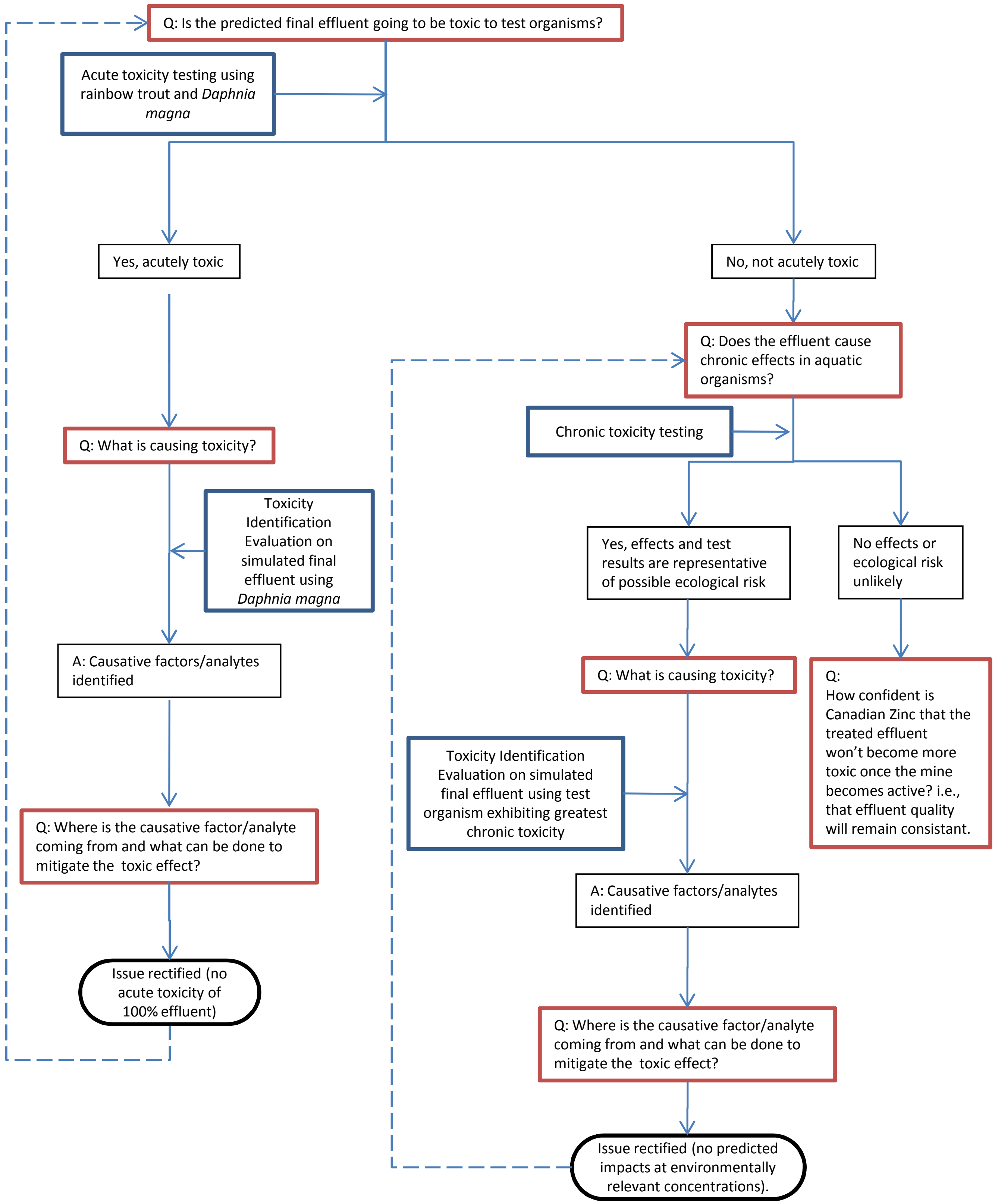
d) Re-compare the predicted concentrations of analytes of concern against the revised list of SSWQOs. If there are predicted metals concentrations exceeding the revised list of site-specific objectives, conduct Water Effects Ratio testing (WER) using Prairie Creek water. The natural hardness of Prairie Creek water will reduce the toxicity of metals in test water, and the use of Prairie Creek water for toxicity test dilutions will also be more representative of actual conditions. The WER testing is designed to quantify the toxicity reducing effect of natural waters relative to the conditions used in the tests upon which the CCME guideline was derived. In order to conduct these tests, selected metals of concern are added as metal salts to both laboratory water and Prairie Creek water at a range of concentrations. The ratio of predicted toxicities is used to modify the CCME guideline upwards. If the modified CCME guideline is greater than the revised site-specific objective derived in the last step, (c) above, adopt the WER modified CCME guideline as the new site-specific objective.

e) Re-compare the predicted concentrations of analytes of concern against the newly revised list of site-specific objectives. Again, if there are predicted analyte concentrations exceeding the revised list of site-specific objectives, derive a northern species toxicity distribution curve for those analytes. This approach uses the dose-response curves of northern species to derive a northern species-specific objective. The dose-response curves are developed by both conducting laboratory toxicity tests using northern species, as well as extracting similar data from the relevant peer-reviewed literature. This approach is very intensive and will likely not be necessary.

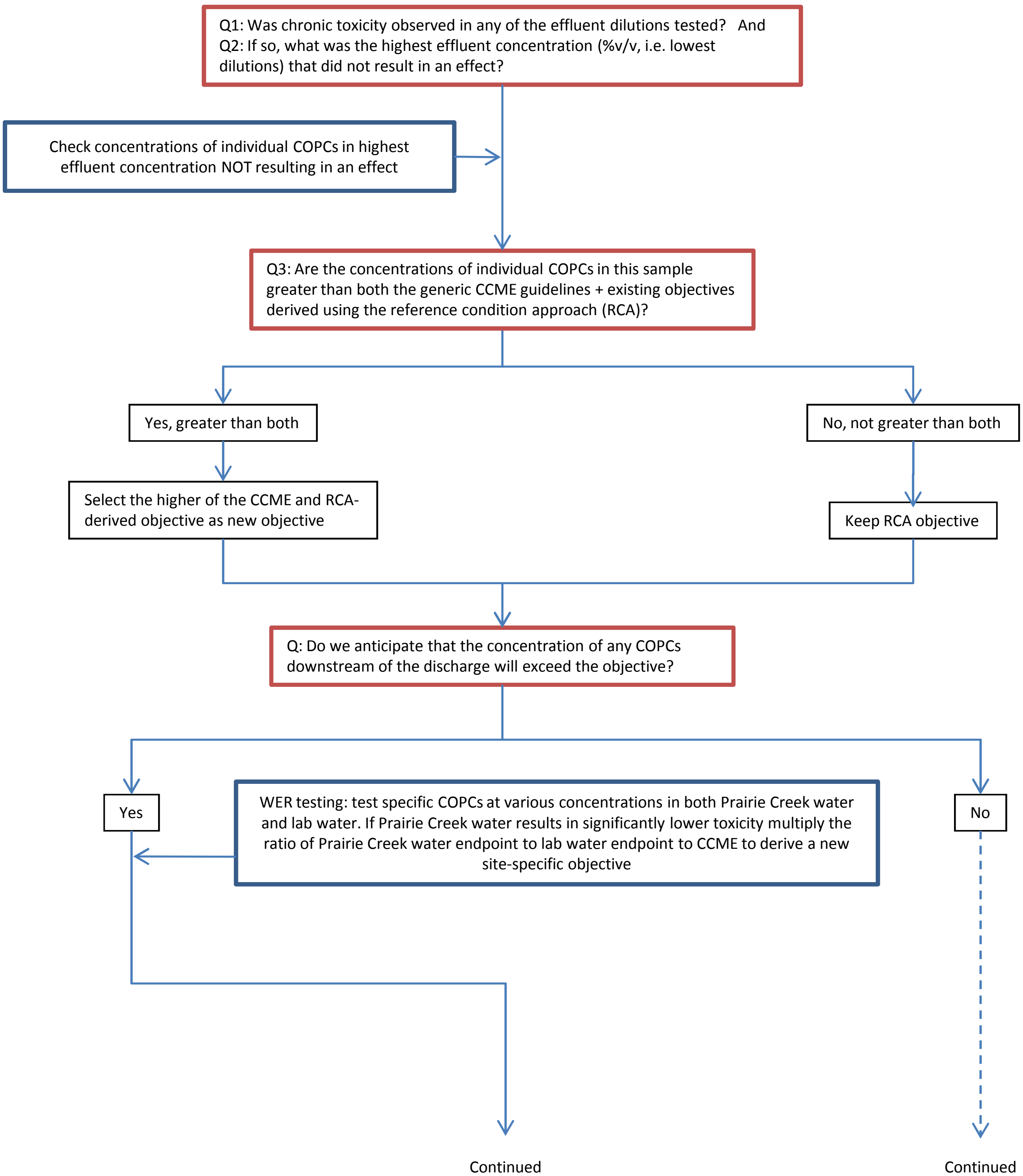
Attachment 1: Pre-operations Overview Slide.



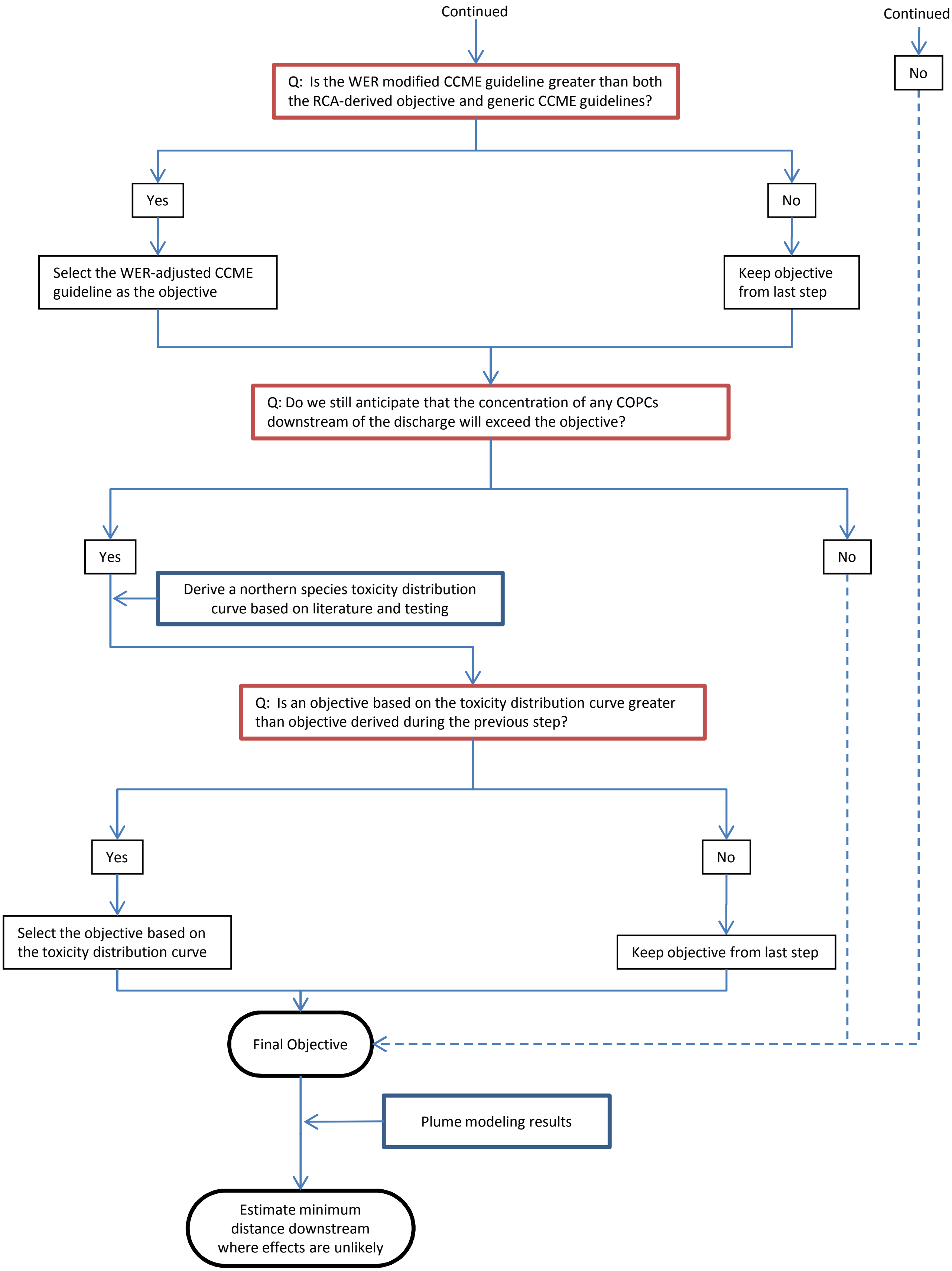
Attachment 2: Pre-operations toxicity testing decision tree.



Attachment 3: Pre-operations site-specific water quality objective derivation decision tree.



Attachment 3: continued.



Appendix A2

Proposed Revisions to the CCME Guidelines for Cadmium, Uranium and Zinc

Environment Canada Environnement Canada

Canada

Federal water quality guidelines for the protection of aquatic life for *cadmium, uranium and zinc* developed under the Chemicals Management Plan

19 June 2009

SETAC Laurentian Annual Meeting, Ottawa

Contact: Susan Roe

National Guidelines and Standards Office

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Special Thanks

Ariane Bouffard,

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Leana Van der Vliet, and

Lauren Clark

Patti Orr, Minnow Environmental Inc.

Outline

- Chemicals Management Plan (CMP)
- Role of Federal Environmental Quality Guidelines (FEQGs) in CMP
- CEQGs (a.k.a. CCME) vs. FEQGs
- Draft Federal Water Quality Guidelines for Zinc, Cadmium, and Uranium
  - Summary of data
  - Adjustments for hardness
- Summary & Questions

Chemicals Management Plan
www.chemicalsubstances.gc.ca

- **Significantly strengthen the existing substances regime:** Categorization of substances on Canada's Domestic Substance List has established a new information baseline that sets clear priorities for action

- **Integrate Governments Activities:** Chemicals Management Plan will strengthen CEPA's coordination with other federal statutes, including: *Hazardous Products Act, Food & Drugs Act*, and *Pest Control Products Act*

- **Establish Government Accountability:** The Plan includes regulations that will draw on:
  - Enhanced monitoring and surveillance activities
  - Increased research activities
  - Enhanced risk communications to Canadians
  - A cyclical update of the Domestic Substances List
  - Public web portal

- **Strengthening industry's role in proactively identifying and safely managing risks associated with chemicals they produce and use**

- **Cooperate with international programs related to chemicals management**

Chemicals Management Plan www.chemicalsubstances.gc.ca

- **Describes the Government's overall approach to assess and manage the risks associated with 4300 existing substances identified through categorization by 2020**
- **Of the 23,000 substances on the Domestic Substances List (DSL), 4300 were prioritized as high (500), medium (2600) and low (1200) concern**
- **Brings all existing federal programs together into a single strategy to ensure that chemicals are managed appropriately to prevent harm to Canadians and their environment**
- **It is science-based and specifically designed to protect human health and the environment through four major areas of action:**
  - Taking action on chemical substances of high concern
  - Taking action on specific industry sectors
  - Investing in research and biomonitoring
  - Improving the information base for decision-making through mandatory submission of use and volume information

Federal Environmental Quality Guidelines

- One tool of many that can be used in both ecological risk assessment and risk management of substances under CMP

- Provide science-based benchmarks for environmental protection, and guidance for toxic impacts
  - A toxicity-derived value which does not take into account policy or socio-economic factors

Federal Legislative Context

Canadian Environmental Protection Act 1999

Statutory obligation (CEPA Part 3)

Section 54 (1)

the Minister shall issue... environmental quality guidelines... specifying recommendations in quantitative or qualitative terms to support and maintain particular uses of the environment

Legislative Context: Other

CEPA Part 7

Protection of the Marine Environment from Land-Based Sources of Pollution... *the Minister may…issue environmental objectives…to prevent and reduce marine pollution from land-based sources*

CEPA Part 9 Government Operations

Section 208 (1) *the minister shall …establish objectives, guidelines and codes of practice…related to the quality of the environment* (e.g., CEPA Glycol Guidelines, 1994)

Performance Measures

… even if release reductions were measured, the levels necessary to bring the risks down to acceptable levels have never been established… it would not be known whether risks to human health or the environment had been sufficiently reduced… (CESD 4.81, 1999)

National vs. Federal EQGs

	CWQG (a.k.a CCME)	New Federal WQGs
Guiding Principle	All species over indefinite exposure	Same
Type	Long-term & short-term	Long-term only
Preferred approach	Species Sensitivity Distribution	Same
Guideline Value	5^{th} percentile	Same
Risk Ranges	N/A	low, medium and high
Data requirements	Rigorous	More flexible
Approval	Federal, provincial and territorial gov'ts (CCME)	Federal
Priorities	National (F/P/T)	CMP medium priorities, CMP monitoring (federal only)

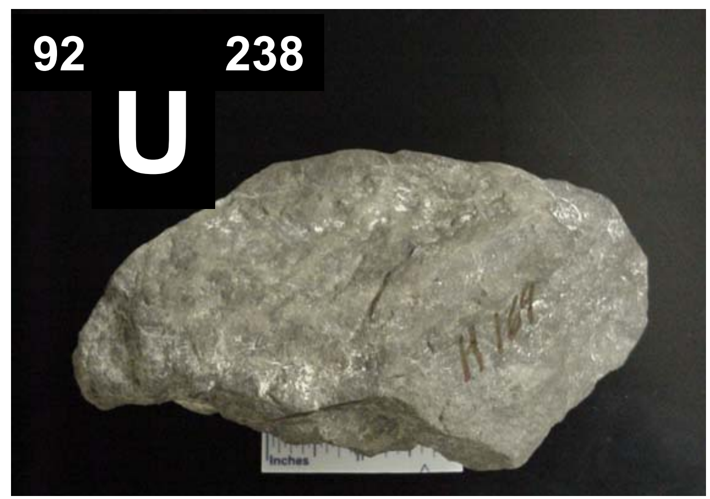
FWQGs: The Guiding Principles

- Protect all forms of aquatic life and all aspects of aquatic life cycles
  - Guideline value aims to approximate level below which there are no observable adverse effects over the long-term
  - If this level is exceeded, there is an increased probability of an adverse effect but no absolute certainty of adverse effect
- Protection of species from negative effects of anthropogenically altered environmental parameters (e.g. pH, temperature, DO) or exposures to substances via the water column

- Zn “tentative” CWQG (1987) = 30 µg/L

- Cd interm CWQG (1996) = $10^{\{0.86[\log(\text{hardness})]-3.2\}}$

- No CWQG
- EC Surface Water Quality Guideline (1983) = 300 µg/L



Toxicity Modifying Factors

- hardness
- pH
- alkalinity
- temperature
- acclimation
- salinity
- dissolved oxygen
- phosphate
- dissolved solids
- dissolved organic matter

developed new relationship for hardness

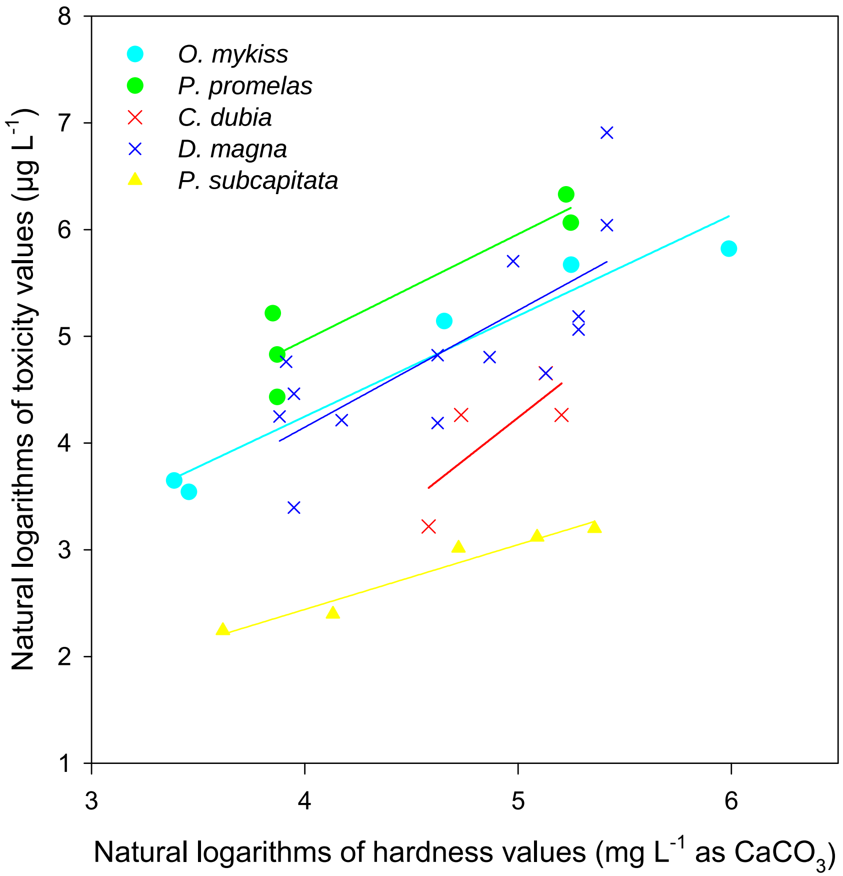
Insufficient data collected to develop new relationship

- *Evaluated existing eq'ns from USEPA (2001) and USGS (2006)*
- *Used slope from USEPA (2001)*
- *Re-calculated intercept*

No relationships developed at this time.

Zinc Relationship with Hardness (Long-term endpoints)

- no significant difference ($p = 0.48$) among the slopes for 2 fish sp., 2 inverts sp., and 1 algae sp.
- pooled slope is 1.049 ($R^2 = 0.8517$; $p < 0.0001$).

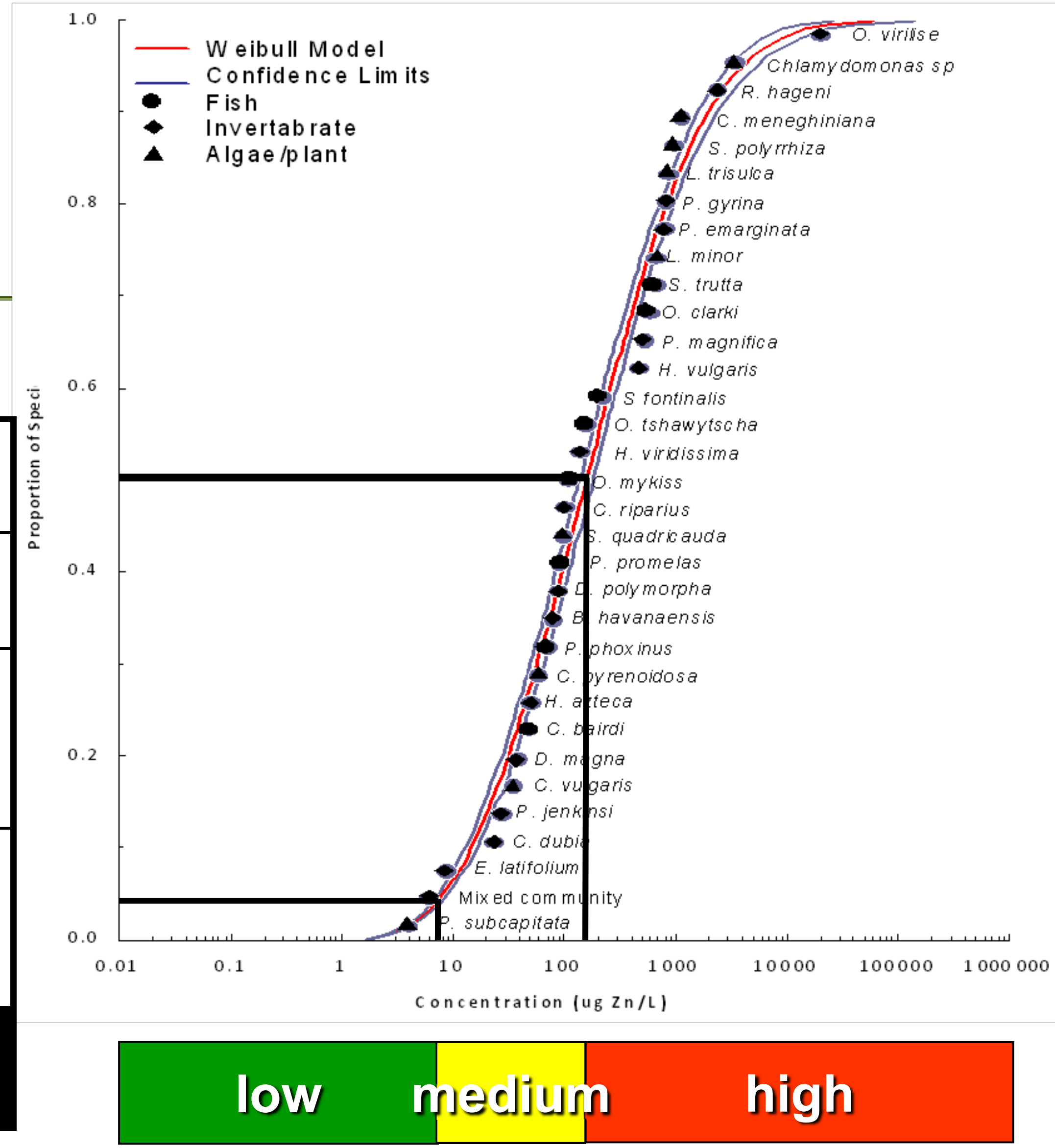


Data for Long-term FWQGs

	Total	No. Spp.	EC_X	EC_{10}	MATC	NOEC	EC_{20}	LOEC	$EC_{26\text{-}49}$	EC_{50} (non-lethal)
	406	33	0	23	4	1	0	2	0	3
	152	29	0	7	14	6	0	0	0	2
	181	10	0	7	3	0	0	0	0	0

Zinc

Statistic	Zinc (µg/L)
Best Fit model	Weibull
90% LFL (5%) SSD 5th percentile	7.4
90% UFL (95%) SSD 5th percentile	9.0
SSD 5th percentile	8.2



Hardness-dependent Equation

- Long-term toxicity-hardness pooled slope is 1.049
- Long-term zinc 5th percentile value at 50 mg/L hardness is 8.2 µg/L
- Therefore slope of the line is known (1.049) and an x,y co-ordinate is known (50, 8.2) so general equation can be determined by solving for the y-intercept
- y-intercept (b) = ln (5th percentile) - [slope X ln(hardness)]

  = ln (8.2) - [1.049 X ln(50)]

  = - 2.0
- The equation to derive the long-term Federal Water Quality Guideline (FWQG) to protect freshwater life is:

$$\mathbf{FWQG = e^{\{1.049[\ln(hardness)] - 2\}}}$$

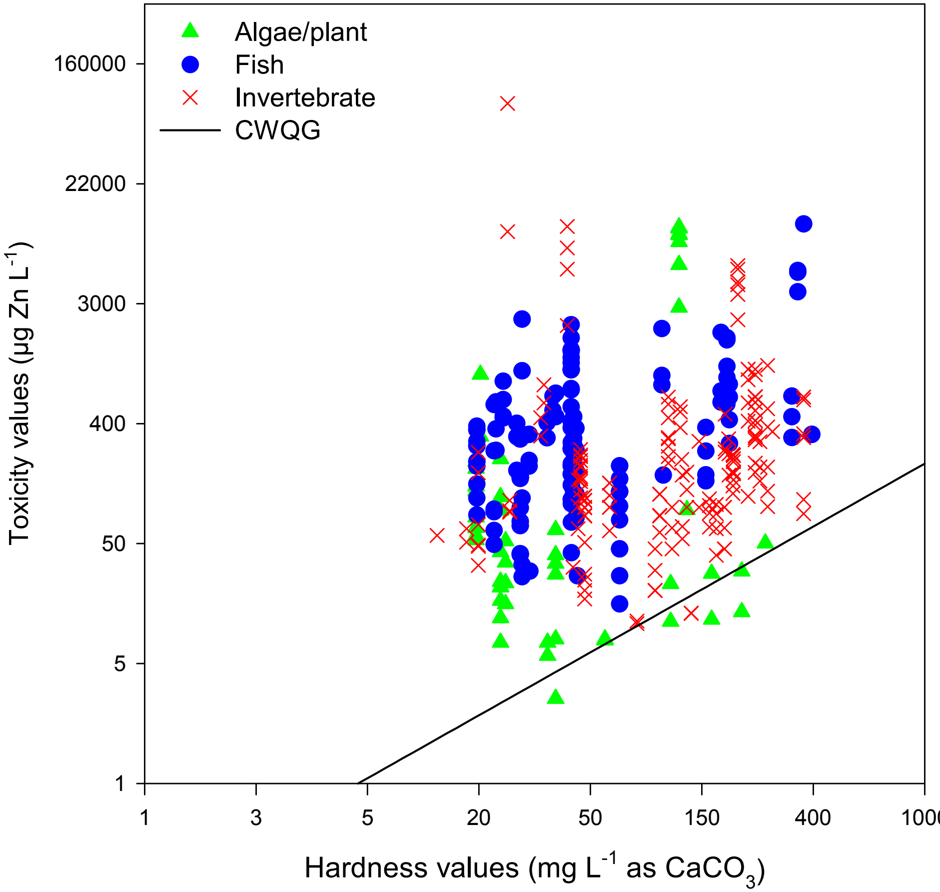
Draft Long-term FWQG at Various Levels of Water Hardness

Hardness	FWQG	CWQG (1987)
mg/L as $CaCO_3$	Zinc µg/L	
Soft (30)	5	30
Standard (50)	8	
Moderate (90)	15	
Hard (120)	21	
Harder (180)	31	
Very Hard (200)	35	
Super Hard (300)	54	

Evaluation of Zn Guideline

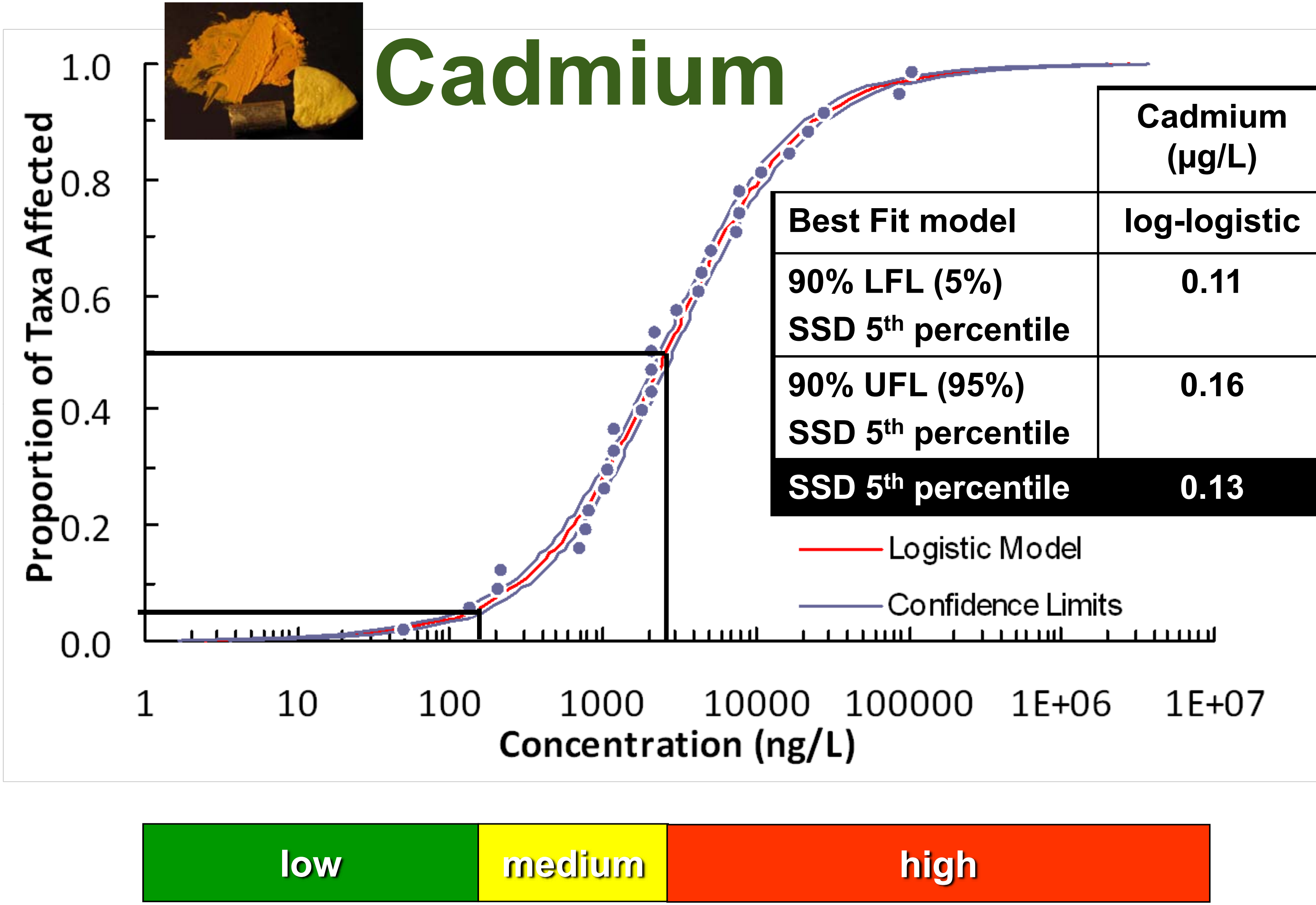
$$FWQG = e^{\{1.049[\ln(\text{hardness})] - 2\}}$$

All uncorrected long-term toxicity values (n = 370) plotted against hardness; 6 below.



Environment Canada Environnement Canada

Canada



	Cadmium (µg/L)
Best Fit model	log-logistic
90% LFL (5%) SSD 5th percentile	0.11
90% UFL (95%) SSD 5th percentile	0.16
SSD 5th percentile	0.13

Cadmium FWQG Hardness-dependent Equation

- Based on U.S. EPA long-term toxicity-hardness slope of 0.7409
- Long-term cadmium 5th percentile value at 50 mg/L hardness is 0.13 µg/L
- Therefore slope of the line is known (0.7409) and an x,y co-ordinate is known (50, 0.13) so a general equation can be determined by solving for the y-intercept
- y-intercept (b) = ln (5th percentile) - [slope X ln(hardness)]

  = ln (0.13) - [0.7409 X ln(50)]

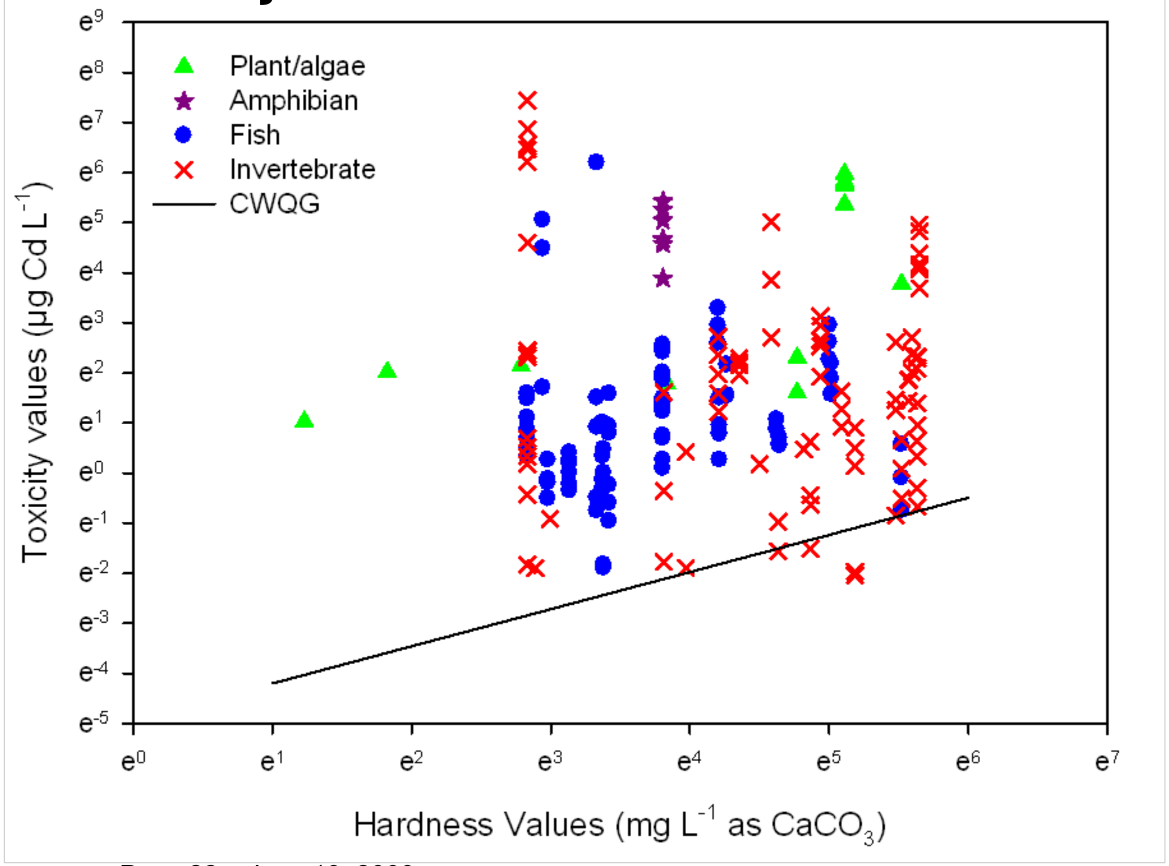
  = - 4.94
- The equation to derive the long-term Federal Water Quality Guideline (FWQG) to protect freshwater life is:

$$\mathbf{FWQG = e^{\{0.7409[\ln(hardness)] - 4.94\}}}$$

Evaluation of Cd Guideline

FWQG = e $^{\{0.7409[\ln(\text{hardness})] – 4.94\}}$

All uncorrected long-term toxicity values (n = 249) plotted against hardness; 5 below

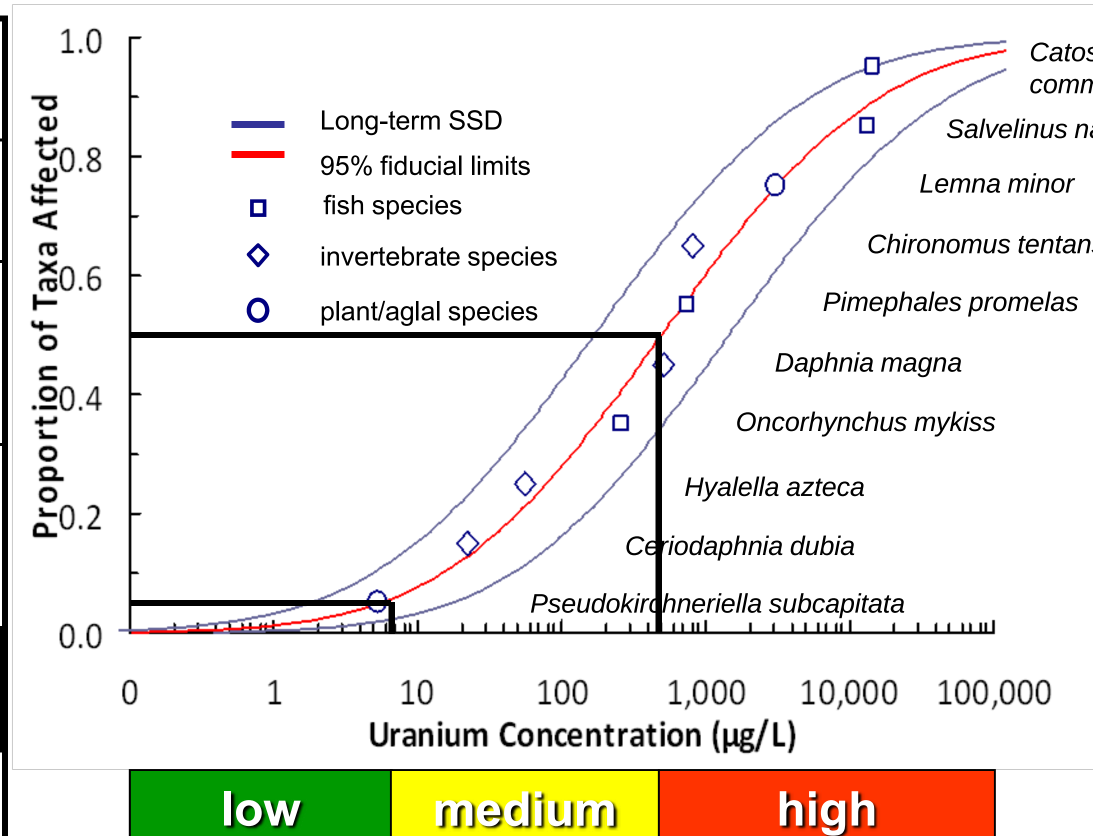


Cadium Guideline at Various Levels of Water Hardness

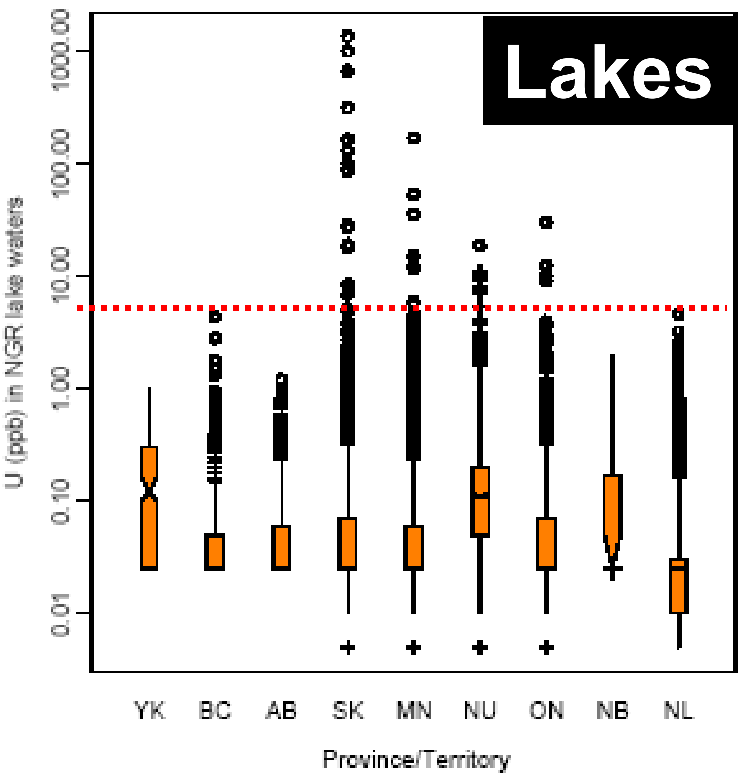
Hardness	FWQG draft	CWQG 1996	Ontario 1994	USEPA 2001	NL 2001	A&NZ 2007
mg/L as $CaCO_3$	Cadmium µg/L					
Very Soft (10)	0.04	0.01	0.1 ≤ 100mg $CaCO_3$/L	0.05	Total 0.4 Disv'd 0.08	0.2
Soft (30)	0.10	0.01		0.11		
Standard (50)	0.13	0.02 (0.017)		0.16		
Moderate (90)	0.20	0.03		0.25		
Hard (150)	0.29	0.05	0.2 > 100mg $CaCO_3$/L	0.37		
Very Hard (210)	0.38	0.06		0.47		

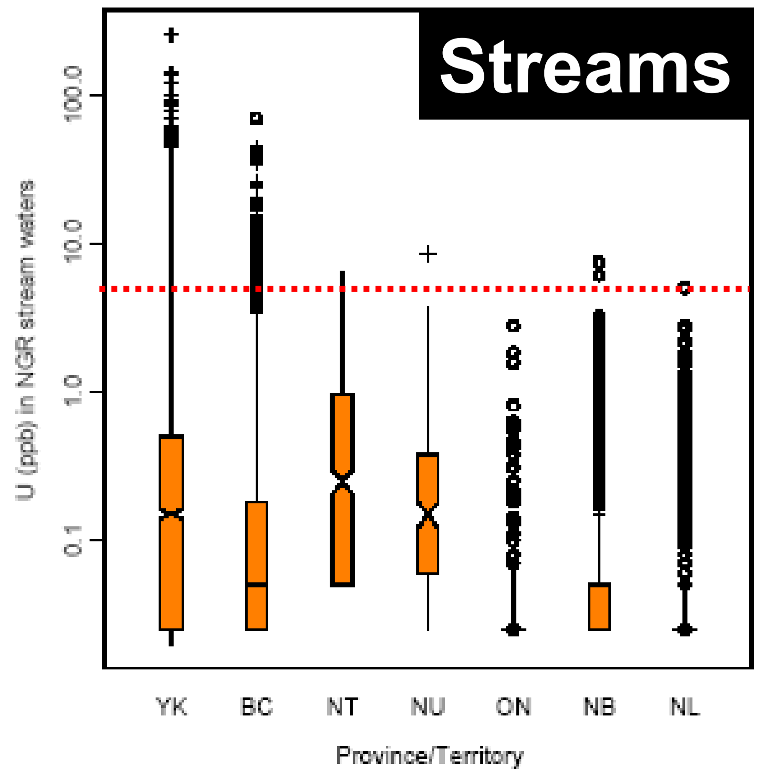
Uranium

Statistic	Uranium (µg/L)
Best Fit model	Log-Normal
90% LFL (5%) SSD 5th percentile	5.5
90% UFL (95%) SSD 5th percentile	1.8
SSD 5th percentile	**17**
EC SWQG (1983)	300



Natural Background





FWQG
= 5.5 µg/L

Summary

- New Federal Water Guidelines contribute to Canada's Chemicals Management Plan
  - Tools for risk assessors and risk managers
- FWQG drafted for Cd, U, and Zn using species sensitivity distributions
- Values will be tabled with CCME for consideration as *Canadian Water Quality Guidelines*

$$\text{FWQG} = e^{\{1.049[\ln(\text{hardness})] - 2\}}$$

$$\text{FWQG} = e^{\{0.7409[\ln(\text{hardness})] - 4.94\}}$$

$$\text{FWQG} = 17\ \mu g/L$$

Questions & Discussion

Appendix A3

Progress Report for Toxicity Testing and Toxicity Identification Evaluation

February 24, 2011

Memo: **Progress report for toxicity testing and toxicity identification evaluation**

To	John Wilcockson	*From*	James Elphick
Affiliation	Hatfield Consultants	*Tel*	250-480-3941
e-mail	jwilcockson@hatfieldgroup.com	*e-mail*	james@nautilusenvironmental.com

The following reflects a summary of results from testing to establish the degree and cause of toxicity associated with laboratory-prepared effluents to simulate future conditions at a mine planned by Canadian Zinc. It should be noted that the results summarized below are preliminary and the results are subject to QA/QC review, and the findings and conclusions may change as a result of that review. Furthermore, Toxicity Identification efforts are on-going, and the conclusions of that process are not yet conclusive. The test results relate only to the samples tested.

Two samples were evaluated for toxicity with two acute and two chronic toxicity tests. One of the water types was comprised of 80% Mine Water and 20% Process water (4:1), and the other comprised of 79% Mine Water, 10% Process Water (8:1) and 11% Ditch Water. Each of these samples was tested using:

- Acute toxicity test (LC50) using rainbow trout
- Acute toxicity test (LC50 using *Daphnia magna*
- Chronic toxicity test using *Ceriodaphnia dubia* (7 d survival and reproduction)
- Chronic toxicity test using *Lemna minor* (7 day frond production/growth)

Each of the acute toxicity tests were conducted using both site water (Prairie Creek) and laboratory water for dilution.

The results from the toxicity tests indicated an absence of adverse toxicological effects in the rainbow trout and *L. minor* tests. Conversely, effects were observed on reproduction of *C. dubia* in all test concentrations, with no reproduction of *C. dubia* in the 40% and higher concentrations in the 4:1, and the 60% and higher concentration in the 8:1 sample. In addition, survival in the *D. magna* test was 40% in one test of the 4:1 sample, and 100% in the second test (average of 70% survival from the two synoptic tests, one using Prairie Creek water and the other laboratory water). There was no effect on survival of *Daphnia* in the full-strength 8:1 sample.

Nautilus Environmental
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Burnaby, BC
V5A 4N7

The results of the testing demonstrated that the samples exhibited effects on reproduction (but not survival) of *Ceriodaphnia*, and that the 4:1 sample exhibited a small degree of effect in the *Daphnia* test. The results were consistent with the Process Water being the source of toxicity in the samples, since the 4:1 sample exhibited a greater degree of adverse effect to daphnids. Further supporting this conclusion, the full strength mine water tested for acute toxicity using *Daphnia*, and resulted in no adverse effect.

A Toxicity Identification Evaluation has been initiated to establish the cause of toxicity. This effort has focussed on the Process Water. Initial treatments included EDTA treatment, which identifies toxicity caused by divalent metal cations (e.g., copper, cadmium, zinc); filtration, which removes toxicity associated with the particulate phase; C18 solid phase extraction, which identifies toxicity caused by non-polar organics; and anion exchange, which identifies toxicity caused by strong anions. None of these treatments were able to remove toxicity in the Process Water diluted to 10%, suggesting that none of these types of materials were solely responsible for the effects observed in the sample diluted to 10%. No adverse effects were observed in the sample diluted to 5%.

Efforts to characterize the cause of toxicity are on-going; however, since the effect observed is on reproduction of *Ceriodaphnia*, each round of tests takes about one week to complete, which is slowing the progress of the tests.

The chemistry associated with the Process Water was reviewed to establish whether any measured materials were present which might explain toxicity observed in the sample diluted to 10%. Of the measured metals which are commonly associated with toxicity, copper (71 μg/L) and zinc (1350 μg/L) were present in full-strength sample at concentrations that exceed thresholds for effects observed in our laboratory using this species under moderately hard conditions. At a 10% dilution of the water, the copper concentration was well below adverse effect concentrations, and elevated hardness in the Process Water would be expected to reduce toxicity associated with this metal. Thus, copper is unlikely contributing to toxicity in the diluted sample. Conversely, zinc was present at a concentration similar to the threshold for effects to this species in the 10% diluted sample. Cadmium and cobalt were at concentrations that were lower than thresholds for effects observed previously for this species.

Major ions (measured generically as Total Dissolved Solids [6100 mg/L]), and sulphate in particular (4500 mg/L), were present in the Process Water sample at a concentration that explains some of the adverse effects observed to this species. However, a 10% dilution of this water should have diluted these materials to less than their effect level to *Ceriodaphnia*.

Additional efforts will focus on establishing the driver of toxicity in the 10% sample. Please feel free to contact me should you have any questions regarding the progress to date.

Yours truly,
James Elphick, R.P.Bio.
Environmental Toxicologist

Appendix A4

Chemistry of Treated Process and Mine Water, and Camp Ditch Water

Table A4.1 Concentration of non-metals in treated process and mine water, and camp ditch water.

Calculated Parameters	Units	Process Treated	Mine Treated	Camp Ditch
Misc. Inorganics				
Dissolved Hardness (CaCO3)	mg/L	470	576	
Anions				
Dissolved Sulphate (SO4)	mg/L	4500	470	110
Dissolved Chloride (Cl)	mg/L	310	1.7	<0.5
Nutrients				
Ammonia (N)	mg/L	0.29 (1)	0.043	0.054
Nitrate (N)	mg/L	<2	<2	0.419
Nitrite (N)	mg/L	<0.5 (1)	<0.5 (1)	<0.002 (1)
Nitrate plus Nitrite (N)	mg/L	<2 (1)	<2 (1)	0.419 (1)
Orthophosphate (P)	mg/L	0.025	<0.005	<0.005
Total Phosphorus (P)	mg/L	0.230	0.003	
Physical Properties				
Conductivity	uS/cm	8820	1010	637
pH				7.96
Physical Properties				
Total Suspended Solids	mg/L	26	<4	<4
Total Dissolved Solids	mg/L	6100	700	380
Calculated Parameters				
Total Hardness (CaCO3)	mg/L	431	569	378
Misc. Inorganics				
Alkalinity (Total as CaCO3)	mg/L			240
Alkalinity (PP as CaCO3)	mg/L			<0.5
Bicarbonate (HCO3)	mg/L			290
Carbonate (CO3)	mg/L			<0.5
Hydroxide (OH)	mg/L			<0.5

RDL = Reportable Detection Limit
EDL = Estimated Detection Limit
(1) = RDL raised due to sample matrix interference.

Table A4.2 Concentration of total metals in treated process and mine water, and camp ditch water.

Total Metals by ICPMS	Units	Process Treated	Mine Treated	Camp Ditch
Total Aluminum (Al)	ug/L	<30	4	5
Total Antimony (Sb)	ug/L	119	25.3	2.2
Total Arsenic (As)	ug/L	9	0.2	0.8
Total Barium (Ba)	ug/L	<10	<1	55
Total Beryllium (Be)	ug/L	<1	<0.1	<0.1
Total Bismuth (Bi)	ug/L	<10	<1	<1
Total Boron (B)	ug/L	<500	<50	<50
Total Cadmium (Cd)	ug/L	24.3	0.04	0.35
Total Chromium (Cr)	ug/L	<10	<1	<1
Total Cobalt (Co)	ug/L	<5	<0.5	<0.5
Total Copper (Cu)	ug/L	71	0.7	2.2
Total Iron (Fe)	ug/L	5400	21	44
Total Lead (Pb)	ug/L	304	1.7	23.2
Total Manganese (Mn)	ug/L	50	<1	1
Total Mercury (Hg)	ug/L	1.9	<0.02	<0.5 (3)
Total Molybdenum (Mo)	ug/L	<10	2	4
Total Nickel (Ni)	ug/L	12	2	2
Total Phosphorus (P)	ug/L	246	<10	<10
Total Selenium (Se)	ug/L	10	2.8	2.4
Total Silicon (Si)	ug/L	13500	2790	2040
Total Silver (Ag)	ug/L	0.7	<0.02	0.05
Total Strontium (Sr)	ug/L	54	180	331
Total Thallium (Tl)	ug/L	<0.5	0.16	<0.05
Total Tin (Sn)	ug/L	<50	<5	<5
Total Titanium (Ti)	ug/L	<50	<5	<5
Total Uranium (U)	ug/L	2	4.9	
Total Vanadium (V)	ug/L	<50	<5	<5
Total Zinc (Zn)	ug/L	1350	<5	53
Total Zirconium (Zr)	ug/L	<5	<0.5	<0.5
Total Calcium (Ca)	mg/L	65.1	25.1	80.6
Total Magnesium (Mg)	mg/L	65.2	123	42.9
Total Potassium (K)	mg/L	7.0	2.86	0.93
Total Sodium (Na)	mg/L	1890	1.54	3.30
Total Sulphur (S)	mg/L	1730	169	46
Elements				
Dissolved Mercury (Hg)	ug/L			0.015 (1)
Total Mercury (Hg)	ug/L			0.028 (2)

RDL = Reportable Detection Limit

EDL = Estimated Detection Limit

Table A4.3 Concentration of dissolved metals in treated process and mine water, and camp ditch water.

Elements	Units	Process Treated	Mine Treated	Camp Ditch
Dissolved Mercury (Hg)	ug/L	0.28	0.02	
Dissolved Metals by ICPMS				
Dissolved Aluminum (Al)	ug/L	<10	11	<3
Dissolved Antimony (Sb)	ug/L	116	25.0	1.6
Dissolved Arsenic (As)	ug/L	8.2	0.2	0.2
Dissolved Barium (Ba)	ug/L	<4	<1	57
Dissolved Beryllium (Be)	ug/L	<0.4	<0.1	<0.1
Dissolved Bismuth (Bi)	ug/L	<4	<1	<1
Dissolved Boron (B)	ug/L	<200	<50	<50
Dissolved Cadmium (Cd)	ug/L	22.6	0.05	0.04
Dissolved Chromium (Cr)	ug/L	<4	<1	<1
Dissolved Cobalt (Co)	ug/L	3	<0.5	<0.5
Dissolved Copper (Cu)	ug/L	79.6	4.5	0.4
Dissolved Iron (Fe)	ug/L	2620	8	<5
Dissolved Lead (Pb)	ug/L	252	1.8	0.5
Dissolved Lithium (Li)	ug/L			6
Dissolved Manganese (Mn)	ug/L	48	13	<1
Dissolved Mercury (Hg)	ug/L			<0.02
Dissolved Molybdenum (Mo)	ug/L	5	2	4
Dissolved Nickel (Ni)	ug/L	13	<1	1
Dissolved Phosphorus (P)	ug/L	390	<10	<10
Dissolved Selenium (Se)	ug/L	10.1	3.2	2.5
Dissolved Silicon (Si)	ug/L	12300	2520	1850
Dissolved Silver (Ag)	ug/L	0.72	<0.02	<0.02
Dissolved Strontium (Sr)	ug/L	52	174	317
Dissolved Thallium (Tl)	ug/L	<0.2	0.17	<0.05
Dissolved Tin (Sn)	ug/L	<20	<5	<5
Dissolved Titanium (Ti)	ug/L	<20	<5	<5
Dissolved Uranium (U)	ug/L	2.7	4.6	8.7
Dissolved Vanadium (V)	ug/L	<20	<5	<5
Dissolved Zinc (Zn)	ug/L	1430	<5	6
Dissolved Zirconium (Zr)	ug/L	<2	<0.5	<0.5
Dissolved Calcium (Ca)	mg/L	67.8	23.9	70.9
Dissolved Magnesium (Mg)	mg/L	73.0	125	36.9
Dissolved Potassium (K)	mg/L	7.7	2.79	0.82
Dissolved Sodium (Na)	mg/L	2260	1.68	2.95
Dissolved Sulphur (S)	mg/L	2020	176	37
Dissolved Hardness (CaCO3)	mg/L			329

RDL = Reportable Detection Limit
EDL = Estimated Detection Limit

APPENDIX E

Preliminary Design of Exfiltration Trench

Northwest Hydraulics Co.

9819 – 12 Avenue SW | Edmonton, AB T6X 0E3 | 780.436.5868 | www.nhcweb.com

nhc
northwest hydraulic consultants

Ref. No. 16987

December 22, 2010

Canadian Zinc Corporation
Suite 1710 - 650 West Georgia Street
Vancouver, BC
V6B 4N9

Attention: David Harpley

Via email: david@canadianzinc.com

Re: Hydraulic Design Details for Exfiltration Trench Outfall to Prairie Creek REVIEW DRAFT

Dear Mr. Harpley:

1.0 INTRODUCTION

The water management plan proposed by Canadian Zinc Corporation (CZN) for operation of the Prairie Creek mine involves treating mine drainage water and mill process water to reduce metal concentrations, then discharging excess treated water to Prairie Creek. The rate of discharge is expected to vary from about 0.01 to 0.11 m^3/s. A NHC letter report dated September 9, 2010 presented a preliminary review of outfall alternatives. A diffuser was ruled out because of the lack of a suitably deep channel. NHC recommended a simple pipe outlet from the bank of Prairie Creek in order to minimize construction impacts. Subsequent mixing analysis for the pipe outlet and discussion with regulatory officials has led to a request by Canadian Zinc for NHC to develop design details for an exfiltration trench as an alternative outfall.

An exfiltration trench outfall consists of a perforated pipe in a pervious-backfill trench beneath the stream bed. Advantages to the exfiltration trench are that (1) outflow is possible at extreme low flow conditions; (2) the design is resilient to minor changes in the elevation or location of the low flow channel; and (3) effluent mixing is significantly improved over a simple pipe outlet. Disadvantages include: (1) a moderate construction impact due to excavation into the channel bed, and (2) the system could be difficult to service if plugged by unexpected solids in the wastewater or by siltation of the trench backfill material.

This report has been prepared to present hydraulic design details and conceptual construction methods for an exfiltration trench outfall from the stream bank to the end of pipe. There are several additional elements to the system which will be included in a final design but are beyond the scope of the present assessment. These elements are:

1) A backflow prevention device;
2) debris screens;
3) a water pump with flow regulating devices: (a) to operate the system under high streamflow conditions, (b) for pressure operation if the exfiltration system should become plugged over time, and (c) for backwashing of the exfiltration trench media; and

4) bubbler pipe details and connections for a future air pump for air-assisted backwashing of the exfiltration trench media.

The exfiltration trench system is being designed to function as a low head system which can pass the anticipated effluent release rates under gravity flow with normal stream water levels. However, because of uncertainty in the permeability of the trench backfill material and possible plugging of the backfill over time, it is recommended that the system be designed to include a pump and the ability to be switched to pressure flow operation when needed. A pump would provide the capabiity to release flows at rates that are considerably higher than the assumed maximum average rate, should the need arise.

2.0 DESIGN SPECIFICATIONS

The design specifications for the exfiltration trench are presented below.

Outfall location: the recommended position for the exfiltration trench is near the downstream end of the site catchment pond as illustrated in the accompanying figures. The trench is to be cut through a sparsely-vegetated section of stream bank about 25 m upstream from the Harrison Creek culverts. The stream bank at this location is gently sloping and complete restoration of the bank after construction should be easy to achieve. The work should avoid disturbance to the near-vertical well-vegetated bank adjacent to the Harrison Creek culverts. Within the stream, the trench is to be aligned perpendicular to the flow.

Exfiltration trench horizontal position: the trench bottom should extend 12 m into the channel relative to the water edge at normal summer flow (about 12 m^3/s). The perforated portion of pipe will begin 4 m from the left water edge and will end near the middle of the channel. Keeping the effluent release away from the left water edge will allow for fish passage avoiding the plume at its maximum concentration at the channel bed, prior to vertical mixing. The trench is kept to the deeper part of the channel (it does not extend to the far side which would be dry under normal winter flow conditions) and this helps to minimize the project footprint and associated construction impacts.

Exfiltration trench vertical position: the trench is to be excavated to have a bottom elevation 0.8 m below the channel thalweg (the deepest part of the channel, in this case near the left bank) so that the top of pipe is a minimum of 0.4 m below the thalweg. This bottom elevation is to be maintained from a starting position about 3 m into the left bank and continuing until the end of trench in the middle of the channel. The trench vertical position is based on a scour assessment which indicated that at flood flow, the existing thalweg reflects the maximum scour depth associated with the channel bed material. The design vertical position is based on a minimum pipe cover equal to a double layer thickness of 20 cm diameter rock.

Exfiltration trench dimensions: the trench cross section is to have a bottom width of 1.0 m and side-slopes of 1.5:1 (H:V). This will involve excavation to 1.2 m below the streambed at the end of the trench, and will require a surface cut 4.6 m wide. At the channel thalweg near the left water edge, the trench will be 0.8 m deep and 3.4 m wide at the streambed surface. A geotextile filter fabric should be placed along the trench bottom, extending up the sides to the same level as the top of pipe.

Exfiltration pipe dimensions: the pipe should have a minimum inside diameter of 0.3 m (12”). We have assumed a pipe outside diameter of 0.4 m for sizing the trench. With the specified pipe inside dimension, the design flows correspond to flow velocities from about 0.55 to 1.5 m/s, and velocity heads from 0.02 to 0.12 m. Assuming total energy losses in the outlet system do not exceed three times the velocity head, the system can perform well under gravity flow with less than 0.4 m water level difference between the catchment pond and the creek.

Exfiltration pipe perforations: the perforated section of the pipe is to be 8.0 m long, starting in the channel 4.0 m from the left water edge (at normal summer flow) and continuing to the end of trench in the middle of the channel. The end of pipe is to be capped. Perforations to allow for effluent release are to consist of a row of vertical slots cut from the upstream and downstream sides of the pipe. The slots should each be about 4 cm wide and 10 cm high and equally spaced at intervals of 25 cm on center for the 8 m length of perforated section. In total, there should be about 62 slots counting both sides of the pipe. The total area of the slots is 0.25 m^2 which is equivalent to 3.5 times the area of a 0.3 m diameter pipe. The perforations have been designed as constructible slots with a width smaller than the smallest rocks anticipated in the backfill material. Slots are specified instead of holes because they should be less likely to be substantially blocked by individual large stones in the backfill.

Optional bubbler pipe dimensions and perforations: specifications are to be determined. An air backwash pipe with a perforated section that coincides with the perforated exfiltration pipe is recommended to be installed in the bottom of trench on the upstream side of the exfiltration pipe. The maximum anticipated diameter of the air backwash pipe is 5 cm. This is for future use in efforts to dislodge fines from the trench backfill if the system hydraulic performance deteriorates over time. The concept is based on air agitation backwash methods that have been developed for water supply infiltration systems.

Trench backfill: The trench backfill is specified with three zones.

> Zone 1. The first and deepest zone is to extend the full 12 m length of trench as described above, including the solid and perforated sections of pipe. A geotextile filter fabric is to be placed along the bottom of trench and up the sideslopes to the level of the top of pipe. The backfill is to consist of large cobble armour placed from the bottom of trench to a height 0.4 m above the top of pipe. The cobbles shall consist of well sorted[1] stones with equivalent diameters between 15 and 20 cm. Suitable material can be sourced from outside of the floodplain, and angular material is acceptable. After placement of the cobble material, the zone is to be top-dressed with well sorted small material with a diameter of about 5 cm, which is slightly larger than the perforation slot width. The top dressing is to be applied to help lock the cobbles together and to provide a filter against the downward migration of materials <5 cm. The top dressing is to be applied to a level which just covers the tops of the cobble material.
>
> Zone 2. The second zone is to be placed over the segment of trench which contains the perforated pipe section. Vertically, it will extend up from the top of the first zone and be shaped to restore the original channel geometry. Material in this zone is to reflect the native bed material, but without fines that would impede percolation. For a design specification, we would suggest a median size in the range 5 to 15 cm, with a minimum size of 1 cm. It should be feasible to obtain a suitable gradation by washing or screening the material excavated from the streambed during trench construction.
>
> Zone 3. The third zone is to be placed over the segment of trench which contains the solid pipe section. Vertically it will extend up from the top of the first zone and be shaped to restore the original channel geometry, including the bank. Material in this zone can use the same material originally excavated from the trench without screening, subject to ensuring that the gradation of the top layer reflects the original surface appearance.

From a fish habitat perspective, the intent with the placement of the Zone 2 and Zone 3 backfill materials is to restore the bed with no loss of habitat value.

---

[1] Well sorted means that the material is all the same size.

3.0 CONSTRUCTION SPECIFICATIONS

Construction specifications presented here are offered as a feasible way in which the work could be performed, based on our understanding of the site and locally available resources. Final specifications will need to be confirmed by, or developed in consultation with, the contractor or personnel who will actually do the work, considering the need to manage water quality and protect the stream.

General Requirements

In-stream construction activity will be limited to a time window that is acceptable from a fisheries perspective. We understand that such a window presently exists from July 16 to August 15. This is based on possible spawning activity outside of the window, although no evidence of spawning has been noted along this stretch of Prairie Creek. Consideration will also need to be given to prevailing creek water levels and the weather forecast. The window is normally a quiescent time of year but intense summer rainfall can change conditions quickly.

In-stream construction activities will be subject to active environmental monitoring and documentation of ambient and downstream water quality while the work is in progress.

Isolation of the Work Area

Several methods have been considered for isolation of the work area during construction. The recommended method is to deflect the channel to the far side of the stream using bulk bags filled with washed rock and to then complete the isolation in tranquil water. At a typical August flow (about 12 m^3/s), the deflection of water to the far side of the channel where the work is proposed will cause a water level increase of about 0.5 m on the upstream side of the deflection berm. Additional bulk bags or possibly other barriers would be used to complete the perimeter berm that isolates the work area. The alignment and area to be enclosed will depend on access needs for the specific equipment that will be used to do the work, and whether the equipment must be kept out of the water.

We propose that a portion of the isolated area be filled with a pad constructed of washed rock, which will allow out-of-water equipment access to the full length of exfiltration trench from the upstream side of the trench. This would involve filling a portion of the channel (within the isolated area) with washed rock, working from the pad to construct the trench, then carefully removing the pad and restoring the channel to its original geometry. Construction and subsequent removal of the pad would likely be done concurrently with construction (and removal) of the deflection berm: the work pad would allow equipment to more easily access the far end of the berm.

Some sort of water block (such as a low permeability geotextile) should be incorporated into the perimeter barrier to isolate the work area. To prevent the release of turbid water, water should be pumped from the work area so that the interior water level is slightly less than the adjacent downstream water level and the direction of flow is into (not out of) the work zone. Water should be pumped to a suitable settling location; pumping to the main storage pond would be a possibility. Pumping would continue during gradual barrier removal to prevent the development of a plume of turbid water.

Another option which was considered would be to do the work in late winter when streamflows are the lowest. However, it was felt that the winter flows (typically about 0.4 m^3/s) are probably still too large for the site to be isolated solely by pumping water around the work zone, and other diversion methods would be complicated by the cold conditions.

We trust that the above assessment meets your immediate needs; please do not hesitate to call if there are any questions.

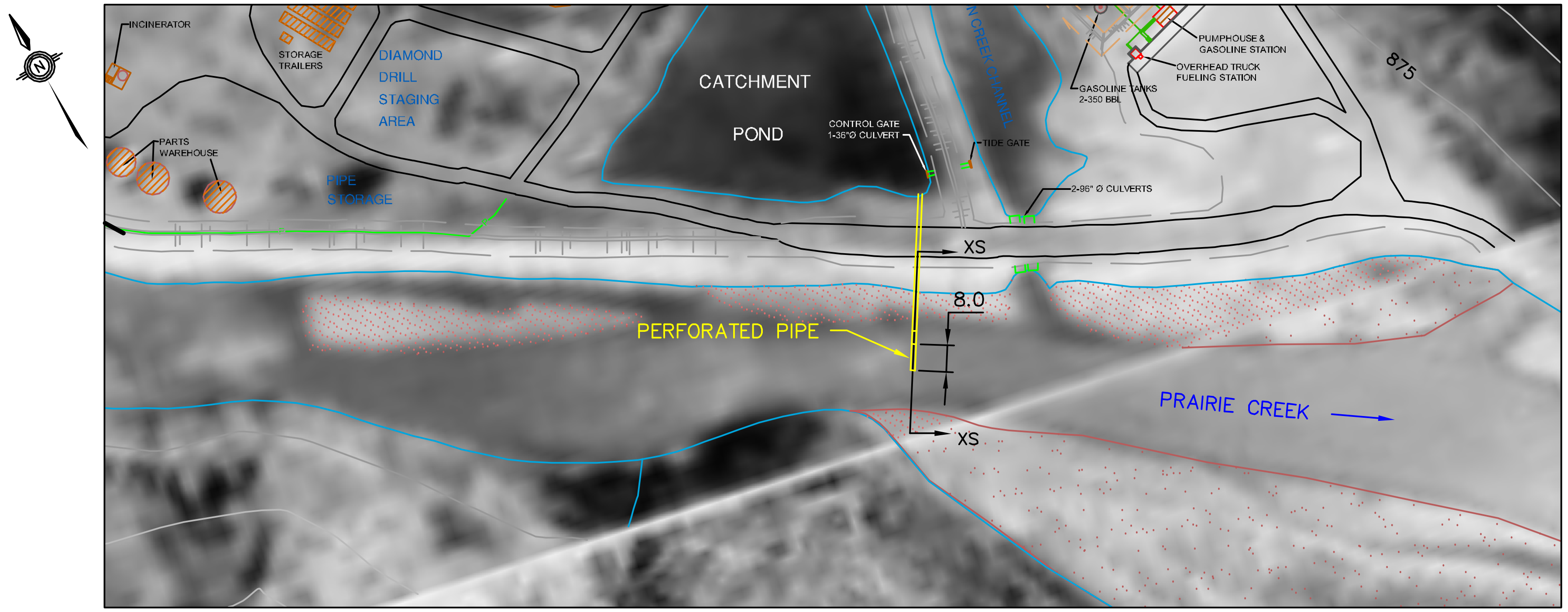
Respectfully submitted,

northwest hydraulic consultants

(review draft)

W.A. (Bill) Rozeboom, M.B.A., P.Eng.
Senior Hydrologist

Gary Van Der Vinne, P.Eng
Principal



SITE PLAN WITH 1994 BACKGROUND IMAGE

50 0 50

SCALE 1:2,000

PHOTO 1. VIEW DOWNSTREAM
PHOTO DATE: AUGUST 9, 2010

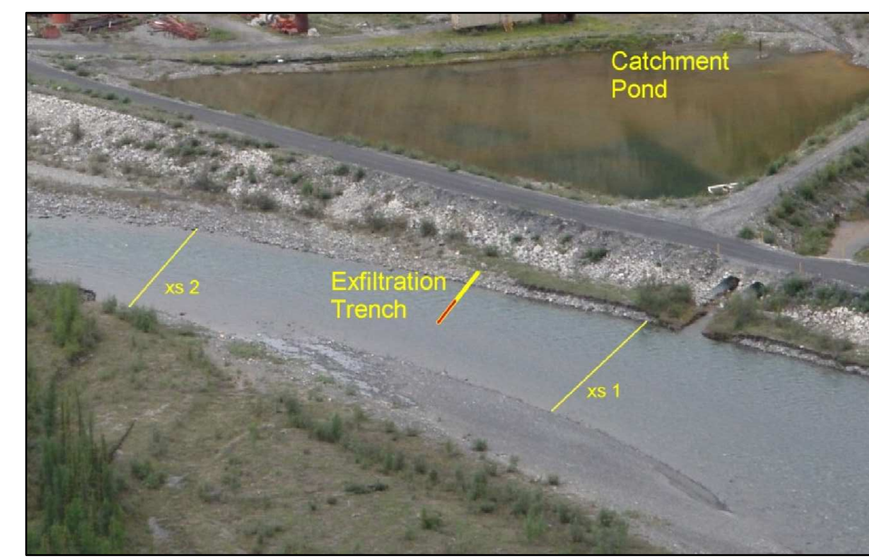
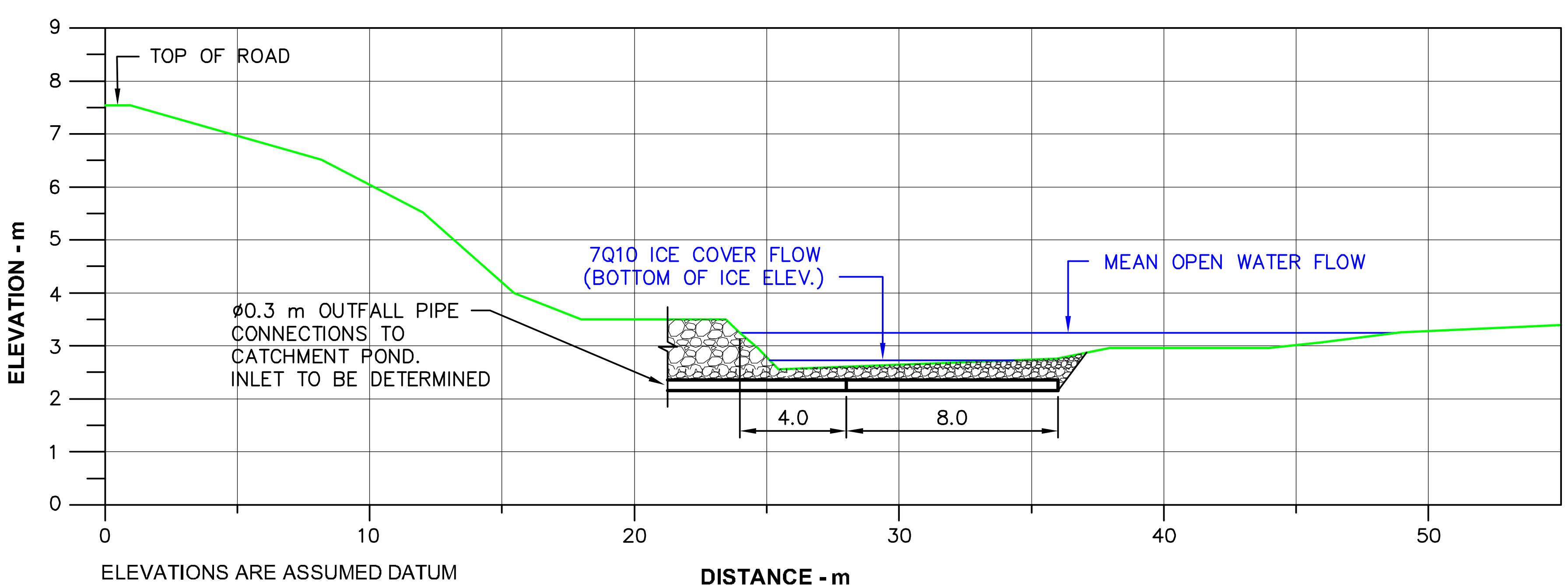


PHOTO 2. EXFILTRATION TRENCH LOCATION
PHOTO DATE: AUGUST 9, 2010



CROSS SECTION AT OUTFALL
(VIEWING DOWNSTREAM)

NOT FOR CONSTRUCTION

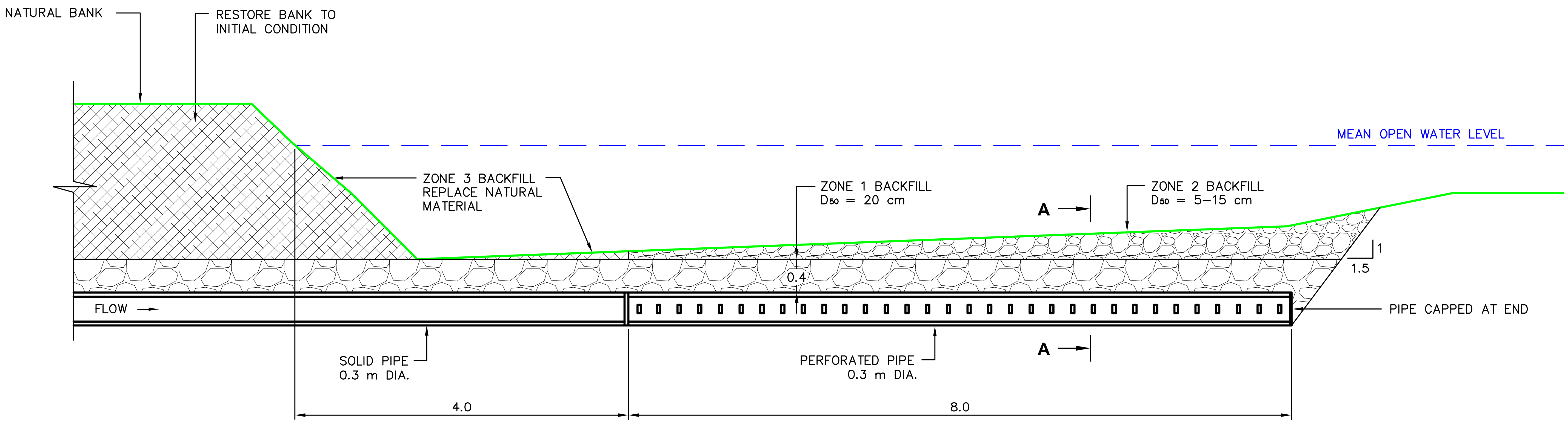
CANADIAN ZINC CORPORATION

PRAIRIE CREEK MINE

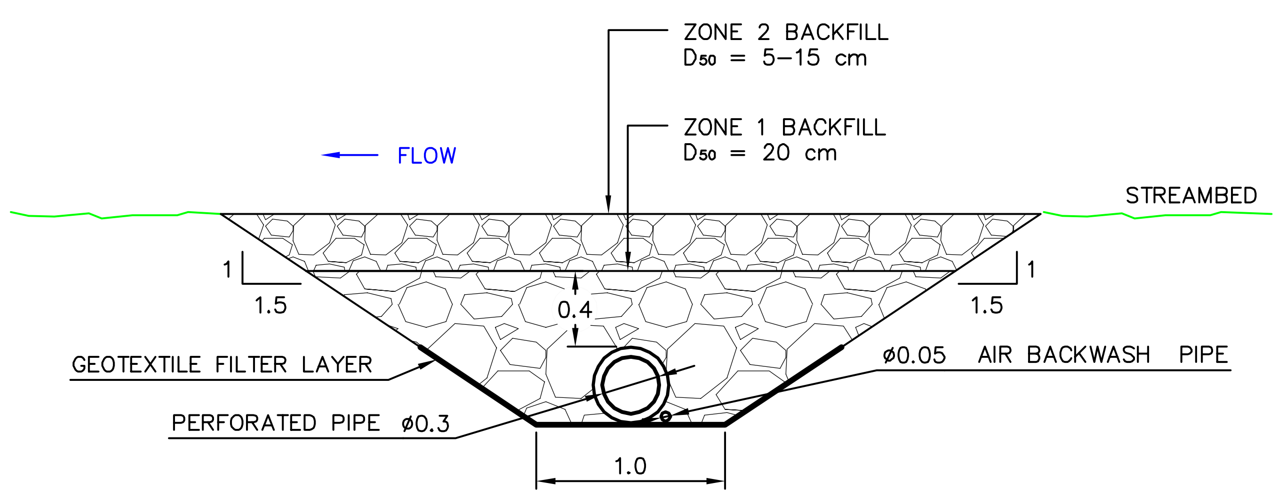
OUTFALL CONCEPTUAL DESIGN
EXFILTRATION TRENCH

Dwg. 6987–006	22 Dec 2010	**Figure 1**

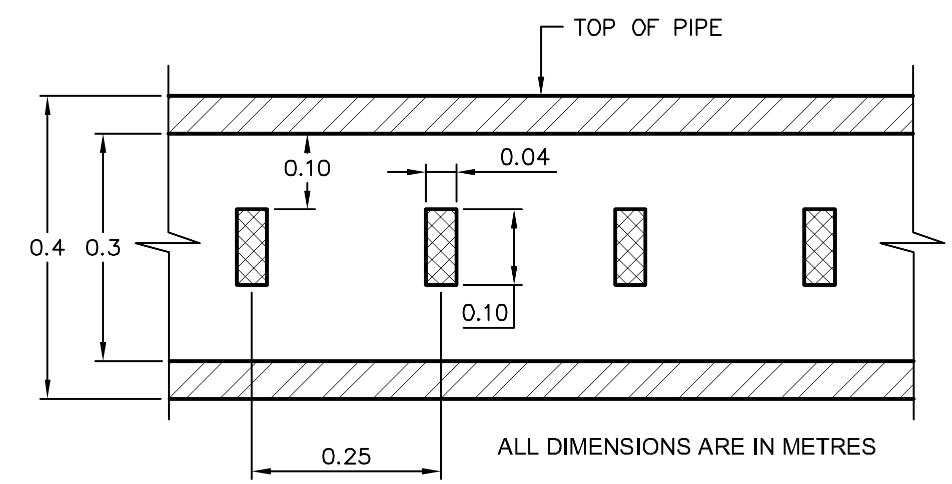
northwest hydraulic consultants



DETAIL 1
EXFILTRATION TRENCH
HORIZONTAL SCALE 1:50
VERTICAL SCALE 1:25



A-A
SCALE 1:40



DETAIL 2
PERFORATED PIPE ELEVATION
SCALE 1:10

CANADIAN ZINC CORPORATION
PRAIRIE CREEK MINE
OUTFALL CONCEPTUAL DESIGN
EXFILTRATION TRENCH

Dwg. 6987–006	22 Dec 2010	**Figure 2**

northwest hydraulic consultants

APPENDIX F

Water Balance and Water Quality

APPENDIX F
WATER BALANCE AND WATER QUALITY

This appendix is a summary of the Prairie Creek Mine site water management plan, Water Storage Pond (WSP) water balance, site discharge water quality and receiving water quality. It is partly based on DAR Appendix 9.

Water Storage Pond

The WSP design has not been changed significantly since production of the DAR Addendum. The WSP is proposed to be a two-celled pond (see Figure F1), one cell for mine water and one for process water. The approach to stabilizing the previously unstable pond backslope remains a combination of slope reduction (excavation), buttress and fill apron placement, and a minimum pond water level of 877 m elevation. CZN considered a three-celled pond in order to have a middle cell adjacent to the unstable backslope area with a water-level maintained at 879-880 m. However, this approach was rejected because it would mean two internal dykes and the loss in pond storage capacity was considered too great. Further, there are merits to having a fluctuating water-level between 877 and 880 m, as is explained below.

One change has been made to the design. Previously, the two cells were to be connected by a pipeline through the dividing dyke, allowing mine water to flow into the process water cell. The new design omits the pipeline in order to keep the two water sources separate. The reason for this is explained below.

Water Management Plan

CZN's proposed water management plan is illustrated in Figure F2. The differences from the previous plan are as follows:

- All mine water is sent to a cell in the WSP first. The cell then feeds water to the Mill and the Water Treatment Plant (WTP); and,
- All process water is sent to a cell in the WSP first. Like the mine water cell, the cell then feeds water to the Mill and the Water Treatment Plant (WTP).

These changes are to age process water before it is fed to the WTP, and to maintain a more consistent water quality in both feed water streams to the Mill and WTP.

Water Balance

Water balances have been developed for the WSP based on four scenarios of mine drainage. Mine drainage will be the largest flow of water to be managed. Estimates of mine drainage have been made by Robertson Geoconsultants (RGC, see Addendum F1). Four scenarios have been developed, termed 'low estimate', 'best estimate', 'high K' and high K + PCAA'. The first three estimates are based on different hydraulic conductivities (K) for the Vein Fault, which is believed to control the ingress of groundwater laterally (from all sides of the underground mine) and vertically (from infiltration of surface water from above). The last estimate assumes a hydraulic connection between the Vein Fault and the Prairie Creek Alluvial Aquifer (PCAA).

Predicted monthly mine drainage estimates for these four scenarios are given in Table F1. The table also includes RGC's assessment of the probability of each scenario occurring. Note that the 'best estimate' scenario is overwhelmingly favoured to be the most accurate prediction (70%), whereas the 'high K + PCAA' scenario is considered to be highly unlikely (5%).

Water balances for each of the four mine drainage scenarios are given in Tables F2 through F5. The composition of the tables is similar, except for the mine drainage flows and the seasonal distribution of flows sent to the WTP.

The top part of each water balance table provides monthly flow rates in Litres/second for:

- process water entering and leaving the Mill, entering the WSP and being sent to the WTP; and,
- entering the WSP and the Mill and being sent to the WTP.

These flow rates are illustrated in a chart for each water balance, shown in Figures F3 through F6. Water entering and leaving the Mill stays constant through the year. Mine drainage and water treatment rates vary seasonally. Mill water feed comprises 35% mine water from Cell A and 65% process water from Cell B. This is to maintain a steady quality of water entering the process and ensure the process involving separation of metal concentrates is not disrupted. Approximately 28% of Mill effluent is treated and discharged to avoid the build-up of major ions in feed water.

The WSP water balance appears below the top part of each table, and consists of monthly flows in cubic metres, most of which are based on the flow rates in the top part of the table. The balance is subdivided in Cells A and B, A for process water and B for mine water, stockpile water and effluent from the Sewage Treatment Plant (STP). The cells are assumed to be of equal volume (225,000 m^3). Other assumptions made to derive the water balance are as follows:

- Upslope ditches will divert runoff so that it will not report to the WSP;
- Direct precipitation is based on the values derived for Prairie Creek in 1980 and the water reports to the balance immediately, even in winter (there may be snow and ice cover, but this will occupy volume and therefore is considered to be water);
- Evaporation is based on the values derived for Prairie Creek in 1980 with minor adjustments of the May and October values;
- Drainage from the Waste Rock Pile, with a catchment area of 50,000 m^2, flows into Cell B during the open water season, and is based on 70% of precipitation; and,
- Drainage from the DMS and ore stockpiles with a combined catchment area of 1,650 m^2 also flows into Cell B during the open water season, and is based on 100% of precipitation.

Each cell in the water balance has total inflows and total outflows, with the difference representing a change in cell storage which is either positive (gaining) or negative (losing). When the sum of monthly differences is near zero (see difference for the year), the cell is considered to be in balance. Balance in each cell is achieved by adjusting the rates at which water is sent to the WTP for treatment. Cumulative difference (Cum. Diff.) is the sum of the difference from a particular month added to the cumulative difference for the previous month. This indicates if the cell is consistently gaining or losing water over several months.

With a maximum water level elevation in each cell of 880 m, and minimum water level of 877 m, each cell has 110,000 m^3 of equivalent storage between the two water levels. Therefore, the cumulative difference for each cell cannot exceed plus or minus 110,000 m^3 because the cell would then be too full or too empty, respectively. In the water balances, the cells are losing water through the summer when the majority of the water treatment occurs, and gaining water through the winter when water treatment is cut back. October is usually the month when each cell starts gaining water after the summer. If the minimum water level is reached at the beginning of October, each cell can then not gain more than 110,000 m^3 through the winter until water treatment ramps up again in May. In developing the balances, a maximum water 'gain' target of less than 100,000 m^3 was assumed to provide for contingencies. In each cell water balance, the last line 'Cum. Diff. Oct-Apr' tracks the accumulation of water over the October-April period. Whatever the total gain is over that period, it follows that the total loss will be similar over the May-September period.

The reason for omitting the connecting pipeline between Cells A and B, and keeping the mine water and process water separate, is that this maintains process water in a 'neat' state for feeding water to the Mill and WTP. The quality of water feeding the Mill from the WTP is controlled by the proportions from each cell. Allowing the water levels in each cell to fluctuate seasonally means that the cells can gain water in winter and less water needs to be treated for discharge over that period.

Other features of the water balances are as follows:

- Mine water and Mill effluent inflows, Mill process feed water outflows and flows to water treatment dominate;
- Precipitation inflows are relatively small from a volume perspective, so possible adjustments for current climatic conditions, and/or global warming, will have a negligible effect on the balance. By the same token, evaporative losses will have even less effect; and,
- Inflows from the Waste Rock Pile are less significant than direct precipitation, and from the stockpiles (ore and DMS) much less so.

In Tables F2 through F5 below the WSP water balances, mine water and process water monthly flows in cubic metres being sent to treatment are shown first, followed by their respective rates in Litres/second. These rates are the same as those in the top part of the tables. Rates are included for flows monitored in the main camp ditch on site. The three flows in combination comprise the total discharge to the environment. The last line shows the proportion of treated process water in the total discharge as a ratio.

Discharge Water Quality

In October 2010, water samples were collected from the mine, the main camp ditch and Prairie Creek upstream of the airstrip. Mine water was collected from the flooded Decline and the 870 Level portal separately. The Decline contributes very little water to the 870 Level, and therefore the portal sample is primarily drainage from the Vein Fault which is exposed underground in several cross-cuts. At the same time, a representative sample of Vein mineralization was collected.

In December 2010, metallurgical testing was initiated by SGS at their facility in Vancouver, B.C. The main purpose of the work was to generate representative process water to be used in water treatment testing, and subsequent toxicity studies. A report from SGS describing their program is given in Addendum F2. SGS used the Vein mineral sample collected, and a 50:50 blend of the Decline water and 870 Level water. This blend is considered to be representative of mine water quality during operations. The 870 Level water is mineralized and strongly influenced by infiltration from surface through the Vein. The Decline water has a lower metal content, but higher TDS and hardness, and is considered more representative of water that will be encountered as the mine is developed to lower levels.

In January 2011, process water from the metallurgical testing was provided to an SGS laboratory in Burnaby, B.C. for water treatment. Treatment was completed on this water (acidification, sulphide addition, lime addition) as well as mine water (lime addition), again based on a 50:50 blend of Decline water and 870 Level water. Procedures and results are provided in Addendum F3.

Samples of water before and after treatment and the ditch water were analysed for total and dissolved metals, major ions, nitrogen (N) species and nutrients. Results for the treated and ditch waters are summarized in Table F6. Based on the concentrations in the table, and the flow rates for the individual discharge streams as defined in Tables F2 through F5, a 'blended' discharge water quality for each parameter was derived for each of the four water balance scenarios. Blended water qualities are shown in Tables F7 through F10.

Table F6 contains N species concentrations for drainage water from the Diavik underground operation. Mining at this operation uses emulsion explosives only, and with strict explosive management practices. CZN is also planning to use emulsion explosives only, and will adopt similarly strict explosive management practices. Diavik records ammonia concentrations in underground drainage water on a daily basis. The average concentration for the period September 1, 2009 to August 31, 2010 is 0.69 mg/L as N (Table F11). Diavik records N species concentrations in the water bi-monthly. Results are shown in Table F12 and Figure F7. In order to derive average concentrations for nitrate and nitrite, the results in Table F12 were 'factored' by the relationship between the ammonia average in Table F12 and the result from Table F11. Factoring was completed after removal of an anomalous sample from July 7, 2010. The factored concentrations are the basis for the Diavik concentrations in Table F6. The ammonia and nitrate concentrations are assumed as the mine water discharge quality in the four water balance scenarios. This is considered a worst-case for ammonia because oxidation and degradation in the WSP for several months will reduce concentrations.

Table F6 also contains water quality from Diavik's sewage treatment plant (STP). Their STP uses alum to precipitate phosphorous. A similar scheme will be adopted at Prairie Creek. Effluent from the Prairie Creek Mine STP will be sent to Cell B of the WTP. It will represent approximately 0.88% of the total cell inflow on an annual basis ('best estimate' scenario). The Diavik total phosphorous concentration was used to adjust the mine water quality in Table F6 based on flow proportions.

Treated process water quality from the January 2011 program is poorer than that generated in 2010 for every constituent except selenium (Table F13). Arsenic, cadmium, copper, lead and zinc concentrations were much higher. This is attributed to higher concentrations in the untreated water and a lower effectiveness of treatment. SGS believe (Addendum F3) that process reagent residues may be to blame as only a few weeks elapsed between process water generation and treatment. During operations, process water will be stored in the WSP for several months and reagent residues are expected to completely degrade. As a result, 2011 treated process water quality is considered to be a worst-case, and potentially un-representative.

Treated mine water in 2011 was similar to results from 2010, although arsenic, copper, selenium and zinc concentrations were lower, and lead higher (Table F13). The lead and zinc values correlate with untreated water quality. However, the arsenic, copper and selenium values do not, and suggest slightly more effective treatment in 2011.

Blended discharge water quality for the four water balance scenarios was also generated using the September 2010 treated water results. Values are found in Tables F14 through F17. Arsenic, copper and zinc concentrations were higher in treated mine water in 2010 than 2011, and higher in treated process water in 2011 than 2010. Therefore, blended discharge quality was calculated using the higher concentrations from both years. Those values are contained in Tables F18 through F21.

Receiving Water Quality

Table F6 also includes concentrations for upstream Prairie Creek which represent the means derived from the database used previously to derive site specific water quality criteria using the reference condition approach (RCA). Table 6 also includes the RCA and CCME water quality criteria. Mean and low flows for Prairie Creek at Harrison Creek and at the Park Boundary were derived previously based on the Water Survey of Canada (WSC) station with a 16-year record. The WSC data was used to derive monthly high flows (the highest flow recorded each month over the 16-year record). The computed mean, low and high flows for Prairie Creek at Harrison Creek and at the Park Boundary are given in Table F22.

Upstream Prairie Creek water (quality in Table F6, flow in Table F22) was numerically blended with the site discharge blends described above. For 2011 treated water quality data and the four water balance scenarios, in-stream blended concentrations for Prairie Creek at Harrison Creek and at the Park Boundary are given in Tables F23 through F34 (main metals, other metals, other parameters). For 2010 treated water quality data and the four water balance scenarios, in-stream blended concentrations for Prairie Creek at Harrison Creek and at the Park Boundary are given in Tables F35 through F42 (main metals, other parameters). For those parameters that were higher in treated mine water in 2010 than 2011, and higher in treated process water in 2011 than 2010 (three main metals), in-stream blended concentrations for Prairie Creek at Harrison Creek and at the Park Boundary are given in Tables F43 through F46. For each metal, concentrations exceeding the RCA and CCME criteria, whichever is higher, are shown in bold type. Non-metal parameters are not similarly compared to criteria. Refer to Appendix D for relevant comparisons.

Table F1: Predictions of Mine Inflow Rates for Active Mining (L/sec)

Scenario	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.	Estimated Probability of Occurrence (%)
Low Estimate (K Fault =1E-5 m/s)	15	15	15	15	21	32	47	38	31	29	25	20	25.2	10%
Best Estimate (Nm15Tr w/ K Fault = 5E-5 m/s)	15	15	15	15	41.3	61.7	90.3	74.3	60.5	55.3	25	20	40.7	70%
High Estimate (K Fault =1E-4 m/s)	15	15	15	15	83	123	181	149	121	111	25	20	72.7	15%
High Estimate with Vein Fault-PCAA Connection	100	100	100	150	207	207	207	207	207	207	150	100	162	5%

flow reduced to account for limited recharge of HCAA during winter freeze-up

TABLE F2: SITE WATER FLOWS (LOW ESTIMATE) AND WSP WATER BALANCE

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
	PROCESS WATER L/s												
Process Feed	14.82	14.82	14.82	14.82	14.82	14.82	14.82	14.82	14.82	14.82	14.82	14.82	22.8
Losses to solids	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Mill Effluent to WSP	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20
Cell A to WTP	1.0	0.0	0.0	1.5	9.5	11.5	11.5	11.5	10.0	5.0	2.5	1.5	5.5
	MINE WATER L/s												
Mine Drainage to WSP	15.0	15.0	15.0	15.0	21.3	31.8	46.6	38.3	31.2	28.5	25.0	20.0	25.2
Process Feed	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	8.0
Cell B to WTP	4.5	2.0	2.0	5.0	34.5	34.5	34.5	34.5	30.0	22.0	11.5	6.5	18.5

	WATER STORAGE POND WATER BALANCE												
Inflows (m^3)	**Process Water Cell (Cell A)**												
Mill Effluent	53,568	48,384	53,568	51,840	53,568	51,840	53,568	53,568	51,840	53,568	51,840	53,568	630,720
Precipitation	1,229	1,229	1,092	1,365	2,184	3,140	4,642	3,823	3,140	2,594	1,638	1,229	27,305
Total	**54,797**	**49,613**	**54,660**	**53,205**	**55,752**	**54,980**	**58,210**	**57,391**	**54,980**	**56,162**	**53,478**	**54,797**	**658,025**
Outflows (m^3)													
Mill Process Feed	39,694	35,853	39,694	38,413	39,694	38,413	39,694	39,694	38,413	39,694	38,413	39,694	467,364
Evaporation	0	0	0	0	1,075	4,096	5,461	4,096	2,731	0	0	0	17,458
To WTP	2,678	0	0	3,888	25,445	29,808	30,802	30,802	25,920	13,392	6,480	4,018	173,232
Total	**42,372**	**35,853**	**39,694**	**42,301**	**66,214**	**72,317**	**75,956**	**74,591**	**67,064**	**53,086**	**44,893**	**43,711**	**658,054**
Difference (m^3)	**12,424**	**13,760**	**14,966**	**10,904**	**-10,461**	**-17,337**	**-17,747**	**-17,201**	**-12,084**	**3,076**	**8,585**	**11,085**	**-29**
Cum. Diff. (m^3)	**12,424**	**26,185**	**41,151**	**52,055**	**41,593**	**24,256**	**6,510**	**-10,691**	**-22,775**	**-19,699**	**-11,114**	**-29**	
Cum. Diff. Oct-Apr (m^3)	**12,424**	**13,760**	**14,966**	**10,904**						**3,076**	**8,585**	**11,085**	**74,801**
Inflows (m^3)	**Mine Water Cell (Cell B)**												
Mine Drainage	40,176	36,288	40,176	38,880	57,050	82,524	124,803	102,689	80,919	76,430	64,800	53,568	798,304
Sewage Water	1,004	907	1,004	972	1,004	972	1,004	1,004	972	1,004	972	1,004	11,826
Waste Rock Pile	0	0	0	0	6,756	2,045	3,023	2,489	2,045	0	0	0	16,358
Stockpiles	0	0	0	0	319	96	142	117	96	0	0	0	771
Precipitation	1,229	1,229	1,092	1,365	2,184	3,140	4,642	3,823	3,140	2,594	1,638	1,229	27,305
Total	**42,409**	**38,424**	**42,273**	**41,217**	**67,314**	**88,777**	**133,614**	**110,123**	**87,172**	**80,028**	**67,410**	**55,801**	**854,563**
Outflows (m^3)													
Process Feed	21,374	19,305	21,374	20,684	21,374	20,684	21,374	21,374	20,684	21,374	20,684	21,374	96
To WTP	12,053	4,838	5,357	12,960	92,405	89,424	92,405	92,405	77,760	58,925	29,808	17,410	585,749
Evaporation	0	0	0	0	1,075	4,096	5,461	4,096	2,731	0	0	0	17,458
Total	**33,426**	**24,144**	**26,730**	**33,644**	**114,853**	**114,204**	**119,239**	**117,874**	**101,175**	**80,298**	**50,492**	**38,783**	**603,303**
Difference (m^3)	**8,983**	**14,280**	**15,542**	**7,573**	**-47,540**	**-25,426**	**14,375**	**-7,751**	**-14,002**	**-270**	**16,918**	**17,018**	**-301**
Cum. Diff. (m^3)	**8,983**	**23,263**	**38,805**	**46,378**	**-1,162**	**-26,588**	**-12,213**	**-19,964**	**-33,966**	**-34,237**	**-17,319**	**-301**	
Cum. Diff. Nov-Apr (m^3)	**8,983**	**14,280**	**15,542**	**7,573**							**16,918**	**17,018**	**80,314**

Mine water treatment m^3	12,053	5,357	5,357	13,392	92,405	92,405	92,405	92,405	80,352	58,925	30,802	17,410	593,266
Process water treatment m^3	2,678	0	0	4,018	25,445	30,802	30,802	30,802	26,784	13,392	6,696	4,018	175,435
Treated mine water L/s	4.5	2	2	5	34.5	34.5	34.5	34.5	30	22	11.5	6.5	18.5
Treated process water L/s	1	0	0	1.5	9.5	11.5	11.5	11.5	10	5	2.5	1.5	5.5
Ditches L/s	0	0	0	2	6	15	15	15	15	0.5	0	0	5.7
Total discharge L/s	5.5	2	2	8.5	50	61	61	61	55	27.5	14	8	29.6
Ratio to process mill water	4.5			4.7	4.3	4.3	4.3	4.3	4.5	4.5	4.6	4.3	

Area of WSP= 107,500 m^2 Rock pile area 50,000 m^2 Sewage L/day 32,400
Volume of WSP= 450,000 m^3 Stockpiles area 1,650 m^2

PC Precip mm	22.9	22.9	20.3	25.4	40.6	58.4	86.4	71.1	58.4	48.3	30.5	22.9	508.0
PC Evap mm	0	0	0	0	20.0	76.2	101.6	76.2	50.8	0	0	0	324.8

TABLE F3: SITE WATER FLOWS (BEST ESTIMATE) AND WSP WATER BALANCE

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
	PROCESS WATER L/s												
Process Feed	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	22.8
Losses to solids	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Mill Effluent to WSP	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20
Cell A to WTP	1.0	0.0	0.0	1.5	9.5	11.5	11.5	11.5	10.0	5.0	2.5	1.5	5.5
	MINE WATER L/s												
Mine Drainage to WSP	15.0	15.0	15.0	15.0	41.3	61.7	90.3	74.3	60.5	55.3	25.0	20.0	40.7
Process Feed	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Cell B to WTP	7.0	2.0	2.0	10.0	61.0	66.0	66.0	66.0	58.5	41.0	18.0	10.0	34.0

	WATER STORAGE POND WATER BALANCE												
Inflows (m^3)	**Process Water Cell (Cell A)**												
Mill Effluent	53,568	48,384	53,568	51,840	53,568	51,840	53,568	53,568	51,840	53,568	51,840	53,568	630,720
Precipitation	1,229	1,229	1,092	1,365	2,184	3,140	4,642	3,823	3,140	2,594	1,638	1,229	27,305
Total	**54,797**	**49,613**	**54,660**	**53,205**	**55,752**	**54,980**	**58,210**	**57,391**	**54,980**	**56,162**	**53,478**	**54,797**	**658,025**
Outflows (m^3)													
Mill Process Feed	39,694	35,853	39,694	38,413	39,694	38,413	39,694	39,694	38,413	39,694	38,413	39,694	467,364
Evaporation	0	0	0	0	1,075	4,096	5,461	4,096	2,731	0	0	0	17,458
To WTP	2,678	0	0	3,888	25,445	29,808	30,802	30,802	25,920	13,392	6,480	4,018	173,232
Total	**42,372**	**35,853**	**39,694**	**42,301**	**66,214**	**72,317**	**75,956**	**74,591**	**67,064**	**53,086**	**44,893**	**43,711**	**658,054**
Difference (m^3)	**12,424**	**13,760**	**14,966**	**10,904**	**-10,461**	**-17,337**	**-17,747**	**-17,201**	**-12,084**	**3,076**	**8,585**	**11,085**	**-29**
Cum. Diff. (m^3)	**12,424**	**26,185**	**41,151**	**52,055**	**41,593**	**24,256**	**6,510**	**-10,691**	**-22,775**	**-19,699**	**-11,114**	**-29**	
Cum. Diff. Oct-Apr (m^3)	**12,424**	**13,760**	**14,966**	**10,904**						**3,076**	**8,585**	**11,085**	**74,801**
Inflows (m^3)	**Mine Water Cell (Cell B)**												
Mine Drainage	40,176	36,288	40,176	38,880	110,618	159,926	241,860	199,005	156,816	148,116	64,800	53,568	1,290,228
Sewage Water	1,004	907	1,004	972	1,004	972	1,004	1,004	972	1,004	972	1,004	11,826
Waste Rock Pile	0	0	0	0	6,756	2,045	3,023	2,489	2,045	0	0	0	16,358
Stockpiles	0	0	0	0	319	96	142	117	96	0	0	0	771
Precipitation	1,229	1,229	1,092	1,365	2,184	3,140	4,642	3,823	3,140	2,594	1,638	1,229	27,305
Total	**42,409**	**38,424**	**42,273**	**41,217**	**120,882**	**166,180**	**250,671**	**206,439**	**163,069**	**151,714**	**67,410**	**55,801**	**1,346,488**
Outflows (m^3)													
Mill Process Feed	21,374	19,305	21,374	20,684	21,374	20,684	21,374	21,374	20,684	21,374	20,684	21,374	251,657
To WTP	18,749	4,838	5,357	25,920	163,382	171,072	176,774	176,774	151,632	109,814	46,656	26,784	1,077,754
Evaporation	0	0	0	0	1,075	4,096	5,461	4,096	2,731	0	0	0	17,458
Total	**40,122**	**24,144**	**26,730**	**46,604**	**185,831**	**195,852**	**203,609**	**202,244**	**175,047**	**131,188**	**67,340**	**48,158**	**1,346,869**
Difference (m^3)	**2,287**	**14,280**	**15,542**	**-5,387**	**-64,949**	**-29,672**	**47,062**	**4,195**	**-11,977**	**20,526**	**70**	**7,643**	**-381**
Cum. Diff. (m^3)	**2,287**	**16,567**	**32,109**	**26,722**	**-38,227**	**-67,899**	**-20,838**	**-16,643**	**-28,620**	**-8,094**	**-8,024**	**-381**	
Cum. Diff. Jul-Mar (m^3)	**2,287**	**14,280**	**15,542**				**47,062**	**4,195**	**-11,977**	**20,526**	**70**	**7,643**	**99,628**

Mine water treatment m^3	18,749	5,357	5,357	26,784	163,382	176,774	176,774	176,774	156,686	109,814	48,211	26,784	1,091,448
Process water treatment m^3	2,678	0	0	4,018	25,445	30,802	30,802	30,802	26,784	13,392	6,696	4,018	175,435
Treated mine water L/s	7	2	2	10	61	66	66	66	58.5	41	18	10	34.0
Treated process water L/s	1	0	0	1.5	9.5	11.5	11.5	11.5	10	5	2.5	1.5	5.5
Ditches L/s	0	0	0	2	6	15	15	15	15	0.5	0	0	5.7
Total discharge L/s	8	2	2	13.5	76.5	92.5	92.5	92.5	83.5	46.5	20.5	11.5	45.1
Ratio to process water	7.0			8.0	7.1	7.0	7.0	7.0	7.4	8.3	7.2	6.7	

Area of WSP=	107,500 m^2			Rock pile area		50,000 m^2			Sewage L/day		32,400		
Volume of WSP=	450,000 m^3			Stockpiles area		1,650 m^2							
PC Precip mm	22.9	22.9	20.3	25.4	40.6	58.4	86.4	71.1	58.4	48.3	30.5	22.9	508.0
PC Evap mm	0	0	0	0	20.0	76.2	101.6	76.2	50.8	0	0	0	324.8

TABLE F4: SITE WATER FLOWS (HIGH K) AND WSP WATER BALANCE

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
	PROCESS WATER L/s												
Process Feed	14.82	14.82	14.82	14.82	14.82	14.82	14.82	14.82	14.82	14.82	14.82	14.82	22.8
Losses to solids	-5.18	-5.18	-5.18	-5.18	-5.18	-5.18	-5.18	-5.18	-5.18	-5.18	-5.18	-5.18	-5.2
Mill Effluent to WSP	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20
Cell A to WTP	1.0	0.0	0.0	1.5	9.5	11.5	11.5	11.5	10.0	5.0	2.5	1.5	5.5
	MINE WATER L/s												
Mine Drainage to WSP	15.0	15.0	15.0	15.0	82.6	123.4	180.6	148.6	121.0	110.6	25.0	20.0	72.7
Process Feed	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	8.0
Cell B to WTP	10.0	6.0	6.0	15.0	90.0	145.0	145.0	145.0	120.0	68.0	27.0	15.0	66.0

	WATER STORAGE POND WATER BALANCE												
Inflows (m^3)	**Process Water Cell (Cell A)**												
Mill Effluent	53,568	48,384	53,568	51,840	53,568	51,840	53,568	53,568	51,840	53,568	51,840	53,568	630,720
Precipitation	1,229	1,229	1,092	1,365	2,184	3,140	4,642	3,823	3,140	2,594	1,638	1,229	27,305
Total	54,797	49,613	54,660	53,205	55,752	54,980	58,210	57,391	54,980	56,162	53,478	54,797	658,025
Outflows (m^3)													
Mill Process Feed	39,694	35,853	39,694	38,413	39,694	38,413	39,694	39,694	38,413	39,694	38,413	39,694	467,364
Evaporation	0	0	0	0	1,075	4,096	5,461	4,096	2,731	0	0	0	17,458
To WTP	2,678	0	0	3,888	25,445	29,808	30,802	30,802	25,920	13,392	6,480	4,018	173,232
Total	42,372	35,853	39,694	42,301	66,214	72,317	75,956	74,591	67,064	53,086	44,893	43,711	658,054
Difference (m^3)	**12,424**	**13,760**	**14,966**	**10,904**	**-10,461**	**-17,337**	**-17,747**	**-17,201**	**-12,084**	**3,076**	**8,585**	**11,085**	**-29**
Cum. Diff. (m^3)	**12,424**	**26,185**	**41,151**	**52,055**	**41,593**	**24,256**	**6,510**	**-10,691**	**-22,775**	**-19,699**	**-11,114**	**-29**	
Cum. Diff. Oct-Mar (m^3)	**12,424**	**13,760**	**14,966**	**10,904**						**3,076**	**8,585**	**11,085**	**74,801**
Inflows (m^3)	**Mine Water Cell (Cell B)**												
Mine Drainage	40,176	36,288	40,176	38,880	221,236	319,853	483,719	398,010	313,632	296,231	64,800	53,568	2,306,569
Sewage Water	1,004	907	1,004	972	1,004	972	1,004	1,004	972	1,004	972	1,004	11,826
Waste Rock Pile	0	0	0	0	6,756	2,045	3,023	2,489	2,045	0	0	0	16,358
Stockpiles	0	0	0	0	319	96	142	117	96	0	0	0	771
Precipitation	1,229	1,229	1,092	1,365	2,184	3,140	4,642	3,823	3,140	2,594	1,638	1,229	27,305
Total	**42,409**	**38,424**	**42,273**	**41,217**	**231,500**	**326,106**	**492,530**	**405,444**	**319,885**	**299,829**	**67,410**	**55,801**	**2,362,829**
Outflows (m^3)													
Process Feed	21,374	19,305	21,374	20,684	21,374	20,684	21,374	21,374	20,684	21,374	20,684	21,374	251,657
To WTP	26,784	14,515	16,070	38,880	241,056	375,840	388,368	388,368	311,040	182,131	69,984	40,176	2,093,213
Evaporation	0	0	0	0	1,075	4,096	5,461	4,096	2,731	0	0	0	17,458
Total	**48,158**	**33,820**	**37,444**	**59,564**	**263,505**	**400,620**	**415,203**	**413,837**	**334,455**	**203,505**	**90,668**	**61,550**	**2,362,328**
Difference (m^3)	**-5,749**	**4,604**	**4,829**	**-18,347**	**-32,005**	**-74,514**	**77,328**	**-8,393**	**-14,569**	**96,325**	**-23,258**	**-5,749**	**501**
Cum. Diff. (m^3)	**-5,749**	**-1,145**	**3,684**	**-14,663**	**-46,668**	**-121,182**	**-43,855**	**-52,248**	**-66,818**	**29,507**	**6,249**	**501**	
Cum. Diff. Oct-Mar (m^3)	**-5,749**	**4,604**	**4,829**							**96,325**	**-23,258**	**-5,749**	**71,002**

Mine water treatment m^3	26,784	16,070	16,070	40,176	241,056	388,368	388,368	388,368	321,408	182,131	72,317	40,176	2,121,293
Process water treatment m^3	2,678	0	0	4,018	25,445	30,802	30,802	30,802	26,784	13,392	6,696	4,018	175,435
Treated mine water L/s	10	6	6	15	90	145	145	145	120	68	27	15	66.0
Treated process water L/s	1	0	0	1.5	9.5	11.5	11.5	11.5	10	5	2.5	1.5	5.5
Ditches L/s	0	0	0	2	6	12	18	12	18	0.5	0	0	5.7
Total discharge L/s	11	6	6	18.5	105.5	168.5	174.5	168.5	148	73.5	29.5	16.5	77.2
Ratio to process water	10.0			11.3	10.1	13.7	14.2	13.7	13.8	13.7	10.8	10.0	

Area of WSP=	107,500 m^2		Rock pile area		50,000 m^2			Sewage L/day		32,400			
Volume of WSP=	450,000 m^3		Stockpiles area		1,650 m^2								
PC Precip mm	22.9	22.9	20.3	25.4	40.6	58.4	86.4	71.1	58.4	48.3	30.5	22.9	508.0
PC Evap mm	0	0	0	0	20.0	76.2	101.6	76.2	50.8	0	0	0	324.8

TABLE F5: SITE WATER FLOWS (HIGH K + PCAA) AND WSP WATER BALANCE

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
	PROCESS WATER L/s												
Process Feed	14.82	14.82	14.82	14.82	14.82	14.82	14.82	14.82	14.82	14.82	14.82	14.82	22.8
Losses to solids	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Mill Effluent to WSP	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20
Cell A to WTP	1.0	0.0	0.0	1.5	9.5	11.5	11.5	11.5	10.0	5.0	2.5	1.5	5.5
	MINE WATER L/s												
Mine Drainage to WSP	100.0	100.0	100.0	150.0	207.0	207.0	207.0	207.0	207.0	207.0	150.0	100.0	161.8
Process Feed	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	8.0
Cell B to WTP	100.0	80.0	80.0	142.0	205.0	206.0	205.0	205.0	205.0	185.0	147.0	100.0	155.0

	WATER STORAGE POND WATER BALANCE												
Inflows (m^3)	**Process Water Cell (Cell A)**												
Mill Effluent	53,568	48,384	53,568	51,840	53,568	51,840	53,568	53,568	51,840	53,568	51,840	53,568	630,720
Precipitation	1,229	1,229	1,092	1,365	2,184	3,140	4,642	3,823	3,140	2,594	1,638	1,229	27,305
Total	54,797	49,613	54,660	53,205	55,752	54,980	58,210	57,391	54,980	56,162	53,478	54,797	658,025
Outflows (m^3)													
Mill Process Feed	39,694	35,853	39,694	38,413	39,694	38,413	39,694	39,694	38,413	39,694	38,413	39,694	467,364
Evaporation	0	0	0	0	1,075	4,096	5,461	4,096	2,731	0	0	0	17,458
To WTP	2,678	0	0	3,888	25,445	29,808	30,802	30,802	25,920	13,392	6,480	4,018	173,232
Total	42,372	35,853	39,694	42,301	66,214	72,317	75,956	74,591	67,064	53,086	44,893	43,711	658,054
Difference (m^3)	**12,424**	**13,760**	**14,966**	**10,904**	**-10,461**	**-17,337**	**-17,747**	**-17,201**	**-12,084**	**3,076**	**8,585**	**11,085**	**-29**
Cum. Diff. (m^3)	**12,424**	**26,185**	**41,151**	**52,055**	**41,593**	**24,256**	**6,510**	**-10,691**	**-22,775**	**-19,699**	**-11,114**	**-29**	
Cum. Diff. Oct-Apr (m^3)	**12,424**	**13,760**	**14,966**	**10,904**						**3,076**	**8,585**	**11,085**	**74,801**
Inflows (m^3)	**Mine Water Cell (Cell B)**												
Mine Drainage	267,840	241,920	267,840	388,800	554,429	536,544	554,429	554,429	536,544	554,429	388,800	267,840	5,113,843
Sewage Water	1,004	907	1,004	972	1,004	972	1,004	1,004	972	1,004	972	1,004	11,826
Waste Rock Pile	0	0	0	0	6,756	2,045	3,023	2,489	2,045	0	0	0	16,358
Stockpiles	0	0	0	0	319	96	142	117	96	0	0	0	771
Precipitation	1,229	1,229	1,092	1,365	2,184	3,140	4,642	3,823	3,140	2,594	1,638	1,229	27,305
Total	**270,073**	**244,056**	**269,937**	**391,137**	**564,693**	**542,797**	**563,240**	**561,862**	**542,797**	**558,027**	**391,410**	**270,073**	**5,170,103**
Outflows (m^3)													
Process Feed	21,374	19,305	21,374	20,684	21,374	20,684	21,374	21,374	20,684	21,374	20,684	21,374	251,657
To WTP	267,840	193,536	214,272	368,064	549,072	533,952	549,072	549,072	531,360	495,504	381,024	267,840	4,900,608
Evaporation	0	0	0	0	1,075	4,096	5,461	4,096	2,731	0	0	0	17,458
Total	**289,214**	**212,841**	**235,646**	**388,748**	**571,521**	**558,732**	**575,907**	**574,541**	**554,775**	**516,878**	**401,708**	**289,214**	**5,169,723**
Difference (m^3)	**-19,141**	**31,215**	**34,291**	**2,389**	**-6,828**	**-15,935**	**-12,666**	**-12,679**	**-11,977**	**41,150**	**-10,298**	**-19,141**	**380**
Cum. Diff. (m^3)	**-19,141**	**12,074**	**46,365**	**48,754**	**41,926**	**25,991**	**13,325**	**646**	**-11,332**	**29,818**	**19,520**	**380**	
Cum. Diff. Oct-Apr (m^3)	**-19,141**	**31,215**	**34,291**	**2,389**						**41,150**	**-10,298**	**-19,141**	**60,465**

Mine water treatment m^3	267,840	214,272	214,272	380,333	549,072	551,750	549,072	549,072	549,072	495,504	393,725	267,840	4,981,824
Process water treatment m^3	2,678	0	0	4,018	25,445	30,802	30,802	30,802	26,784	13,392	6,696	4,018	175,435
Treated mine water L/s	100	80	80	142	205	206	205	205	205	185	147	100	155.0
Treated process water L/s	1	0	0	1.5	9.5	11.5	11.5	11.5	10	5	2.5	1.5	5.5
Ditches L/s	0	0	0	2	6	12	18	12	18	0.5	0	0	5.7
Total discharge L/s	101	80	80	145.5	220.5	229.5	234.5	228.5	233	190.5	149.5	101.5	166.2
Ratio to process water	100.0			96.0	22.2	19.0	19.4	18.9	22.3	37.1	58.8	66.7	

Area of WSP=	107,500 m^2			Rock pile area		50,000 m^2			Sewage L/day		32,400		
Volume of WSP=	450,000 m^3			Stockpiles area		1,650 m^2							
PC Precip mm	22.9	22.9	20.3	25.4	40.6	58.4	86.4	71.1	58.4	48.3	30.5	22.9	508.0
PC Evap mm	0	0	0	0	20.0	76.2	101.6	76.2	50.8	0	0	0	324.8

TABLE F6: TREATED WATER AND DITCH WATER QUALITY

Source Quality mg/L	Total Metals										
	Ag	**As**	**Cd**	**Cu**	**Fe**	**Hg**	**Pb**	**Sb**	**Se**	**Zn**	**Na**
Treated Mine Water	0.00001	0.0002	0.00004	0.0007	0.021	0.00001	0.0017	0.0253	0.0028	0.0025	1.54
Treated Mill Water	0.0007	0.009	0.0243	0.071	5.4	0.0019	0.304	0.119	0.01	1.35	1890
Camp Ditch	0.00005	0.0008	0.00035	0.0022	0.044	0.000028	0.0232	0.0022	0.0024	0.053	3.3
Upstream Prairie Creek	0.000029	0.00024	0.000048	0.00057	0.0486	0.00002	0.00023	0.000244	0.00116	0.00714	
CCME	0.0001	0.005	0.000017	0.004	0.3	0.000026	0.007	20[1]	0.001	0.03	
Site Specific RCA Values	0.000103	0.00056	0.000172	0.00253	0.229	0.000034	0.00113	0.000605	0.00216	0.02265	
Source Quality mg/L	**Dissolved Metals**										
	Ag	**As**	**Cd**	**Cu**	**Fe**	**Hg**	**Pb**	**Sb**	**Se**	**Zn**	**Na**
Treated Mine Water	0.00001	0.0002	0.00005	0.0045	0.008	0.00002	0.0018	0.025	0.0032	0.0025	1.68
Treated Mill Water	0.00072	0.0082	0.0226	0.0796	2.62	0.00028	0.252	0.116	0.0101	1.43	2260
Camp Ditch	0.00001	0.0002	0.00004	0.0004	0.0025	0.000015	0.0005	0.0016	0.0025	0.006	2.95
Upstream Prairie Creek											
Site Specific RCA Values											
Source Quality mg/L	**NH^3 N**	**NO^3 N**	**NO^2 N**	**Tot. P**	**Ortho P**	**SO^4**	**TDS**	**TSS**	**Hardness**	**pH**	
Treated Mine Water	0.043	1	0.25	0.00334	0.0025	470	700	2	576	9.09	
Treated Mill Water	0.29	1	0.25	0.230	0.025	4500	6100	26	470	8.91	
Camp Ditch	0.054	0.419	0.001	0.005	0.0025	110	380	2	378	7.96	
Upstream Prairie Creek	0.005	0.14	0.08	0.007		67.8	274				
Diavik U/G Drainage	0.69	5.354	0.013								
Diavik Sewage Effluent	0.0097	5.210		0.0414	<0.001			12			
Wendigo Sewage Effluent	<0.05							14			
CCME	Varies	2.9	0.06	0.004		100					
Site Specific RCA Values	0.013	0.23	1.03	0.016		119.3	413				

* Non-detect values set at half the detection limit

1 Ontario Guideline

TABLE F7: WATER QUALITY OF BLENDED DISCHARGE - 2011 TREATED WATER, LOW ESTIMATE MINE FLOWS

Source Flow			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Treated mine water L/s			4.5	2	2	5	34.5	34.5	34.5	34.5	30	22	11.5	6.5
Treated mill water L/s			1	0	0	1.5	9.5	11.5	11.5	11.5	10	5	2.5	1.5
Ditches L/s			0	0	0	2	6	15	15	15	15	0.5	0	0
Combined L/s			5.5	2	2	8.5	50	61	61	61	55	27.5	14	8
Combined Water Quality mg/L	Total Metals	Ag	0.00014	0.00001	0.00001	0.00014	0.00015	0.00015	0.00015	0.00015	0.00015	0.00014	0.00013	0.00014
		As	0.00180	0.00020	0.00020	0.00189	0.00194	0.00201	0.00201	0.00201	0.00196	0.00181	0.00177	0.00185
		Cd	0.00445	0.00004	0.00004	0.00439	0.00469	0.00469	0.00469	0.00469	0.00454	0.00446	0.00437	0.00459
		Cu	0.01348	0.00070	0.00070	0.01346	0.01424	0.01432	0.01432	0.01432	0.01389	0.01351	0.01325	0.01388
		Fe	0.999	0.021	0.021	0.976	1.046	1.041	1.041	1.041	1.005	0.999	0.982	1.030
		Hg	0.00035	0.00001	0.00001	0.00035	0.00037	0.00037	0.00037	0.00037	0.00036	0.00035	0.00035	0.00036
		Pb	0.05666	0.00170	0.00170	0.06011	0.06172	0.06398	0.06398	0.06398	0.06253	0.05705	0.05568	0.05838
		Sb	0.0423	0.0253	0.0253	0.0359	0.0401	0.0367	0.0367	0.0367	0.0354	0.0419	0.0420	0.0429
		Se	0.00411	0.00280	0.00280	0.00398	0.00412	0.00406	0.00406	0.00406	0.00400	0.00410	0.00409	0.00415
		Zn	0.2475	0.0025	0.0025	0.2522	0.2646	0.2690	0.2690	0.2690	0.2613	0.2484	0.2431	0.2552
		Na	345	2	2	335	361	358	358	358	345	345	339	356
	Dissolved Metals	Ag	0.00014	0.00001	0.00001	0.00014	0.00014	0.00014	0.00014	0.00014	0.00014	0.00014	0.00014	0.00014
		As	0.00165	0.00020	0.00020	0.00161	0.00172	0.00171	0.00171	0.00171	0.00165	0.00165	0.00163	0.00170
		Cd	0.00415	0.00005	0.00005	0.00403	0.00433	0.00430	0.00430	0.00430	0.00415	0.00415	0.00408	0.00428
		Cu	0.01815	0.00450	0.00450	0.01679	0.01828	0.01765	0.01765	0.01765	0.01704	0.01808	0.01791	0.01858
		Fe	0.483	0.008	0.008	0.468	0.504	0.499	0.499	0.499	0.481	0.483	0.474	0.498
		Hg	0.00007	0.00002	0.00002	0.00006	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007
		Pb	0.04729	0.00180	0.00180	0.04565	0.04918	0.04865	0.04865	0.04865	0.04694	0.04727	0.04648	0.04871
		Sb	0.0415	0.0250	0.0250	0.0356	0.0395	0.0364	0.0364	0.0364	0.0352	0.0411	0.0413	0.0421
		Se	0.00445	0.00320	0.00320	0.00425	0.00443	0.00433	0.00433	0.00433	0.00426	0.00444	0.00443	0.00449
		Zn	0.2620	0.0025	0.0025	0.2552	0.2741	0.2725	0.2725	0.2725	0.2630	0.2621	0.2574	0.2702
		Na	412	2	2	401	431	428	428	428	413	412	405	425
	Other Parameters	NH^4 N	0.617	0.690	0.690	0.470	0.538	0.458	0.458	0.458	0.444	0.606	0.619	0.615
		NO^3 N	4.562	5.354	5.354	3.424	3.934	3.320	3.320	3.320	3.216	4.473	4.576	4.538
		NO^2 N	0.250	0.250	0.250	0.191	0.220	0.189	0.189	0.189	0.182	0.245	0.250	0.250
		Tot. P	0.045	0.003	0.003	0.044	0.047	0.046	0.046	0.046	0.045	0.045	0.044	0.046
		Ortho P	0.007	0.003	0.003	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
		SO^4	1203	470	470	1096	1193	1141	1141	1141	1105	1196	1190	1226
		TDS	1682	700	700	1578	1688	1639	1639	1639	1595	1676	1664	1713
		TSS	6	2	2	6	7	7	7	7	6	6	6	7
		Hardness	557	576	576	511	532	507	507	507	503	553	557	556
		pH	9.06	9.09	9.09	8.79	8.92	8.78	8.78	8.78	8.75	9.04	9.06	9.06

TABLE F8: WATER QUALITY OF BLENDED DISCHARGE - 2011 TREATED WATER, BEST ESTIMATE MINE FLOWS

Source Flow			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Treated mine water L/s			7	2	2	10	61	66	66	66	58.5	41	18	10
Treated mill water L/s			1	0	0	1.5	9.5	11.5	11.5	11.5	10	5	2.5	1.5
Ditches L/s			0	0	0	2	6	15	15	15	15	0.5	0	0
Combined L/s			8	2	2	13.5	76.5	92.5	92.5	92.5	83.5	46.5	20.5	11.5
Combined Water Quality mg/L	Total Metals	Ag	0.00010	0.00001	0.00001	0.00009	0.00010	0.00010	0.00010	0.00010	0.00010	0.00008	0.00009	0.00010
		As	0.00130	0.00020	0.00020	0.00127	0.00134	0.00139	0.00139	0.00139	0.00136	0.00115	0.00127	0.00135
		Cd	0.00307	0.00004	0.00004	0.00278	0.00308	0.00311	0.00311	0.00311	0.00300	0.00265	0.00300	0.00320
		Cu	0.00949	0.00070	0.00070	0.00873	0.00955	0.00968	0.00968	0.00968	0.00939	0.00828	0.00927	0.00987
		Fe	0.693	0.021	0.021	0.622	0.691	0.693	0.693	0.693	0.669	0.600	0.677	0.723
		Hg	0.00025	0.00001	0.00001	0.00022	0.00025	0.00025	0.00025	0.00025	0.00024	0.00021	0.00024	0.00026
		Pb	0.03949	0.00170	0.00170	0.03847	0.04093	0.04277	0.04277	0.04277	0.04177	0.03444	0.03857	0.04113
		Sb	0.0370	0.0253	0.0253	0.0320	0.0350	0.0328	0.0328	0.0328	0.0320	0.0351	0.0367	0.0375
		Se	0.00370	0.00280	0.00280	0.00354	0.00366	0.00363	0.00363	0.00363	0.00359	0.00357	0.00368	0.00374
		Zn	0.1709	0.0025	0.0025	0.1597	0.1738	0.1782	0.1782	0.1782	0.1729	0.1479	0.1668	0.1783
		Na	238	2	2	212	236	237	237	237	228	205	232	248
	Dissolved Metals	Ag	0.00010	0.00001	0.00001	0.00009	0.00010	0.00010	0.00010	0.00010	0.00010	0.00009	0.00010	0.00010
		As	0.00120	0.00020	0.00020	0.00109	0.00119	0.00119	0.00119	0.00119	0.00116	0.00106	0.00118	0.00124
		Cd	0.00287	0.00005	0.00005	0.00255	0.00285	0.00285	0.00285	0.00285	0.00275	0.00247	0.00280	0.00299
		Cu	0.01389	0.00450	0.00450	0.01224	0.01350	0.01317	0.01317	0.01317	0.01276	0.01253	0.01366	0.01430
		Fe	0.335	0.008	0.008	0.297	0.332	0.332	0.332	0.332	0.320	0.289	0.327	0.349
		Hg	0.00005	0.00002	0.00002	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
		Pb	0.03308	0.00180	0.00180	0.02941	0.03277	0.03270	0.03270	0.03270	0.03153	0.02869	0.03231	0.03443
		Sb	0.0364	0.0250	0.0250	0.0316	0.0345	0.0325	0.0325	0.0325	0.0317	0.0345	0.0361	0.0369
		Se	0.00406	0.00320	0.00320	0.00386	0.00400	0.00394	0.00394	0.00394	0.00390	0.00393	0.00404	0.00410
		Zn	0.1809	0.0025	0.0025	0.1616	0.1800	0.1805	0.1805	0.1805	0.1741	0.1560	0.1766	0.1887
		Na	284	2	2	253	282	283	283	283	272	245	277	296
	Other Parameters	NH^4 N	0.640	0.690	0.690	0.551	0.590	0.537	0.537	0.537	0.528	0.640	0.641	0.638
		NO^3 N	4.810	5.354	5.354	4.139	4.426	4.012	4.012	4.012	3.946	4.833	4.823	4.786
		NO^2 N	0.250	0.250	0.250	0.213	0.230	0.210	0.210	0.210	0.205	0.247	0.250	0.250
		Tot. P	0.032	0.003	0.003	0.029	0.032	0.032	0.032	0.032	0.031	0.028	0.031	0.033
		Ortho P	0.005	0.003	0.003	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
		SO^4	974	470	470	864	942	913	913	913	888	899	961	996
		TDS	1375	700	700	1253	1345	1319	1319	1319	1289	1277	1359	1404
		TSS	5	2	2	5	5	5	5	5	5	5	5	5
		Hardness	563	576	576	535	547	531	531	531	528	562	563	562
		pH	9.07	9.09	9.09	8.90	8.98	8.88	8.88	8.88	8.87	9.06	9.07	9.07

TABLE F9: WATER QUALITY OF BLENDED DISCHARGE - 2011 TREATED WATER, HIGH K MINE FLOWS

Source Flow			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Treated mine water L/s			10	6	6	15	90	145	145	145	120	68	27	15
Treated mill water L/s			1	0	0	1.5	9.5	11.5	11.5	11.5	10	5	2.5	1.5
Ditches L/s			0	0	0	2	6	12	18	12	18	0.5	0	0
Combined L/s			11	6	6	18.5	105.5	168.5	174.5	168.5	148	73.5	29.5	16.5
Combined Water Quality mg/L	**Total Metals**	**Ag**	0.00007	0.00001	0.00001	0.00007	0.00007	0.00006	0.00006	0.00006	0.00006	0.00006	0.00007	0.00007
		As	0.00100	0.00020	0.00020	0.00098	0.00103	0.00084	0.00084	0.00084	0.00087	0.00080	0.00095	0.00100
		Cd	0.00225	0.00004	0.00004	0.00204	0.00224	0.00172	0.00167	0.00172	0.00172	0.00169	0.00210	0.00225
		Cu	0.00709	0.00070	0.00070	0.00656	0.00712	0.00560	0.00549	0.00560	0.00563	0.00549	0.00666	0.00709
		Fe	0.510	0.021	0.021	0.460	0.507	0.390	0.378	0.390	0.387	0.387	0.477	0.510
		Hg	0.00018	0.00001	0.00001	0.00017	0.00018	0.00014	0.00014	0.00014	0.00014	0.00014	0.00017	0.00018
		Pb	0.02918	0.00170	0.00170	0.02854	0.03014	0.02386	0.02384	0.02386	0.02474	0.02241	0.02732	0.02918
		Sb	0.0338	0.0253	0.0253	0.0302	0.0323	0.0299	0.0289	0.0299	0.0286	0.0315	0.0332	0.0338
		Se	0.00345	0.00280	0.00280	0.00334	0.00343	0.00326	0.00323	0.00326	0.00324	0.00329	0.00341	0.00345
		Zn	0.1250	0.0025	0.0025	0.1172	0.1267	0.0981	0.0965	0.0981	0.0997	0.0945	0.1167	0.1250
		Na	173	2	2	155	172	131	126	131	129	130	162	173
	Dissolved Metals	**Ag**	0.00007	0.00001	0.00001	0.00007	0.00007	0.00006	0.00006	0.00006	0.00006	0.00006	0.00007	0.00007
		As	0.00093	0.00020	0.00020	0.00085	0.00092	0.00075	0.00073	0.00075	0.00074	0.00074	0.00088	0.00093
		Cd	0.00210	0.00005	0.00005	0.00188	0.00208	0.00159	0.00154	0.00159	0.00157	0.00158	0.00196	0.00210
		Cu	0.01133	0.00450	0.00450	0.01015	0.01103	0.00933	0.00903	0.00933	0.00908	0.00958	0.01086	0.01133
		Fe	0.245	0.008	0.008	0.219	0.243	0.186	0.180	0.186	0.184	0.186	0.229	0.245
		Hg	0.00004	0.00002	0.00002	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004
		Pb	0.02455	0.00180	0.00180	0.02195	0.02426	0.01878	0.01815	0.01878	0.01855	0.01881	0.02300	0.02455
		Sb	0.0333	0.0250	0.0250	0.0298	0.0319	0.0295	0.0286	0.0295	0.0283	0.0310	0.0327	0.0333
		Se	0.00383	0.00320	0.00320	0.00368	0.00378	0.00362	0.00358	0.00362	0.00358	0.00366	0.00378	0.00383
		Zn	0.1323	0.0025	0.0025	0.1186	0.1312	0.1002	0.0969	0.1002	0.0994	0.0996	0.1235	0.1323
		Na	207	2	2	185	205	156	151	156	154	155	193	207
	Other Parameters	**NH^4 N**	0.654	0.690	0.690	0.589	0.618	0.617	0.598	0.617	0.586	0.658	0.656	0.654
		NO^3 N	4.958	5.354	5.354	4.467	4.681	4.705	4.558	4.705	4.460	5.024	4.985	4.958
		NO^2 N	0.250	0.250	0.250	0.223	0.236	0.232	0.224	0.232	0.220	0.248	0.250	0.250
		Tot. P	0.024	0.003	0.003	0.022	0.024	0.019	0.018	0.019	0.019	0.019	0.023	0.024
		Ortho P	0.005	0.003	0.003	0.004	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.005
		SO^4	836	470	470	758	812	719	698	719	699	742	812	836
		TDS	1191	700	700	1103	1168	1046	1023	1046	1026	1065	1158	1191
		TSS	4	2	2	4	4	4	4	4	4	4	4	4
		Hardness	566	576	576	546	555	555	549	555	545	567	567	566
		pH	9.07	9.09	9.09	8.95	9.01	9.00	8.96	9.00	8.94	9.07	9.07	9.07

TABLE F10: WATER QUALITY OF BLENDED DISCHARGE - 2011 TREATED WATER, HIGH K + PCAA MINE FLOWS

Source Flow			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Treated mine water L/s			100	80	80	142	205	206	205	205	205	185	147	100
Treated mill water L/s			1	0	0	1.5	9.5	11.5	11.5	11.5	10	5	2.5	1.5
Ditches L/s			0	0	0	2	6	12	18	12	18	0.5	0	0
Combined L/s			101	80	80	145.5	220.5	229.5	234.5	228.5	233	190.5	149.5	101.5
Combined Water Quality mg/L	**Total Metals**	**Ag**	0.00002	0.00001	0.00001	0.00002	0.00004	0.00005	0.00005	0.00005	0.00004	0.00003	0.00002	0.00002
		As	0.00029	0.00020	0.00020	0.00030	0.00060	0.00067	0.00068	0.00067	0.00062	0.00043	0.00035	0.00033
		Cd	0.00028	0.00004	0.00004	0.00029	0.00109	0.00127	0.00125	0.00128	0.00111	0.00068	0.00045	0.00040
		Cu	0.00140	0.00070	0.00070	0.00145	0.00377	0.00430	0.00426	0.00432	0.00383	0.00255	0.00188	0.00174
		Fe	0.074	0.021	0.021	0.077	0.253	0.292	0.287	0.293	0.254	0.162	0.111	0.100
		Hg	0.00003	0.00001	0.00001	0.00003	0.00009	0.00011	0.00010	0.00011	0.00009	0.00006	0.00004	0.00004
		Pb	0.00469	0.00170	0.00170	0.00511	0.01531	0.01797	0.01818	0.01804	0.01634	0.00969	0.00676	0.00617
		Sb	0.0262	0.0253	0.0253	0.0259	0.0286	0.0287	0.0280	0.0287	0.0274	0.0277	0.0269	0.0267
		Se	0.00287	0.00280	0.00280	0.00287	0.00310	0.00314	0.00312	0.00314	0.00308	0.00299	0.00292	0.00291
		Zn	0.0158	0.0025	0.0025	0.0171	0.0619	0.0727	0.0725	0.0730	0.0642	0.0380	0.0250	0.0224
		Na	20	2	2	21	83	96	94	97	83	51	33	29
	Dissolved Metals	**Ag**	0.00002	0.00001	0.00001	0.00002	0.00004	0.00005	0.00004	0.00005	0.00004	0.00003	0.00002	0.00002
		As	0.00028	0.00020	0.00020	0.00028	0.00054	0.00060	0.00059	0.00060	0.00054	0.00041	0.00033	0.00032
		Cd	0.00027	0.00005	0.00005	0.00028	0.00102	0.00118	0.00116	0.00118	0.00102	0.00064	0.00043	0.00038
		Cu	0.00524	0.00450	0.00450	0.00522	0.00762	0.00805	0.00787	0.00806	0.00741	0.00646	0.00576	0.00561
		Fe	0.034	0.008	0.008	0.035	0.120	0.139	0.136	0.139	0.120	0.077	0.052	0.047
		Hg	0.00002	0.00002	0.00002	0.00002	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00002	0.00002
		Pb	0.00428	0.00180	0.00180	0.00436	0.01254	0.01427	0.01397	0.01432	0.01244	0.00836	0.00598	0.00550
		Sb	0.0259	0.0250	0.0250	0.0256	0.0283	0.0283	0.0277	0.0284	0.0271	0.0273	0.0265	0.0263
		Se	0.00327	0.00320	0.00320	0.00326	0.00348	0.00351	0.00348	0.00351	0.00344	0.00338	0.00332	0.00330
		Zn	0.0166	0.0025	0.0025	0.0173	0.0641	0.0742	0.0728	0.0745	0.0640	0.0400	0.0264	0.0236
		Na	24	2	2	25	99	115	113	115	99	61	39	35
	Other Parameters	**NH^4 N**	0.686	0.690	0.690	0.677	0.655	0.637	0.622	0.636	0.624	0.678	0.683	0.684
		NO^3 N	5.311	5.354	5.354	5.241	5.032	4.878	4.762	4.876	4.786	5.227	5.281	5.290
		NO^2 N	0.250	0.250	0.250	0.247	0.243	0.237	0.231	0.237	0.231	0.249	0.250	0.250
		Tot. P	0.006	0.003	0.003	0.006	0.013	0.015	0.015	0.015	0.013	0.009	0.007	0.007
		Ortho P	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.003	0.003	0.003	0.003
		SO^4	510	470	470	507	634	653	640	654	615	575	537	530
		TDS	753	700	700	751	924	954	940	955	907	841	790	780
		TSS	2	2	2	2	3	3	3	3	3	3	2	2
		Hardness	575	576	576	572	566	560	556	560	556	573	574	574
		pH	9.09	9.09	9.09	9.07	9.05	9.02	8.99	9.02	8.99	9.08	9.09	9.09

TABLE F11: AMMONIA CONCENTRATIONS IN DIAVIK UNDERGROUND MINE DRAINAGE

Date	NH^4 N	Date	NH^4 N	Date	NH^4 N	Date	NH^4 N	Date	NH^4 N	Date	NH^4 N	Date	NH^4 N
1-Sep-09	0.38	27-Oct-09	0.54	21-Dec-09	0.17	13-Feb-10	0.39	18-Apr-10	0.45	11-Jun-10	1.33	4-Aug-10	0.22
2-Sep-09	0.15	28-Oct-09	0.60	22-Dec-09	9.00	14-Feb-10	0.11	19-Apr-10	0.28	12-Jun-10	1.92	5-Aug-10	0.97
3-Sep-09	0.15	29-Oct-09	0.24	23-Dec-09	0.21	15-Feb-10	0.01	20-Apr-10	0.20	13-Jun-10	0.91	6-Aug-10	0.77
4-Sep-09	0.61	30-Oct-09	0.21	24-Dec-09	0.18	26-Feb-10	0.19	21-Apr-10	0.02	14-Jun-10	0.84	7-Aug-10	0.53
5-Sep-09	0.36	31-Oct-09	0.39	25-Dec-09	0.13	27-Feb-10	0.46	22-Apr-10	0.12	15-Jun-10	0.72	8-Aug-10	0.55
6-Sep-09	0.35	1-Nov-09	0.05	26-Dec-09	0.04	28-Feb-10	0.13	23-Apr-10	0.01	16-Jun-10	0.02	9-Aug-10	0.68
7-Sep-09	0.30	2-Nov-09	0.10	27-Dec-09	0.12	1-Mar-10	0.22	24-Apr-10	0.22	17-Jun-10	1.51	10-Aug-10	0.01
8-Sep-09	0.31	3-Nov-09	0.78	28-Dec-09	0.04	2-Mar-10	0.40	25-Apr-10	0.13	18-Jun-10	0.35	11-Aug-10	0.56
9-Sep-09	1.14	4-Nov-09	0.36	29-Dec-09	0.27	3-Mar-10	0.01	26-Apr-10	0.51	19-Jun-10	1.40	12-Aug-10	0.65
10-Sep-09	0.39	5-Nov-09	0.34	30-Dec-09	0.99	4-Mar-10	0.17	27-Apr-10	1.15	20-Jun-10	0.80	13-Aug-10	0.28
11-Sep-09	0.21	6-Nov-09	0.49	31-Dec-09	0.39	5-Mar-10	0.04	28-Apr-10	0.54	21-Jun-10	0.66	14-Aug-10	1.78
12-Sep-09	3.00	7-Nov-09	0.36	1-Jan-10	0.07	6-Mar-10	0.01	29-Apr-10	1.32	22-Jun-10	1.15	15-Aug-10	0.84
13-Sep-09	0.57	8-Nov-09	0.10	2-Jan-10	0.07	7-Mar-10	0.21	30-Apr-10	0.56	23-Jun-10	0.33	16-Aug-10	0.36
14-Sep-09	1.64	9-Nov-09	0.27	3-Jan-10	1.14	8-Mar-10	0.18	1-May-10	0.12	24-Jun-10	0.76	17-Aug-10	0.21
15-Sep-09	0.58	10-Nov-09	0.21	4-Jan-10	0.50	9-Mar-10	0.09	2-May-10	0.42	25-Jun-10	0.32	18-Aug-10	0.88
16-Sep-09	0.78	11-Nov-09	0.13	5-Jan-10	1.01	10-Mar-10	0.34	3-May-10	0.18	26-Jun-10	1.19	19-Aug-10	0.55
17-Sep-09	1.35	12-Nov-09	0.10	6-Jan-10	3.00	11-Mar-10	0.11	4-May-10	0.07	27-Jun-10	0.93	20-Aug-10	0.63
18-Sep-09	0.62	13-Nov-09	0.13	7-Jan-10	1.12	12-Mar-10	0.68	5-May-10	0.12	28-Jun-10	0.33	21-Aug-10	0.45
19-Sep-09	1.10	14-Nov-09	0.20	8-Jan-10	0.54	13-Mar-10	2.00	6-May-10	0.01	29-Jun-10	0.39	22-Aug-10	0.29
20-Sep-09	2.00	15-Nov-09	0.08	9-Jan-10	0.37	14-Mar-10	0.27	7-May-10	0.05	30-Jun-10	0.27	23-Aug-10	0.41
21-Sep-09	2.06	16-Nov-09	0.23	10-Jan-10	0.41	15-Mar-10	0.42	8-May-10	0.01	1-Jul-10	0.17	24-Aug-10	0.16
22-Sep-09	0.07	17-Nov-09	0.13	11-Jan-10	4.00	16-Mar-10	0.14	9-May-10	0.04	2-Jul-10	0.57	25-Aug-10	0.33
23-Sep-09	0.07	18-Nov-09	0.06	12-Jan-10	1.28	17-Mar-10	0.15	10-May-10	1.54	3-Jul-10	0.40	26-Aug-10	0.38
24-Sep-09	15.00	19-Nov-09	0.06	13-Jan-10	1.00	18-Mar-10	0.21	11-May-10	1.44	4-Jul-10	0.43	27-Aug-10	0.21
25-Sep-09	0.99	21-Nov-09	0.01	14-Jan-10	0.94	19-Mar-10	0.14	12-May-10	0.74	5-Jul-10	1.17	28-Aug-10	0.15
26-Sep-09	0.28	22-Nov-09	0.10	15-Jan-10	9.00	20-Mar-10	0.25	13-May-10	0.07	6-Jul-10	0.52	29-Aug-10	0.11
27-Sep-09	0.81	23-Nov-09	0.06	16-Jan-10	2.20	21-Mar-10	0.14	14-May-10	2.43	7-Jul-10	11.00	30-Aug-10	0.82
28-Sep-09	4.00	24-Nov-09	0.04	17-Jan-10	2.22	22-Mar-10	0.22	15-May-10	0.12	8-Jul-10	1.20	31-Aug-10	0.46
29-Sep-09	0.54	25-Nov-09	0.03	18-Jan-10	0.01	23-Mar-10	0.20	16-May-10	0.21	9-Jul-10	1.10	Average	0.69
30-Sep-09	0.41	26-Nov-09	0.03	19-Jan-10	0.05	24-Mar-10	0.27	17-May-10	0.10	10-Jul-10	0.72		
1-Oct-09	0.13	27-Nov-09	1.21	20-Jan-10	0.36	25-Mar-10	0.35	18-May-10	0.16	11-Jul-10	0.60	All concentrations mg/L as N	
2-Oct-09	0.16	28-Nov-09	0.13	21-Jan-10	1.22	26-Mar-10	0.03	19-May-10	0.19	12-Jul-10	0.36		
3-Oct-09	0.28	29-Nov-09	0.12	22-Jan-10	9.00	27-Mar-10	0.72	20-May-10	0.40	13-Jul-10	0.71		
6-Oct-09	0.53	30-Nov-09	0.09	23-Jan-10	1.62	28-Mar-10	0.56	21-May-10	0.11	14-Jul-10	1.01		
7-Oct-09	0.69	1-Dec-09	0.14	24-Jan-10	0.84	29-Mar-10	1.36	22-May-10	0.08	15-Jul-10	1.06		
8-Oct-09	0.29	2-Dec-09	0.26	25-Jan-10	2.06	30-Mar-10	0.59	23-May-10	0.08	16-Jul-10	1.27		
9-Oct-09	0.49	3-Dec-09	0.08	26-Jan-10	2.01	31-Mar-10	0.95	24-May-10	0.03	17-Jul-10	0.85		
10-Oct-09	1.72	4-Dec-09	0.33	27-Jan-10	2.27	1-Apr-10	0.41	25-May-10	0.05	18-Jul-10	0.36		
11-Oct-09	0.23	5-Dec-09	0.40	28-Jan-10	1.26	2-Apr-10	0.15	26-May-10	0.27	19-Jul-10	0.68		
12-Oct-09	1.09	6-Dec-09	0.27	29-Jan-10	0.63	3-Apr-10	2.20	27-May-10	0.56	20-Jul-10	0.72		
13-Oct-09	1.01	7-Dec-09	0.16	30-Jan-10	1.48	4-Apr-10	0.22	28-May-10	0.51	21-Jul-10	0.27		
14-Oct-09	0.24	8-Dec-09	0.17	31-Jan-10	0.81	5-Apr-10	0.35	29-May-10	0.85	22-Jul-10	0.36		
15-Oct-09	0.13	9-Dec-09	0.13	1-Feb-10	0.42	6-Apr-10	0.54	30-May-10	0.77	23-Jul-10	0.35		
16-Oct-09	0.25	10-Dec-09	0.29	2-Feb-10	0.63	7-Apr-10	0.83	31-May-10	0.64	24-Jul-10	0.52		
17-Oct-09	0.06	11-Dec-09	0.19	3-Feb-10	0.75	8-Apr-10	0.21	1-Jun-10	0.67	25-Jul-10	0.21		
18-Oct-09	0.20	12-Dec-09	0.42	4-Feb-10	1.31	9-Apr-10	0.48	2-Jun-10	1.82	26-Jul-10	0.26		
19-Oct-09	0.03	13-Dec-09	0.01	5-Feb-10	0.21	10-Apr-10	0.89	3-Jun-10	1.78	27-Jul-10	0.35		
20-Oct-09	0.85	14-Dec-09	0.16	6-Feb-10	1.74	11-Apr-10	1.69	4-Jun-10	0.25	28-Jul-10	0.51		
21-Oct-09	0.25	15-Dec-09	0.22	7-Feb-10	0.93	12-Apr-10	0.96	5-Jun-10	0.34	29-Jul-10	0.53		
22-Oct-09	0.01	16-Dec-09	0.10	8-Feb-10	0.42	13-Apr-10	1.17	6-Jun-10	0.62	30-Jul-10	0.01		
23-Oct-09	0.78	17-Dec-09	0.15	9-Feb-10	0.21	14-Apr-10	0.43	7-Jun-10	0.07	31-Jul-10	0.15		
24-Oct-09	0.06	18-Dec-09	0.13	10-Feb-10	0.18	15-Apr-10	0.94	8-Jun-10	0.20	1-Aug-10	0.51		
25-Oct-09	0.93	19-Dec-09	0.12	11-Feb-10	0.41	16-Apr-10	0.81	9-Jun-10	0.06	2-Aug-10	0.24		
26-Oct-09	0.37	20-Dec-09	0.20	12-Feb-10	0.35	17-Apr-10	0.24	10-Jun-10	0.30	3-Aug-10	0.35		

TABLE F12: DIAVIK UNDERGROUND MINE DRAINAGE N CONCENTRATIONS

Date	NH^4 N	NO^3 N	NO^2 N
Dec 9 09	0.182	0.747	0.0281
Dec 23 09	0.167	2.06	0.0588
Feb 3	0.624	2.16	0.0691
Mar 3	0.132	2.06	0.0377
Mar 17	0.162	0.842	0.0262
Mar 31	0.999	2.97	0.293
Apr 14	0.597	1.71	0.0672
Apr 28	0.598	2.28	0.194
May 12	0.828	2.07	0.285
May 26	0.279	1.28	0.163
Jun 9	0.344	2.54	0.277
Jun 23	0.9	3.03	0.71
Jul 7	8.13	14.4	0.302
Jul 22	0.379	3.35	0.136
Sep 1	0.427	2.5	0.0794
Sep 15	0.516	2.86	0.144
Sep 29	0.88	4.23	0.097
Oct 13	0.429	3.59	0.351
Avg.	0.921	3.038	0.184
Avg. ex Jul 7	0.520	2.406	0.178
Factor	0.69	3.192	0.236

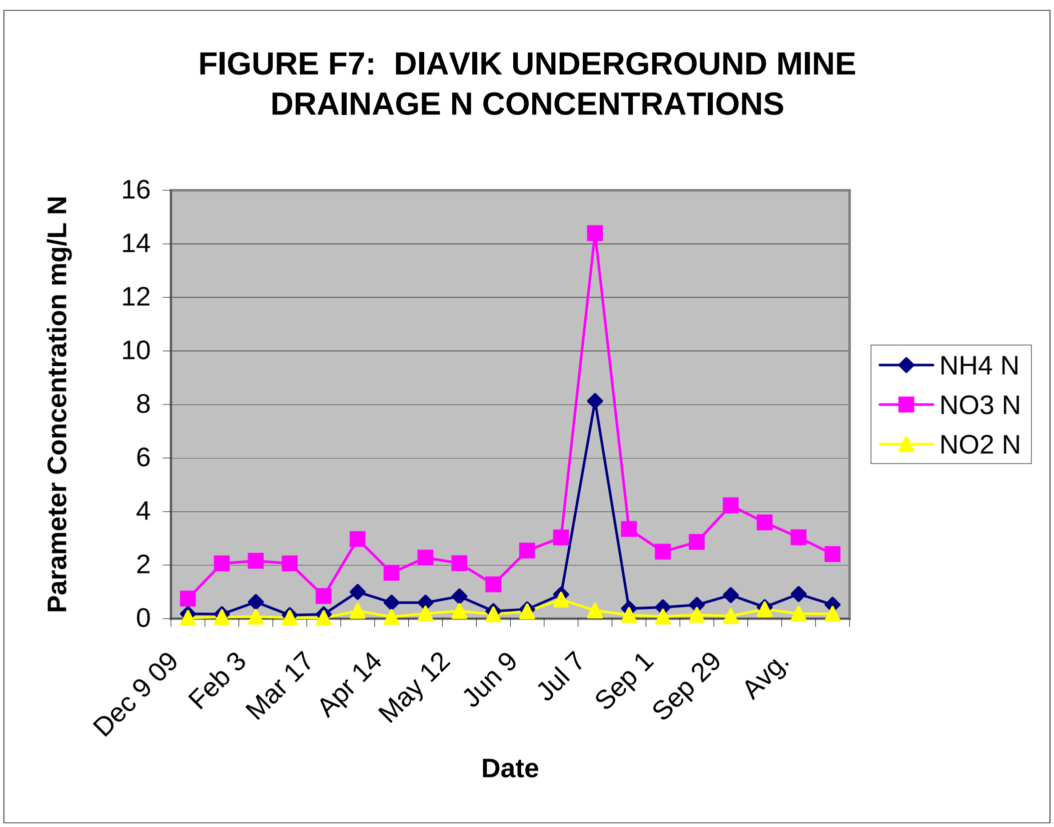


TABLE F13: 2010 AND 2011 UNTREATED AND TREATED WATER QUALITY COMPARISON

	Source Quality mg/L	Total Metals									
		Ag	**As**	**Cd**	**Cu**	**Fe**	**Hg**	**Pb**	**Sb**	**Se**	**Zn**
Mine Water	Untreated Sep 2010		0.0009	**0.0208**	0.0128	0.014	<0.00002	0.0006	0.0238	0.0028	**4.25**
	Untreated Jan 2011	0.00007	0.0139	0.0115	0.0905	7.4	0.00004	0.0125	0.0351	0.0029	1.53
	Treated Sep 2010	0.00001	**0.0028**	0.00001	**0.0072**	0.0025	0.00001	0.0001	0.0229	**0.0033**	**0.017**
	Treated Jan 2011	<0.00002	0.0002	0.00004	0.0007	0.021	<0.00002	0.0017	0.0253	0.0028	<0.005
Process Water	Untreated Sep 2010		**0.509**	0.0825	0.0032	**0.147**	0.00168	5.26	0.273	0.104	**3.42**
	Untreated Jan 2011	0.069	0.427	1.24	3.95	<0.5	0.888	30.8	0.647	0.116	2.74
	Treated Sep 2010	0.00004	0.0018	0.00262	0.0021	0.043	**0.0020**	0.0932	0.0112	**0.039**	0.039
	Treated Jan 2011	0.0007	0.009	0.02430	0.071	5.4	0.0019	0.304	0.119	0.010	1.35

Bold = Higher in 2010

TABLE F14: WATER QUALITY OF BLENDED DISCHARGE - 2010 TREATED WATER, LOW ESTIMATE MINE FLOWS

Source Flow			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Treated mine water L/s			4.5	2	2	5	34.5	34.5	34.5	34.5	30	22	11.5	6.5
Treated mill water L/s			1	0	0	1.5	9.5	11.5	11.5	11.5	10	5	2.5	1.5
Ditches L/s			0	0	0	2	6	15	15	15	15	0.5	0	0
Combined L/s			5.5	2	2	8.5	50	61	61	61	55	27.5	14	8
Combined Water Quality mg/L	Total Metals	**Ag**	0.00002	0.00001	0.00001	0.00002	0.00002	0.00003	0.00003	0.00003	0.00003	0.00002	0.00002	0.00002
		As	0.00262	0.00280	0.00280	0.00215	0.00237	0.00212	0.00212	0.00212	0.00207	0.00258	0.00262	0.00261
		Cd	0.00048	0.00001	0.00001	0.00055	0.00055	0.00059	0.00059	0.00059	0.00058	0.00049	0.00048	0.00050
		Cu	0.00627	0.00720	0.00720	0.00512	0.00563	0.00501	0.00501	0.00501	0.00491	0.00618	0.00629	0.00624
		Fe	0.00986	0.00250	0.00250	0.01941	0.01518	0.02034	0.02034	0.02034	0.02118	0.01062	0.00973	0.01009
		Hg	0.00038	0.00001	0.00001	0.00037	0.00040	0.00040	0.00040	0.00040	0.00038	0.00038	0.00037	0.00039
		Pb	0.01703	0.00010	0.00010	0.02196	0.02056	0.02333	0.02333	0.02333	0.02333	0.01745	0.01673	0.01756
		Sb	0.02077	0.02290	0.02290	0.01545	0.01793	0.01506	0.01506	0.01506	0.01453	0.02036	0.02081	0.02071
		Se	0.00983	0.00330	0.00330	0.00942	0.01001	0.00985	0.00985	0.00985	0.00958	0.00981	0.00971	0.01003
		Zn	0.02100	0.01700	0.01700	0.02935	0.02550	0.03000	0.03000	0.03000	0.03082	0.02165	0.02093	0.02113

TABLE F15: WATER QUALITY OF BLENDED DISCHARGE - 2010 TREATED WATER, BEST ESTIMATE MINE FLOWS

Source Flow			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Treated mine water L/s			7	2	2	10	61	66	66	66	58.5	41	18	10
Treated mill water L/s			1	0	0	1.5	9.5	11.5	11.5	11.5	10	5	2.5	1.5
Ditches L/s			0	0	0	2	6	15	15	15	15	0.5	0	0
Combined L/s			8	2	2	13.5	76.5	92.5	92.5	92.5	83.5	46.5	20.5	11.5
Combined Water Quality mg/L	Total Metals	Ag	0.00001	0.00001	0.00001	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00001	0.00001	0.00001
		As	0.00268	0.00280	0.00280	0.00239	0.00252	0.00235	0.00235	0.00235	0.00232	0.00267	0.00268	0.00267
		Cd	0.00034	0.00001	0.00001	0.00035	0.00036	0.00039	0.00039	0.00039	0.00038	0.00029	0.00033	0.00035
		Cu	0.00656	0.00720	0.00720	0.00589	0.00617	0.00576	0.00576	0.00576	0.00569	0.00660	0.00658	0.00653
		Fe	0.00756	0.00250	0.00250	0.01315	0.01078	0.01426	0.01426	0.01426	0.01481	0.00730	0.00744	0.00778
		Hg	0.00026	0.00001	0.00001	0.00024	0.00026	0.00027	0.00027	0.00027	0.00026	0.00023	0.00026	0.00027
		Pb	0.01174	0.00010	0.00010	0.01387	0.01347	0.01542	0.01542	0.01542	0.01540	0.01036	0.01145	0.01224
		Sb	0.02144	0.02290	0.02290	0.01821	0.01965	0.01773	0.01773	0.01773	0.01739	0.02140	0.02147	0.02137
		Se	0.00779	0.00330	0.00330	0.00716	0.00769	0.00762	0.00762	0.00762	0.00744	0.00715	0.00768	0.00798
		Zn	0.01975	0.01700	0.01700	0.02478	0.02256	0.02557	0.02557	0.02557	0.02610	0.01975	0.01968	0.01987

TABLE F16: WATER QUALITY OF BLENDED DISCHARGE - 2010 TREATED WATER, HIGH K MINE FLOWS

Source Flow			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Treated mine water L/s			10	6	6	15	90	145	145	145	120	68	27	15
Treated mill water L/s			1	0	0	1.5	9.5	11.5	11.5	11.5	10	5	2.5	1.5
Ditches L/s			0	0	0	2	6	12	18	12	18	0.5	0	0
Combined L/s			11	6	6	18.5	105.5	168.5	174.5	168.5	148	73.5	29.5	16.5
Combined Water Quality mg/L	Total Metals	Ag	0.00001	0.00001	0.00001	0.00002	0.00001	0.00001	0.00002	0.00001	0.00002	0.00001	0.00001	0.00001
		As	0.00271	0.00280	0.00280	0.00250	0.00260	0.00259	0.00253	0.00259	0.00249	0.00272	0.00272	0.00271
		Cd	0.00025	0.00001	0.00001	0.00026	0.00026	0.00021	0.00022	0.00021	0.00023	0.00019	0.00023	0.00025
		Cu	0.00674	0.00720	0.00720	0.00625	0.00646	0.00650	0.00635	0.00650	0.00625	0.00682	0.00677	0.00674
		Fe	0.00618	0.00250	0.00250	0.01027	0.00851	0.00822	0.00945	0.00822	0.01028	0.00554	0.00593	0.00618
		Hg	0.00019	0.00001	0.00001	0.00018	0.00019	0.00015	0.00015	0.00015	0.00015	0.00015	0.00018	0.00019
		Pb	0.00856	0.00010	0.00010	0.01015	0.00980	0.00810	0.00862	0.00810	0.00920	0.00659	0.00799	0.00856
		Sb	0.02184	0.02290	0.02290	0.01948	0.02054	0.02047	0.01977	0.02047	0.01932	0.02195	0.02191	0.02184
		Se	0.00656	0.00330	0.00330	0.00611	0.00648	0.00569	0.00557	0.00569	0.00562	0.00574	0.00634	0.00656
		Zn	0.01900	0.01700	0.01700	0.02268	0.02103	0.02107	0.02216	0.02107	0.02286	0.01874	0.01886	0.01900

TABLE F17: WATER QUALITY OF BLENDED DISCHARGE - 2010 TREATED WATER, HIGH K + PCAA MINE FLOWS

Source Flow			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Treated mine water L/s			100	80	80	142	205	206	205	205	205	185	147	100
Treated mill water L/s			1	0	0	1.5	9.5	11.5	11.5	11.5	10	5	2.5	1.5
Ditches L/s			0	0	0	2	6	12	18	12	18	0.5	0	0
Combined L/s			101	80	80	145.5	220.5	229.5	234.5	228.5	233	190.5	149.5	101.5
Combined Water Quality mg/L	**Total Metals**	**Ag**	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
		As	0.00279	0.00280	0.00280	0.00276	0.00270	0.00265	0.00260	0.00264	0.00260	0.00277	0.00278	0.00279
		Cd	0.00004	0.00001	0.00001	0.00004	0.00013	0.00016	0.00016	0.00016	0.00015	0.00008	0.00005	0.00005
		Cu	0.00715	0.00720	0.00720	0.00708	0.00684	0.00668	0.00657	0.00668	0.00659	0.00705	0.00711	0.00712
		Fe	0.00290	0.00250	0.00250	0.00349	0.00537	0.00670	0.00767	0.00672	0.00744	0.00367	0.00318	0.00310
		Hg	0.00003	0.00001	0.00001	0.00003	0.00010	0.00011	0.00011	0.00011	0.00010	0.00006	0.00004	0.00004
		Pb	0.00102	0.00010	0.00010	0.00138	0.00474	0.00597	0.00644	0.00600	0.00588	0.00260	0.00166	0.00148
		Sb	0.02278	0.02290	0.02290	0.02246	0.02177	0.02112	0.02057	0.02111	0.02063	0.02253	0.02270	0.02273
		Se	0.00366	0.00330	0.00330	0.00366	0.00482	0.00505	0.00499	0.00506	0.00477	0.00424	0.00390	0.00383
		Zn	0.01722	0.01700	0.01700	0.01772	0.01893	0.01998	0.02084	0.02000	0.02073	0.01767	0.01737	0.01733

TABLE F18:

WATER QUALITY OF BLENDED DISCHARGE - TREATED 2010 MINE + 2011 PROCESS WATER, LOW ESTIMATE MINE FLOWS

Source Flow			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Treated mine water L/s			4.5	2	2	5	34.5	34.5	34.5	34.5	30	22	11.5	6.5
Treated mill water L/s			1	0	0	1.5	9.5	11.5	11.5	11.5	10	5	2.5	1.5
Ditches L/s			0	0	0	2	6	15	15	15	15	0.5	0	0
Combined L/s			5.5	2	2	8.5	50	61	61	61	55	27.5	14	8
Combined Water Quality mg/L	**Total Metals**	**As**	0.00393	0.00280	0.00280	0.00342	0.00374	0.00348	0.00348	0.00348	0.00338	0.00389	0.00391	0.00396
		Cu	0.01880	0.00720	0.00720	0.01728	0.01872	0.01800	0.01800	0.01800	0.01744	0.01871	0.01859	0.01916
		Zn	0.25936	0.01700	0.01700	0.26071	0.27459	0.27716	0.27716	0.27716	0.26918	0.26002	0.25504	0.26694

TABLE F19:
WATER QUALITY OF BLENDED DISCHARGE - TREATED 2010 MINE + 2011 PROCESS WATER, BEST ESTIMATE MINE FLOWS

Source Flow			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Treated mine water L/s			7	2	2	10	61	66	66	66	58.5	41	18	10
Treated mill water L/s			1	0	0	1.5	9.5	11.5	11.5	11.5	10	5	2.5	1.5
Ditches L/s			0	0	0	2	6	15	15	15	15	0.5	0	0
Combined L/s			8	2	2	13.5	76.5	92.5	92.5	92.5	83.5	46.5	20.5	11.5
Combined Water Quality mg/L	Total Metals	As	0.00358	0.00280	0.00280	0.00319	0.00341	0.00325	0.00325	0.00325	0.00318	0.00345	0.00356	0.00361
		Cu	0.01518	0.00720	0.00720	0.01355	0.01473	0.01432	0.01432	0.01432	0.01394	0.01401	0.01498	0.01552
		Zn	0.18363	0.01700	0.01700	0.17044	0.18536	0.18856	0.18856	0.18856	0.18311	0.16072	0.17956	0.19087

TABLE F20:
WATER QUALITY OF BLENDED DISCHARGE - TREATED 2010 MINE + 2011 PROCESS WATER, HIGH K MINE FLOWS

Source Flow			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Treated mine water L/s			10	6	6	15	90	145	145	145	120	68	27	15
Treated mill water L/s			1	0	0	1.5	9.5	11.5	11.5	11.5	10	5	2.5	1.5
Ditches L/s			0	0	0	2	6	12	18	12	18	0.5	0	0
Combined L/s			11	6	6	18.5	105.5	168.5	174.5	168.5	148	73.5	29.5	16.5
Combined Water Quality mg/L	**Total Metals**	**As**	0.00336	0.00280	0.00280	0.00309	0.00324	0.00308	0.00300	0.00308	0.00298	0.00321	0.00333	0.00336
		Cu	0.01300	0.00720	0.00720	0.01183	0.01266	0.01120	0.01089	0.01120	0.01090	0.01151	0.01261	0.01300
		Zn	0.13818	0.01700	0.01700	0.12897	0.13908	0.11054	0.10856	0.11054	0.11145	0.10793	0.12997	0.13818

TABLE F21:
WATER QUALITY OF BLENDED DISCHARGE - TREATED 2010 MINE + 2011 PROCESS WATER, HIGH K + PCAA MINE FLOWS

Source Flow			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Treated mine water L/s			100	80	80	142	205	206	205	205	205	185	147	100
Treated mill water L/s			1	0	0	1.5	9.5	11.5	11.5	11.5	10	5	2.5	1.5
Ditches L/s			0	0	0	2	6	12	18	12	18	0.5	0	0
Combined L/s			101	80	80	145.5	220.5	229.5	234.5	228.5	233	190.5	149.5	101.5
Combined Water Quality mg/L	Total Metals	As	0.00286	0.00280	0.00280	0.00284	0.00301	0.00301	0.00295	0.00301	0.00291	0.00296	0.00290	0.00289
		Cu	0.00783	0.00720	0.00720	0.00779	0.00981	0.01014	0.00994	0.01015	0.00955	0.00886	0.00827	0.00814
		Zn	0.03020	0.01700	0.01700	0.03124	0.07541	0.08568	0.08513	0.08598	0.07699	0.05208	0.03929	0.03670

TABLE F22:
COMPUTED MEAN, LOW AND HIGH FLOWS FOR PRAIRIE CREEK AT HARRISON CREEK AND THE PARK BOUNDARY

FLOWS AT STATIONS ON PRAIRIE CREEK (L/sec)

	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
WSC Station	Mean	530	381	309	819	12,358	17,237	11,780	9,336	6,318	2,762	1,294	838
	Min	145	48	38	78	7,840	10,800	5,960	5,120	3,660	1,540	828	254
	Max	1,230	868	661	4,340	18,400	37,400	19,700	16,900	9,080	5,610	1,720	1,840
Prairie Ck at Harrison	Mean	540	388	315	835	12,608	17,587	12,019	9,526	6,446	2,818	1,320	855
	Min	148	49	39	80	7,999	11,019	6,081	5,224	3,734	1,571	845	259
	Max	1,255	886	674	4,428	18,774	38,160	20,100	17,243	9,264	5,724	1,755	1,877
Prairie Ck at Park Boundary	Mean	602	433	351	930	14,040	19,584	13,384	10,607	7,178	3,138	1,470	952
	Min	165	55	43	89	8,908	12,271	6,772	5,817	4,158	1,750	941	289
	Max	1,397	986	751	4,931	20,905	42,492	22,382	19,201	10,316	6,374	1,954	2,091

FLOWS AT STATIONS ON PRAIRIE CREEK (m^3/sec)

	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
WSC Station	Mean	0.530	0.381	0.309	0.819	12.358	17.237	11.780	9.336	6.318	2.762	1.294	0.838
	Min	0.145	0.048	0.038	0.078	7.840	10.800	5.960	5.120	3.660	1.540	0.828	0.254
	Max	1.230	0.868	0.661	4.340	18.400	37.400	19.700	16.900	9.080	5.610	1.720	1.840
Prairie Ck at Harrison	Mean	0.540	0.388	0.315	0.835	12.608	17.587	12.019	9.526	6.446	2.818	1.320	0.855
	Min	0.148	0.049	0.039	0.080	7.999	11.019	6.081	5.224	3.734	1.571	0.845	0.259
	Max	1.255	0.886	0.674	4.428	18.774	38.160	20.100	17.243	9.264	5.724	1.755	1.877
Prairie Ck at Park Boundary	Mean	0.602	0.433	0.351	0.930	14.040	19.584	13.384	10.607	7.178	3.138	1.470	0.952
	Min	0.165	0.055	0.043	0.089	8.908	12.271	6.772	5.817	4.158	1.750	0.941	0.289
	Max	1.397	0.986	0.751	4.931	20.905	42.492	22.382	19.201	10.316	6.374	1.954	2.091

TABLE F23: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2011 TREATED WATER DATA, MAIN METALS, LOW ESTIMATE MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Total Cadmium	Mean	0.00009	0.00005	0.00005	0.00009	0.00007	0.00006	0.00007	0.00008	0.00009	0.00009	0.00009	0.00009
	Min	0.00021	0.00005	0.00005	0.00047	0.00008	0.00007	0.00009	0.00010	0.00011	0.00012	0.00012	0.00018
	Max	0.00007	0.00005	0.00005	0.00006	0.00006	0.00006	0.00006	0.00006	0.00007	0.00007	0.00008	0.00007
Total Copper	Mean	0.00070	0.00057	0.00057	0.00070	0.00062	0.00062	0.00064	0.00066	0.00068	0.00070	0.00070	0.00069
	Min	0.00103	0.00058	0.00058	0.00181	0.00065	0.00065	0.00071	0.00073	0.00076	0.00079	0.00078	0.00097
	Max	0.00063	0.00057	0.00057	0.00059	0.00061	0.00059	0.00061	0.00062	0.00065	0.00063	0.00067	0.00063
Total Lead	Mean	0.00080	0.00024	0.00024	0.00083	0.00047	0.00045	0.00055	0.00064	0.00076	0.00078	0.00081	0.00077
	Min	0.00225	0.00029	0.00030	0.00601	0.00061	0.00058	0.00086	0.00097	0.00113	0.00121	0.00113	0.00197
	Max	0.00048	0.00023	0.00023	0.00034	0.00039	0.00033	0.00042	0.00045	0.00060	0.00050	0.00067	0.00048
Total Selenium	Mean	0.00119	0.00117	0.00117	0.00119	0.00117	0.00117	0.00117	0.00118	0.00118	0.00119	0.00119	0.00119
	Min	0.00127	0.00122	0.00124	0.00143	0.00118	0.00118	0.00119	0.00119	0.00120	0.00121	0.00121	0.00125
	Max	0.00117	0.00116	0.00116	0.00117	0.00117	0.00116	0.00117	0.00117	0.00118	0.00117	0.00118	0.00117
Total Zinc	Mean	0.0096	0.0071	0.0071	0.0096	0.0082	0.0080	0.0085	0.0088	0.0093	0.0095	0.0096	0.0094
	Min	0.0158	0.0070	0.0069	**0.0308**	0.0087	0.0086	0.0097	0.0102	0.0108	0.0113	0.0110	0.0146
	Max	0.0082	0.0071	0.0071	0.0076	0.0078	0.0076	0.0079	0.0081	0.0086	0.0083	0.0090	0.0082
		Prairie Creek at Park Boundary											
Total Cadmium	Mean	0.00009	0.00005	0.00005	0.00009	0.00006	0.00006	0.00007	0.00007	0.00008	0.00009	0.00009	0.00009
	Min	0.00019	0.00005	0.00005	0.00043	0.00007	0.00007	0.00009	0.00010	0.00011	0.00012	0.00011	0.00017
	Max	0.00007	0.00005	0.00005	0.00006	0.00006	0.00005	0.00006	0.00006	0.00007	0.00007	0.00008	0.00007
Total Copper	Mean	0.00069	0.00057	0.00057	0.00069	0.00062	0.00061	0.00063	0.00065	0.00067	0.00068	0.00069	0.00068
	Min	0.00099	0.00057	0.00058	0.00170	0.00065	0.00064	0.00069	0.00071	0.00074	0.00077	0.00076	0.00093
	Max	0.00062	0.00057	0.00057	0.00059	0.00060	0.00059	0.00061	0.00061	0.00064	0.00063	0.00066	0.00062
Total Lead	Mean	0.00074	0.00024	0.00024	0.00077	0.00045	0.00043	0.00052	0.00059	0.00070	0.00072	0.00075	0.00071
	Min	0.00205	0.00028	0.00030	0.00547	0.00057	0.00055	0.00080	0.00089	0.00104	0.00111	0.00104	0.00180
	Max	0.00045	0.00023	0.00023	0.00033	0.00038	0.00032	0.00040	0.00043	0.00056	0.00047	0.00062	0.00045
Total Selenium	Mean	0.00119	0.00117	0.00117	0.00119	0.00117	0.00117	0.00117	0.00118	0.00118	0.00119	0.00119	0.00118
	Min	0.00126	0.00122	0.00123	0.00141	0.00118	0.00117	0.00119	0.00119	0.00120	0.00121	0.00120	0.00124
	Max	0.00117	0.00116	0.00116	0.00116	0.00117	0.00116	0.00117	0.00117	0.00118	0.00117	0.00118	0.00117
Total Zinc	Mean	0.0093	0.0071	0.0071	0.0094	0.0081	0.0080	0.0083	0.0086	0.0091	0.0092	0.0094	0.0092
	Min	0.0149	0.0070	0.0069	0.0286	0.0086	0.0084	0.0095	0.0099	0.0105	0.0109	0.0106	0.0138
	Max	0.0081	0.0071	0.0071	0.0076	0.0078	0.0075	0.0079	0.0080	0.0085	0.0082	0.0088	0.0081

TABLE F24: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2011 TREATED WATER DATA, MAIN METALS, BEST ESTIMATE MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Total Cadmium	Mean	0.00009	0.00005	0.00005	0.00009	0.00007	0.00006	0.00007	0.00008	0.00009	0.00009	0.00009	0.00009
	Min	**0.00020**	0.00005	0.00005	**0.00044**	0.00008	0.00007	0.00009	0.00010	0.00011	0.00012	0.00012	**0.00018**
	Max	0.00007	0.00005	0.00005	0.00006	0.00006	0.00006	0.00006	0.00006	0.00007	0.00007	0.00008	0.00007
Total Copper	Mean	0.00070	0.00057	0.00057	0.00070	0.00062	0.00062	0.00064	0.00066	0.00068	0.00070	0.00070	0.00069
	Min	0.00103	0.00058	0.00058	0.00175	0.00066	0.00065	0.00071	0.00073	0.00076	0.00079	0.00078	0.00097
	Max	0.00063	0.00057	0.00057	0.00059	0.00061	0.00059	0.00061	0.00062	0.00065	0.00063	0.00067	0.00063
Total Lead	Mean	0.00080	0.00024	0.00024	0.00084	0.00048	0.00045	0.00055	0.00064	0.00076	0.00079	0.00082	0.00077
	Min	0.00224	0.00029	0.00030	0.00578	0.00062	0.00058	0.00087	0.00097	0.00114	0.00121	0.00114	0.00197
	Max	0.00048	0.00023	0.00023	0.00035	0.00040	0.00033	0.00042	0.00046	0.00060	0.00051	0.00067	0.00048
Total Selenium	Mean	0.00120	0.00117	0.00117	0.00120	0.00118	0.00117	0.00118	0.00118	0.00119	0.00120	0.00120	0.00119
	Min	0.00129	0.00122	0.00124	0.00151	0.00118	0.00118	0.00120	0.00120	0.00121	0.00123	0.00122	0.00127
	Max	0.00118	0.00116	0.00116	0.00117	0.00117	0.00117	0.00117	0.00117	0.00118	0.00118	0.00119	0.00118
Total Zinc	Mean	0.0095	0.0071	0.0071	0.0096	0.0081	0.0080	0.0084	0.0088	0.0093	0.0094	0.0096	0.0094
	Min	0.0155	0.0070	0.0069	0.0293	0.0087	0.0086	0.0097	0.0101	0.0108	0.0112	0.0109	0.0144
	Max	0.0082	0.0071	0.0071	0.0076	0.0078	0.0076	0.0079	0.0081	0.0086	0.0083	0.0090	0.0082
		Prairie Creek at Park Boundary											
Total Cadmium	Mean	0.00009	0.00005	0.00005	0.00009	0.00006	0.00006	0.00007	0.00007	0.00008	0.00009	0.00009	0.00009
	Min	**0.00019**	0.00005	0.00005	**0.00041**	0.00007	0.00007	0.00009	0.00010	0.00011	0.00012	0.00011	0.00017
	Max	0.00007	0.00005	0.00005	0.00006	0.00006	0.00005	0.00006	0.00006	0.00007	0.00007	0.00008	0.00007
Total Copper	Mean	0.00069	0.00057	0.00057	0.00069	0.00062	0.00061	0.00063	0.00065	0.00067	0.00068	0.00069	0.00068
	Min	0.00098	0.00057	0.00058	0.00165	0.00065	0.00064	0.00069	0.00071	0.00074	0.00077	0.00076	0.00093
	Max	0.00062	0.00057	0.00057	0.00059	0.00060	0.00059	0.00061	0.00061	0.00064	0.00063	0.00066	0.00062
Total Lead	Mean	0.00075	0.00024	0.00024	0.00078	0.00045	0.00043	0.00052	0.00060	0.00071	0.00073	0.00076	0.00072
	Min	0.00205	0.00028	0.00030	0.00529	0.00058	0.00055	0.00080	0.00090	0.00105	0.00112	0.00105	0.00180
	Max	0.00045	0.00023	0.00023	0.00033	0.00038	0.00032	0.00041	0.00043	0.00056	0.00048	0.00063	0.00045
Total Selenium	Mean	0.00119	0.00117	0.00117	0.00119	0.00117	0.00117	0.00118	0.00118	0.00119	0.00120	0.00119	0.00119
	Min	0.00128	0.00122	0.00123	0.00147	0.00118	0.00118	0.00119	0.00120	0.00121	0.00122	0.00121	0.00126
	Max	0.00117	0.00116	0.00116	0.00117	0.00117	0.00117	0.00117	0.00117	0.00118	0.00118	0.00119	0.00117
Total Zinc	Mean	0.0093	0.0071	0.0071	0.0093	0.0080	0.0079	0.0083	0.0086	0.0090	0.0092	0.0093	0.0092
	Min	0.0147	0.0070	0.0069	0.0273	0.0086	0.0084	0.0094	0.0098	0.0104	0.0108	0.0105	0.0137
	Max	0.0081	0.0071	0.0071	0.0076	0.0077	0.0075	0.0078	0.0080	0.0085	0.0082	0.0088	0.0081

TABLE F25: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2011 TREATED WATER DATA, MAIN METALS, HIGH K MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Total Cadmium	Mean	0.00009	0.00005	0.00005	0.00009	0.00007	0.00006	0.00007	0.00008	0.00009	0.00009	0.00009	0.00009
	Min	**0.00020**	0.00005	0.00005	**0.00042**	0.00008	0.00007	0.00009	0.00010	0.00011	0.00012	0.00012	**0.00018**
	Max	0.00007	0.00005	0.00005	0.00006	0.00006	0.00006	0.00006	0.00006	0.00007	0.00007	0.00008	0.00007
Total Copper	Mean	0.00070	0.00057	0.00057	0.00070	0.00062	0.00062	0.00064	0.00066	0.00068	0.00070	0.00070	0.00069
	Min	0.00102	0.00058	0.00059	0.00170	0.00066	0.00065	0.00071	0.00073	0.00076	0.00079	0.00078	0.00096
	Max	0.00063	0.00057	0.00057	0.00059	0.00061	0.00059	0.00061	0.00062	0.00065	0.00063	0.00067	0.00063
Total Lead	Mean	0.00081	0.00025	0.00026	0.00084	0.00048	0.00045	0.00057	0.00064	0.00078	0.00079	0.00082	0.00078
	Min	0.00223	0.00039	0.00043	0.00557	0.00062	0.00059	0.00089	0.00097	0.00116	0.00122	0.00114	0.00196
	Max	0.00048	0.00024	0.00024	0.00035	0.00040	0.00033	0.00043	0.00046	0.00062	0.00051	0.00068	0.00048
Total Selenium	Mean	0.00121	0.00118	0.00119	0.00121	0.00118	0.00118	0.00119	0.00120	0.00121	0.00121	0.00121	0.00120
	Min	0.00132	0.00134	0.00138	0.00157	0.00119	0.00119	0.00122	0.00123	0.00124	0.00126	0.00124	0.00130
	Max	0.00118	0.00117	0.00117	0.00117	0.00117	0.00117	0.00118	0.00118	0.00119	0.00119	0.00120	0.00118
Total Zinc	Mean	0.0095	0.0071	0.0071	0.0095	0.0081	0.0080	0.0084	0.0087	0.0092	0.0094	0.0095	0.0094
	Min	0.0153	0.0066	0.0065	0.0279	0.0087	0.0085	0.0096	0.0100	0.0107	0.0110	0.0108	0.0142
	Max	0.0082	0.0071	0.0071	0.0076	0.0078	0.0075	0.0079	0.0080	0.0086	0.0082	0.0090	0.0082
		Prairie Creek at Park Boundary											
Total Cadmium	Mean	0.00009	0.00005	0.00005	0.00009	0.00006	0.00006	0.00007	0.00007	0.00008	0.00009	0.00009	0.00009
	Min	**0.00019**	0.00005	0.00005	**0.00039**	0.00007	0.00007	0.00009	0.00010	0.00011	0.00011	0.00011	0.00017
	Max	0.00007	0.00005	0.00005	0.00006	0.00006	0.00005	0.00006	0.00006	0.00007	0.00007	0.00008	0.00007
Total Copper	Mean	0.00069	0.00057	0.00057	0.00069	0.00062	0.00061	0.00063	0.00065	0.00067	0.00068	0.00069	0.00068
	Min	0.00098	0.00058	0.00059	0.00160	0.00065	0.00064	0.00069	0.00071	0.00074	0.00077	0.00076	0.00092
	Max	0.00062	0.00057	0.00057	0.00059	0.00060	0.00059	0.00061	0.00061	0.00064	0.00063	0.00066	0.00062
Total Lead	Mean	0.00075	0.00025	0.00025	0.00078	0.00045	0.00043	0.00053	0.00060	0.00073	0.00074	0.00076	0.00072
	Min	0.00204	0.00038	0.00041	0.00512	0.00058	0.00055	0.00082	0.00090	0.00107	0.00112	0.00105	0.00180
	Max	0.00046	0.00024	0.00024	0.00034	0.00038	0.00032	0.00041	0.00044	0.00058	0.00048	0.00063	0.00046
Total Selenium	Mean	0.00120	0.00118	0.00119	0.00120	0.00118	0.00118	0.00119	0.00119	0.00120	0.00121	0.00120	0.00120
	Min	0.00130	0.00132	0.00136	0.00154	0.00119	0.00119	0.00121	0.00122	0.00123	0.00125	0.00123	0.00128
	Max	0.00118	0.00117	0.00117	0.00117	0.00117	0.00117	0.00118	0.00118	0.00119	0.00118	0.00119	0.00118
Total Zinc	Mean	0.0093	0.0071	0.0071	0.0093	0.0080	0.0079	0.0083	0.0086	0.0090	0.0091	0.0093	0.0091
	Min	0.0145	0.0067	0.0066	0.0262	0.0085	0.0084	0.0094	0.0097	0.0103	0.0107	0.0105	0.0135
	Max	0.0081	0.0071	0.0071	0.0076	0.0077	0.0075	0.0078	0.0079	0.0084	0.0081	0.0088	0.0081

TABLE F26: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2011 TREATED WATER DATA, MAIN METALS, HIGH K + PCAA MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Total Cadmium	Mean	0.00008	0.00005	0.00005	0.00008	0.00007	0.00006	0.00007	0.00008	0.00008	0.00009	0.00009	0.00009
	Min	0.00014	0.00004	0.00004	**0.00021**	0.00008	0.00007	0.00009	0.00010	0.00011	0.00012	0.00011	0.00015
	Max	0.00007	0.00005	0.00005	0.00006	0.00006	0.00006	0.00006	0.00006	0.00007	0.00007	0.00008	0.00007
Total Copper	Mean	0.00070	0.00059	0.00060	0.00070	0.00062	0.00062	0.00064	0.00066	0.00068	0.00070	0.00070	0.00069
	Min	0.00091	0.00065	0.00066	0.00114	0.00066	0.00065	0.00071	0.00073	0.00076	0.00078	0.00077	0.00090
	Max	0.00063	0.00058	0.00058	0.00060	0.00061	0.00059	0.00061	0.00062	0.00065	0.00063	0.00067	0.00063
Total Lead	Mean	0.00093	0.00048	0.00053	0.00095	0.00049	0.00046	0.00057	0.00065	0.00079	0.00083	0.00089	0.00086
	Min	0.00204	0.00114	0.00122	0.00339	0.00063	0.00059	0.00090	0.00098	0.00118	0.00125	0.00121	0.00190
	Max	0.00056	0.00035	0.00039	0.00039	0.00041	0.00034	0.00044	0.00046	0.00063	0.00053	0.00074	0.00053
Total Selenium	Mean	0.00143	0.00144	0.00149	0.00141	0.00119	0.00119	0.00120	0.00121	0.00123	0.00128	0.00134	0.00135
	Min	0.00185	**0.00218**	**0.00226**	**0.00226**	0.00121	0.00120	0.00123	0.00124	0.00127	0.00136	0.00142	0.00165
	Max	0.00129	0.00130	0.00133	0.00121	0.00118	0.00117	0.00118	0.00119	0.00121	0.00122	0.00130	0.00125
Total Zinc	Mean	0.0085	0.0063	0.0062	0.0086	0.0081	0.0080	0.0084	0.0087	0.0091	0.0091	0.0090	0.0088
	Min	0.0107	0.0043	0.0040	0.0136	0.0086	0.0085	0.0096	0.0099	0.0105	0.0105	0.0098	0.0114
	Max	0.0078	0.0068	0.0066	0.0075	0.0078	0.0075	0.0079	0.0080	0.0085	0.0081	0.0085	0.0079
		Prairie Creek at Park Boundary											
Total Cadmium	Mean	0.00008	0.00005	0.00005	0.00008	0.00006	0.00006	0.00007	0.00007	0.00008	0.00008	0.00008	0.00008
	Min	0.00014	0.00004	0.00004	**0.00020**	0.00007	0.00007	0.00009	0.00009	0.00010	0.00011	0.00010	0.00014
	Max	0.00006	0.00005	0.00005	0.00006	0.00006	0.00005	0.00006	0.00006	0.00007	0.00007	0.00008	0.00006
Total Copper	Mean	0.00069	0.00059	0.00059	0.00069	0.00062	0.00061	0.00063	0.00065	0.00067	0.00068	0.00069	0.00068
	Min	0.00088	0.00065	0.00065	0.00111	0.00065	0.00064	0.00069	0.00071	0.00074	0.00076	0.00075	0.00087
	Max	0.00063	0.00058	0.00058	0.00060	0.00060	0.00059	0.00061	0.00061	0.00064	0.00063	0.00066	0.00062
Total Lead	Mean	0.00087	0.00046	0.00050	0.00089	0.00046	0.00044	0.00054	0.00061	0.00074	0.00077	0.00083	0.00080
	Min	0.00193	0.00110	0.00118	0.00326	0.00059	0.00056	0.00083	0.00090	0.00108	0.00116	0.00112	0.00177
	Max	0.00053	0.00034	0.00037	0.00037	0.00039	0.00033	0.00042	0.00044	0.00059	0.00050	0.00069	0.00050
Total Selenium	Mean	0.00141	0.00142	0.00146	0.00139	0.00119	0.00118	0.00119	0.00120	0.00122	0.00126	0.00132	0.00133
	Min	0.00181	0.00214	**0.00223**	**0.00222**	0.00121	0.00120	0.00123	0.00123	0.00126	0.00134	0.00140	0.00161
	Max	0.00128	0.00128	0.00132	0.00121	0.00118	0.00117	0.00118	0.00118	0.00120	0.00121	0.00129	0.00124
Total Zinc	Mean	0.0084	0.0064	0.0063	0.0085	0.0080	0.0079	0.0083	0.0085	0.0089	0.0089	0.0088	0.0086
	Min	0.0104	0.0044	0.0041	0.0133	0.0085	0.0083	0.0093	0.0096	0.0102	0.0102	0.0096	0.0111
	Max	0.0077	0.0068	0.0067	0.0074	0.0077	0.0075	0.0078	0.0079	0.0084	0.0080	0.0084	0.0078

TABLE F27: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2011 TREATED WATER DATA, OTHER METALS, LOW ESTIMATE MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Total Silver	Mean	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Min	0.00003	0.00003	0.00003	0.00004	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Max	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
Total Arsenic	Mean	0.00026	0.00024	0.00024	0.00026	0.00025	0.00025	0.00025	0.00025	0.00025	0.00026	0.00026	0.00025
	Min	0.00030	0.00024	0.00024	0.00040	0.00025	0.00025	0.00026	0.00026	0.00027	0.00027	0.00026	0.00029
	Max	0.00025	0.00024	0.00024	0.00024	0.00024	0.00024	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025
Total Iron	Mean	0.058	0.048	0.048	0.058	0.053	0.052	0.054	0.055	0.057	0.058	0.058	0.058
	Min	0.083	0.048	0.047	0.138	0.055	0.054	0.058	0.060	0.062	0.065	0.064	0.078
	Max	0.053	0.049	0.049	0.050	0.051	0.050	0.052	0.052	0.054	0.053	0.056	0.053
Total Mercury	Mean	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
	Min	0.00003	0.00002	0.00002	**0.00005**	0.00002	0.00002	0.00002	0.00002	0.00002	0.00003	0.00003	0.00003
	Max	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Total Antimony	Mean	0.0007	0.0004	0.0004	0.0006	0.0004	0.0004	0.0004	0.0005	0.0005	0.0006	0.0007	0.0006
	Min	0.0018	0.0012	0.0015	0.0037	0.0005	0.0004	0.0006	0.0007	0.0008	0.0010	0.0009	0.0015
	Max	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0005	0.0004	0.0006	0.0004
		Prairie Creek at Park Boundary											
Total Silver	Mean	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Min	0.00003	0.00003	0.00003	0.00004	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Max	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
Total Arsenic	Mean	0.00025	0.00024	0.00024	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025
	Min	0.00029	0.00024	0.00024	0.00038	0.00025	0.00025	0.00026	0.00026	0.00026	0.00026	0.00026	0.00028
	Max	0.00025	0.00024	0.00024	0.00024	0.00024	0.00024	0.00024	0.00025	0.00025	0.00025	0.00025	0.00025
Total Iron	Mean	0.057	0.048	0.048	0.057	0.052	0.052	0.053	0.054	0.056	0.057	0.057	0.057
	Min	0.079	0.048	0.047	0.130	0.054	0.054	0.057	0.059	0.061	0.063	0.062	0.075
	Max	0.052	0.049	0.049	0.050	0.051	0.050	0.051	0.052	0.054	0.053	0.055	0.052
Total Mercury	Mean	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
	Min	0.00003	0.00002	0.00002	**0.00005**	0.00002	0.00002	0.00002	0.00002	0.00002	0.00003	0.00002	0.00003
	Max	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Total Antimony	Mean	0.0006	0.0004	0.0004	0.0006	0.0004	0.0004	0.0004	0.0005	0.0005	0.0006	0.0006	0.0006
	Min	0.0016	0.0011	0.0014	0.0034	0.0005	0.0004	0.0006	0.0006	0.0007	0.0009	0.0009	0.0014
	Max	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0005	0.0004

TABLE F28: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2011 TREATED WATER DATA, OTHER METALS, BEST ESTIMATE MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Total Silver	Mean	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Min	0.00003	0.00003	0.00003	0.00004	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Max	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
Total Arsenic	Mean	0.00026	0.00024	0.00024	0.00026	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00026	0.00025
	Min	0.00029	0.00024	0.00024	0.00039	0.00025	0.00025	0.00026	0.00026	0.00026	0.00027	0.00026	0.00029
	Max	0.00025	0.00024	0.00024	0.00024	0.00024	0.00024	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025
Total Iron	Mean	0.058	0.048	0.048	0.058	0.052	0.052	0.054	0.055	0.057	0.058	0.058	0.058
	Min	0.082	0.048	0.047	0.132	0.055	0.054	0.058	0.060	0.062	0.064	0.063	0.077
	Max	0.053	0.049	0.049	0.050	0.051	0.050	0.052	0.052	0.054	0.053	0.056	0.053
Total Mercury	Mean	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
	Min	0.00003	0.00002	0.00002	**0.00005**	0.00002	0.00002	0.00002	0.00002	0.00002	0.00003	0.00003	0.00003
	Max	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Total Antimony	Mean	0.0008	0.0004	0.0004	0.0007	0.0005	0.0004	0.0005	0.0006	0.0006	0.0008	0.0008	0.0007
	Min	0.0021	0.0012	0.0015	0.0048	0.0006	0.0005	0.0007	0.0008	0.0009	0.0012	0.0011	0.0018
	Max	0.0005	0.0003	0.0003	0.0003	0.0004	0.0003	0.0004	0.0004	0.0005	0.0005	0.0007	0.0005
		Prairie Creek at Park Boundary											
Total Silver	Mean	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Min	0.00003	0.00003	0.00003	0.00004	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Max	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
Total Arsenic	Mean	0.00025	0.00024	0.00024	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025
	Min	0.00029	0.00024	0.00024	0.00038	0.00025	0.00025	0.00026	0.00026	0.00026	0.00026	0.00026	0.00028
	Max	0.00025	0.00024	0.00024	0.00024	0.00024	0.00024	0.00024	0.00025	0.00025	0.00025	0.00025	0.00025
Total Iron	Mean	0.057	0.048	0.048	0.057	0.052	0.052	0.053	0.054	0.056	0.057	0.057	0.057
	Min	0.078	0.048	0.047	0.124	0.054	0.053	0.057	0.059	0.061	0.063	0.062	0.074
	Max	0.052	0.049	0.049	0.050	0.051	0.050	0.051	0.052	0.054	0.053	0.055	0.052
Total Mercury	Mean	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
	Min	0.00003	0.00002	0.00002	**0.00005**	0.00002	0.00002	0.00002	0.00002	0.00002	0.00003	0.00002	0.00003
	Max	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Total Antimony	Mean	0.0007	0.0004	0.0004	0.0007	0.0004	0.0004	0.0005	0.0005	0.0006	0.0008	0.0007	0.0007
	Min	0.0019	0.0011	0.0014	0.0044	0.0005	0.0005	0.0007	0.0008	0.0009	0.0011	0.0010	0.0017
	Max	0.0005	0.0003	0.0003	0.0003	0.0004	0.0003	0.0004	0.0004	0.0005	0.0005	0.0006	0.0004

TABLE F29: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2011 TREATED WATER DATA, OTHER METALS, HIGH K ESTIMATE MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Total Silver	Mean	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Min	0.00003	0.00003	0.00003	0.00004	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Max	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
Total Arsenic	Mean	0.00026	0.00024	0.00024	0.00026	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00026	0.00025
	Min	0.00029	0.00024	0.00023	0.00038	0.00025	0.00025	0.00026	0.00026	0.00026	0.00027	0.00026	0.00029
	Max	0.00025	0.00024	0.00024	0.00024	0.00024	0.00024	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025
Total Iron	Mean	0.058	0.048	0.048	0.058	0.052	0.052	0.053	0.055	0.056	0.057	0.058	0.057
	Min	0.081	0.046	0.045	0.126	0.055	0.054	0.058	0.059	0.062	0.064	0.063	0.076
	Max	0.053	0.048	0.048	0.050	0.051	0.050	0.051	0.052	0.054	0.053	0.056	0.053
Total Mercury	Mean	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
	Min	0.00003	0.00002	0.00002	**0.00005**	0.00002	0.00002	0.00002	0.00002	0.00002	0.00003	0.00003	0.00003
	Max	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Total Antimony	Mean	0.0009	0.0006	0.0007	0.0009	0.0005	0.0005	0.0007	0.0008	0.0009	0.0010	0.0010	0.0009
	Min	0.0026	0.0030	0.0036	0.0059	0.0007	0.0007	0.0010	0.0012	0.0013	0.0016	0.0014	0.0023
	Max	0.0005	0.0004	0.0005	0.0004	0.0004	0.0004	0.0005	0.0005	0.0007	0.0006	0.0008	0.0005
		Prairie Creek at Park Boundary											
Total Silver	Mean	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Min	0.00003	0.00003	0.00003	0.00004	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Max	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
Total Arsenic	Mean	0.00025	0.00024	0.00024	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025
	Min	0.00029	0.00024	0.00024	0.00037	0.00025	0.00025	0.00026	0.00026	0.00026	0.00026	0.00026	0.00028
	Max	0.00025	0.00024	0.00024	0.00024	0.00024	0.00024	0.00024	0.00025	0.00025	0.00025	0.00025	0.00025
Total Iron	Mean	0.057	0.048	0.048	0.057	0.052	0.052	0.053	0.054	0.055	0.056	0.057	0.056
	Min	0.077	0.046	0.045	0.120	0.054	0.053	0.057	0.058	0.060	0.062	0.062	0.074
	Max	0.052	0.048	0.048	0.050	0.051	0.050	0.051	0.052	0.053	0.052	0.055	0.052
Total Mercury	Mean	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
	Min	0.00003	0.00002	0.00002	**0.00005**	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00003
	Max	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Total Antimony	Mean	0.0008	0.0006	0.0007	0.0008	0.0005	0.0005	0.0006	0.0007	0.0008	0.0010	0.0009	0.0008
	Min	0.0023	0.0027	0.0033	0.0054	0.0006	0.0006	0.0010	0.0011	0.0012	0.0015	0.0012	0.0021
	Max	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0006	0.0006	0.0007	0.0005

TABLE F30: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2011 TREATED WATER DATA, OTHER METALS, HIGH K + PCAA ESTIMATE MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Total Silver	Mean	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Min	0.00002	0.00002	0.00002	0.00002	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Max	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
Total Arsenic	Mean	0.00025	0.00023	0.00023	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025
	Min	0.00026	0.00022	0.00021	0.00028	0.00025	0.00025	0.00026	0.00026	0.00026	0.00026	0.00026	0.00027
	Max	0.00024	0.00024	0.00024	0.00024	0.00024	0.00024	0.00025	0.00025	0.00025	0.00025	0.00025	0.00024
Total Iron	Mean	0.053	0.044	0.043	0.053	0.052	0.052	0.053	0.054	0.056	0.056	0.055	0.054
	Min	0.059	0.031	0.030	0.067	0.054	0.054	0.057	0.059	0.061	0.061	0.058	0.063
	Max	0.051	0.046	0.046	0.049	0.051	0.050	0.051	0.052	0.054	0.052	0.053	0.051
Total Mercury	Mean	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
	Min	0.00002	0.00001	0.00001	0.00003	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00003
	Max	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Total Antimony	Mean	0.0043	0.0045	0.0053	0.0041	0.0007	0.0006	0.0008	0.0009	0.0012	0.0020	0.0030	0.0030
	Min	0.0108	0.0158	0.0171	0.0168	0.0010	0.0008	0.0013	0.0014	0.0018	0.0032	0.0042	0.0077
	Max	0.0022	0.0023	0.0029	0.0011	0.0006	0.0004	0.0006	0.0006	0.0009	0.0011	0.0023	0.0016
		Prairie Creek at Park Boundary											
Total Silver	Mean	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Min	0.00002	0.00002	0.00002	0.00002	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Max	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
Total Arsenic	Mean	0.00025	0.00023	0.00023	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025
	Min	0.00026	0.00022	0.00021	0.00028	0.00025	0.00025	0.00025	0.00026	0.00026	0.00026	0.00025	0.00026
	Max	0.00024	0.00024	0.00024	0.00024	0.00024	0.00024	0.00024	0.00025	0.00025	0.00025	0.00025	0.00024
Total Iron	Mean	0.052	0.044	0.043	0.052	0.052	0.051	0.053	0.054	0.055	0.055	0.054	0.054
	Min	0.058	0.032	0.031	0.066	0.054	0.053	0.057	0.058	0.059	0.060	0.057	0.062
	Max	0.050	0.047	0.046	0.049	0.051	0.050	0.051	0.051	0.053	0.052	0.053	0.051
Total Mercury	Mean	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
	Min	0.00002	0.00001	0.00001	0.00003	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
	Max	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Total Antimony	Mean	0.0040	0.0042	0.0049	0.0037	0.0007	0.0006	0.0007	0.0008	0.0011	0.0018	0.0027	0.0028
	Min	0.0101	0.0151	0.0165	0.0162	0.0009	0.0008	0.0012	0.0013	0.0017	0.0029	0.0039	0.0071
	Max	0.0020	0.0021	0.0027	0.0010	0.0005	0.0004	0.0005	0.0006	0.0008	0.0010	0.0021	0.0015

TABLE F31: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2011 TREATED WATER DATA, OTHER PARAMETERS, LOW ESTIMATE MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Ammonia	Mean	0.011	0.009	0.009	0.010	0.007	0.007	0.007	0.008	0.009	0.011	0.011	0.011
	Min	0.027	0.032	0.039	0.050	0.008	0.007	0.010	0.010	0.011	0.015	0.015	0.023
	Max	0.008	0.007	0.007	0.006	0.006	0.006	0.006	0.007	0.008	0.008	0.010	0.008
Nitrate	Mean	0.185	0.167	0.173	0.173	0.155	0.151	0.156	0.160	0.166	0.182	0.187	0.181
	Min	0.299	0.345	0.396	0.457	0.164	0.158	0.172	0.177	0.185	0.215	0.212	0.272
	Max	0.159	0.152	0.155	0.146	0.150	0.145	0.150	0.151	0.158	0.161	0.175	0.159
Total Phosphorous	Mean	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
	Min	0.008	0.007	0.007	0.011	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008
	Max	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
Sulphate	Mean	79.2	69.9	70.3	78.2	72.2	71.5	73.2	74.6	76.6	78.7	79.6	78.5
	Min	108.5	83.6	87.5	167.1	74.8	73.7	78.5	80.2	82.8	87.2	86.1	102.5
	Max	72.8	68.7	69.0	69.8	70.8	69.5	71.0	71.6	73.9	73.2	76.7	72.7
TDS	Mean	288.2	276.2	276.7	287.1	279.6	278.7	280.9	282.7	285.2	287.5	288.6	287.3
	Min	324.5	290.7	294.9	399.8	282.8	281.5	287.6	289.8	293.2	298.1	296.7	317.1
	Max	280.1	275.0	275.3	276.5	277.8	276.2	278.1	278.8	281.8	280.7	285.0	280.1
		Prairie Creek at Park Boundary											
Ammonia	Mean	0.011	0.008	0.009	0.009	0.007	0.006	0.007	0.008	0.008	0.010	0.011	0.010
	Min	0.025	0.029	0.035	0.046	0.008	0.007	0.009	0.010	0.011	0.014	0.014	0.021
	Max	0.007	0.006	0.007	0.006	0.006	0.006	0.006	0.006	0.007	0.008	0.009	0.007
Nitrate	Mean	0.180	0.164	0.170	0.170	0.153	0.150	0.154	0.158	0.163	0.178	0.182	0.177
	Min	0.283	0.324	0.371	0.427	0.161	0.156	0.168	0.173	0.180	0.207	0.205	0.259
	Max	0.157	0.151	0.154	0.146	0.149	0.145	0.149	0.150	0.156	0.159	0.172	0.157
Total Phosphorous	Mean	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
	Min	0.008	0.007	0.007	0.010	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008
	Max	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
Sulphate	Mean	78.1	69.7	70.1	77.1	71.8	71.1	72.7	73.9	75.7	77.6	78.4	77.4
	Min	104.5	82.0	85.6	157.8	74.1	73.1	77.4	78.9	81.3	85.3	84.3	99.0
	Max	72.2	68.6	68.9	69.6	70.5	69.3	70.7	71.2	73.3	72.6	75.8	72.2
TDS	Mean	286.8	276.0	276.4	285.8	279.0	278.2	280.2	281.8	284.0	286.2	287.1	286.0
	Min	319.5	289.1	292.9	388.1	281.9	280.8	286.2	288.2	291.2	295.7	294.4	312.8
	Max	279.5	274.9	275.1	276.2	277.4	276.0	277.7	278.3	281.0	280.0	283.9	279.5

TABLE F32: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2011 TREATED WATER DATA, OTHER PARAMETERS, BEST ESTIMATE MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Ammonia	Mean	0.014	0.009	0.009	0.014	0.009	0.008	0.009	0.010	0.012	0.015	0.015	0.013
	Min	0.038	0.032	0.039	0.084	0.011	0.009	0.013	0.014	0.016	0.023	0.020	0.032
	Max	0.009	0.007	0.007	0.007	0.007	0.006	0.007	0.008	0.010	0.010	0.012	0.009
Nitrate	Mean	0.208	0.167	0.173	0.204	0.166	0.160	0.170	0.177	0.189	0.216	0.212	0.202
	Min	0.380	0.345	0.396	0.720	0.181	0.172	0.198	0.207	0.223	0.275	0.251	0.337
	Max	0.170	0.152	0.155	0.152	0.157	0.149	0.158	0.161	0.174	0.178	0.194	0.168
Total Phosphorous	Mean	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
	Min	0.008	0.007	0.007	0.010	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008
	Max	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
Sulphate	Mean	81.0	69.9	70.3	80.5	73.1	72.2	74.3	75.9	78.3	81.3	81.5	80.1
	Min	114.3	83.6	87.5	183.3	76.1	74.8	80.5	82.5	85.7	91.7	89.0	107.2
	Max	73.5	68.7	69.0	70.2	71.3	69.8	71.7	72.3	75.1	74.5	78.1	73.4
TDS	Mean	290.1	276.2	276.7	289.6	280.5	279.5	282.0	284.1	287.0	290.3	290.6	289.0
	Min	330.5	290.7	294.9	415.9	284.2	282.7	289.7	292.2	296.2	302.8	299.7	322.0
	Max	281.0	275.0	275.3	277.0	278.3	276.5	278.8	279.6	283.1	282.1	286.5	280.9
		Prairie Creek at Park Boundary											
Ammonia	Mean	0.013	0.008	0.009	0.013	0.008	0.008	0.009	0.010	0.011	0.014	0.014	0.013
	Min	0.034	0.029	0.035	0.077	0.010	0.009	0.012	0.013	0.015	0.021	0.019	0.029
	Max	0.009	0.006	0.007	0.006	0.007	0.006	0.007	0.008	0.009	0.010	0.012	0.008
Nitrate	Mean	0.201	0.164	0.170	0.197	0.163	0.158	0.167	0.173	0.184	0.209	0.204	0.195
	Min	0.356	0.324	0.371	0.669	0.176	0.169	0.192	0.201	0.215	0.261	0.240	0.318
	Max	0.167	0.151	0.154	0.151	0.156	0.148	0.156	0.159	0.171	0.174	0.189	0.165
Total Phosphorous	Mean	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
	Min	0.008	0.007	0.007	0.010	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008
	Max	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
Sulphate	Mean	79.7	69.7	70.1	79.2	72.5	71.8	73.6	75.1	77.2	79.9	80.1	78.9
	Min	109.8	82.0	85.6	173.1	75.2	74.1	79.2	81.0	83.9	89.3	86.9	103.4
	Max	73.0	68.6	68.9	70.0	71.0	69.6	71.3	71.9	74.4	73.8	77.1	72.9
TDS	Mean	288.4	276.0	276.4	288.0	279.8	278.9	281.2	283.0	285.7	288.6	288.9	287.5
	Min	325.0	289.1	292.9	403.4	283.1	281.8	288.1	290.4	294.0	300.0	297.1	317.3
	Max	280.3	274.9	275.1	276.7	277.9	276.3	278.3	279.0	282.2	281.3	285.3	280.2

TABLE F33: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2011 TREATED WATER DATA, OTHER PARAMETERS, HIGH K MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Ammonia	Mean	0.018	0.015	0.018	0.018	0.010	0.011	0.013	0.016	0.018	0.022	0.019	0.017
	Min	0.050	0.080	0.097	0.115	0.013	0.014	0.022	0.024	0.027	0.034	0.027	0.044
	Max	0.011	0.010	0.011	0.007	0.008	0.008	0.010	0.011	0.014	0.013	0.016	0.011
Nitrate	Mean	0.236	0.219	0.238	0.234	0.178	0.183	0.203	0.219	0.237	0.264	0.246	0.231
	Min	0.473	0.709	0.839	0.956	0.199	0.209	0.263	0.283	0.305	0.358	0.303	0.428
	Max	0.182	0.175	0.186	0.158	0.165	0.160	0.178	0.184	0.208	0.202	0.220	0.182
Total Phosphorous	Mean	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
	Min	0.008	0.007	0.007	0.010	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008
	Max	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
Sulphate	Mean	83.1	73.9	75.3	82.8	74.0	74.0	76.8	79.1	82.0	84.9	84.1	82.3
	Min	121.0	111.7	121.7	198.0	77.5	77.6	85.4	88.2	91.8	97.9	92.9	113.8
	Max	74.5	70.5	71.3	70.7	72.0	70.7	73.2	74.1	77.7	76.3	80.1	74.5
TDS	Mean	292.3	280.5	282.0	292.0	281.4	281.3	284.7	287.4	290.9	294.1	293.3	291.4
	Min	337.5	320.5	331.1	430.4	285.6	285.6	294.9	298.1	302.7	309.4	303.8	328.9
	Max	282.0	276.9	277.8	277.5	279.0	277.4	280.4	281.5	285.8	284.0	288.6	282.0
		Prairie Creek at Park Boundary											
Ammonia	Mean	0.017	0.014	0.017	0.016	0.010	0.010	0.013	0.015	0.017	0.020	0.018	0.016
	Min	0.046	0.073	0.089	0.106	0.012	0.013	0.020	0.022	0.025	0.031	0.025	0.040
	Max	0.010	0.009	0.010	0.007	0.008	0.007	0.010	0.010	0.013	0.012	0.015	0.010
Nitrate	Mean	0.227	0.211	0.228	0.224	0.174	0.179	0.197	0.211	0.227	0.252	0.235	0.222
	Min	0.442	0.657	0.776	0.887	0.193	0.202	0.251	0.269	0.288	0.337	0.287	0.401
	Max	0.178	0.172	0.181	0.156	0.163	0.158	0.174	0.180	0.201	0.196	0.212	0.178
Total Phosphorous	Mean	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
	Min	0.008	0.007	0.007	0.010	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.008
	Max	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
Sulphate	Mean	81.6	73.3	74.6	81.3	73.4	73.4	75.9	78.0	80.5	83.2	82.4	80.9
	Min	115.9	107.7	116.9	187.0	76.5	76.6	83.6	86.1	89.5	95.0	90.4	109.4
	Max	73.8	70.2	71.0	70.4	71.5	70.4	72.7	73.5	76.7	75.5	78.9	73.8
TDS	Mean	290.5	279.8	281.2	290.2	280.7	280.6	283.6	286.1	289.2	292.1	291.4	289.6
	Min	331.4	316.2	326.0	417.2	284.5	284.5	292.8	295.7	299.8	305.9	300.9	323.6
	Max	281.2	276.6	277.4	277.1	278.5	277.0	279.8	280.7	284.6	283.0	287.1	281.2

TABLE F34: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2011 TREATED WATER DATA, OTHER PARAMETERS, HIGH K + PCAA MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Ammonia	Mean	0.112	0.122	0.144	0.105	0.016	0.013	0.017	0.020	0.027	0.048	0.074	0.077
	Min	0.281	0.430	0.466	0.439	0.022	0.018	0.028	0.031	0.041	0.078	0.107	0.196
	Max	0.056	0.062	0.078	0.026	0.013	0.009	0.012	0.013	0.020	0.027	0.058	0.040
Nitrate	Mean	0.954	1.030	1.197	0.897	0.224	0.201	0.228	0.251	0.302	0.462	0.663	0.686
	Min	2.238	3.374	3.652	3.438	0.271	0.237	0.312	0.338	0.413	0.690	0.913	1.589
	Max	0.525	0.572	0.693	0.302	0.197	0.168	0.193	0.202	0.254	0.304	0.544	0.404
Total Phosphorous	Mean	0.007	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
	Min	0.006	0.005	0.005	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
	Max	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
Sulphate	Mean	137.4	136.5	149.3	132.9	77.5	75.3	78.8	81.5	86.9	99.9	115.6	116.8
	Min	247.2	317.3	338.7	351.5	83.0	79.7	89.0	92.4	99.9	122.6	138.4	197.8
	Max	100.7	101.1	110.4	81.8	74.4	71.3	74.4	75.5	81.2	84.1	104.7	91.5
TDS	Mean	349.5	346.7	360.3	344.8	285.2	282.8	286.8	290.0	296.1	309.9	326.5	327.7
	Min	468.5	538.2	560.9	582.5	291.4	287.9	298.7	302.5	311.2	335.3	351.6	416.3
	Max	309.7	309.3	319.2	289.2	281.5	278.1	281.7	282.9	289.5	292.3	314.5	299.9
		Prairie Creek at Park Boundary											
Ammonia	Mean	0.103	0.112	0.132	0.096	0.015	0.012	0.016	0.018	0.024	0.044	0.068	0.070
	Min	0.264	0.412	0.450	0.423	0.021	0.017	0.026	0.029	0.038	0.071	0.098	0.182
	Max	0.051	0.056	0.071	0.024	0.012	0.008	0.011	0.012	0.019	0.025	0.053	0.036
Nitrate	Mean	0.883	0.954	1.109	0.830	0.216	0.195	0.220	0.240	0.286	0.431	0.615	0.636
	Min	2.105	3.240	3.526	3.310	0.258	0.227	0.295	0.319	0.387	0.639	0.845	1.480
	Max	0.489	0.531	0.642	0.286	0.191	0.165	0.188	0.196	0.243	0.288	0.505	0.378
Total Phosphorous	Mean	0.007	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
	Min	0.006	0.005	0.005	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
	Max	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
Sulphate	Mean	131.4	130.6	142.5	127.2	76.6	74.6	77.7	80.2	85.0	96.8	111.2	112.3
	Min	235.8	307.0	329.0	340.5	81.5	78.5	87.0	90.0	96.8	117.6	132.2	187.9
	Max	97.6	98.0	106.5	80.4	73.7	70.9	73.7	74.7	79.9	82.5	101.2	89.2
TDS	Mean	342.9	340.5	353.2	338.6	284.0	281.9	285.5	288.4	293.9	306.4	321.7	322.7
	Min	456.2	527.3	550.7	570.6	289.7	286.5	296.3	299.7	307.6	329.7	344.8	405.6
	Max	306.3	306.0	315.0	287.7	280.8	277.7	280.9	282.0	288.0	290.5	310.7	297.4

TABLE F35: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2010 TREATED WATER DATA, MAIN METALS, LOW ESTIMATE MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Total Cadmium	Mean	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
	Min	0.00006	0.00005	0.00005	0.00010	0.00005	0.00005	0.00005	0.00005	0.00006	0.00006	0.00005	0.00006
	Max	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Total Copper	Mean	0.00063	0.00060	0.00061	0.00062	0.00059	0.00059	0.00059	0.00060	0.00061	0.00062	0.00063	0.00062
	Min	0.00077	0.00083	0.00090	0.00101	0.00060	0.00059	0.00061	0.00062	0.00063	0.00067	0.00066	0.00074
	Max	0.00059	0.00058	0.00059	0.00058	0.00058	0.00058	0.00058	0.00059	0.00060	0.00060	0.00062	0.00059
Total Lead	Mean	0.00040	0.00023	0.00023	0.00045	0.00031	0.00031	0.00035	0.00038	0.00043	0.00040	0.00040	0.00039
	Min	0.00083	0.00022	0.00022	0.00233	0.00036	0.00036	0.00046	0.00050	0.00057	0.00053	0.00050	0.00075
	Max	0.00030	0.00023	0.00023	0.00027	0.00028	0.00027	0.00030	0.00031	0.00037	0.00031	0.00036	0.00030
Total Selenium	Mean	0.00125	0.00117	0.00117	0.00124	0.00119	0.00119	0.00120	0.00122	0.00123	0.00124	0.00125	0.00124
	Min	0.00147	0.00124	0.00126	0.00196	0.00121	0.00121	0.00125	0.00126	0.00128	0.00131	0.00130	0.00143
	Max	0.00120	0.00116	0.00117	0.00118	0.00118	0.00117	0.00119	0.00119	0.00121	0.00120	0.00123	0.00120
Total Zinc	Mean	0.0073	0.0072	0.0072	0.0074	0.0072	0.0072	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073
	Min	0.0076	0.0075	0.0076	0.0093	0.0073	0.0073	0.0074	0.0074	0.0075	0.0074	0.0074	0.0076
	Max	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0073	0.0072	0.0072	0.0072
		Prairie Creek at Park Boundary											
Total Cadmium	Mean	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
	Min	0.00006	0.00005	0.00005	0.00009	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00006
	Max	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Total Copper	Mean	0.00062	0.00060	0.00061	0.00061	0.00059	0.00058	0.00059	0.00060	0.00060	0.00062	0.00062	0.00062
	Min	0.00075	0.00080	0.00086	0.00097	0.00060	0.00059	0.00061	0.00062	0.00063	0.00066	0.00065	0.00072
	Max	0.00059	0.00058	0.00059	0.00058	0.00058	0.00058	0.00058	0.00058	0.00059	0.00059	0.00061	0.00059
Total Lead	Mean	0.00038	0.00023	0.00023	0.00043	0.00030	0.00030	0.00033	0.00036	0.00041	0.00038	0.00039	0.00037
	Min	0.00077	0.00023	0.00022	0.00213	0.00034	0.00034	0.00044	0.00047	0.00053	0.00050	0.00047	0.00070
	Max	0.00030	0.00023	0.00023	0.00027	0.00028	0.00026	0.00029	0.00030	0.00035	0.00030	0.00035	0.00030
Total Selenium	Mean	0.00124	0.00117	0.00117	0.00123	0.00119	0.00119	0.00120	0.00121	0.00122	0.00124	0.00124	0.00123
	Min	0.00144	0.00124	0.00125	0.00188	0.00121	0.00120	0.00124	0.00125	0.00127	0.00129	0.00129	0.00140
	Max	0.00119	0.00116	0.00117	0.00117	0.00118	0.00117	0.00118	0.00119	0.00120	0.00120	0.00122	0.00119
Total Zinc	Mean	0.0073	0.0072	0.0072	0.0073	0.0072	0.0072	0.0072	0.0073	0.0073	0.0073	0.0073	0.0073
	Min	0.0076	0.0075	0.0076	0.0091	0.0072	0.0073	0.0073	0.0074	0.0074	0.0074	0.0073	0.0075
	Max	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0073	0.0072	0.0072	0.0072

TABLE F36: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2010 TREATED WATER DATA, MAIN METALS, BEST ESTIMATE MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Total Cadmium	Mean	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
	Min	0.00006	0.00005	0.00005	0.00009	0.00005	0.00005	0.00005	0.00005	0.00006	0.00006	0.00005	0.00006
	Max	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Total Copper	Mean	0.00066	0.00060	0.00061	0.00065	0.00060	0.00060	0.00061	0.00062	0.00064	0.00067	0.00066	0.00065
	Min	0.00088	0.00083	0.00090	0.00134	0.00062	0.00061	0.00065	0.00066	0.00068	0.00074	0.00071	0.00082
	Max	0.00061	0.00058	0.00059	0.00059	0.00059	0.00058	0.00059	0.00060	0.00062	0.00062	0.00064	0.00061
Total Lead	Mean	0.00040	0.00023	0.00023	0.00045	0.00031	0.00031	0.00035	0.00038	0.00042	0.00039	0.00040	0.00039
	Min	0.00082	0.00022	0.00022	0.00221	0.00036	0.00036	0.00046	0.00049	0.00056	0.00052	0.00050	0.00074
	Max	0.00030	0.00023	0.00023	0.00027	0.00028	0.00027	0.00030	0.00031	0.00037	0.00031	0.00036	0.00030
Total Selenium	Mean	0.00126	0.00117	0.00117	0.00126	0.00120	0.00119	0.00121	0.00122	0.00124	0.00126	0.00126	0.00125
	Min	0.00150	0.00124	0.00126	0.00203	0.00122	0.00121	0.00126	0.00127	0.00130	0.00133	0.00131	0.00145
	Max	0.00120	0.00116	0.00117	0.00118	0.00119	0.00118	0.00119	0.00119	0.00122	0.00121	0.00124	0.00120
Total Zinc	Mean	0.0073	0.0072	0.0072	0.0074	0.0072	0.0072	0.0073	0.0073	0.0074	0.0073	0.0073	0.0073
	Min	0.0078	0.0075	0.0076	0.0097	0.0073	0.0073	0.0074	0.0075	0.0076	0.0075	0.0074	0.0077
	Max	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0073	0.0072	0.0073	0.0072
		Prairie Creek at Park Boundary											
Total Cadmium	Mean	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
	Min	0.00006	0.00005	0.00005	0.00009	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00006
	Max	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Total Copper	Mean	0.00065	0.00060	0.00061	0.00065	0.00060	0.00059	0.00061	0.00061	0.00063	0.00066	0.00065	0.00064
	Min	0.00085	0.00080	0.00086	0.00127	0.00062	0.00061	0.00064	0.00065	0.00067	0.00073	0.00070	0.00080
	Max	0.00060	0.00058	0.00059	0.00058	0.00059	0.00058	0.00059	0.00059	0.00061	0.00061	0.00063	0.00060
Total Lead	Mean	0.00038	0.00023	0.00023	0.00043	0.00030	0.00030	0.00033	0.00036	0.00040	0.00038	0.00038	0.00037
	Min	0.00076	0.00023	0.00022	0.00203	0.00034	0.00034	0.00043	0.00047	0.00053	0.00049	0.00047	0.00069
	Max	0.00030	0.00023	0.00023	0.00027	0.00028	0.00026	0.00029	0.00030	0.00035	0.00030	0.00035	0.00030
Total Selenium	Mean	0.00125	0.00117	0.00117	0.00125	0.00120	0.00119	0.00120	0.00122	0.00123	0.00125	0.00125	0.00124
	Min	0.00147	0.00124	0.00125	0.00195	0.00122	0.00121	0.00125	0.00126	0.00128	0.00132	0.00130	0.00142
	Max	0.00120	0.00116	0.00117	0.00118	0.00118	0.00117	0.00119	0.00119	0.00121	0.00120	0.00123	0.00120
Total Zinc	Mean	0.0073	0.0072	0.0072	0.0074	0.0072	0.0072	0.0073	0.0073	0.0074	0.0073	0.0073	0.0073
	Min	0.0077	0.0075	0.0076	0.0095	0.0073	0.0073	0.0074	0.0074	0.0075	0.0075	0.0074	0.0076
	Max	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0073	0.0072	0.0073	0.0072

TABLE F37: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2010 TREATED WATER DATA, MAIN METALS, HIGH K MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Total Cadmium	Mean	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
	Min	0.00006	0.00004	0.00004	0.00009	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00006
	Max	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Total Copper	Mean	0.00069	0.00067	0.00069	0.00069	0.00062	0.00063	0.00065	0.00067	0.00070	0.00073	0.00071	0.00069
	Min	0.00100	0.00129	0.00146	0.00164	0.00065	0.00066	0.00073	0.00076	0.00079	0.00085	0.00078	0.00094
	Max	0.00062	0.00061	0.00063	0.00059	0.00060	0.00060	0.00062	0.00063	0.00066	0.00065	0.00067	0.00062
Total Lead	Mean	0.00040	0.00023	0.00023	0.00044	0.00031	0.00030	0.00035	0.00037	0.00043	0.00039	0.00040	0.00039
	Min	0.00081	0.00022	0.00021	0.00210	0.00035	0.00035	0.00046	0.00048	0.00057	0.00051	0.00049	0.00073
	Max	0.00030	0.00023	0.00023	0.00027	0.00028	0.00026	0.00030	0.00031	0.00037	0.00031	0.00036	0.00030
Total Selenium	Mean	0.00127	0.00119	0.00120	0.00127	0.00120	0.00120	0.00122	0.00124	0.00126	0.00128	0.00127	0.00126
	Min	0.00153	0.00139	0.00145	0.00209	0.00123	0.00123	0.00128	0.00130	0.00133	0.00136	0.00133	0.00148
	Max	0.00121	0.00117	0.00118	0.00118	0.00119	0.00118	0.00120	0.00120	0.00123	0.00122	0.00125	0.00121
Total Zinc	Mean	0.0074	0.0073	0.0073	0.0075	0.0073	0.0073	0.0074	0.0074	0.0075	0.0074	0.0074	0.0074
	Min	0.0080	0.0082	0.0085	0.0101	0.0073	0.0073	0.0076	0.0076	0.0077	0.0077	0.0075	0.0078
	Max	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0073	0.0073	0.0074	0.0073	0.0073	0.0072
		Prairie Creek at Park Boundary											
Total Cadmium	Mean	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
	Min	0.00006	0.00004	0.00004	0.00008	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00006
	Max	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Total Copper	Mean	0.00068	0.00066	0.00068	0.00068	0.00061	0.00062	0.00064	0.00066	0.00068	0.00071	0.00069	0.00068
	Min	0.00096	0.00123	0.00138	0.00155	0.00064	0.00065	0.00072	0.00074	0.00077	0.00082	0.00076	0.00090
	Max	0.00062	0.00061	0.00062	0.00059	0.00060	0.00059	0.00061	0.00062	0.00065	0.00064	0.00066	0.00062
Total Lead	Mean	0.00038	0.00023	0.00023	0.00042	0.00030	0.00030	0.00034	0.00035	0.00041	0.00038	0.00038	0.00037
	Min	0.00075	0.00022	0.00021	0.00194	0.00034	0.00034	0.00044	0.00045	0.00054	0.00049	0.00047	0.00068
	Max	0.00030	0.00023	0.00023	0.00027	0.00028	0.00026	0.00029	0.00030	0.00036	0.00030	0.00035	0.00030
Total Selenium	Mean	0.00126	0.00119	0.00120	0.00126	0.00120	0.00120	0.00122	0.00123	0.00125	0.00126	0.00126	0.00125
	Min	0.00150	0.00137	0.00142	0.00202	0.00122	0.00122	0.00127	0.00129	0.00131	0.00134	0.00132	0.00145
	Max	0.00120	0.00117	0.00118	0.00118	0.00119	0.00118	0.00119	0.00120	0.00122	0.00121	0.00124	0.00120
Total Zinc	Mean	0.0074	0.0073	0.0073	0.0074	0.0072	0.0073	0.0073	0.0074	0.0075	0.0074	0.0074	0.0073
	Min	0.0079	0.0081	0.0083	0.0098	0.0073	0.0073	0.0075	0.0075	0.0077	0.0076	0.0075	0.0078
	Max	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0073	0.0073	0.0074	0.0073	0.0073	0.0072

TABLE F38: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2010 TREATED WATER DATA, MAIN METALS, HIGH K + PCAA MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Total Cadmium	Mean	0.00005	0.00004	0.00004	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
	Min	0.00004	0.00002	0.00002	0.00004	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
	Max	0.00005	0.00004	0.00004	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Total Copper	Mean	0.00161	0.00170	0.00191	0.00154	0.00068	0.00065	0.00068	0.00071	0.00078	0.00098	0.00124	0.00127
	Min	0.00324	**0.00468**	**0.00504**	**0.00478**	0.00074	0.00069	0.00079	0.00083	0.00092	0.00127	0.00155	0.00241
	Max	0.00106	0.00112	0.00127	0.00078	0.00064	0.00061	0.00064	0.00065	0.00072	0.00078	0.00108	0.00091
Total Lead	Mean	0.00035	0.00021	0.00020	0.00040	0.00031	0.00030	0.00035	0.00037	0.00043	0.00038	0.00038	0.00036
	Min	0.00055	0.00015	0.00014	0.00097	0.00035	0.00035	0.00046	0.00047	0.00056	0.00049	0.00044	0.00058
	Max	0.00029	0.00022	0.00022	0.00027	0.00028	0.00026	0.00030	0.00031	0.00037	0.00031	0.00034	0.00029
Total Selenium	Mean	0.00155	0.00153	0.00159	0.00153	0.00122	0.00121	0.00123	0.00125	0.00129	0.00135	0.00144	0.00144
	Min	**0.00217**	**0.00249**	**0.00260**	**0.00277**	0.00126	0.00124	0.00130	0.00132	0.00137	0.00149	0.00157	0.00191
	Max	0.00135	0.00134	0.00139	0.00124	0.00120	0.00118	0.00120	0.00121	0.00125	0.00126	0.00138	0.00130
Total Zinc	Mean	0.0087	0.0088	0.0091	0.0087	0.0073	0.0073	0.0074	0.0074	0.0076	0.0078	0.0082	0.0082
	Min	0.0112	0.0133	0.0138	0.0140	0.0075	0.0074	0.0076	0.0077	0.0079	0.0083	0.0087	0.0100
	Max	0.0079	0.0080	0.0082	0.0075	0.0073	0.0072	0.0073	0.0073	0.0075	0.0075	0.0079	0.0077
		Prairie Creek at Park Boundary											
Total Cadmium	Mean	0.00005	0.00004	0.00004	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
	Min	0.00004	0.00003	0.00002	0.00004	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
	Max	0.00005	0.00005	0.00004	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Total Copper	Mean	0.00152	0.00160	0.00180	0.00145	0.00067	0.00064	0.00067	0.00070	0.00076	0.00094	0.00117	0.00120
	Min	0.00307	**0.00451**	**0.00488**	**0.00461**	0.00072	0.00068	0.00077	0.00080	0.00089	0.00121	0.00147	0.00228
	Max	0.00101	0.00107	0.00121	0.00076	0.00064	0.00060	0.00063	0.00064	0.00070	0.00076	0.00104	0.00087
Total Lead	Mean	0.00034	0.00021	0.00021	0.00039	0.00030	0.00030	0.00034	0.00035	0.00041	0.00037	0.00036	0.00035
	Min	0.00053	0.00015	0.00015	0.00094	0.00034	0.00034	0.00044	0.00045	0.00053	0.00046	0.00043	0.00055
	Max	0.00028	0.00022	0.00022	0.00026	0.00028	0.00026	0.00029	0.00030	0.00035	0.00030	0.00033	0.00029
Total Selenium	Mean	0.00152	0.00149	0.00156	0.00150	0.00122	0.00121	0.00123	0.00124	0.00127	0.00134	0.00141	0.00142
	Min	0.00211	**0.00243**	**0.00255**	**0.00271**	0.00125	0.00123	0.00129	0.00131	0.00135	0.00146	0.00154	0.00185
	Max	0.00133	0.00132	0.00137	0.00123	0.00120	0.00118	0.00120	0.00121	0.00124	0.00125	0.00135	0.00128
Total Zinc	Mean	0.0086	0.0087	0.0090	0.0086	0.0073	0.0073	0.0074	0.0074	0.0076	0.0077	0.0081	0.0081
	Min	0.0110	0.0130	0.0135	0.0137	0.0074	0.0074	0.0076	0.0076	0.0079	0.0082	0.0085	0.0098
	Max	0.0078	0.0079	0.0081	0.0074	0.0073	0.0072	0.0073	0.0073	0.0074	0.0074	0.0079	0.0076

TABLE F39: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2010 TREATED WATER DATA, OTHER METALS, LOW ESTIMATE MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Total Silver	Mean	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Min	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Max	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
Total Arsenic	Mean	0.00026	0.00025	0.00026	0.00026	0.00025	0.00025	0.00025	0.00025	0.00026	0.00026	0.00026	0.00026
	Min	0.00033	0.00034	0.00037	0.00042	0.00025	0.00025	0.00026	0.00026	0.00027	0.00028	0.00028	0.00031
	Max	0.00025	0.00025	0.00025	0.00024	0.00025	0.00024	0.00025	0.00025	0.00025	0.00025	0.00026	0.00025
Total Iron	Mean	0.048	0.048	0.048	0.048	0.048	0.049	0.048	0.048	0.048	0.048	0.048	0.048
	Min	0.047	0.047	0.046	0.046	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.047
	Max	0.048	0.048	0.048	0.049	0.049	0.049	0.049	0.049	0.048	0.048	0.048	0.048
Total Mercury	Mean	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
	Min	0.00003	0.00002	0.00002	**0.00005**	0.00002	0.00002	0.00002	0.00002	0.00003	0.00003	0.00003	0.00003
	Max	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Total Antimony	Mean	0.0005	0.0004	0.0004	0.0004	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0005	0.0004
	Min	0.0010	0.0011	0.0014	0.0017	0.0004	0.0003	0.0004	0.0004	0.0005	0.0006	0.0006	0.0009
	Max	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0003
		Prairie Creek at Park Boundary											
Total Silver	Mean	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Min	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Max	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
Total Arsenic	Mean	0.00026	0.00025	0.00025	0.00026	0.00025	0.00025	0.00025	0.00025	0.00025	0.00026	0.00026	0.00026
	Min	0.00032	0.00033	0.00035	0.00041	0.00025	0.00025	0.00026	0.00026	0.00026	0.00028	0.00027	0.00030
	Max	0.00025	0.00025	0.00025	0.00024	0.00025	0.00024	0.00025	0.00025	0.00025	0.00025	0.00026	0.00025
Total Iron	Mean	0.048	0.048	0.048	0.048	0.048	0.049	0.048	0.048	0.048	0.048	0.048	0.048
	Min	0.047	0.047	0.047	0.046	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
	Max	0.048	0.049	0.048	0.049	0.049	0.049	0.049	0.049	0.048	0.048	0.048	0.048
Total Mercury	Mean	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
	Min	0.00003	0.00002	0.00002	**0.00005**	0.00002	0.00002	0.00002	0.00002	0.00002	0.00003	0.00003	0.00003
	Max	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Total Antimony	Mean	0.0004	0.0003	0.0004	0.0004	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004
	Min	0.0009	0.0010	0.0012	0.0016	0.0003	0.0003	0.0004	0.0004	0.0004	0.0006	0.0005	0.0008
	Max	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0003

TABLE F40: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2010 TREATED WATER DATA, OTHER METALS, BEST ESTIMATE MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Total Silver	Mean	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Min	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Max	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
Total Arsenic	Mean	0.00028	0.00025	0.00026	0.00027	0.00025	0.00025	0.00026	0.00026	0.00027	0.00028	0.00028	0.00027
	Min	0.00036	0.00034	0.00037	0.00055	0.00026	0.00026	0.00027	0.00028	0.00029	0.00031	0.00030	0.00034
	Max	0.00026	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00026	0.00026	0.00027	0.00025
Total Iron	Mean	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
	Min	0.046	0.047	0.046	0.043	0.048	0.048	0.048	0.048	0.048	0.047	0.048	0.047
	Max	0.048	0.048	0.048	0.048	0.048	0.049	0.048	0.048	0.048	0.048	0.048	0.048
Total Mercury	Mean	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
	Min	0.00003	0.00002	0.00002	**0.00005**	0.00002	0.00002	0.00002	0.00002	0.00003	0.00003	0.00003	0.00003
	Max	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Total Antimony	Mean	0.0006	0.0004	0.0004	0.0005	0.0004	0.0003	0.0004	0.0004	0.0005	0.0006	0.0006	0.0005
	Min	0.0013	0.0011	0.0014	0.0028	0.0004	0.0004	0.0005	0.0005	0.0006	0.0009	0.0007	0.0011
	Max	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0005	0.0004
		Prairie Creek at Park Boundary											
Total Silver	Mean	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Min	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Max	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
Total Arsenic	Mean	0.00027	0.00025	0.00025	0.00027	0.00025	0.00025	0.00025	0.00026	0.00026	0.00028	0.00027	0.00027
	Min	0.00035	0.00033	0.00035	0.00052	0.00026	0.00026	0.00027	0.00027	0.00028	0.00030	0.00029	0.00033
	Max	0.00025	0.00025	0.00025	0.00025	0.00025	0.00024	0.00025	0.00025	0.00026	0.00026	0.00027	0.00025
Total Iron	Mean	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
	Min	0.047	0.047	0.047	0.044	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.047
	Max	0.048	0.049	0.048	0.049	0.048	0.049	0.048	0.048	0.048	0.048	0.048	0.048
Total Mercury	Mean	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
	Min	0.00003	0.00002	0.00002	**0.00005**	0.00002	0.00002	0.00002	0.00002	0.00002	0.00003	0.00003	0.00003
	Max	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Total Antimony	Mean	0.0005	0.0003	0.0004	0.0005	0.0003	0.0003	0.0004	0.0004	0.0004	0.0006	0.0005	0.0005
	Min	0.0012	0.0010	0.0012	0.0026	0.0004	0.0004	0.0005	0.0005	0.0006	0.0008	0.0007	0.0011
	Max	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0005	0.0004

TABLE F41: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2010 TREATED WATER DATA, OTHER METALS, HIGH K MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Total Silver	Mean	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Min	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Max	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
Total Arsenic	Mean	0.00029	0.00028	0.00029	0.00029	0.00026	0.00026	0.00027	0.00028	0.00029	0.00030	0.00029	0.00029
	Min	0.00041	0.00052	0.00058	0.00067	0.00027	0.00028	0.00030	0.00031	0.00033	0.00035	0.00032	0.00039
	Max	0.00026	0.00026	0.00026	0.00025	0.00025	0.00025	0.00026	0.00026	0.00028	0.00027	0.00028	0.00026
Total Iron	Mean	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
	Min	0.046	0.044	0.042	0.041	0.048	0.048	0.048	0.047	0.047	0.047	0.047	0.046
	Max	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
Total Mercury	Mean	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
	Min	0.00003	0.00002	0.00002	**0.00005**	0.00002	0.00002	0.00002	0.00002	0.00002	0.00003	0.00003	0.00003
	Max	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Total Antimony	Mean	0.0007	0.0006	0.0007	0.0007	0.0004	0.0004	0.0005	0.0006	0.0007	0.0008	0.0007	0.0007
	Min	0.0017	0.0027	0.0033	0.0039	0.0005	0.0005	0.0008	0.0009	0.0010	0.0012	0.0010	0.0015
	Max	0.0004	0.0004	0.0004	0.0003	0.0004	0.0003	0.0004	0.0004	0.0005	0.0005	0.0006	0.0004
		Prairie Creek at Park Boundary											
Total Silver	Mean	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Min	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Max	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
Total Arsenic	Mean	0.00028	0.00028	0.00028	0.00028	0.00026	0.00026	0.00027	0.00028	0.00029	0.00030	0.00029	0.00028
	Min	0.00039	0.00049	0.00055	0.00063	0.00027	0.00027	0.00030	0.00031	0.00032	0.00034	0.00032	0.00037
	Max	0.00026	0.00026	0.00026	0.00025	0.00025	0.00025	0.00026	0.00026	0.00027	0.00027	0.00028	0.00026
Total Iron	Mean	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
	Min	0.046	0.044	0.043	0.042	0.048	0.048	0.048	0.047	0.047	0.047	0.047	0.046
	Max	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
Total Mercury	Mean	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
	Min	0.00003	0.00002	0.00002	**0.00005**	0.00002	0.00002	0.00002	0.00002	0.00002	0.00003	0.00002	0.00003
	Max	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Total Antimony	Mean	0.0006	0.0006	0.0006	0.0006	0.0004	0.0004	0.0005	0.0006	0.0006	0.0007	0.0007	0.0006
	Min	0.0016	0.0025	0.0030	0.0036	0.0005	0.0005	0.0007	0.0008	0.0009	0.0011	0.0009	0.0014
	Max	0.0004	0.0004	0.0004	0.0003	0.0003	0.0003	0.0004	0.0004	0.0005	0.0005	0.0006	0.0004

TABLE F42: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2010 TREATED WATER DATA, OTHER METALS, HIGH K + PCAA MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Total Silver	Mean	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Min	0.00002	0.00002	0.00002	0.00002	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00002
	Max	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
Total Arsenic	Mean	0.00064	0.00068	0.00076	0.00061	0.00028	0.00027	0.00029	0.00030	0.00032	0.00040	0.00050	0.00051
	Min	0.00127	0.00183	0.00196	0.00187	0.00031	0.00029	0.00033	0.00034	0.00038	0.00051	0.00062	0.00096
	Max	0.00043	0.00045	0.00051	0.00032	0.00027	0.00025	0.00027	0.00027	0.00030	0.00032	0.00044	0.00037
Total Iron	Mean	0.041	0.041	0.039	0.042	0.048	0.048	0.048	0.048	0.047	0.046	0.044	0.044
	Min	0.030	0.020	0.018	0.019	0.047	0.048	0.047	0.047	0.046	0.044	0.042	0.036
	Max	0.045	0.045	0.044	0.047	0.048	0.048	0.048	0.048	0.048	0.047	0.045	0.046
Total Mercury	Mean	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
	Min	0.00002	0.00001	0.00001	0.00003	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00003
	Max	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Total Antimony	Mean	0.0038	0.0041	0.0048	0.0035	0.0006	0.0005	0.0006	0.0007	0.0010	0.0017	0.0025	0.0026
	Min	0.0094	0.0143	0.0155	0.0146	0.0008	0.0007	0.0010	0.0011	0.0014	0.0027	0.0036	0.0066
	Max	0.0019	0.0021	0.0026	0.0010	0.0005	0.0004	0.0005	0.0005	0.0007	0.0010	0.0020	0.0014
		Prairie Creek at Park Boundary											
Total Silver	Mean	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
	Min	0.00002	0.00002	0.00002	0.00002	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00002
	Max	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
Total Arsenic	Mean	0.00061	0.00064	0.00072	0.00058	0.00028	0.00027	0.00028	0.00029	0.00031	0.00038	0.00047	0.00049
	Min	0.00121	0.00176	0.00190	0.00181	0.00030	0.00028	0.00032	0.00033	0.00037	0.00049	0.00059	0.00090
	Max	0.00041	0.00043	0.00049	0.00031	0.00027	0.00025	0.00026	0.00027	0.00029	0.00031	0.00042	0.00036
Total Iron	Mean	0.042	0.041	0.040	0.042	0.048	0.048	0.048	0.048	0.047	0.046	0.044	0.044
	Min	0.031	0.021	0.019	0.021	0.048	0.048	0.047	0.047	0.046	0.044	0.042	0.037
	Max	0.046	0.045	0.044	0.047	0.048	0.048	0.048	0.048	0.048	0.047	0.045	0.046
Total Mercury	Mean	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
	Min	0.00002	0.00001	0.00001	0.00003	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00003
	Max	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Total Antimony	Mean	0.0035	0.0038	0.0045	0.0033	0.0006	0.0005	0.0006	0.0007	0.0009	0.0015	0.0023	0.0024
	Min	0.0088	0.0137	0.0150	0.0141	0.0008	0.0006	0.0009	0.0010	0.0013	0.0024	0.0033	0.0061
	Max	0.0018	0.0019	0.0024	0.0009	0.0005	0.0004	0.0005	0.0005	0.0007	0.0009	0.0018	0.0013

TABLE F43: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2010 TREATED MINE WATER - 2011 TREATED PROCESS WATER DATA, LOW ESTIMATE MINE FLOWS

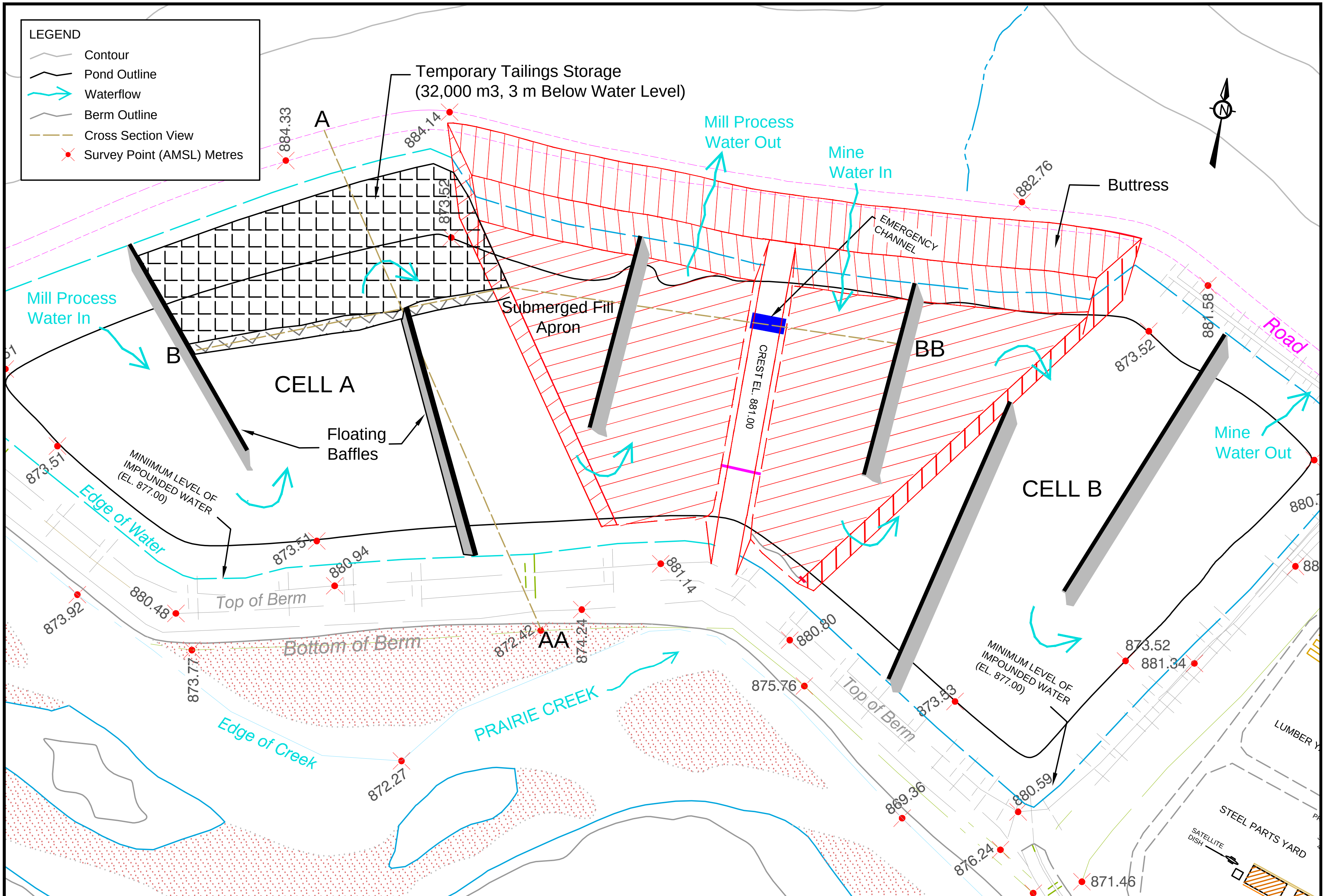
Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Total Arsenic	Mean	0.00028	0.00025	0.00026	0.00027	0.00025	0.00025	0.00026	0.00026	0.00027	0.00028	0.00028	0.00027
	Min	0.00037	0.00034	0.00037	0.00055	0.00026	0.00026	0.00027	0.00028	0.00029	0.00030	0.00030	0.00035
	Max	0.00026	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00026	0.00026	0.00027	0.00026
Total Copper	Mean	0.00075	0.00060	0.00061	0.00074	0.00064	0.00063	0.00066	0.00068	0.00071	0.00075	0.00076	0.00074
	Min	0.00122	0.00083	0.00090	0.00218	0.00068	0.00067	0.00074	0.00077	0.00081	0.00088	0.00086	0.00113
	Max	0.00065	0.00058	0.00059	0.00060	0.00062	0.00060	0.00062	0.00063	0.00067	0.00066	0.00071	0.00065
Total Zinc	Mean	0.0097	0.0072	0.0072	0.0097	0.0082	0.0081	0.0085	0.0089	0.0094	0.0096	0.0097	0.0095
	Min	0.0162	0.0075	0.0076	**0.0316**	0.0088	0.0086	0.0098	0.0103	0.0109	0.0115	0.0112	0.0149
	Max	0.0082	0.0072	0.0072	0.0076	0.0079	0.0076	0.0080	0.0081	0.0087	0.0083	0.0091	0.0082
		Prairie Creek at Park Boundary											
Total Arsenic	Mean	0.00027	0.00025	0.00025	0.00027	0.00025	0.00025	0.00025	0.00026	0.00026	0.00027	0.00027	0.00027
	Min	0.00036	0.00033	0.00035	0.00052	0.00026	0.00026	0.00027	0.00027	0.00028	0.00030	0.00029	0.00034
	Max	0.00025	0.00025	0.00025	0.00025	0.00025	0.00024	0.00025	0.00025	0.00026	0.00026	0.00027	0.00025
Total Copper	Mean	0.00074	0.00060	0.00061	0.00072	0.00063	0.00062	0.00065	0.00067	0.00070	0.00073	0.00074	0.00072
	Min	0.00116	0.00080	0.00086	0.00203	0.00067	0.00066	0.00073	0.00075	0.00079	0.00085	0.00083	0.00107
	Max	0.00064	0.00058	0.00059	0.00060	0.00061	0.00059	0.00062	0.00063	0.00066	0.00065	0.00070	0.00064
Total Zinc	Mean	0.0094	0.0072	0.0072	0.0094	0.0081	0.0080	0.0084	0.0087	0.0091	0.0093	0.0095	0.0093
	Min	0.0153	0.0075	0.0076	0.0293	0.0086	0.0085	0.0096	0.0099	0.0106	0.0111	0.0108	0.0141
	Max	0.0081	0.0072	0.0072	0.0076	0.0078	0.0075	0.0079	0.0080	0.0085	0.0082	0.0089	0.0081

TABLE F44: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2010 TREATED MINE WATER - 2011 TREATED PROCESS WATER DATA, BESTESTIMATE MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Total Arsenic	Mean	0.00029	0.00025	0.00026	0.00029	0.00026	0.00026	0.00026	0.00027	0.00028	0.00029	0.00029	0.00028
	Min	0.00041	0.00034	0.00037	0.00067	0.00027	0.00027	0.00029	0.00029	0.00030	0.00033	0.00032	0.00038
	Max	0.00026	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00026	0.00027	0.00027	0.00028	0.00026
Total Copper	Mean	0.00078	0.00060	0.00061	0.00078	0.00066	0.00064	0.00068	0.00070	0.00074	0.00079	0.00079	0.00077
	Min	0.00132	0.00083	0.00090	0.00245	0.00070	0.00068	0.00078	0.00081	0.00086	0.00096	0.00091	0.00121
	Max	0.00066	0.00058	0.00059	0.00061	0.00063	0.00060	0.00063	0.00064	0.00069	0.00068	0.00074	0.00066
Total Zinc	Mean	0.0097	0.0072	0.0072	0.0097	0.0082	0.0081	0.0085	0.0089	0.0094	0.0096	0.0098	0.0096
	Min	0.0162	0.0075	0.0076	**0.0308**	0.0088	0.0087	0.0099	0.0103	0.0110	0.0116	0.0112	0.0149
	Max	0.0083	0.0072	0.0072	0.0076	0.0079	0.0076	0.0080	0.0081	0.0087	0.0084	0.0091	0.0083
		Prairie Creek at Park Boundary											
Total Arsenic	Mean	0.00028	0.00025	0.00025	0.00028	0.00026	0.00025	0.00026	0.00027	0.00027	0.00029	0.00029	0.00028
	Min	0.00039	0.00033	0.00035	0.00063	0.00027	0.00026	0.00028	0.00029	0.00030	0.00032	0.00031	0.00037
	Max	0.00026	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00026	0.00026	0.00027	0.00026
Total Copper	Mean	0.00076	0.00060	0.00061	0.00076	0.00065	0.00063	0.00066	0.00069	0.00072	0.00077	0.00077	0.00075
	Min	0.00125	0.00080	0.00086	0.00229	0.00069	0.00067	0.00076	0.00079	0.00083	0.00092	0.00088	0.00114
	Max	0.00065	0.00058	0.00059	0.00061	0.00062	0.00060	0.00063	0.00064	0.00068	0.00067	0.00072	0.00065
Total Zinc	Mean	0.0095	0.0072	0.0072	0.0095	0.0081	0.0080	0.0084	0.0087	0.0092	0.0094	0.0095	0.0093
	Min	0.0153	0.0075	0.0076	0.0287	0.0087	0.0085	0.0096	0.0100	0.0106	0.0111	0.0108	0.0142
	Max	0.0081	0.0072	0.0072	0.0076	0.0078	0.0075	0.0079	0.0080	0.0086	0.0083	0.0089	0.0081

TABLE F45: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2010 TREATED MINE WATER - 2011 TREATED PROCESS WATER DATA, HIGH K MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Total Arsenic	Mean	0.00030	0.00028	0.00029	0.00030	0.00026	0.00027	0.00028	0.00029	0.00030	0.00032	0.00031	0.00030
	Min	0.00046	0.00052	0.00058	0.00078	0.00028	0.00028	0.00032	0.00033	0.00034	0.00037	0.00034	0.00043
	Max	0.00027	0.00026	0.00026	0.00025	0.00026	0.00025	0.00026	0.00027	0.00028	0.00028	0.00029	0.00027
Total Copper	Mean	0.00082	0.00067	0.00069	0.00081	0.00067	0.00067	0.00072	0.00075	0.00080	0.00085	0.00083	0.00081
	Min	0.00143	0.00129	0.00146	0.00269	0.00073	0.00073	0.00086	0.00090	0.00096	0.00106	0.00098	0.00131
	Max	0.00068	0.00061	0.00063	0.00062	0.00064	0.00062	0.00066	0.00067	0.00073	0.00071	0.00077	0.00068
Total Zinc	Mean	0.0098	0.0073	0.0073	0.0098	0.0082	0.0081	0.0086	0.0089	0.0095	0.0097	0.0098	0.0096
	Min	0.0162	0.0082	0.0085	**0.0301**	0.0089	0.0087	0.0100	0.0104	0.0111	0.0116	0.0113	0.0150
	Max	0.0083	0.0072	0.0072	0.0076	0.0079	0.0076	0.0080	0.0081	0.0088	0.0084	0.0092	0.0083
		Prairie Creek at Park Boundary											
Total Arsenic	Mean	0.00030	0.00028	0.00028	0.00030	0.00026	0.00026	0.00028	0.00028	0.00030	0.00031	0.00030	0.00029
	Min	0.00044	0.00049	0.00055	0.00073	0.00028	0.00028	0.00031	0.00032	0.00033	0.00036	0.00033	0.00041
	Max	0.00026	0.00026	0.00026	0.00025	0.00026	0.00025	0.00026	0.00026	0.00028	0.00027	0.00029	0.00026
Total Copper	Mean	0.00079	0.00066	0.00068	0.00079	0.00066	0.00066	0.00070	0.00074	0.00078	0.00082	0.00081	0.00078
	Min	0.00135	0.00123	0.00138	0.00252	0.00071	0.00071	0.00083	0.00087	0.00093	0.00101	0.00094	0.00124
	Max	0.00067	0.00061	0.00062	0.00061	0.00063	0.00061	0.00065	0.00066	0.00072	0.00069	0.00075	0.00067
Total Zinc	Mean	0.0095	0.0073	0.0073	0.0095	0.0081	0.0080	0.0084	0.0088	0.0092	0.0094	0.0096	0.0094
	Min	0.0153	0.0081	0.0083	0.0282	0.0087	0.0085	0.0097	0.0101	0.0107	0.0112	0.0109	0.0142
	Max	0.0082	0.0072	0.0072	0.0076	0.0078	0.0075	0.0079	0.0080	0.0086	0.0083	0.0090	0.0082



CANADIAN ZINC
CORPORATION

Date:	Feb 2011
Drawn By:	C. Reeves
Scale:	As Shown
Drawing:	IR2_Fig_F1.dwg

SCALE

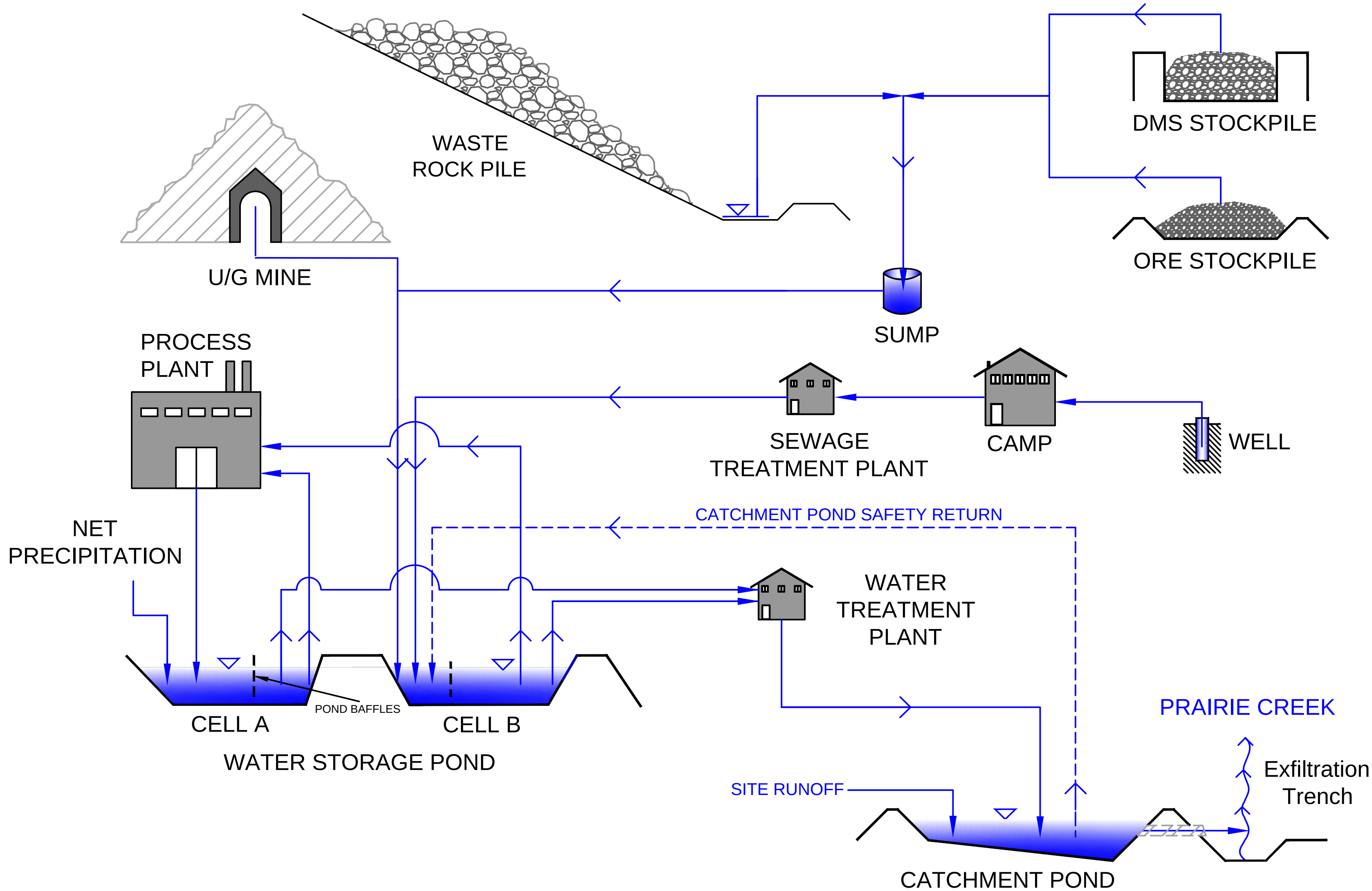
0 20 40 60 80 100

METRES

PRAIRIE CREEK MINE

FIGURE F1:

WATER STORAGE POND



CANADIAN ZINC CORPORATION

Date:	February 2011
Drawn By:	C. Reeves
Scale:	Not To Scale
Drawing:	IR2_Fig_F2.dwg

PRAIRIE CREEK MINE

FIGURE F2:

SITE WATER MANAGEMENT

TABLE F46: IN-STREAM CONCENTRATIONS IN PRAIRIE CREEK
2010 TREATED MINE WATER - 2011 TREATED PROCESS WATER DATA, HIGH K + PCAA MINE FLOWS

Parameter	Creek Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Prairie Creek at Harrison Creek											
Total Arsenic	Mean	0.00065	0.00068	0.00076	0.00063	0.00029	0.00028	0.00029	0.00030	0.00033	0.00041	0.00051	0.00052
	Min	0.00130	0.00183	0.00196	0.00192	0.00031	0.00030	0.00034	0.00036	0.00040	0.00053	0.00064	0.00099
	Max	0.00044	0.00045	0.00051	0.00032	0.00027	0.00026	0.00027	0.00028	0.00031	0.00033	0.00045	0.00038
Total Copper	Mean	0.00171	0.00170	0.00191	0.00164	0.00073	0.00069	0.00075	0.00079	0.00088	0.00109	0.00135	0.00137
	Min	0.00352	**0.00468**	**0.00504**	**0.00524**	0.00082	0.00077	0.00092	0.00097	0.00110	0.00147	0.00173	0.00270
	Max	0.00111	0.00112	0.00127	0.00080	0.00068	0.00063	0.00068	0.00070	0.00079	0.00084	0.00117	0.00096
Total Zinc	Mean	0.0108	0.0088	0.0091	0.0107	0.0083	0.0082	0.0086	0.0090	0.0096	0.0100	0.0104	0.0103
	Min	0.0165	0.0133	0.0138	0.0227	0.0090	0.0087	0.0100	0.0104	0.0112	0.0120	0.0120	0.0155
	Max	0.0089	0.0080	0.0082	0.0079	0.0079	0.0076	0.0080	0.0082	0.0089	0.0086	0.0097	0.0087
		Prairie Creek at Park Boundary											
Total Arsenic	Mean	0.00062	0.00064	0.00072	0.00059	0.00028	0.00027	0.00029	0.00030	0.00032	0.00040	0.00049	0.00050
	Min	0.00124	0.00176	0.00190	0.00185	0.00031	0.00029	0.00033	0.00034	0.00038	0.00051	0.00061	0.00093
	Max	0.00042	0.00043	0.00049	0.00031	0.00027	0.00025	0.00027	0.00027	0.00030	0.00032	0.00043	0.00036
Total Copper	Mean	0.00161	0.00160	0.00180	0.00155	0.00071	0.00068	0.00073	0.00077	0.00085	0.00104	0.00128	0.00130
	Min	0.00333	**0.00451**	**0.00488**	**0.00506**	0.00079	0.00075	0.00088	0.00093	0.00105	0.00138	0.00163	0.00254
	Max	0.00106	0.00107	0.00121	0.00078	0.00067	0.00062	0.00067	0.00068	0.00077	0.00081	0.00112	0.00092
Total Zinc	Mean	0.0105	0.0087	0.0090	0.0104	0.0082	0.0080	0.0085	0.0088	0.0093	0.0097	0.0101	0.0100
	Min	0.0159	0.0130	0.0135	0.0221	0.0088	0.0086	0.0098	0.0101	0.0108	0.0116	0.0115	0.0148
	Max	0.0087	0.0079	0.0081	0.0078	0.0079	0.0076	0.0079	0.0081	0.0087	0.0084	0.0094	0.0085

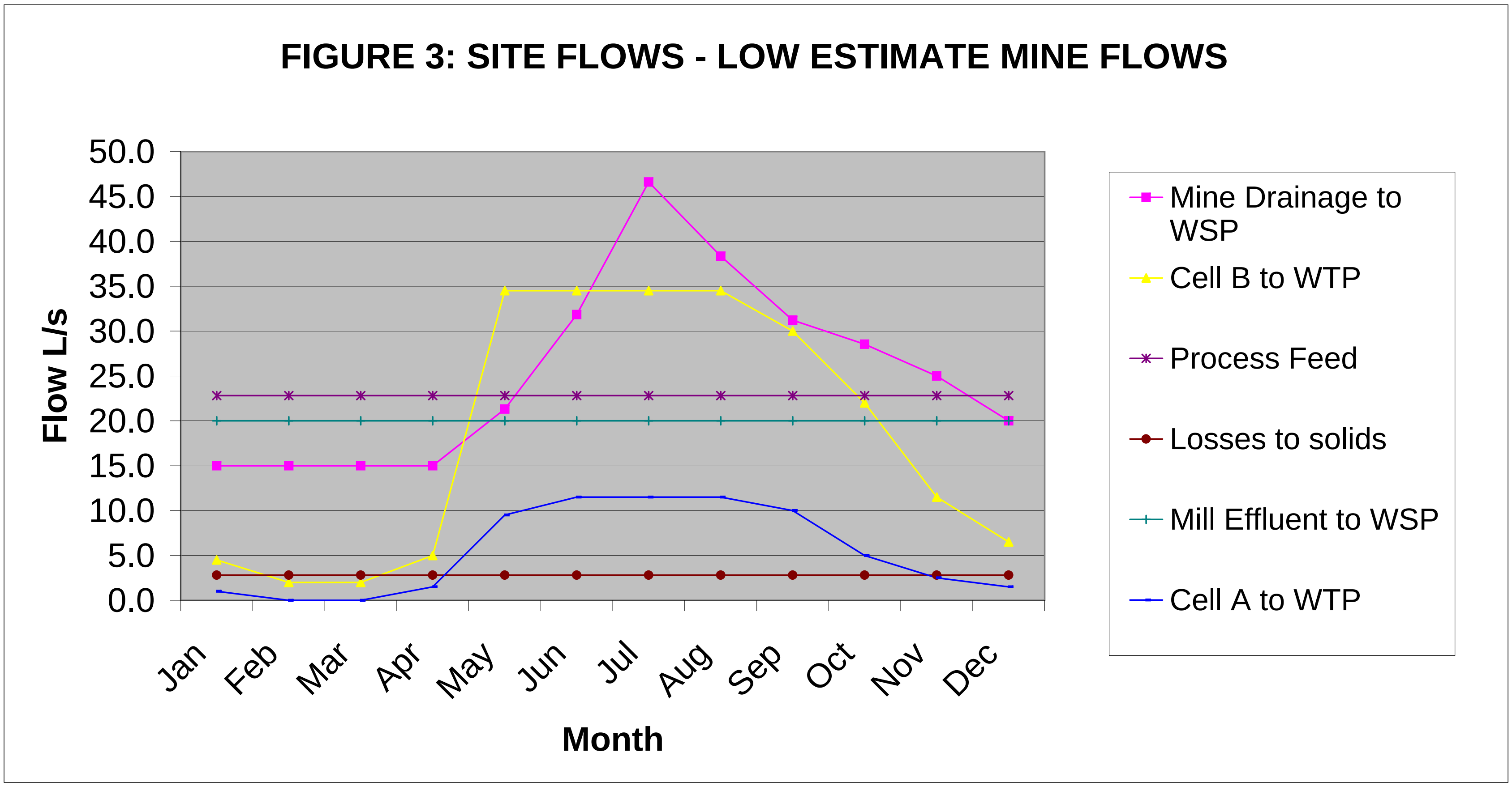


FIGURE 3: SITE FLOWS - LOW ESTIMATE MINE FLOWS
Flow L/s
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Mine Drainage to WSP
Cell B to WTP
Process Feed
Losses to solids
Mill Effluent to WSP
Cell A to WTP

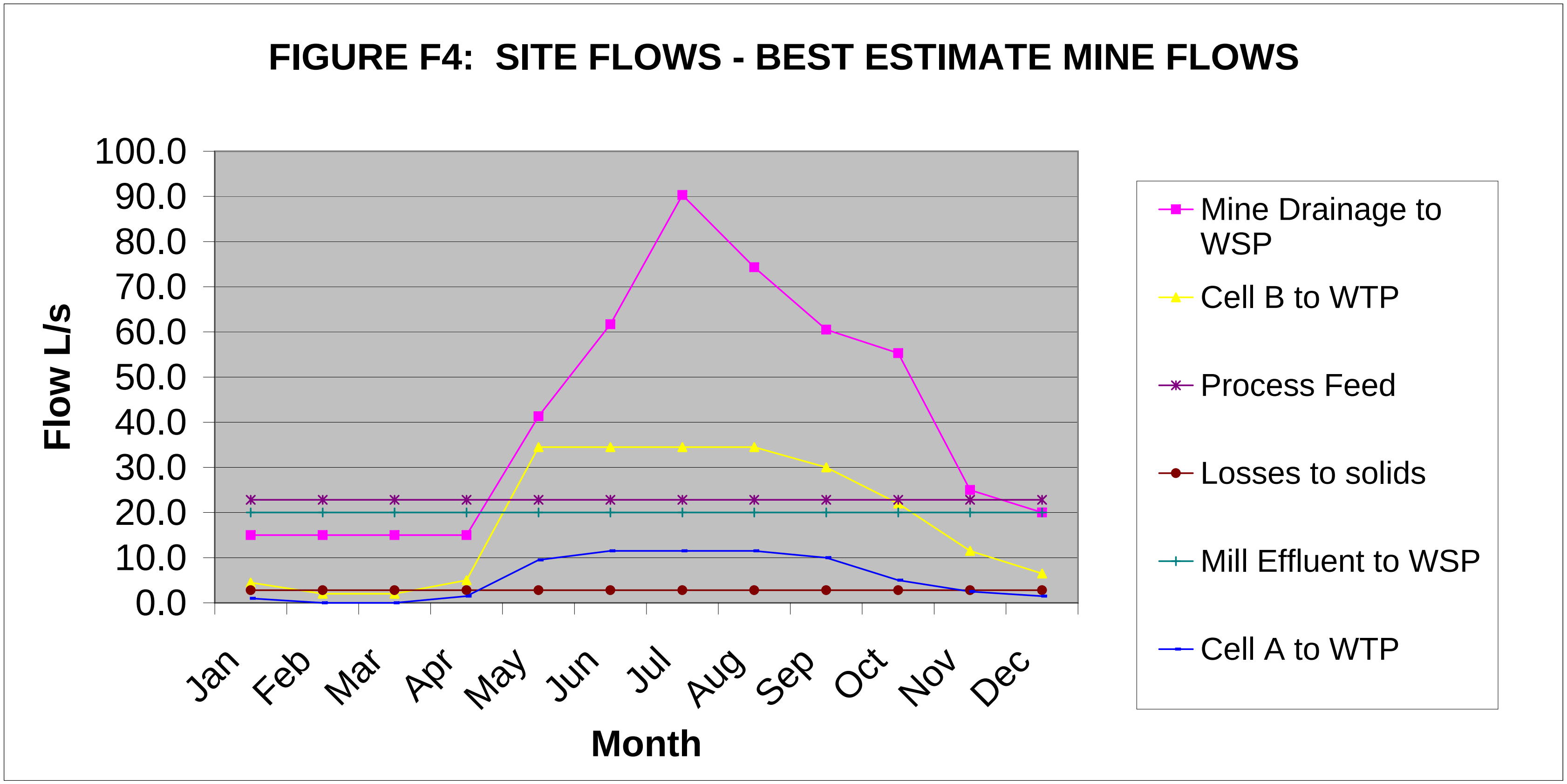


FIGURE F4: SITE FLOWS - BEST ESTIMATE MINE FLOWS
Flow L/s
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Mine Drainage to WSP
Cell B to WTP
Process Feed
Losses to solids
Mill Effluent to WSP
Cell A to WTP

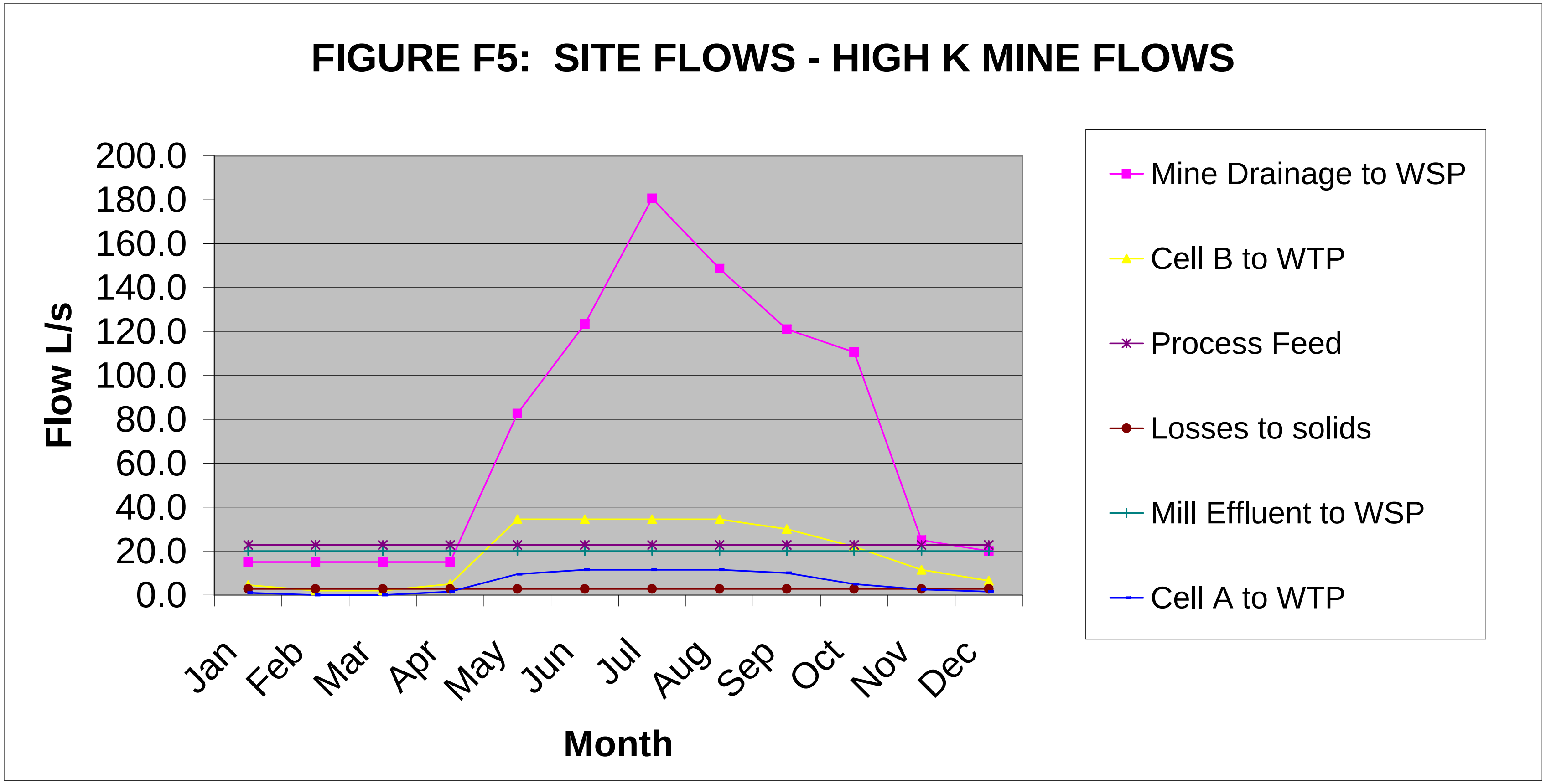


FIGURE F5: SITE FLOWS - HIGH K MINE FLOWS
Flow L/s
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Mine Drainage to WSP
Cell B to WTP
Process Feed
Losses to solids
Mill Effluent to WSP
Cell A to WTP

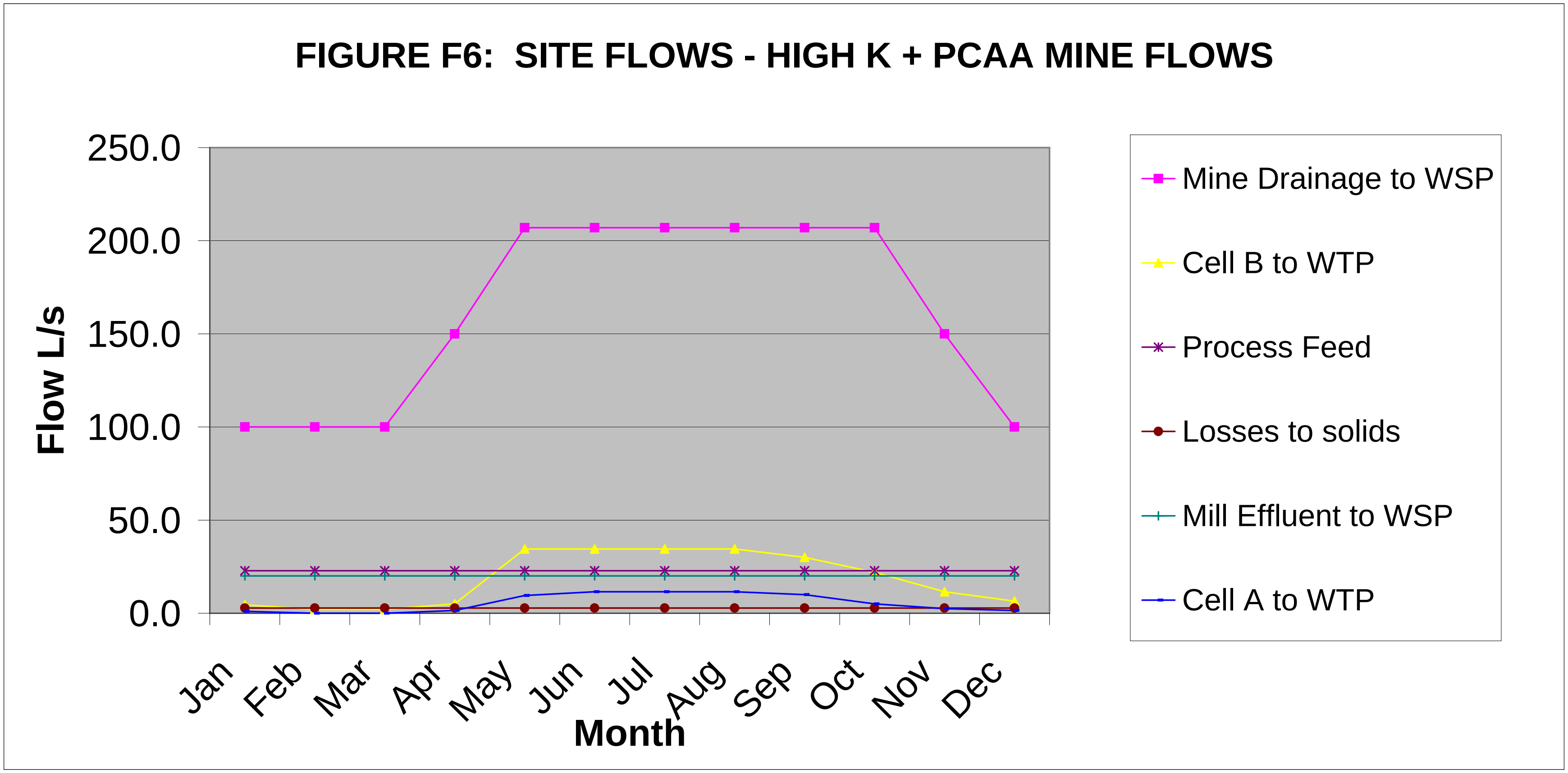


FIGURE F6: SITE FLOWS - HIGH K + PCAA MINE FLOWS
Flow L/s
250.0
200.0
150.0
100.0
50.0
0.0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Mine Drainage to WSP
Cell B to WTP
Process Feed
Losses to solids
Mill Effluent to WSP
Cell A to WTP

ADDENDUM F1

ROBERTSON GEOCONSULTANTS INC. *A Robertson Group Company*

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February 18, 2011
RGC Project No: 148002/2

Canadian Zinc Corporation

Suite 1710 – 650 West Georgia Street
Vancouver, B.C.
V6B 4N9

Attention: Dave Harpley

RE: REV 0 - Results of Additional Groundwater Flow Modeling, Prairie Creek Mine, NWT

Dave,

This letter report summarizes the results of additional groundwater flow modeling completed for the Prairie Creek Mine site in support of a DAR application by Canadian Zinc Corporation (CZN) to the Mackenzie Valley Review Board.

This letter report should be read in conjunction with the Site Hydrogeology Report for the Prairie Creek Mine site (RGC, 2010a)[1] which describes the conceptual and numerical groundwater flow model and an earlier letter report (RGC, 2010b)[2] which describes preliminary transient calibration results.

1 Background and Scope of Work

A groundwater model was developed for the Prairie Creek Mine site to assess groundwater flow at the mine site for past, current and future conditions. During the initial phase of this study groundwater flow was simulated assuming steady-state conditions. These steady-state modeling runs provided initial estimates of (mean annual)

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[1] Robertson GeoConsultants Inc. (2010a) "Site Hydrogeology Report" RGC Report 148002/1 prepared for Canadian Zinc Corporation, February 2010.

[2] Robertson GeoConsultants Inc. (2010b) "REV 0 - ADDENDUM to Site Hydrogeology Report - Results of Transient Groundwater Modeling, Prairie Creek Mine, NWT" RGC Letter Report prepared for Canadian Zinc Corporation, March 17, 2010.

groundwater flow at the site for pre-mining, pre-decline development, current mine development, end-of-mining and post-closure (RGC, 2010a).

The scope of the initial groundwater flow modeling for the DAR submission was subsequently extended to include transient modeling of groundwater flow (RGC, 2010b). A first transient calibration of the flow model was completed in March 2010 using the seasonal variations of outflow from the 870 tunnel as primary calibration targets. Once calibrated, this transient flow model was used to provide estimates of seasonal dewatering rates during active mining and seasonal groundwater flow after closure of the mine (RGC, 2010b).

In the second round of information requests, INAC raised several questions related to the modeling assumptions & predictions and requested upper and lower bounds on predicted mine inflows. Additional modeling runs have since been completed to address some of these questions and are summarized in the following sections.

2 Sensitivity Analysis using Transient Model

2.1 Scope of Sensitivity Analysis

Four additional transient model runs were completed for current conditions to determine the sensitivity of simulated mine outflow from 870 Portal to a range of hydraulic parameters. Table 1 shows the hydraulic parameters used in these four sensitivity runs. The hydraulic parameters determined during initial model calibration (in March 2010) are also shown for ease of reference (model run “NM10tr”). The hydraulic parameters which were changed with respect to the calibrated model are highlighted in the table.

Specific yield was assumed to be constant at 1.0 % for the fault and 0.1 % for bedrock. A value of 43.2 1/d was used as transfer rate for the fault and 2.59x10-2 1/d for bedrock. Recharge was applied on two zones with a time varying cyclical function. Yearly recharge over the mine foot print was 200 mm/year, and 100 mm/year for the remaining areas. The transient model was run for five consecutive years to allow equilibration with the transient recharge conditions (see RGC, 2010b for more details).

2.2 Results

Figure 1 shows the simulated seasonal inflow to the current mine workings for the four sensitivity runs. The simulated flows for the initial calibration run (NM10Tr) and the observed seasonal outflow from the 870 Portal are also shown for comparison. Table 2 summarizes the simulated minimum (winter) and maximum (summer) fluxes to the current mine workings for the different sensitivity runs.

Figure 2 shows the simulated groundwater discharge to the Harrison Creek alluvial aquifer via the MQV fault zone. Table 3 summarizes minimum (winter) and maximum (summer) flows from the MQV into Harrison Creek. Note that earlier load calculations (using zinc loading) had suggested a groundwater discharge from the MQV into Harrison Creek of about 1.7 L/s (RGC, 2010c)[3].

The following conclusions can be drawn from these additional sensitivity runs:

- All of the sensitivity runs over-predicted the observed minimum (winter) inflows to the mine workings (by 1.5-2.5 L/s);
- All of the sensitivity runs matched the observed maximum (summer) inflows to the mine workings reasonably well considering the uncertainty in simulated summer flows (note: oscillation in summer flows suggested some numerical instability);
- The calibration run (NMtr10) and sensitivity run 1 (high K fault) best reproduced the rapid decline in the observed inflow to the mine workings after spring/summer runoff period suggesting that groundwater inflow is dominated by direct recharge to the fault zone;
- Groundwater discharge from the MQV into the Harrison Creek alluvial aquifer is almost directly proportional to the assumed K in the MQV (and Vein Fault) but less sensitive to the assumed bedrock K; the MQV discharge predicted for the two low-K fault scenarios (w/ $K=1*10^{-5}$ m/s) is considered more realistic (see section 3 below).

In summary, the additional sensitivity runs demonstrate that there is some remaining uncertainty in the actual hydraulic parameters of the Vein Fault and the bedrock because the main target for transient calibration (mine inflow to current mine workings, i.e. 870 Portal outflow) is not very sensitive to the hydraulic parameters (within the range of K and S varied).

Groundwater discharge from the MQV into Harrison Creek is better suited for calibration of the fault K. However, groundwater discharge via the MQV cannot be measured directly and has to be estimated using loading calculations which carry some uncertainty (see Section 3 below).

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[3] Robertson GeoConsultants Inc. (2010c) "REV 1 – Load balance calculations for Mine Water and Surface Water, Prairie Creek Mine, NWT", Letter Report prepared for Canadian Zinc Corporation, March 17, 2010.

It is concluded that the hydraulic parameters obtained during initial calibration (NM10Tr) should be retained as best estimates. However, the range of hydraulic parameters assumed in the four sensitivity runs is plausible and should be used for estimating “high flow scenarios” for active mining.

3 Additional Sensitivity Analysis for Active Mining

According to our conceptual model of the site hydrogeology, the highly-permeable Vein Fault extends into the Harrison Creek valley but does not intersect the Prairie Creek valley. Consequently, the more permeable “fault zone” unit introduced into the numerical model does not intersect the southern model boundary representing the Prairie Creek Alluvial Aquifer, PCAA (RGC, 2010a).

On the request of INAC, additional sensitivity runs were completed using the steady state model to assess the sensitivity of mine inflow during active mining (see section 4.4.1 in RGC, 2010a for details) on the southern extent of the permeable Vein Fault.

For the purpose of this sensitivity analysis, the permeable “fault zone” was extended to the southern model boundary representing the PCAA (see right panel in Figure 3). Two different scenarios were run with this extended fault zone:

- HCAA supplying recharge to bedrock aquifer (spring/summer runoff conditions)
- HCAA not supplying recharge to bedrock aquifer (winter baseflow conditions)

Note that aerial recharge (from precipitation) was also “turned off” for the winter scenario. This winter scenario is considered a worst-case scenario with respect to seepage from PCAA towards the mine workings. In other words, this scenario would produce the highest likely seepage from the PCAA to the mine workings. These sensitivity runs were completed for both the “low flow” scenario (Run “AM13” w/ fault K =1x10-5 m/s) and the “high flow” scenario (Run “AM21” w/ K=1x10-4 m/s).

Table 4 compares the simulated total inflow to the mine workings and the simulated contribution (or “seepage”) from the Prairie Creek Alluvial Aquifer for the four sensitivity scenarios. The original estimates of these flows (assuming no extension of the Vein fault to PCAA) are also shown for ease of comparison.

During spring runoff/summer conditions when flow in HCAA is providing adequate recharge to the bedrock aquifer, the vast majority of inflow to the mine workings is still provided from the HCAA. Assuming the Vein Fault extends into Prairie Creek valley the additional seepage from PCAA contributing to mine inflow is predicted to range from 1.7 to 13.3 L/s, i.e. representing only about 5-6% of the total mine inflow.

During winter conditions, when Harrison Creek is frozen and recharge from the HCAA is assumed to be negligible, seepage from the PCAA would represent the main source of recharge to the active mine workings (assuming, of course, that the Vein Fault intersects the PCAA). Under those conditions, seepage from the PCAA could range from 9-90 L/s, depending on the effective permeability of the Vein Fault potentially connecting the mine workings to the PCAA (see AM13a runs in Table 4).

4 Updated Estimates Of Seasonal Mine Inflow (Active Mining)

In our response to the first round of Information Requests (submitted September 6, 2010 to CZN) we provided initial estimates of seasonal inflow to the active mine workings (see Table 6 of the September 6 letter report). These initial estimates did not take into account the effects of limited recharge from HCAA during winter baseflow, nor did they take into account the potential for recharge from PCAA via a permeable fault zone.

Our sensitivity runs described in Section 2 of this letter report illustrate that the seasonal mine inflow rates are strongly dependent on the effective permeability of any fault structure connecting HCAA and/or PCAA with the existing and future mine workings.

As described in Section 2, the current outflow from the 870 Portal is not a good predictor of the effective permeability of the Vein fault. Instead, current zinc loading to HCAA provides a better estimate of the effective permeability of the Vein Fault (at least between the mine workings and HCAA).

Earlier mixing calculations using estimated sulphate and zinc loading in Harrison Creek (at HC-3) had suggested a seepage flow from the Vein Fault (with elevated SO_4 and zinc) of about 1.7 L/s for November 2009 (see Table 2-1a in RGC, 2010c). However, additional sampling performed at HC-3 in September 2010 showed much lower zinc concentrations (7 ug/L instead of 230 ug/L) suggesting no impact from Vein Fault flow with elevated zinc concentrations. No stream flow estimates were available to assess the influence of discharge on the observed (large) variation in surface water quality in Harrison Creek. Nevertheless, these variations highlight the uncertainty in estimating Vein Fault flow based on water quality in Harrison Creek.

An alternative method of estimating groundwater discharge from the Vein fault to HCAA is to estimate the zinc load in HCAA (upstream of the mill area where other sources of zinc may contribute to zinc loading). Zinc concentrations observed at MW09-14, screened in HCAA upstream of the mill, range from 58 to 105 ug/L with an average of 84 ug/L. Assuming these zinc concentrations are representative of the HCAA and further assuming a zinc concentration in the mineralized Vein fault of 2,120 ug/L (as observed at

MW09), the contribution of mineralized groundwater from the MQV to the HCAA is estimated to range from 2 to 4.5% of total flow in the HCAA. Using our estimates of groundwater in the HCAA (ranging from 5.0 to 16.5 L/s, see Table 4-4 in RGC, 2010a) the discharge of mineralized groundwater from the MQV to HCAA is estimated to range from 0.1 to 0.75 L/s. These zinc loading calculations are more consistent with the "low flow" scenario (i.e. Vein Fault K = $1*10^{-5}$ m/s) than the "high flow" scenario (Vein Fault K = $1*10^{-4}$ m/s).

Based on all available information to date, we conclude that the calibrated transient flow model (with a Vein fault K = $5*10^{-5}$ m/s) provides a reasonably conservative estimate of seasonal groundwater inflow to the active mine workings. The Vein fault K values assumed for the earlier steady-state simulations (i.e. Vein Fault K = $1*10^{-5}$ m/s for "low flow" and Vein fault K = $1*10^{-4}$ m/s for "high flow") provide reasonable upper and lower bounds for these mine inflow estimates.

Table 5 shows our updated best estimate of seasonal inflow to future mine workings. This best estimate uses the monthly inflows to the mine workings simulated with the calibrated transient model (with a fault K=$5*10^{-5}$ m/s) for the spring/summer high flow period when Harrison Creek provides adequate recharge to HCAA. During the winter months, the predicted inflows are reduced to take into account the freeze-up of Harrison Creek and the limited supply of recharge from HCAA.

5 Closure

We trust that the information provided in this memo meets your requirements.

Please contact the undersigned if you have any questions regarding the content of this report or require further information.

Best Regards,

ROBERTSON GEOCONSULTANTS INC.

ORIGINAL SIGNED

Dr. Christoph Wels, M.Sc., P.Geo.
Principal and Senior Hydrogeologist

6 References

Robertson GeoConsultants Inc. (2010), Site Hydrogeology Report, Prairie Creek Mine, Northwest Territories, February 2010.

Robertson GeoConsultants Inc. (2010b) “REV 0 - ADDENDUM to Site Hydrogeology Report - Results of Transient Groundwater Modeling, Prairie Creek Mine, NWT” RGC Letter Report prepared for Canadian Zinc Corporation, March 17, 2010.

Robertson GeoConsultants Inc. (2010c) “REV 1 – Load balance calculations for Mine Water and Surface Water, Prairie Creek Mine, NWT”, Letter Report prepared for Canadian Zinc Corporation, March 17, 2010.

Figures

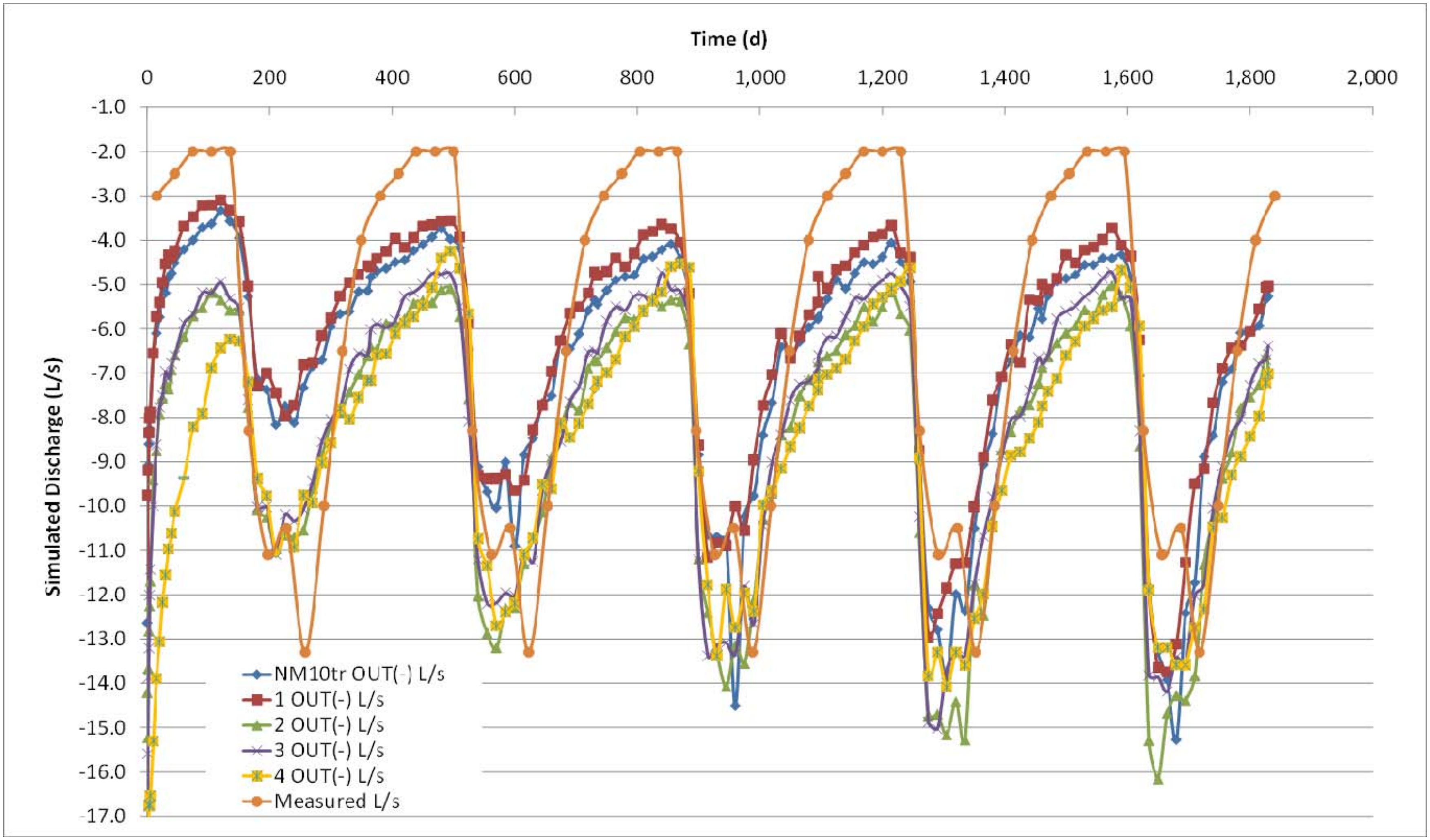

Figure 1. Simulated discharge to current mine workings (870 Portal).

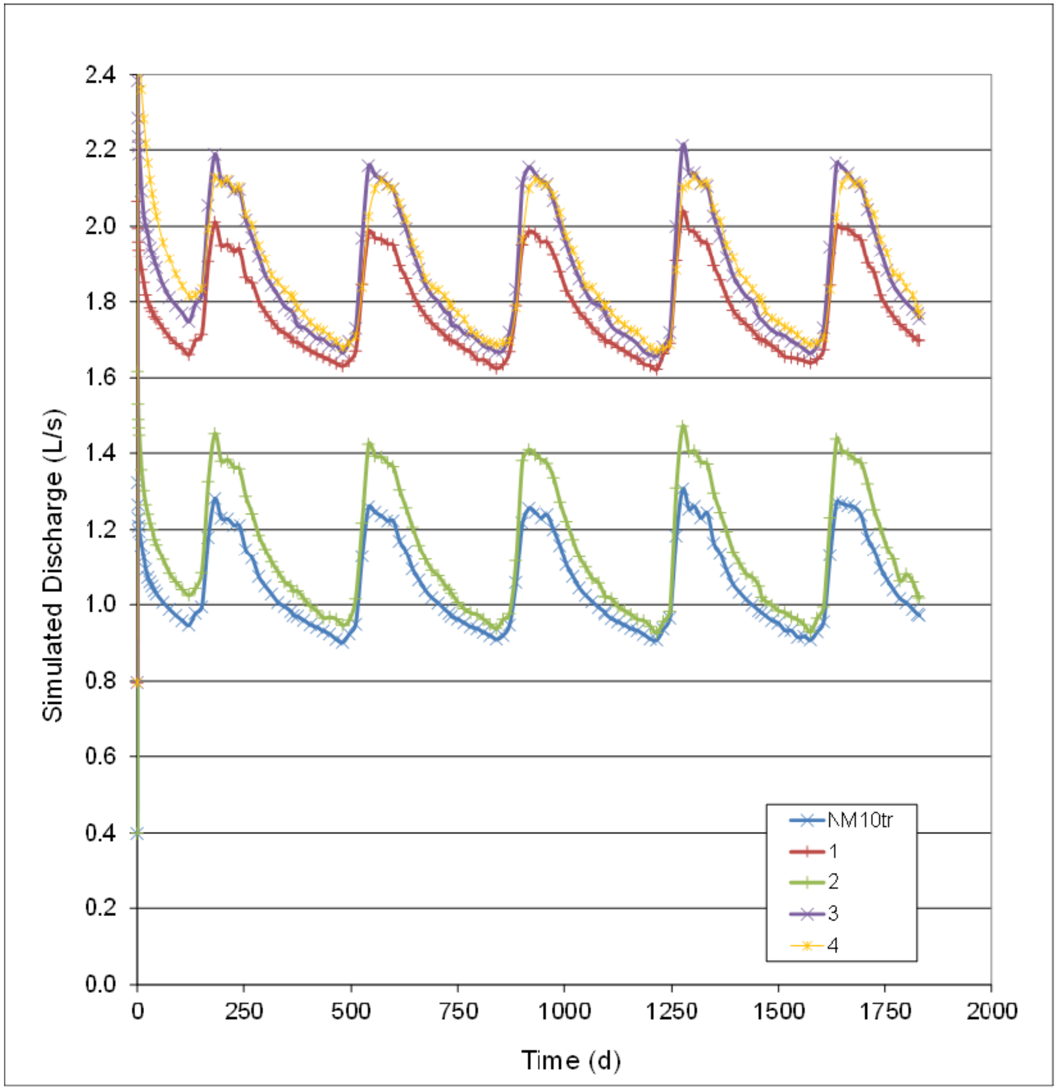

Figure 2. Simulated discharge to Harrison Creek via fault.

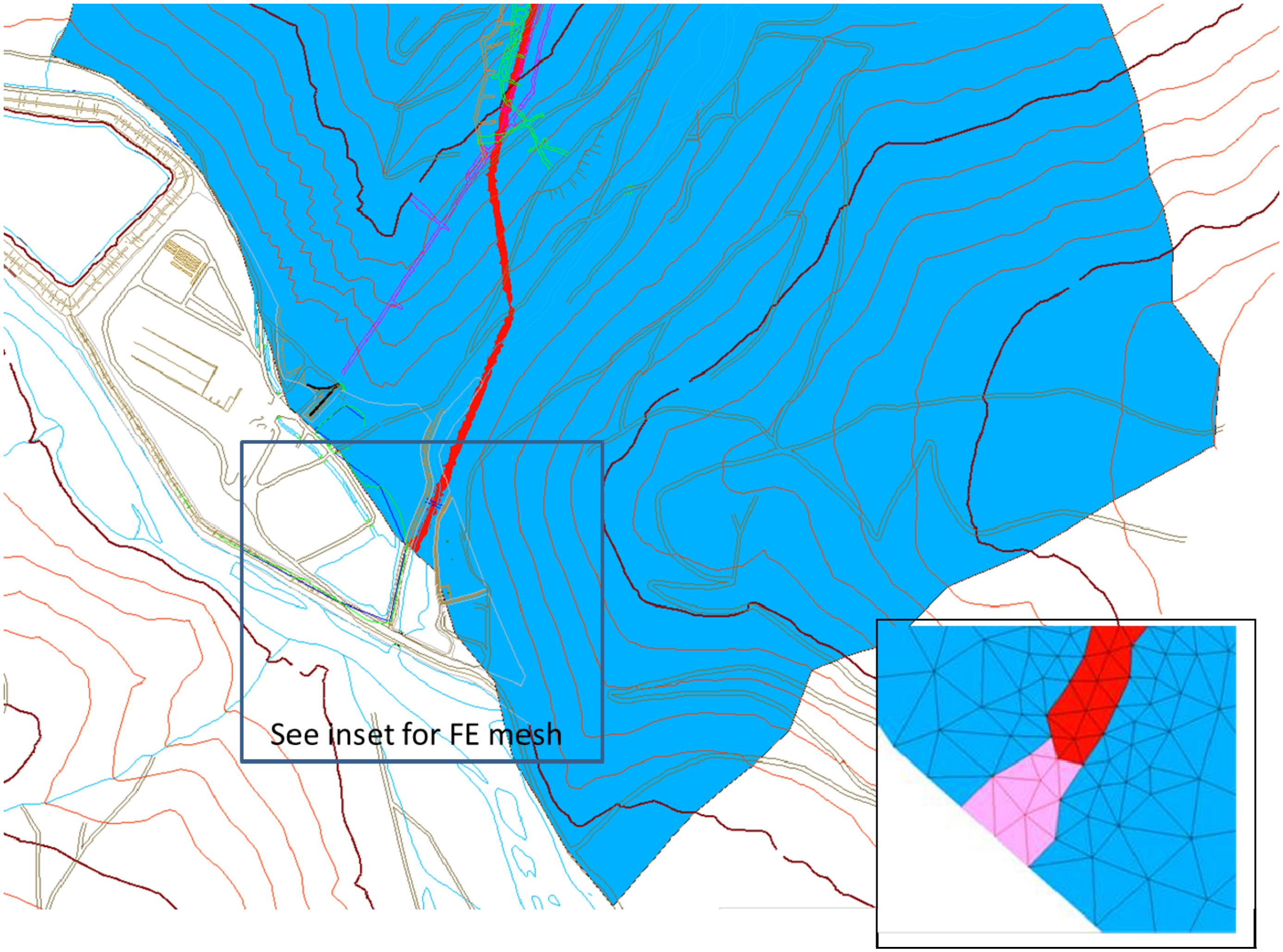

Figure 3. Extension of permeable Vein Fault unit to PCAA in FE mesh (red zone represents original extent and purple zone represents extension).

Tables

Table 1. Hydraulic Parameters for Sensitivity Analysis

No.	**Run**	Fault		Bedrock	
		K (m/s)	**Ss (1/m)**	**K (m/s)**	**Ss (1/m)**
0	NM10tr	5.0E-05	1.0E-06	3.0E-08	1.0E-07
1	CC1tr	**1.0E-04**	1.0E-06	3.0E-08	1.0E-07
2	CC2tr	5.0E-05	1.0E-06	**5.0E-08**	1.0E-07
3	CC3tr	**1.0E-04**	1.0E-06	**5.0E-08**	1.0E-07
4	CC4tr	**1.0E-04**	**1.0E-05**	**5.0E-08**	**1.0E-06**

Table 2. Total Flow to the Mine in L/s

No.	**Qmin**	**Qmax**	**Difference**
0	4.4	13.9	9.5
1	3.9	13.0	9.1
2	5.2	15.3	10.1
3	4.9	14.2	9.3
4	4.7	13.6	8.9
TARGET	**2.5**	**13.3**	**10.8**

Table 3. Total Flow to Harrison Creek via Fault in L/s

No.	Q out min	Q out max	Differenc e
0	0.9	1.4	0.5
1	1.7	2.0	0.3
2	0.9	1.4	0.5
3	1.7	2.2	0.5
4	1.7	2.1	0.4
TARGET	**1.0**	**2.0**	**1.0**

Table 4. Results of Sensitivity Analysis on Southern Extent of Permeable Vein Fault.

	Low Flow Scenario (Fault K=1E-5 m/s)			**High Flow Scenario (Fault K=1E-4 m/s)**		
Description	Low Flow Estimate (RGC, 2010a)	AM13 w/ Vein Fault extended to PCAA	AM13a w/o recharge from HCAA	Low Flow Estimate (RGC, 2010a)	AM13 w/ Vein Fault extended to PCAA	AM13a w/o recharge from HCAA
Run	AM13	AM13a		AM13	AM13a	
Mine Inflow (L/s)	28.8	28.9	18.3	205.1	206.2	105.4
Seepage from PCAA (L/s)	0.0	1.7	9.1	0.0	13.3	88.8

Table 5. Updated estimates of seasonal mine inflow during active mining. Also shown are estimated upper and lower bounds and their estimated likelihood of occurrence.

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.	Estimated Probability of Occurrence (%)
Low Estimate (K Fault =1E-5 m/s)	15	15	15	15	21	32	47	38	31	29	25	20	25.2	10%
Best Estimate (Nm15Tr w/ K Fault = 5E-5 m/s)	15	15	15	15	41.3	61.7	90.3	74.3	60.5	55.3	25	20	40.7	70%
High Estimate (K Fault =1E-4 m/s)	15	15	15	15	83	123	181	149	121	111	25	20	72.7	15%
High Estimate with Vein Fault-PCAA Connection	100	100	100	150	207	207	207	207	207	207	150	100	162	5%

(yellow) flow reduced to account for limited recharge of HCAA during winter freeze-up

ADDENDUM F2

February 18, 2011

Mr. Alan Taylor
Canadian Zinc Corporation
Suite 1710, 650 West Georgia Street,
PO Box 11644,
Vancouver, BC V6B 4N9, Canada

C.C.: Byard MacLean
SNC-LAVALIN Inc.

Re: Raw Water Usage and Recycle Water Generation – CAVM-50098-001- LCT-2 Test

Dear Mr. Taylor,

This memorandum details the general procedures for water production during the recent locked cycle test conducted at SGS Vancouver.

This is reference to the locked cycle test LCT-2 conducted on January 6th, 7th, and 10th of 2011 at SGS Vancouver, as a part of the project CAVM-50098-001 and on behalf of Canadian Zinc Corporation. This 6 cycle test used 10 kg charges of resource material per cycle as the solid component and 180 litres of raw water (90 L of 'Adit' water and 90 litres of 'Decline' water) supplied by Canadian Zinc Corporation. The flotation test flowsheet, reagents and the dosages were designed by SGS Lakefield during the development of Phase 5 (Project 12018-001 – Report 5, dated February 9, 2009). The test flowsheet is shown in Figure 1.

The objective of the test was to simulate the Prairie Creek process flowsheet in a locked cycle test, using only a limited quantity of raw water (180 L) and generate a minimum of 100 L of process (reclaim) water. Process and reclaim water was collected from (1) Zn concentrate filtrate (2), Pb Oxide feed thickener overflow (3), Pb Oxide concentrate filtrate and (4), Pb Oxide scavenger tail filtrate. Process water generated was tested to determine the water quality and project effluent concentration levels for the mine.

The main water usage in the locked cycle test can be categorized into three areas. They are grinding, maintaining level of flotation cells and assisting transfer of solids. The types of water used in the test are classified as raw, reclaim and internal circulating waters.

Raw Water: This is 'Adit' and 'Decline' water supplied by Canadian Zinc and mixed at a ratio of 50:50.
Reclaim Water: This is the process water reclaimed from the designated outlets i.e., filtrates from the three concentrate products, Pb oxide feed thickener overflow, and the final tailing during the locked cycle test. The filtrate water collected from the intermediate streams at the end of the LCT test, are also classified as reclaim

water. The only reclaim water used in the locked cycle test was when Pb oxide scavenger tail filtrate from LCT-1 and LCT-2 were mixed with raw water at identified intervals.

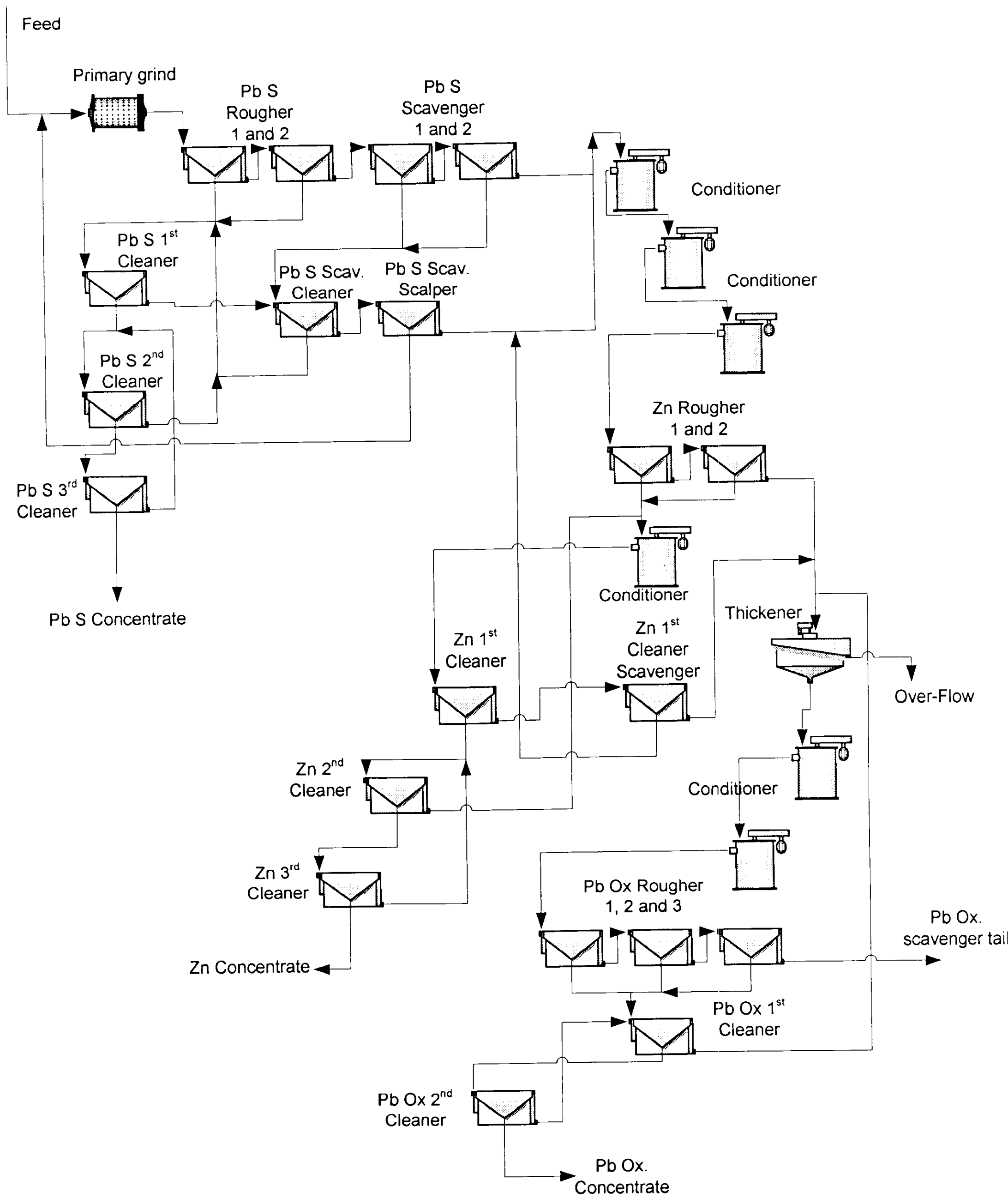

Figure 1: LCT Test Flowsheet

Internal Circulating Water (ICW): These are the excess waters collected within a process and used either in the same cycle or in subsequent cycles. An ideal example is the Pb sulphide 3rd cleaner tailing. The water in this cell in a particular cycle is combined with the Pb sulphide 2nd cleaner concentrate of the next cycle (to fill the 3rd cleaner flotation cell). Another significant type of ICW is when the Pb sulphide scavenger scalper tail of one cycle is mixed with Pb sulphide scavenger tail to be the Zn conditioner feed. In this case water will be in excess and collected as ICW. The ICW collected within a section of a circuit (e.g. Pb sulphide, Zn sulphide and Pb oxide circuits) are generally used within the circuits.

Grinding: Approximately 90% of the water used in grinding originated from an outside source, i.e. reclaim or raw water. About 10% returned with the Pb S Scavenger scalp concentrate and is ICW. During the LCT 2 test, whenever possible, raw water was used as the outside source water. This water is then transferred to the rougher flotation cell and used as the second category.

Maintain Flotation cell Levels: The largest consumption of water in the locked cycle test is in filling the flotation cells to maintain their levels. In the first cycle, all the water used is raw water. As cycling progresses, ICW became the predominant part of the water used in this area.

Assisting Transfer of Solids: The consumption of water in this area was low. With the exception of the first cycle, all waters were ICW. Washing flotation cell lips, cleaning impeller and shaft and cleaning the cell bottoms were the most common uses.

The following sequence of events related to water usage and reclaiming took place during the locked cycle test. Note that in each cycle, reclaim waters from the same source were allowed to accumulate.

Cycle # 1:

- Mixed 54 L of Adit water and 54 L of Decline water.
- Used ~ 70 L of the raw water during the cycle, leaving ~ 38 L for the 2nd cycle.
- Reclaim waters were allowed to accumulate and not used in the LC test.

Cycle # 2:

- Used ~ 32 L of the process raw water during the cycle, leaving ~ 6 L for the 3rd cycle.
- Reclaim waters were allowed to accumulate and not used in the LC test

Cycle # 3:

- Mixed 36 L of 'Adit' water, 36 L of 'Decline' water and 18 L of each of Pb Oxide scavenger tail filtrate from LCT 1 and LCT 2, respectively.
- Used ~ 32 L of the process (raw + reclaim) water during the cycle, leaving ~ 82 L for the rest of the test.
- Reclaim waters were allowed to accumulate and not used in the LC test.

The justification for mixing before cycle # 3, type and quantity of water used:

1. Only ~ 6 L of raw water were left after cycle # 2 and the average consumption was 32 L per cycle, i.e. required ~128 L to complete the test.
2. The impact of reclaim water on the process was the least when it is mixed with raw water. After 2 cycles, there was 72 L of raw water left. Therefore the mix needed to happen at this time to minimize the impact on the process.
3. The largest component of reclaim was LCT 2 Pb oxide scavenger tail filtrate and only ~23 L were available by the middle of cycle # 2. Therefore this component needed to be supplemented.
4. LCT 1 used the same solids samples, used only raw water and followed the same process flowsheet. Therefore, the quality of Pb oxide scavenger filtrate was expected to be similar to LCT 2 Pb oxide scavenger tail filtrate. LCT 1 Pb oxide scavenger filtrate was the largest component of reclaim water available other than LCT 2 Pb oxide scavenger tail filtrate.

Cycle # 4:

- Used ~ 32 L of the process (raw + reclaim) water during the cycle, leaving ~ 50 L for the rest of the test.
- Reclaim waters were allowed to accumulate and not used in the LC test.

Cycle # 5:

- Used ~ 31 L of the process (raw + reclaim) water during the cycle, leaving ~ 19 L for the rest of the test.
- Reclaim waters were allowed to accumulate and not used in the LC test.

Cycle # 6:

- Mixed the remaining 19 L of process water (mixture of raw and reclaim) with 5 L of Pb Oxide scavenger tail filtrate from LCT 2.
- Used ~ 24 L of the process (raw + reclaim) water during the cycle, leaving ~ 82 L for the rest of the test.
- Reclaim waters were allowed to accumulate and not used in the LC test.

The water usage of the components as a percentage in each cycle is presented in Table 1.

Table 1: Water Usage as a Percentage of the Components

Water usage as a percentage

Cycle	1	2	3	4	5	6
Adit	50	50	34	34	34	27
Decline	50	50	34	34	34	27
LCT 1 Pb Ox tail	0	0	16	16	16	13
LCT 2 Pb Ox tail	0	0	16	16	16	33
Total - %	100	100	100	100	100	100

After the completion of the last cycle all the intermediate and final products were filtered and the total water reclaimed was determined. The total reclaim water volumes and the water balance of the test are presented in Table 2.

Table 2: LCT 2 Water Balance

Water Usage	Liters
Adit water	90
Decline water	90
LCT1 Pb Ox Scav tail filtrate	18
LCT2 Pb Ox Scav tail filtrate	23
Total feed water supplied	221

Water Reclaimed	Liters
Pb Ox Scav tail flitrate	133
Pb Ox feed thickener O/F	20.5
Zn CL 3 Conc filtrate	9.8
Pb CL 3 Conc filtrate	6
Pb Ox CL 2 Conc filtrate	8
Pb S. 3rd Cleaner Tail - F	1.8
Pb S. 2nd Cleaner Tail - F	1.4
Pb S. Scav Cleaner Conc - F	0.6
Pb S. Scav Scalper Conc - F	0.4
Pb S. Scav Scalper Tail - F	4
Zn 3rd Cleaner tail - F	4.4
Zn 2nd Cleaner tail - F	4.4
Zn 1st Clean/Scav Conc - F	0.5
Pb Ox. 2nd Cleaner Tail - F	1.8
Pb Ox. 1st Cleaner Tail - F	3.9
Feed water sample	4
Losses to filter cakes	8.2
Spliage and losses	8
Total water reclaimed	221

The final goal of the exercise was to compose 100 L of reclaim water for the water treatment and toxicity testing. The bulk water sample was formed as shown in Table 3. Note that the representation of Pb. Ox cleaner concentrate filtrate, Zn 3rd cleaner concentrate filtrate and the Pb Ox dewatering thickener overflow in the bulk sample, is high. This may cause the bulk water sample to be a ‘worst case scenario’ with respect to water quality.

SGS

Table 3: Making of the Bulk Water Sample

Making of Bulk Sample	Available L	Make L
Pb Ox Cleaner Conc filtrate	13.7	13
Zn Cleaner 3 conc. filtrate	19.1	19
Pb Oxide dewater thickener	20.5	20
Pb Ox Scav tail flitrate	110	48

As requested by Canadian Zinc, the bulk water sample was sent to SGS CEMI.

Kind Regards,

Sarath Ratnayake
Senior Metallurgist, Vancouver Metallurgy

Jake Lang, B.E. Sc.,
Lead Metallurgist, Metallurgical Operations

ADDENDUM F3

Canadian Zinc Water Treatment Tests
Memo N° 1102-0211M03-00

Phone: (604) 267-2364
Fax: (604) 264-5535
E-mail: **Sohan.Basra@sgs.com**
Prab.Bhatia@sgs.com

Memorandum

Date: February 9, 2011

To: Dave Harpley

Re: Large Batch Treatment for Toxicity
Project: CEMI-1102
Memo N° 1102-0211M03-00

Following the initial scoping test work, details of which are provided in SGS Memo No. 1102-0111MO3-00 (see Appendix B), a larger batch of both mine water and process water was treated and submitted for acute and chronic toxicity test work. The complete analysis results for the influent and treated water are provided in Appendix A.

Mine Water

Approximately 105L sample of the mine water was treated with lime to pH 9.3 and 60 minute retention time. After treatment, anionic polymer flocculent Magnafloc-10 was added (7 mg/L) to enhance settling. Following 4hours of setting, the sample was transferred into clean pails and submitted for toxicity analysis.

DATE	Project No.	Sample No.	Sample Description
28-Jan-11	1102	11-041	Mine Water Feed
28-Jan-11	1102	11-042	Mine Water Effluent

Process Water

Small batches of process water were treated initially to confirm the effectiveness of the previously developed treatment approach. The initial batches did not respond to treatment as well as expected (see Appendix B). It was concluded that organic process reagents added in the metallurgical process to produce the water were interfering with treatment chemicals. Previous testing was based on water that had ‘aged’ for approximately one month. The recent process water sample was subsequently aerated and mixed to promote break-down of the organic reagents. After treatment of further small batches, the decision was made to proceed with large batch treatment.

Approximately 55L sample of the process water was treated using the sulphide/ferric treatment process. The sample was acidified to pH 4.53 using 1N sulphuric acid and solution purged with nitrogen. Sodium sulphide was then added at 40 mg/L sulphide concentration. The test was carried out in a closed container and solution mixed for 30 minutes. After 30 minutes of vigorous mixing, the redox was -215mV and pH was 5.78. Magnafloc-10 was then added (10 mg/L) to the solution and allowed to settle for 4hours. After the settling, the redox had further decreased to -297mV and pH had increased to 7.09. The solution was then aerated for 60 minutes to remove excess sulphide. Once the redox had reached 47mV, 80 mg/L of ferric iron was added to the solution and pH increased to 9.43 using hydrated lime. After 60 minutes of mixing at pH 9.43, Magnafloc-10 was added (4 mg/L) to flocculate the precipitate and solution was settled for 60 minutes. The settled solution was then filtered through 1 micron filter (to simulate clarification) and transferred into clean pails and sent for toxicity analysis.

DATE	Project No.	Sample No.	Sample Description
28-Jan-11	1102	11-039	Process Water Feed
28-Jan-11	1102	11-040	Process Water Effluent

Appendix A

Analysis Report

Your P.O. #: WT-11014
Your Project #: 1102 CANADIAN ZINC
Your C.O.C. #: 08328403

Attention: Rik Vos
SGS CEMI Inc.
6927 Antrim Ave.
Burnaby, BC
CANADA V5J 4M5

Report Date: 2011/02/01

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B107289
Received: 2011/01/31, 10:45

Sample Matrix: Water
Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Hardness Total (calculated as CaCO3)	4	N/A	2011/02/01		
Na, K, Ca, Mg, S by CRC ICPMS (total)	4	2011/01/31	2011/02/01	BBY7SOP-00002	Based on EPA 200.8
Elements by CRC ICPMS (total)	3	2011/01/31	2011/01/31	BBY7SOP-00002	Based on EPA 200.8
Elements by CRC ICPMS (total)	1	2011/01/31	2011/02/01	BBY7SOP-00002	Based on EPA 200.8

* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

LANOY LUANGKHAMDENG, Burnaby Customer Service
Email: LLuangkhamdeng@maxxam.ca
Phone# (604) 638-2636

==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 1

Maxxam Job #: B107289
Report Date: 2011/02/01

SGS CEMI Inc.
Client Project #: 1102 CANADIAN ZINC

Your P.O. #: WT-11014

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		Z63655	Z63656	Z63657	Z63658		
Sampling Date		2011/01/28 15:00	2011/01/28 15:00	2011/01/28 15:00	2011/01/28 15:00		
	Units	**11-039**	**11-040**	**11-041**	**11-042**	**RDL**	**QC Batch**
Calculated Parameters							
Total Hardness (CaCO3)	mg/L	207	431	863	569	0.5	4596062

RDL = Reportable Detection Limit

Maxxam Job #: B107289
Report Date: 2011/02/01

SGS CEMI Inc.
Client Project #: 1102 CANADIAN ZINC

Your P.O. #: WT-11014

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		Z63655		Z63656		Z63657	Z63658		
Sampling Date		2011/01/28 15:00		2011/01/28 15:00		2011/01/28 15:00	2011/01/28 15:00		
	Units	**11-039**	**RDL**	**11-040**	**RDL**	**11-041**	**11-042**	**RDL**	**QC Batch**
Total Metals by ICPMS									
Total Aluminum (Al)	ug/L	<300	300	<30	30	45	4	3	4598081
Total Antimony (Sb)	ug/L	647	50	119	5	35.1	25.3	0.5	4598081
Total Arsenic (As)	ug/L	427	10	9	1	13.9	0.2	0.1	4598081
Total Barium (Ba)	ug/L	<100	100	<10	10	17	<1	1	4598081
Total Beryllium (Be)	ug/L	<10	10	<1	1	<0.1	<0.1	0.1	4598081
Total Bismuth (Bi)	ug/L	<100	100	<10	10	<1	<1	1	4598081
Total Boron (B)	ug/L	<5000	5000	<500	500	<50	<50	50	4598081
Total Cadmium (Cd)	ug/L	1240	1	24.3	0.1	11.5	0.04	0.01	4598081
Total Chromium (Cr)	ug/L	<100	100	<10	10	<1	<1	1	4598081
Total Cobalt (Co)	ug/L	<50	50	<5	5	1.1	<0.5	0.5	4598081
Total Copper (Cu)	ug/L	3950	20	71	2	90.5	0.7	0.2	4598081
Total Iron (Fe)	ug/L	<500	500	5400	50	7400	21	5	4598081
Total Lead (Pb)	ug/L	30800	20	304	2	12.5	1.7	0.2	4598081
Total Manganese (Mn)	ug/L	<100	100	50	10	50	<1	1	4598081
Total Mercury (Hg)	ug/L	888	2	1.9	0.2	0.04	<0.02	0.02	4598081
Total Molybdenum (Mo)	ug/L	<100	100	<10	10	3	2	1	4598081
Total Nickel (Ni)	ug/L	<100	100	12	10	10	2	1	4598081
Total Phosphorus (P)	ug/L	<1000	1000	246	100	<10	<10	10	4598081
Total Selenium (Se)	ug/L	116	10	10	1	2.9	2.8	0.1	4598081
Total Silicon (Si)	ug/L	38700	10000	13500	1000	2850	2790	100	4598081
Total Silver (Ag)	ug/L	69	2	0.7	0.2	0.07	<0.02	0.02	4598081
Total Strontium (Sr)	ug/L	<100	100	54	10	905	180	1	4598081
Total Thallium (Tl)	ug/L	19	5	<0.5	0.5	0.28	0.16	0.05	4598081
Total Tin (Sn)	ug/L	<500	500	<50	50	<5	<5	5	4598081
Total Titanium (Ti)	ug/L	<500	500	<50	50	<5	<5	5	4598081
Total Uranium (U)	ug/L	<10	10	2	1	27.1	4.9	0.1	4598081
Total Vanadium (V)	ug/L	<500	500	<50	50	<5	<5	5	4598081
Total Zinc (Zn)	ug/L	2740	500	1350	50	1530	<5	5	4598081
Total Zirconium (Zr)	ug/L	<50	50	<5	5	<0.5	<0.5	0.5	4598081
Total Calcium (Ca)	mg/L	16	5	65.1	0.5	193	25.1	0.05	4596065
Total Magnesium (Mg)	mg/L	41	5	65.2	0.5	92.5	123	0.05	4596065
Total Potassium (K)	mg/L	7	5	7.0	0.5	2.79	2.86	0.05	4596065
Total Sodium (Na)	mg/L	2110	5	1890	0.5	1.53	1.54	0.05	4596065
Total Sulphur (S)	mg/L	884	300	1730	30	178	169	3	4596065

RDL = Reportable Detection Limit

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER) Comments

Sample Z63655-01 Elements by CRC ICPMS (total): RDL raised due to sample matrix interference.

Sample Z63656-01 Elements by CRC ICPMS (total): RDL raised due to sample matrix interference.

Maxxam

Maxxam Job #: B107289
Report Date: 2011/02/01

SGS CEMI Inc.
Client Project #: 1102 CANADIAN ZINC

Your P.O. #: WT-11014

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
4598081	Total Arsenic (As)	2011/01/31	98	80 - 120	94	80 - 120	<0.1	ug/L	NC	20
4598081	Total Beryllium (Be)	2011/01/31	103	80 - 120	100	80 - 120	<0.1	ug/L	NC	20
4598081	Total Cadmium (Cd)	2011/01/31	101	80 - 120	98	80 - 120	0.02, RDL=0.01	ug/L	17.4	20
4598081	Total Chromium (Cr)	2011/01/31	139 (1)	80 - 120	92	80 - 120	<1	ug/L	NC	20
4598081	Total Cobalt (Co)	2011/01/31	95	80 - 120	95	80 - 120	<0.5	ug/L	NC	20
4598081	Total Copper (Cu)	2011/01/31	NC	80 - 120	100	80 - 120	<0.2	ug/L	4.9	20
4598081	Total Lead (Pb)	2011/01/31	102	80 - 120	97	80 - 120	<0.2	ug/L	3.3	20
4598081	Total Nickel (Ni)	2011/01/31	98	80 - 120	97	80 - 120	<1	ug/L	NC	20
4598081	Total Selenium (Se)	2011/01/31	102	80 - 120	98	80 - 120	<0.1	ug/L	NC	20
4598081	Total Uranium (U)	2011/01/31	98	80 - 120	94	80 - 120	<0.1	ug/L	NC	20
4598081	Total Vanadium (V)	2011/01/31	97	80 - 120	95	80 - 120	<5	ug/L	NC	20
4598081	Total Zinc (Zn)	2011/01/31	NC	80 - 120	96	80 - 120	<5	ug/L	2.7	20
4598081	Total Aluminum (Al)	2011/01/31					5, RDL=3	ug/L	8.4	20
4598081	Total Antimony (Sb)	2011/01/31					<0.5	ug/L	NC	20
4598081	Total Barium (Ba)	2011/01/31					<1	ug/L	4.7	20
4598081	Total Bismuth (Bi)	2011/01/31					<1	ug/L	NC	20
4598081	Total Boron (B)	2011/01/31					<50	ug/L	NC	20
4598081	Total Iron (Fe)	2011/01/31					<5	ug/L	6.8	20
4598081	Total Manganese (Mn)	2011/01/31					<1	ug/L	7.0	20
4598081	Total Mercury (Hg)	2011/01/31					<0.02	ug/L	NC	20
4598081	Total Molybdenum (Mo)	2011/01/31					<1	ug/L	NC	20
4598081	Total Phosphorus (P)	2011/01/31					<10	ug/L		
4598081	Total Silicon (Si)	2011/01/31					<100	ug/L	4.4	20
4598081	Total Silver (Ag)	2011/01/31					<0.02	ug/L	NC	20
4598081	Total Strontium (Sr)	2011/01/31					<1	ug/L	4.3	20
4598081	Total Thallium (Tl)	2011/01/31					<0.05	ug/L	NC	20
4598081	Total Tin (Sn)	2011/01/31					<5	ug/L	NC	20
4598081	Total Titanium (Ti)	2011/01/31					<5	ug/L	NC	20
4598081	Total Zirconium (Zr)	2011/01/31					<0.5	ug/L	NC	20

N/A = Not Applicable

RDL = Reportable Detection Limit

RPD = Relative Percent Difference

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

(1) - Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

Maxxam Analytics Inc

Calgary: 2021-41st Ave. NE, T2E 6P2. Ph: (403) 291-3077, Fax: (403) 291-9468, Toll free: (800) 386-7247
Edmonton: 9619 - 42 Ave. T6E 5R2. Ph: (780) 465-1212, Fax: (780) 450-4187, Toll free: (877) 465-8889
Burnaby: 8577 Commerce Court, V5A 4N5 Ph: (604) 444-4808, Fax (604) 444-4511, Toll free: (800) 440-4808

08328403

ANALYTICAL REQUEST FORM

Page 1 of 1

Invoice To: Require Report? Yes X No

Company Name: SGS-CEMI
Contact Name: Rik Vos
Address: 6927 Antrim Avenue, Burnaby, BC, V5J4M5
PC:
Phone / Fax#: Ph: 604-264-5536 Fax: 604-264-5535

Report To:

SGS-CEMI B107289
Prab Bhatia
6927 Antrim Avenue, Burnaby, BC, V5J4M5
PC:
Ph: 604-264-5536 Fax: 604-264-5535

PO# / AFE#:	WT-11014
Quotation #:	A60050
Project #:	1102
Proj. Name:	Canadian Zinc
Location:	
Sampler's Initials:	

REGULATORY REQUIREMENTS:

- [ ] AT1 - Soil Contamination
- [ ] CCME
- [ ] CCME FWAL
- [ ] Regulatory Limits to appear on Final report
- [ ] PST
- [ ] CDWQG
- [ ] G50

REPORT DISTRIBUTION:

- [x] Mail
- [ ] Fax
- [x] PDF
- [x] Excel
- [ ] Other:
- [x] Email: prab.bhatia@sgs.com, david@canadianzinc.com

SERVICE REQUESTED:

- [x] RUSH (Please ensure you contact the lab)
  Date Required: by Feb 1, 2011 (48hr)
- [ ] REGULAR Turnaround

METALS: (WATERS)

- [x] Total
- [ ] Extractable
- [ ] Dissolved

ANALYSIS REQUESTED

	Sample Identification	Matrix	Date/Time Sampled	Sample Type Grab/Comp	Hold > 60 Days	Sample Container #	REGICPMS W/ Hg by CVAA (T	Alkalinity	TSS	Conductivity	Ammonia (Low Level DL)	Nitrate	Nitrite	Chloride	Sulphate	TDS	Total Phosphorous (LL DL)	Ortho-Phosphate					
1	11-039	WW	28-01-11 @ 15:00				X																
2	11-040	WW	28-01-11 @ 15:00				X																
3	11-041	WW	28-01-11 @ 15:00				X																
4	11-042	WW	28-01-11 @ 15:00				X																
5																							
6																							
7																							
8																							
9																							
10																							
11																							
12																							

** For water samples, please indicate if sample container has been preserved (P) and/or filtered (F).

Relinquished By: Prab Bhatia **Date/Time:** 28-Jan-11

Signature:

COMMENTS/SPECIAL INSTRUCTIONS:

Received
C. Rosso
11 01 31
1045

Temperature
5/4/5

C of C #

FCD - 0026 Chain of Custody R4 - April 11, 2005

Your P.O. #: WT-11013
Your Project #: 1102 CANADIAN ZINC
Your C.O.C. #: 08328404

Attention: Rik Vos
SGS CEMI Inc.
6927 Antrim Ave.
Burnaby, BC
CANADA V5J 4M5

Report Date: 2011/02/04
This report supersedes all previous reports with the same Maxxam job number

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B107295
Received: 2011/01/31, 10:45

Sample Matrix: Water
Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity - Water	4	2011/01/31	2011/01/31	BBY6SOP-00026	Based on SM2320B
Chloride by Automated Colourimetry	3	N/A	2011/01/31	BBY6SOP-00011	Based on EPA 325.2
Chloride by Automated Colourimetry	1	N/A	2011/02/01	BBY6SOP-00011	Based on EPA 325.2
Conductance - water	4	N/A	2011/01/31	BBY6SOP-00026	Based on SM-2510B
Hardness (calculated as CaCO3)	4	N/A	2011/02/01		
Mercury (Dissolved) by CVAF	4	N/A	2011/02/02	65-A-002-10	EPA 245.7
Na, K, Ca, Mg, S by CRC ICPMS (diss.)	4	N/A	2011/02/01	BBY7SOP-00002	Based on EPA 200.8
Elements by CRC ICPMS (dissolved)	4	N/A	2011/01/31	BBY7SOP-00002	Based on EPA 200.8
Ammonia-N	4	N/A	2011/02/01	BBY6SOP-00044	Based on EPA 350.1
Nitrate + Nitrite (N)	4	N/A	2011/01/31	BBY6SOP-00010	Based on USEPA 353.2
Nitrite (N) by CFA	4	N/A	2011/01/31	BBY6SOP-00010	EPA 353.2
Nitrogen - Nitrate (as N)	4	N/A	2011/01/31	BBY6SOP-00010	Based on EPA 353.2
Filter and HNO3 Preserve for Metals	4	N/A	2011/01/31	BBY6WI-00001	Based on EPA 200.2
pH Water	4	N/A	2011/01/31	BBY6SOP-00026	Based on SM-4500H+B
Orthophosphate by Konelab	4	N/A	2011/01/31		
Sulphate by Automated Colourimetry	3	N/A	2011/01/31	BBY6SOP-00017	Based on EPA 375.4
Sulphate by Automated Colourimetry	1	N/A	2011/02/03	BBY6SOP-00017	Based on EPA 375.4
Total Dissolved Solids (Filt. Residue)	4	N/A	2011/01/31	BBY6SOP-00033	SM 2540C
Total Phosphorus	3	N/A	2011/02/01	BBY6SOP-00013	SM 4500
Total Phosphorus	1	N/A	2011/02/04	BBY6SOP-00013	SM 4500
Total Suspended Solids	4	N/A	2011/01/31	BBY6SOP-00034	Based on SM - 2540 D

* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

LANOY LUANGKHAMDENG, Burnaby Customer Service
Email: LLuangkhamdeng@maxxam.ca
Phone# (604) 638-2636

==
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Total cover pages: 1

Success Through Science®

Maxxam Job #: B107295
Report Date: 2011/02/04

SGS CEMI Inc.
Client Project #: 1102 CANADIAN ZINC

Your P.O. #: WT-11013

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		Z63673			Z63674			Z63675		Z63676		
Sampling Date		2011/01/28 15:00			2011/01/28 15:00			2011/01/28 15:00		2011/01/28 15:00		
	Units	**11-039**	**RDL**	**QC Batch**	**11-040**	**RDL**	**QC Batch**	**11-041**	**QC Batch**	**11-042**	**RDL**	**QC Batch**
ANIONS												
Nitrite (N)	mg/L	<0.5(1)	0.5	4598893	<0.5(1)	0.5	4598893	<0.5(1)	4598893	<0.5(1)	0.5	4598893
Calculated Parameters												
Filter and HNO3 Preservation	N/A	FIELD	N/A	ONSITE	FIELD	N/A	ONSITE	FIELD	ONSITE	FIELD	N/A	ONSITE
Nitrate (N)	mg/L	<2	2	4596066	<2	2	4596066	<2	4596066	<2	2	4596066
Misc. Inorganics												
Dissolved Hardness (CaCO3)	mg/L	188	0.5	4596063	470	0.5	4596063	872	4596063	576	0.5	4596063
Alkalinity (Total as CaCO3)	mg/L	2400	0.5	4598902	250	0.5	4598902	370	4598902	86	0.5	4598902
Alkalinity (PP as CaCO3)	mg/L	650	0.5	4598902	31	0.5	4598902	<0.5	4598902	11	0.5	4598902
Bicarbonate (HCO3)	mg/L	1300	0.5	4598902	230	0.5	4598902	450	4598902	78	0.5	4598902
Carbonate (CO3)	mg/L	780	0.5	4598902	37	0.5	4598902	<0.5	4598902	14	0.5	4598902
Hydroxide (OH)	mg/L	<0.5	0.5	4598902	<0.5	0.5	4598902	<0.5	4598902	<0.5	0.5	4598902
Anions												
Dissolved Sulphate (SO4)	mg/L	1900	5	4598975	4500	50	4609682	500	4598975	470	5	4598975
Dissolved Chloride (Cl)	mg/L	410	5	4598972	310	5	4598972	0.8	4602530	1.7	0.5	4598972
Nutrients												
Ammonia (N)	mg/L	0.21(1)	0.05	4599629	0.29(1)	0.05	4599629	0.059	4599629	0.043	0.005	4599629
Orthophosphate (P)	mg/L	0.058	0.005	4595984	0.025	0.005	4595984	<0.005	4595984	<0.005	0.005	4595984
Nitrate plus Nitrite (N)	mg/L	<2(1)	2	4598886	<2(1)	2	4598886	<2(1)	4598886	<2(1)	2	4598886
Total Phosphorus (P)	mg/L	0.63	0.02	4598719	0.230	0.002	4609042	0.003	4598719	0.003	0.002	4598719
Physical Properties												
Conductivity	uS/cm	8240	1	4598901	8820	1	4598901	1410	4598901	1010	1	4598901
pH	pH Units	9.65		4598900	8.91		4598900	8.18	4598900	9.09		4598900
Physical Properties												
Total Suspended Solids	mg/L	50	4	4596583	26	4	4596583	20	4596583	<4	4	4596583
Total Dissolved Solids	mg/L	5200	10	4598883	6100	10	4598883	1000	4598883	700	10	4598883

N/A = Not Applicable
RDL = Reportable Detection Limit
(1) - RDL raised due to sample matrix interference.

Maxxam Job #: B107295
Report Date: 2011/02/04

SGS CEMI Inc.
Client Project #: 1102 CANADIAN ZINC

Your P.O. #: WT-11013

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		Z63673		Z63674		Z63675	Z63676		
Sampling Date		2011/01/28 15:00		2011/01/28 15:00		2011/01/28 15:00	2011/01/28 15:00		
	Units	**11-039**	**RDL**	**11-040**	**RDL**	**11-041**	**11-042**	**RDL**	**QC Batch**
Elements									
Dissolved Mercury (Hg)	ug/L	700	0.02	0.28	0.02	<0.02	0.02	0.02	4603040

RDL = Reportable Detection Limit

Maxxam Job #: B107295
Report Date: 2011/02/04

SGS CEMI Inc.
Client Project #: 1102 CANADIAN ZINC

Your P.O. #: WT-11013

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		Z63673		Z63674		Z63675	Z63676		
Sampling Date		2011/01/28 15:00		2011/01/28 15:00		2011/01/28 15:00	2011/01/28 15:00		
	Units	**11-039**	**RDL**	**11-040**	**RDL**	**11-041**	**11-042**	**RDL**	**QC Batch**
Dissolved Metals by ICPMS									
Dissolved Aluminum (Al)	ug/L	<300	300	<10	10	5	11	3	4598256
Dissolved Antimony (Sb)	ug/L	565	50	116	2	26.4	25.0	0.5	4598256
Dissolved Arsenic (As)	ug/L	404	10	8.2	0.4	0.2	0.2	0.1	4598256
Dissolved Barium (Ba)	ug/L	<100	100	<4	4	15	<1	1	4598256
Dissolved Beryllium (Be)	ug/L	<10	10	<0.4	0.4	<0.1	<0.1	0.1	4598256
Dissolved Bismuth (Bi)	ug/L	<100	100	<4	4	<1	<1	1	4598256
Dissolved Boron (B)	ug/L	<5000	5000	<200	200	<50	<50	50	4598256
Dissolved Cadmium (Cd)	ug/L	1070	1	22.6	0.04	5.19	0.05	0.01	4598256
Dissolved Chromium (Cr)	ug/L	<100	100	<4	4	<1	<1	1	4598256
Dissolved Cobalt (Co)	ug/L	<50	50	3	2	0.8	<0.5	0.5	4598256
Dissolved Copper (Cu)	ug/L	3120	20	79.6	0.8	9.2	4.5	0.2	4598256
Dissolved Iron (Fe)	ug/L	<500	500	2620	20	<5	8	5	4598256
Dissolved Lead (Pb)	ug/L	27200	20	252	0.8	<0.2	1.8	0.2	4598256
Dissolved Manganese (Mn)	ug/L	<100	100	48	4	44	13	1	4598256
Dissolved Molybdenum (Mo)	ug/L	<100	100	5	4	2	2	1	4598256
Dissolved Nickel (Ni)	ug/L	<100	100	13	4	8	<1	1	4598256
Dissolved Phosphorus (P)	ug/L	1030	1000	390	40	<10	<10	10	4598256
Dissolved Selenium (Se)	ug/L	119	10	10.1	0.4	3.2	3.2	0.1	4598256
Dissolved Silicon (Si)	ug/L	30400	10000	12300	400	2550	2520	100	4598256
Dissolved Silver (Ag)	ug/L	68	2	0.72	0.08	<0.02	<0.02	0.02	4598256
Dissolved Strontium (Sr)	ug/L	<100	100	52	4	885	174	1	4598256
Dissolved Thallium (Tl)	ug/L	<5	5	<0.2	0.2	0.30	0.17	0.05	4598256
Dissolved Tin (Sn)	ug/L	<500	500	<20	20	<5	<5	5	4598256
Dissolved Titanium (Ti)	ug/L	<500	500	<20	20	<5	<5	5	4598256
Dissolved Uranium (U)	ug/L	29	10	2.7	0.4	24.6	4.6	0.1	4598256
Dissolved Vanadium (V)	ug/L	<500	500	<20	20	<5	<5	5	4598256
Dissolved Zinc (Zn)	ug/L	855	500	1430	20	932	<5	5	4598256
Dissolved Zirconium (Zr)	ug/L	<50	50	<2	2	<0.5	<0.5	0.5	4598256
Dissolved Calcium (Ca)	mg/L	13	5	67.8	0.2	189	23.9	0.05	4596064
Dissolved Magnesium (Mg)	mg/L	38	5	73.0	0.2	97.4	125	0.05	4596064
Dissolved Potassium (K)	mg/L	8	5	7.7	0.2	2.79	2.79	0.05	4596064
Dissolved Sodium (Na)	mg/L	2350	5	2260	0.2	1.73	1.68	0.05	4596064
Dissolved Sulphur (S)	mg/L	1210	300	2020	10	183	176	3	4596064

RDL = Reportable Detection Limit

Maxxam Job #: B107295
Report Date: 2011/02/04

SGS CEMI Inc.
Client Project #: 1102 CANADIAN ZINC

Your P.O. #: WT-11013

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER) Comments

Sample Z63673-06 Elements by CRC ICPMS (dissolved): RDL raised due to sample matrix interference.

Sample Z63674-06 Elements by CRC ICPMS (dissolved): RDL raised due to sample matrix interference.

Maxxam Job #: B107295
Report Date: 2011/02/04

SGS CEMI Inc.
Client Project #: 1102 CANADIAN ZINC

Your P.O. #: WT-11013

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
4595984	Orthophosphate (P)	2011/01/31	97	80 - 120	97	80 - 120	<0.005	mg/L	NC	20
4596583	Total Suspended Solids	2011/01/31	105	80 - 120	97	80 - 120	<4	mg/L	NC	20
4598256	Dissolved Arsenic (As)	2011/01/31	101	80 - 120	102	80 - 120	<0.1	ug/L	1.5	20
4598256	Dissolved Beryllium (Be)	2011/01/31	98	80 - 120	95	80 - 120	<0.1	ug/L		
4598256	Dissolved Cadmium (Cd)	2011/01/31	98	80 - 120	101	80 - 120	<0.01	ug/L	4.3	20
4598256	Dissolved Chromium (Cr)	2011/01/31	100	80 - 120	103	80 - 120	<1	ug/L		
4598256	Dissolved Cobalt (Co)	2011/01/31	99	80 - 120	103	80 - 120	<0.5	ug/L		
4598256	Dissolved Copper (Cu)	2011/01/31	94	80 - 120	104	80 - 120	<0.2	ug/L	4.5	20
4598256	Dissolved Lead (Pb)	2011/01/31	95	80 - 120	101	80 - 120	<0.2	ug/L	NC	20
4598256	Dissolved Nickel (Ni)	2011/01/31	97	80 - 120	103	80 - 120	<1	ug/L		
4598256	Dissolved Selenium (Se)	2011/01/31	104	80 - 120	101	80 - 120	<0.1	ug/L	1.7	20
4598256	Dissolved Uranium (U)	2011/01/31	98	80 - 120	99	80 - 120	<0.1	ug/L		
4598256	Dissolved Vanadium (V)	2011/01/31	102	80 - 120	101	80 - 120	<5	ug/L		
4598256	Dissolved Zinc (Zn)	2011/01/31	NC	80 - 120	100	80 - 120	<5	ug/L	NC	20
4598256	Dissolved Aluminum (Al)	2011/01/31					<3	ug/L		
4598256	Dissolved Antimony (Sb)	2011/01/31					<0.5	ug/L		
4598256	Dissolved Barium (Ba)	2011/01/31					<1	ug/L		
4598256	Dissolved Bismuth (Bi)	2011/01/31					<1	ug/L		
4598256	Dissolved Boron (B)	2011/01/31					<50	ug/L		
4598256	Dissolved Iron (Fe)	2011/01/31					<5	ug/L		
4598256	Dissolved Manganese (Mn)	2011/01/31					<1	ug/L		
4598256	Dissolved Molybdenum (Mo)	2011/01/31					<1	ug/L	1.3	20
4598256	Dissolved Phosphorus (P)	2011/01/31					<10	ug/L		
4598256	Dissolved Silicon (Si)	2011/01/31					<100	ug/L		
4598256	Dissolved Silver (Ag)	2011/01/31					<0.02	ug/L		
4598256	Dissolved Strontium (Sr)	2011/01/31					<1	ug/L		
4598256	Dissolved Thallium (Tl)	2011/01/31					<0.05	ug/L		
4598256	Dissolved Tin (Sn)	2011/01/31					<5	ug/L		
4598256	Dissolved Titanium (Ti)	2011/01/31					<5	ug/L		
4598256	Dissolved Zirconium (Zr)	2011/01/31					<0.5	ug/L		
4598719	Total Phosphorus (P)	2011/02/01	99	80 - 120	94	80 - 120	<0.002	mg/L	NC	20
4598883	Total Dissolved Solids	2011/01/31	110	80 - 120	98	80 - 120	<10	mg/L	0	20
4598886	Nitrate plus Nitrite (N)	2011/01/31	103	80 - 120	107	80 - 120	<0.02	mg/L	NC	25
4598893	Nitrite (N)	2011/01/31	100	80 - 120	102	80 - 120	<0.005	mg/L	NC	20
4598901	Conductivity	2011/01/31			103	80 - 120	<1	uS/cm	0.9(1)	20
4598902	Alkalinity (Total as CaCO3)	2011/01/31	NC	80 - 120	96	80 - 120	<0.5	mg/L	3.6	20
4598902	Alkalinity (PP as CaCO3)	2011/01/31					<0.5	mg/L	NC	20
4598902	Bicarbonate (HCO3)	2011/01/31					<0.5	mg/L	3.6	20
4598902	Carbonate (CO3)	2011/01/31					<0.5	mg/L	NC	20

Maxxam

Success Through Science®

Maxxam Job #: B107295
Report Date: 2011/02/04

SGS CEMI Inc.
Client Project #: 1102 CANADIAN ZINC

Your P.O. #: WT-11013

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
4598902	Hydroxide (OH)	2011/01/31					<0.5	mg/L	NC	20
4598972	Dissolved Chloride (Cl)	2011/01/31			102	80 - 120	0.5, RDL=0.5	mg/L	6.8	20
4598975	Dissolved Sulphate (SO4)	2011/01/31			103	80 - 120	0.7, RDL=0.5	mg/L	0.7	20
4599629	Ammonia (N)	2011/02/01	86	80 - 120	99	80 - 120	<0.005	mg/L	NC	20
4602530	Dissolved Chloride (Cl)	2011/02/01			101	80 - 120	<0.5	mg/L		
4603040	Dissolved Mercury (Hg)	2011/02/02					<0.02	ug/L	0.6	20
4609042	Total Phosphorus (P)	2011/02/04	101	80 - 120	100	80 - 120	<0.002	mg/L	1	20
4609682	Dissolved Sulphate (SO4)	2011/02/03	108	80 - 120	100	80 - 120	<0.5	mg/L	0.3	20

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.
(1) - Fails SQC rule#3. Four of 5 points in zone A or B same side of mean.

Maxxam Analytics Inc

Calgary: 2021-41st Ave. NE, T2E 6P2. Ph: (403) 291-3077, Fax: (403) 291-9468, Toll free: (800) 386-7247
Edmonton: 9619 - 42 Ave, T6E 5R2. Ph: (780) 465-1212, Fax: (780) 450-4187, Toll free: (877) 465-8889
Burnaby: 8577 Commerce Court, V5A 4N5 Ph: (604) 444-4808, Fax (604) 444-4511, Toll free: (800) 440-4808

08328404

NALYTICAL REQUEST FORM

Invoice To: Require Report? Yes [X] No [ ]

	Invoice To	Report To: B107295
Company Name:	SGS-CEMI	SGS-CEMI
Contact Name:	Rik Vos	Prab Bhatia
Address:	6927 Antrim Avenue, Burnaby, BC, V5J4M5	6927 Antrim Avenue, Burnaby, BC, V5J4M5
	PC:	PC:
Phone / Fax#:	Ph: 604-264-5536 Fax: 604-264-5535	Ph: 604-264-5536 Fax: 604-264-5535

PO# / AFE#:	WT-11013
Quotation #:	A60050
Project # :	1102
Proj. Name:	Canadian Zinc
Location:	
Sampler's Initials:	

REGULATORY REQUIREMENTS:

- [ ] AT1 - Soil Contamination
- [ ] CCME
- [ ] CCME FWAL
- [ ] PST
- [ ] CDWQG
- [ ] G50
- [ ] Regulatory Limits to appear on Final report

REPORT DISTRIBUTION:

- [x] Mail
- [ ] Fax
- [x] PDF
- [x] Excel
- [ ] Other:
- [x] Email: prab.bhatia@sgs.com, david@canadianzinc.com

SERVICE REQUESTED:

- [X] RUSH (Please ensure you contact the lab)
  Date Required: by Feb 1, 2011 (48hr)
- [ ] REGULAR Turnaround

METALS: (WATERS)

- [ ] Total
- [ ] Extractable
- [X] Dissolved

ANALYSIS REQUESTED

	Sample Identification	Matrix	Date/Time Sampled	Sample Type Grab/Comp	Hold > 60 Days	Sample Container #	REGICPMS W/ Hg by CVAA	Alkalinity	TSS	Conductivity	Ammonia (Low Level DL)	Nitrate	Nitrite	Chloride	Sulphate	TDS	Total Phosphorous (LL DL)	Ortho-Phosphate					
1	11-039	WW	28-01-11 @ 15:00				X	X	X	X	X	X	X	X	X	X	X	X					
2	11-040	WW	28-01-11 @ 15:00				X	X	X	X	X	X	X	X	X	X	X	X					
3	11-041	WW	28-01-11 @ 15:00				X	X	X	X	X	X	X	X	X	X	X	X					
4	11-042	WW	28-01-11 @ 15:00				X	X	X	X	X	X	X	X	X	X	X	X					
5																							
6																							
7																							
8																							
9																							
10																							
11																							
12																							

** For water samples, please indicate if sample container has been preserved (P) and/or filtered (F).

Relinquished By: Prab Bhatia **Date/Time:** 28-Jan-11

Signature:

COMMENTS/SPECIAL INSTRUCTIONS:

Received
C. ROSEN
110131
1045

Temperature
5/4/5

C of C #

FCD - 0026 Chain of Custody R4 - April 11, 2005

Appendix B

Scoping Process Water Treatment Test Work

(SGS Memo No. 1102-0111M02-00)

Canadian Zinc Water Treatment Tests

Memo N^{o} 1102-0111M02-00

Phone: (604) 267-2364
Fax: (604) 264-5535
E-mail: **Sohan.Basra@sgs.com**
Prab.Bhatia@sgs.com

Memorandum

Date: January 18, 2011

To: Dave Harpley

Re: Process Water Treatment Results
Project: CEMI-1102
Memo N^{o} 1102-0111M02-00

As discussed, the process water generated from the lock cycle tests was treated using sulphide to remove metals of concern. This memo briefly outlines the procedure for sulphide treatment and summarizes the results.

Feed Analysis
pH: 9.74
Conductivity: 8.14 mS/cm

Sample Name		Process Feed
SGS CEMI ID:		11-017
DISSOLVED METALS		
Aluminum (Al)	mg/L	<0.3
Antimony (Sb)	**mg/L**	**0.499**
Arsenic (As)	**mg/L**	**0.398**
Barium (Ba)	mg/L	<0.1
Beryllium (Be)	mg/L	<0.01
Bismuth (Bi)	mg/L	<0.1
Boron (B)	mg/L	<5
Cadmium (Cd)	**mg/L**	**1.14**
Calcium (Ca)	mg/L	14
Chromium (Cr)	mg/L	<0.1
Cobalt (Co)	mg/L	<0.05
Copper (Cu)	**mg/L**	**3.74**
Iron (Fe)	mg/L	<0.5
Lead (Pb)	**mg/L**	**29.7**
Magnesium (Mg)	mg/L	38
Manganese (Mn)	mg/L	<0.1
Mercury (Hg)	**ug/L**	**759**
Molybdenum (Mo)	mg/L	<0.1
Nickel (Ni)	mg/L	<0.1
Phosphorus (P)	mg/L	<1
Potassium (K)	mg/L	9
Selenium (Se)	mg/L	0.07
Silicon (Si)	mg/L	36.6
Silver (Ag)	mg/L	0.074
Sodium (Na)	mg/L	1920
Strontium (Sr)	mg/L	<0.1
Sulphur (S)	mg/L	844
Thallium (Tl)	mg/L	0.023
Tin (Sn)	mg/L	<0.5
Titanium (Ti)	mg/L	<0.5
Uranium (U)	mg/L	0.031
Vanadium (V)	mg/L	<0.5
Zinc (Zn)	**mg/L**	**2.44**
Zirconium (Zr)	mg/L	<0.05

SULPHIDE TREATMENT

Test ID: 1P

- Acidified 0.5L of process water to pH 4.51 using sulphuric acid
  - 30mL of 1N H_2SO_4 were added
- Added sodium sulphide and mixed for 10 minutes
  - 20ppm of S^{2-} added
  - Redox: -85mV after 10 minutes
- Sample was aerated for 10 minutes. Ferric sulphate was added and pH increased to 9.36 using 5% hydrated lime slurry
  - 80ppm of Fe added
  - Final pH = 9.36 (Sample ID: 11-020)

Sample Name		Process Feed	Test #1P
SGS CEMI ID:		11-017	11-020
DISSOLVED METALS			
Aluminum (Al)	mg/L	<0.3	<0.3
Antimony (Sb)	**mg/L**	**0.499**	**0.4**
Arsenic (As)	**mg/L**	**0.398**	**0.128**
Barium (Ba)	mg/L	<0.1	<0.1
Beryllium (Be)	mg/L	<0.01	<0.01
Bismuth (Bi)	mg/L	<0.1	<0.1
Boron (B)	mg/L	<5	<5
Cadmium (Cd)	**mg/L**	**1.14**	**0.909**
Calcium (Ca)	mg/L	14	9
Chromium (Cr)	mg/L	<0.1	<0.1
Cobalt (Co)	mg/L	<0.05	<0.05
Copper (Cu)	**mg/L**	**3.74**	**1.76**
Iron (Fe)	mg/L	<0.5	<0.5
Lead (Pb)	**mg/L**	**29.7**	**20**
Magnesium (Mg)	mg/L	38	35
Manganese (Mn)	mg/L	<0.1	<0.1
Mercury (Hg)	**ug/L**	**759**	**669**
Molybdenum (Mo)	mg/L	<0.1	<0.1
Nickel (Ni)	mg/L	<0.1	<0.1
Phosphorus (P)	mg/L	<1	<1
Potassium (K)	mg/L	9	9
Selenium (Se)	mg/L	0.07	0.061
Silicon (Si)	mg/L	36.6	11.3
Silver (Ag)	mg/L	0.074	0.075
Sodium (Na)	mg/L	1920	1760
Strontium (Sr)	mg/L	<0.1	<0.1
Sulphur (S)	mg/L	844	812
Thallium (Tl)	mg/L	0.023	0.014
Tin (Sn)	mg/L	<0.5	<0.5
Titanium (Ti)	mg/L	<0.5	<0.5
Uranium (U)	mg/L	0.031	0.025
Vanadium (V)	mg/L	<0.5	<0.5
Zinc (Zn)	**mg/L**	**2.44**	**0.733**
Zirconium (Zr)	mg/L	<0.05	<0.05

Test ID: 3P

- Neutralized 0.5L of process water to pH 9.96 using 5% hydrated lime slurry and iron added to enhance co-precipitation with iron
    - Iron was added prior to lime addition to increase total Fe to other metals ratio
        - 200ppm Fe added
        - 20.6mL of 5% $Ca(OH)_2$ added
- After 45minutes, slurry was filtered with No. 1 Whatman filter paper
    - Sample collected for analysis and filtered using 0.45 micron membrane filter (Sample ID: 11-024)
- Filtered water (520mL) was further treated using sulphide by acidifying to pH 4.60 using sulphuric acid
    - 16mL of 1N H_2SO_4 added
- Sample was then purged with nitrogen and sodium sulphide added
    - 20ppm S^{2-} added
    - Redox: -215mV after 15 minutes
- Sample was aerated for 60 minutes until redox was 0. Ferric sulphate was then added and pH increased to 9.50 using 5% hydrated lime slurry
    - 40ppm of Fe added
    - Final pH = 9.50
    - Sample collected for analysis and filtered using 0.45 micron membrane filter (Sample ID: 11-025)

		Process Feed	Test#3P - Lime Treatment	Test #3P - Sulphide Treatment
		11-017	**11-024**	**11-025**
DISSOLVED METALS				
Aluminum (Al)	mg/L	<0.3	0.026	0.04
Antimony (Sb)	**mg/L**	**0.499**	**0.343**	**0.0783**
Arsenic (As)	**mg/L**	**0.398**	**0.0069**	**0.0007**
Barium (Ba)	mg/L	<0.1	<0.001	0.005
Beryllium (Be)	mg/L	<0.01	<0.0001	<0.0001
Bismuth (Bi)	mg/L	<0.1	<0.001	<0.001
Boron (B)	mg/L	<5	0.097	0.112
Cadmium (Cd)	**mg/L**	**1.14**	**0.72**	**0.048**
Calcium (Ca)	mg/L	14	7.53	48.1
Chromium (Cr)	mg/L	<0.1	<0.001	<0.001
Cobalt (Co)	mg/L	<0.05	0.0012	0.0015
Copper (Cu)	**mg/L**	**3.74**	**1.6**	**0.228**
Iron (Fe)	mg/L	<0.5	0.065	2.29
Lead (Pb)	**mg/L**	**29.7**	**16.4**	**9.84**
Magnesium (Mg)	mg/L	38	44.7	53
Manganese (Mn)	mg/L	<0.1	0.023	0.003
Mercury (Hg)	**ug/L**	**759**	**715**	**1.05**
Molybdenum (Mo)	mg/L	<0.1	0.044	0.022
Nickel (Ni)	mg/L	<0.1	0.007	0.011
Phosphorus (P)	mg/L	<1	0.329	0.233
Potassium (K)	mg/L	9	6.87	6.13
Selenium (Se)	mg/L	0.07	0.047	0.0075
Silicon (Si)	mg/L	36.6	1.71	0.379
Silver (Ag)	mg/L	0.074	0.0681	0.00111
Sodium (Na)	mg/L	1920	1720	1520
Strontium (Sr)	mg/L	<0.1	0.007	0.024
Sulphur (S)	mg/L	844	1130	1490
Thallium (Tl)	mg/L	0.023	0.0003	0.00018
Tin (Sn)	mg/L	<0.5	<0.005	<0.005
Titanium (Ti)	mg/L	<0.5	<0.005	<0.005
Uranium (U)	mg/L	0.031	0.0196	0.005
Vanadium (V)	mg/L	<0.5	<0.005	<0.005
Zinc (Zn)	**mg/L**	**2.44**	**0.47**	**0.15**
Zirconium (Zr)	mg/L	<0.05	<0.0005	<0.0005

Test ID: 4P

- Acidified 0.5L of process water to pH 4.39 using sulphuric acid
  - 30.9mL of 1N H_2SO_4 added
  - Redox: 242mV
- Added sodium sulphide and mixed for 15 minutes.
  - 40ppm of sulphur added
  - Redox: -215mV after 15 minutes
  - Sample collected for analysis and filtered using 0.45 micron membrane filter (Sample ID: 11-026)
- Sample was aerated for 20 minutes. Ferric sulphate was added and pH increased to 9.42 using 5% hydrated lime slurry
  - 80ppm of Fe added
  - Final pH = 9.42
  - Sample collected for analysis and filtered using 0.45 micron membrane filter (Sample ID: 11-027)

		Process Feed	Test #4P - Sulphide Treatment	Test# 4P - Lime Treatment
		11-017	11-026	11-027
DISSOLVED METALS				
Aluminum (Al)	mg/L	<0.3	0.051	0.021
Antimony (Sb)	**mg/L**	**0.499**	**0.028**	**0.113**
Arsenic (As)	**mg/L**	**0.398**	**0.0265**	**0.024**
Barium (Ba)	mg/L	<0.1	0.02	0.006
Beryllium (Be)	mg/L	<0.01	<0.0001	<0.0001
Bismuth (Bi)	mg/L	<0.1	<0.001	<0.001
Boron (B)	mg/L	<5	0.068	0.071
Cadmium (Cd)	**mg/L**	**1.14**	**0.029**	**0.0702**
Calcium (Ca)	mg/L	14	15.3	84.5
Chromium (Cr)	mg/L	<0.1	<0.001	<0.001
Cobalt (Co)	mg/L	<0.05	0.0012	0.0017
Copper (Cu)	**mg/L**	**3.74**	**0.072**	**0.635**
Iron (Fe)	mg/L	<0.5	0.327	3.43
Lead (Pb)	**mg/L**	**29.7**	**15.8**	**11.7**
Magnesium (Mg)	mg/L	38	36.8	47.8
Manganese (Mn)	mg/L	<0.1	0.026	0.007
Mercury (Hg)	**ug/L**	**759**	**3.7**	**0.8**
Molybdenum (Mo)	mg/L	<0.1	<0.001	0.02
Nickel (Ni)	mg/L	<0.1	0.009	0.011
Phosphorus (P)	mg/L	<1	0.709	0.435
Potassium (K)	mg/L	9	19.9	20.5
Selenium (Se)	mg/L	0.07	0.0083	0.0165
Silicon (Si)	mg/L	36.6	34.4	12
Silver (Ag)	mg/L	0.074	0.0001	0.00032
Sodium (Na)	mg/L	1920	2010	1920
Strontium (Sr)	mg/L	<0.1	0.064	0.064
Sulphur (S)	mg/L	844	1760	1920
Thallium (Tl)	mg/L	0.023	0.00024	0.00022
Tin (Sn)	mg/L	<0.5	<0.005	<0.005
Titanium (Ti)	mg/L	<0.5	<0.005	<0.005
Uranium (U)	mg/L	0.031	0.0274	0.0111
Vanadium (V)	mg/L	<0.5	<0.005	<0.005
Zinc (Zn)	**mg/L**	**2.44**	**0.878**	**0.175**
Zirconium (Zr)	mg/L	<0.05	0.0035	<0.0005

APPENDIX G

Toxicity IR Replies

Hatfield Consultants

Hatfield CONSULTANTS

MEMO

Date: February 28, 2011 HCP Ref No.: CZN1682

From: John Wilcockson / Martin Davies

To: David Harpley, CZN

Subject: Hatfield responses to information requests

Parks Canada, October 29, 2010.

IR Number: Parks_Canada_2-2

Subject: Prairie Creek water quality that is protective of aquatic life.

As discussed in Hatfield memo: *Prairie Creek Mine - assessment of potential aquatic effects.*

(Appendix D), proposed Site Specific Water Quality Objectives (SSWQO) were derived either from upstream Prairie Creek concentrations using the CCME reference condition approach (RCA; mean +2SD), or by using published, toxicity-based guidelines from CCME or other sources. In most instances, the mine will utilize the RCA-derived SSWQO. CCME guidelines were adopted only where the RCA-SSWQO could not be met and where there was scientific justification for their use. Results from toxicity testing support the choice of appropriate SSWQO for metals.

IR Number: Parks_Canada_2-3

Subject: Prairie Creek water quality – downstream mixing zone

1) The downstream mixing analysis (exfiltration trench outfall) is provided in the Northwest Hydraulics Company (NHC) memo, *Mixing analysis for exfiltration trench*

outfall to Prairie Creek - DRAFT (Appendix L). All of the scenarios modelled are discussed in the NHC memo. The following scenarios were modelled:

- low, best, high and extreme mine-water flows;
- low, high and mean winter (ice-covered) creek flows; and
- low, high and mean open-water creek flows.

Low and high creek flows were based on historical WSC data (monthly lows and highs).

2) Typical ranges and worst case conditions are also provided.
3) Concentration contours are provided in figures 4 and 5 of the NHC memo, *Mixing analysis for exfiltration trench outfall to Prairie Creek - DRAFT*, Appendix L, which represent average open water and ice covered conditions.
4) NHC provided mixing ratios at complete vertical mixing and at complete vertical + transverse mixing. These were used in Hatfield Memo: *Prairie Creek Mine - assessment of potential aquatic effects.* Appendix D to predict downstream concentrations of each analyte of concern. The goal was to have no SSWQO excursions downstream of the point where full vertical mixing occurs (i.e., downstream of the initial dilution zone [IDZ]).
5) An IDZ (effluent mixing zone) was defined as the area of the creak downstream of the outfall to the point of full vertical mixing. Given the proposed use of an exfiltration trench for effluent dispersion, effluent dispersion will occur rapidly, with most dilution occurring when the effluent is fully vertically mixed. During winter-low-flow conditions. the point of vertical mixing was predicted to occur only 1.6 m downstream of the outfall, while during open-water-high-flow conditions, the point of vertical mixing was predicted to occur 31 m downstream. For logistical and safety reasons, the IDZ sampling site has been proposed for 100 m downstream of the exfiltration trench.
6) Potential impacts within the IDZ have been assessed by comparison of acute and sub-lethal toxicity being conducted on simulated, treated effluent with predicted effluent concentrations immediately downstream of the outfall. Given rapid mixing in the IDZ, effluent concentrations are expected to fall below those that could cause acute or sub-lethal toxicity within a few metres of the discharge. Downstream of the IDZ, water quality will need to meet the SSWQO, not cause sub-lethal toxicity, and avoid any deleterious aquatic effects (to be assessed through Environmental Effects Monitoring studies).

IR Number: Parks_Canada_2-4

Subject: Prairie Creek water quality predictions and mine site water balance.

1) In-stream Prairie Creek water quality predictions at Harrison Creek and at the Park Boundary correspond generally to the vertical mixing and transverse mixing scenarios provided in the NHC memo *Mixing analysis for exfiltration trench outfall to Prairie Creek - DRAFT* (Appendix L). Use of the complete, transverse mixing location instead of the Park Boundary in some analyses is a more conservative assessment approach, although concentrations of analytes of concern will not likely be much lower at the Park boundary given little dilution enters the creek in the intervening reach. Hatfield adopted the dilution factors provided by NHC and calculated concentrations of each of the AOC for each of the scenarios requested.
3) Comparison of predicted receiving water quality concentrations were screened against the SSWQO. As discussed in the Hatfield memo, *Prairie Creek Mine - assessment of potential aquatic effects, A*ppendix D, most objectives used were derived following the reference condition approach. The remaining were derived using the CCME water quality guidelines or other criteria from other regulatory jurisdictions. Whole effluent toxicity testing was performed to confirm the lack of effect when concentrations are below the SSWQO.

IR Number: Parks_Canada_2-5

Subject: Potential for bioaccumulation of mercury

1) The Hatfield memo, *Prairie Creek Mine - assessment of potential aquatic effects, A*ppendix D, indicates that mercury in the receiving environment will be within the range of natural variability (i.e., less than the RCA-derived water quality objective) and therefore should not result in an incremental risk to the aquatic environment. However, given environmental risks of mercury to aquatic life pertain primarily to bioaccumulation, fish-tissue studies conducted as part of the mine's Environmental Effects Monitoring (EEM) program will be conducted to assess any changes in mercury concentrations in fish tissue once the mine becomes operational.
2) As noted, downstream mercury concentrations were predicted for mine operations. Mercury in fish and/or benthic invertebrate tissues will be analyzed during the federal

EEM program (a mercury concentration in effluent of >0.01 μg/L is a regulated trigger for the fish-tissue component of EEM). Other biological end-points assessed during the EEM program will also indicate potential effects from mercury.

Environment Canada

IR Number: EC2-1

Subject: Effluent quality predictions

4) The Hatfield memo *Prairie Creek Mine - assessment of potential aquatic effects, A*ppendix D, discusses predicted concentrations of metals, nutrients and major ions at the point of complete vertical mixing and also complete transverse mixing. These concentrations were compared against the proposed SSWQO. An attachment to the Hatfield memo summarizes the whole effluent toxicity testing results to date. Additional toxicity identification evaluations are on-going and results are anticipated soon.
5) The mine has the ability to temporarily reduce or curtail the discharge of treated process water, as necessary, if abnormally low winter flows occur, this being the scenario when SSWQO might be exceeded. Currently, CZN has planned for significantly reducing the discharge of treated process water over the winter. The Surveillance Network Plan (SNP) outlined in the Hatfield Memo *Proposed Aquatic Monitoring Framework for CZN's Prairie Creek Mine,* Appendix O provides various monitoring triggers and associated action responses.

Department of Fisheries and Oceans (DFO), October 29th, 2010

IR Number: DFO_2-1

Subject: Nutrient Loadings

1) b) Please refer to the Hatfield memo, *Prairie Creek Mine - assessment of potential aquatic effects*, Appendix D, section 5.0 (enrichment). Briefly, water quality modelling results suggest that there is a possibility of incremental increases in bio-available phosphorous concentrations to cause minor enrichment in the creek, but that bio-available phosphorus would remain below 2 μg/L and remain

limiting to periphyton growth. The mine is already proposing the use of alum to precipitate phosphorous from sanitary waste water. In addition, treated sanitary water will be temporarily stored in the Water Storage Pond, as will mine water and process water. Therefore, the low phosphorous concentrations used in simulations could in fact be significantly lower. The mine has also opted for using specialized explosives during mine development, which will minimize the release of nitrogen from the mine via treated mine water. On-going EEM studies will be used to assess any actual enrichment in the creek.

IR Number: DFO_2-3

Subject: Outfall design.

3) Previous fisheries studies, as summarized in *Prairie Creek Mine Outfall and IDZ Fish and Fish Habitat Information,* Appendix Q, indicate that the proposed location of the exfiltration trench (and immediately downstream) is only suitable for fish migration. “The creek gradient is steep, causing a fast-flowing character with numerous white rapids in its course and very little pool development.” Further… “Substrates on the banks and creek bed were composed mainly of boulders, cobbles and pebbles with very little gravel. The reaches below the Mine were categorized as migration habitat.” The only documented spawning area near the mine was upstream of the mine, “most likely in Funeral Creek.”

Indian and Northern Affairs Canada

IR Number: INAC02-1

Subject: Effluent discharge and receiving water quality – operations

1) Tables of expected water quality downstream of the mine (at the point of complete vertical mixing and also complete transverse mixing) once the mine is operable are provided in the Hatfield memo, *Prairie Creek Mine - assessment of potential aquatic effects*, Appendix D. An explanation of the calculations used is provided. The calculations used predicted dilutions provided in the NHC memo, *Mixing analysis for exfiltration trench outfall to Prairie Creek - DRAFT*, Appendix L. An explanation of the dilution modelling approach was provided.

2) All analytes of concern (AOC) proposed by regulators in previous IR's were modelled and screened against proposed site-specific water quality objectives (SSWQO). Based on modelled concentrations, there is little risk of effects on aquatic organisms due to potential toxicity of individual constituents. However, whole-effluent testing also is being conducted on simulated, treated effluents to assess toxicity, and a Toxicity Identification Evaluation (TIE) is being conducted to identify the cause of any toxicity observed. This should provide greater confidence in the quality of the effluent with regard to its effects on aquatic life. Nutrients discharged with effluent, namely phosphorous, are at concentrations that could potentially cause mild enrichment; however, concentrations of bio-available phosphorus are expected to remain low and limiting to algal growth. For further detail, refer to Section 5 of the Hatfield memo, *Prairie Creek Mine - assessment of potential aquatic effects,* appendix D.
3) Ammonia and mercury were included in the modelling scenarios, and these contaminants were also screened against proposed SSWQO. Concentrations at both the point of vertical mixing and at the point of transverse (complete) mixing are provided in Hatfield memo, *Prairie Creek Mine - assessment of potential aquatic effects*, Appendix D. Dilution factors used in the Hatfield calculations were provided in the NHC memo, *Mixing analysis for exfiltration trench outfall to Prairie Creek - DRAFT*, Appendix L.
4) A mixing zone (Initial Dilution Zone, or IDZ) extending 100 m downstream of the outfall is defined in the Hatfield memo, *Prairie Creek Mine - assessment of potential aquatic effects,* Appendix D. This IDZ captures the downstream extent of the majority of effluent mixing, which is predicted to be less than 40 m downstream of the exfiltration trench (where complete vertical mixing occurs). However, the downstream edge of the IDZ has been proposed at 100 m downstream, because the creek is narrow, unbraided, and safe to sample at this location. Dilution modelling indicated very little difference in dilution between the point of complete vertical mixing and 100 m downstream (e.g., 1.7% to 1.6% v/v for mean ice cover conditions, and 1.5% to 1.2% v/v for mean open water conditions). Modelled concentrations under several scenarios of effluent flow and creek flow indicated that concentrations would meet the proposed SSWQO.
5) This request no longer applies. CZN has opted to install an exfiltration trench. This will result in much more rapid mixing and consequently, a smaller IDZ.
6) The estimates of AOC concentrations at the bottom of the IDZ are based on minimal flows during the winter months, and no discharge of treated process water during the lowest flow winter months. See NHC memo *Mixing analysis for exfiltration trench outfall to Prairie Creek - DRAFT*, Appendix L for model assumptions. CZN has shown elsewhere

that the Water Storage Pond is capable of holding additional quantities of water over the winter months, as discussed in *Water Balance and Water Quality*, Appendix F.

IR Number: INAC 02-08

Subject: Effluent discharge and monitoring

1) Downstream monitoring points will include the downstream edge of the IDZ as well as Environmental Effects Monitoring (EEM) locations. In the Hatfield memo, *Prairie Creek Mine - assessment of potential aquatic effects*, Appendix D, the point 100 m downstream of the outfall (on the left bank) has been identified as the Surveillance Network Program (SNP) monitoring location. Water will be regularly collected from this location and compared against the SSWQO (and against data from samples collected upstream of the discharge) to ensure compliance with the water discharge permit. EEM sampling locations for benthic community assemblages, periphyton and fish will be discussed in an EEM pre-design document. As stipulated under the MMER, this document is created once the mine becomes active. However, it is anticipated that sampling locations will be consistent with baseline studies identified by Bowman *et al.* (2009) and Spencer *et al.* (2008). These monitoring plans are described in further detail in the Hatfield memo, *Proposed Aquatic Monitoring Framework for CZN's Prairie Creek Mine,* Appendix O.
2) The Hatfield memo, *Proposed Aquatic Monitoring Framework for CZN's Prairie Creek Mine,* Appendix O, provides a tiered, trigger-response strategy. The intent of the trigger-response strategy is consistent with the intent of this request.
3) Again, please refer to Hatfield memo, *Proposed Aquatic Monitoring Framework for CZN's Prairie Creek Mine,* Appendix O, for medium-effect level response. Decreasing or halting discharge should generally only occur in winter (December to April particularly). The water management plan includes creating water storage capacity in the Water Storage Pond during the summer, so that this capacity is available in winter. More information describing water management appears in the CZN memo, *Water Balance and Water Quality,* Appendix F.
4) Monitoring and reporting are described in the Hatfield memo, *Proposed Aquatic Monitoring Framework for CZN's Prairie Creek Mine, A*ppendix O. Briefly, the plan includes a single set of SSWQO and EQC. Continuous flow monitoring of both effluent and creek will be done to ensure that actions can be taken to meet SSWQO.

IR Number: INAC02-09
Subject: AEMP

1) The AEMP outlined in the Hatfield Document *Proposed Aquatic Monitoring Framework for CZN's Prairie Creek Mine.* Appendix O, will follow federal EEM protocols, including the establishment of a Technical Advisory Group (TAG). This group will consist of mine personal, regulators, aboriginal groups and other interested parties. The TAG will review and provide feedback on the AEMP. Hatfield intends to follow the recommendations made in Bowman *et al.* (2009) and Spencer *et al.* (2008) for the AEMP design.
2) Monitoring of the epilithon will be included in the AEMP. The primary importance will be the assessment of potential creek enrichment. However, the epilithon can also provide an indication of contaminant-mediated effects. End-points will include total biomass, chlorophyll-a concentration and possibly an analysis of community assemblage. Periphyton studies elsewhere have indicated that these end-points are sufficiently sensitive to identify relevant changes in water quality and nutrient status that may arise downstream of industrial discharges. For algal components of the epilithon, which are generally more sensitive to pollution than the bacterial (autotrophic) fraction of periphyton, whole-effluent toxicity tests using plant species have indicated no acute or sub-lethal toxicity of 100% effluent on *Lemna minor*, which is supportive of a lack of effect of effluent on primary producers. Operational toxicity testing using algal species (*Pseudokirchneriella subcapitata*) will be conducted as part of the mine's MMER-required EEM program, and will provide further information regarding potential effects of effluent on algae.
3) While it will be possible to cease treated process water discharge to the environment during abnormally low flows in winter, the mine wishes to retain some operational flexibility, enabling the discharge of some treated process water during the winter period.
4) A description of the EQC and their application are provided in Hatfield Memo, *Prairie Creek Mine - assessment of potential aquatic effects,* Appendix D.

Dehcho First Nations (DFN)

IR Number: DFN-2

Subject: Where can IDZ's be used?

The CCME guidance does not specify the size of the receiving water body; however, there must be no acute toxicity within the IDZ and no environmental effects downstream of the IDZ. In Hatfield's memo, *Prairie Creek Mine - assessment of potential aquatic effects*, Appendix D, dilution modelling indicated that Prairie Creek is sufficiently large to assimilate regulated final effluent inputs from the mine. Note that the release of treated process water will be reduced or curtailed in the winter months, in order to meet the SSWQO at the downstream edge of the IDZ.

IR Number: DFN-3

Subject: Design standards for the use of IDZ's

Much of this question appears to be related to the previous outfall design, a single end-of-pipe discharge. The proposed IDZ, of the new exfiltration trench outfall design, was designed to meet the CCME criteria for establishing an IDZ. Modelled effluent concentrations at complete vertical mixing and at transverse mixing, under several scenarios of effluent and creek flow, are provided in the Hatfield Memo, *Prairie Creek Mine - assessment of potential aquatic effects,* Appendix D. Dilution factors were taken from the NHC memo, *Mixing analysis for exfiltration trench outfall to Prairie Creek – DRAFT,* Appendix L, which also provides cross-sectional diagrams of plume concentrations based on %v/v of the original effluent.

APPENDIX H

Wildlife IR Replies

Golder Associates

February 25, 2011

Project No. 09-1422-5007
E/11/0333

David Harpley, P.Geo., Vice President Environment and Permitting Affairs
Canadian Zinc Corporation
Suite 1710 - 650 West Georgia Street
Vancouver, BC
V6B 4N9

RESPONSES TO PARKS CANADA AGENCY INFORMATION REQUESTS – EA0809-002, PRAIRIE CREEK MINE, CANADIAN ZINC CORPORATION

Dear Mr. Harpley,

As per your request, Golder Associates Ltd. (Golder) has prepared the following responses to Information Requests (IR) from Parks Canada Agency (PCA) related to their review of the Canadian Zinc Corporation (CZN) Prairie Creek Mine Project Developer's Assessment Report (DAR). The information requests as stated by PC in their letter dated October 29, 2010 to the Mackenzie Valley Environmental Impact Review Board (MVEIRB) are presented below, with responses summarized under each information request. The responses are based on information reviewed during preparation of the Draft Wildlife Management Plan and subsequent discussions with the Dehcho Regional Biologist.

1.0 IR PARKS CANADA 2-6 – ADAPTIVE MANAGEMENT OF WILDLIFE IMPACTS

Parks Canada states that the Developer's Assessment Report does not provide a sufficient amount of information on how the wildlife monitoring program and associated adaptive management process will occur.

Request:

Outline the adaptive management process proposed by CZN.

Response:

Canadian Zinc has developed a Draft Wildlife Management Plan (Draft WMP) for the Prairie Creek Mine based on the principles of adaptive management (discussed below). The purpose of the WMP is to ensure that effects from operation of the Mine and access road on wildlife are minimized. The *Mitigation* section of the Draft WMP outlines practices and procedures aimed at preventing, minimizing or mitigating potential adverse effects of the project on wildlife and wildlife habitats. The *Monitoring* section outlines the steps considered necessary to ensure that mitigation measures are effectively minimizing effects of the Mine site, access road, and associated infrastructure on wildlife and wildlife habitats in the Project Area.

The following addresses each of the five sub-points raised by PC:

a) *Selection of valued ecosystem components that will be monitored with a clear rationale on:*

   i) *how they indicate trends for the ecosystem and anthropogenic change;*

   ii) *which areas and seasons within the study area will be addressed by their inclusion; and*

   iii) *which variable will be monitored (e.g., Dall's sheep recruitment, grizzly bear occupancy).*

The Draft WMP, while covering the broad range of species occurring within the Project area, focuses on wildlife Valued Components (VCs) that were identified in the *Vegetation and Wildlife Assessment Report,* which was incorporated by CZN into its Developer's Assessment Report (DAR). Wildlife VCs represent species and species habitats considered to be important to local First Nations, social, cultural, economic, or aesthetic values and scientific community concerns. Regarding disturbance effects on wildlife, the reporting of wildlife incidents and observations by mine staff will be important in the analysis of wildlife incident trends, and in minimizing wildlife conflicts through the adaptive management process.

Table 1 presents selected VCs and the rationale for their inclusion.

Table 1: Wildlife Valued Components (VCs) identified in the Prairie Creek Mine and Access Road Project Area

VC	Rationale for Inclusion	SARA Listing	COSEWIC Listing	GNWT Listing
Woodland caribou (*Rangifer tarandus*)	*Northern Mountain Ecotype* ■ Confirmed present in the Project area during winter. ■ Designated as Special Concern under SARA. ■ Designated as Special Concern under COSEWIC. ■ Highlighted by GNWT as at-risk for access road related mortality during winter hauling operations. ■ Species of local economic importance to hunters/outfitters.	Special Concern	Special Concern	Secure
	Boreal Ecotype ■ Confirmed present at the eastern portion of the Project area. ■ Designated as Threatened under SARA. ■ Designated as Threatened under COSEWIC. ■ Highlighted by GNWT as at-risk for access road related mortality during winter hauling operations.	Threatened	Threatened	Sensitive
Grizzly Bear (*Ursus arctos*)	■ Confirmed present in the Project area. ■ Designated as Special Concern under COSEWIC. ■ Highlighted by GNWT as at-risk for wildlife encounters at mine site during spring, summer, and fall.	None	Special Concern	Sensitive
Wolverine (*Gulo gulo*)	■ Confirmed present in the Project area. ■ Designated as Special Concern under COSEWIC. ■ Highlighted by GNWT as at-risk for wildlife encounters at mine site during all seasons.	None	Special Concern	Sensitive

VC	Rationale for Inclusion	SARA Listing	COSEWIC Listing	GNWT Listing
Wood Bison (*Bos bison athabascae*)	■ Confirmed present in the Project area. ■ Designated as Threatened under SARA. ■ Designated as Threatened under COSEWIC. ■ Designated as At-Risk under GNWT General Status Ranks of Wild Species. ■ Highlighted by GNWT as at-risk for access road related mortality during winter hauling operations.	Threatened	Threatened	At Risk
Dall's sheep (*Ovis dalli*)	■ Confirmed present in the Project area. ■ Highlighted by GNWT as at-risk for aircraft related disturbance at the mine site during the spring lambing season. ■ Species of local economic importance to hunters/outfitters.	None	None	Secure
Moose (*Alces alces*)	■ Confirmed present in the Project area. ■ Highlighted by GNWT as at risk for access road related mortality during winter hauling operations. ■ Identified as important to First Nations as traditional food source. ■ Source of local economic importance to hunters/outfitters.	None	None	None
Raptors	■ Peregrine falcon (*Falco peregrines anatum*) designated as Threatened under SARA. ■ Short-eared owl (*Asio flammeus*) designated as Special Concern under SARA and COSEWIC.			
Waterfowl	■ Horned grebe (*Podiceps auritus*) designated as Special Concern under COSEWIC.			
Passerines	■ Rusty blackbird (*Euphagus carolinus*) designated as Special Concern under SARA and COSEWIC, designated as May Be At Risk under GNWT Status Ranks. ■ Olive-sided flycatcher (*Contopus cooperi*) designated as Threatened under SARA and COSEWIC.			
Non-passerines	■ Common nighthawk (*Chordeiles minor*) designated as Threatened under SARA and COSEWIC.			

Avian VCs (raptors, waterfowl, passerines, and non-passerines) are not expected to be affected by the Project as only a limited amount of additional land clearing and vegetation removal will be necessary for the mine site (approximately 6 ha of the Spruce-Lichen vegetation unit) and the breeding season for these species is well outside of the hauling period. Therefore, no specific monitoring programs for these species have been developed. For additional wildlife VCs that are expected to occur in the Project area during operation of the mine site and access road, variables to be monitored are outlined in the Draft WMP and include:

- Monitoring of caribou movements across the Mine site, airstrip, and access road so that mine personnel are aware of their presence and relative location. The Draft WMP identifies a course of action for removing caribou from roads and the airstrip when necessary. Site environmental staff will monitor caribou activity around the Project footprint, and will be able to identify and manage problems as they arise. . Depending on the findings of the caribou monitoring program, adjustments to traffic management will be considered to lessen potential effects, particularly during the winter range use period;

- Monitoring of carnivore incidents at the Mine site, airstrip, and access road so that mine personnel are aware of their presence and relative location. Depending on findings, adjustments to the Waste Management Plan will be considered to lessen the potential for wildlife attraction to the mine site and the potential for increased predation pressure on prey species (*e.g.,* caribou);
- Monitoring of the Dall's sheep population near the mine site and airstrip to document numbers, activity and range use;
- Monitoring of Dall's sheep behavioural response to aircraft over-flight events. Depending on findings, adjustments to the Flight Impact Management Plan will be considered to lessen the potential for effects, particularly during the lambing period; and
- In addition, CZN committed to undertaking three surveys over the 2010/2011 winter in the Project area and vicinity to estimate caribou occupancy in relation to the Mine site and access road. Results of these surveys will be used to assess the extent of winter habitat use by caribou in the Project area and to identify areas where human-caribou conflict might occur.

b) Design of monitoring programs including geographic extent, timing, survey method, personnel requirements, and study controls that will be used to allow development specific change to be detected and mitigated.

Canadian Zinc will implement a year-round operational wildlife monitoring program. As part of the monitoring program, information on the presence of VC wildlife species at the mine site and along the access road will be recorded and entered into a tracking database. Mine environmental staff will review wildlife observations and incidents on an on-going basis. As a component of this review, the data will be analyzed for issues or potential problems such as seasonal concentration areas or sections along the access road that have a high incidence of collisions or near miss occurrences. Mine environmental staff will contribute to a quarterly data report and annual summary report of wildlife observations and incidents that occurred during the monitoring period. Wildlife reports will be submitted to First Nations, GNWT ENR, and Parks Canada Agency to solicit review of the effectiveness of mitigation measures and, following discussion in Technical Advisory Committee meetings, to suggest modifications to mitigation and monitoring plans, as necessary.

For species in which Project-related activities may impact populations during sensitive time periods (*i.e.,* Dall 's sheep, caribou), specific monitoring programs are outlined in the Draft WMP, as briefly described below.

- For Dall's sheep, a monitoring program will be implemented within a 5 km radius surrounding the mine site and airstrip to examine the response of female sheep to aircraft overflights events during the lambing period (generally mid-April to mid-June). If sheep are recorded in the study area during the lambing period, a ground-based behavioural observation survey plan will be implemented to document sheep movements, activity, and behaviour in relation to aircraft activity for the duration of the lambing period. The survey will extend into the immediate post-lambing period as females with lambs remain on lambing grounds for 3-4 weeks after birth. Monitoring of Dall's sheep will be conducted by a qualified wildlife biologist with assistance from Wildlife Monitors. The biologist will have prior experience conducting extensive behavioural monitoring studies of wildlife. The Dall's sheep monitoring program will need to be further developed; however a general approach to monitoring is outlined in the Draft WMP.

- For caribou, ongoing operational monitoring for presence, distribution, and seasonal movements in the vicinity of the mine site and along the access road will be conducted. This monitoring procedure will be important in the analysis of caribou incident trends and in effective mitigation and management. In addition, mine site staff, truck drivers, and pilots will record caribou presence around the mine site and along the access road during mine operations. Mine environmental staff will continually review and monitor caribou activity around the Project footprint, and will be able to identify and manage problems as they arise. An occupancy modelling study is currently underway to determine the extent of winter habitat use by caribou in the Project area. Mine environmental staff will use this information to educate mine staff and truck drivers about potential areas of human-caribou conflict.

c) *Indicate the thresholds that will be used to determine change, including descriptions of effect size, power, confidence, sample size, and frequency.*

The general approach for wildlife monitoring and determining Project-related impacts to wildlife was provided in the DAR and is further detailed in the Draft WMP. Canadian Zinc will implement an operational wildlife monitoring program at the mine site, airstrip, and access road. The advantage of operational monitoring is that continuous updates can be provided on wildlife information to inform decisions on adaptive management approaches. Operational monitoring will provide real time data which will inform the Draft WMP and provide direct input to the success of mitigation strategies. It is anticipated that the operational monitoring program will be further developed prior to mine start up and the first year of operation of the access road, with input from interested parties.

In order to gauge the extent to which mitigation strategies have been achieved, threshold values or statements have been set which, if reached, will trigger specific management responses. Specific attention will be given to species listed as “May Be at Risk” or “At Risk” under the NWT Status Ranks or “Special Concern”, “Threatened”, or “Endangered” on Schedule 1 of SARA. This includes caribou, wood bison, grizzly bear, and wolverine. The population densities of these animals are naturally low, and the reported home ranges of these species are large relative to the footprint of the mine site and access road. Further, historical and recent survey data indicate that those animals that do occur in the area are not proximal to the mine site or access road, with occasional exceptions. Project thresholds are, therefore, based on the operational monitoring program outlined in the Draft WMP and not on estimates of population change or population trends, which are influenced by several broader environmental and biological factors. Nevertheless, Project-related mortality thresholds for caribou, wood bison, grizzly bear, wolverine and several migratory bird species (peregrine falcon, short-eared owl, horned grebe, rusty blackbird, olive-sided flycatcher, and common nighthawk) will be set to zero. Should any of the wildlife mortality thresholds be crossed, an immediate review of the incident will be triggered and mitigation strategies will be reassessed.

Non-fatal disturbance threshold statements have also been outlined in the Draft WMP for the Project area, based on incident monitoring, incidental wildlife observation tracking, and monitoring programs. In addition, CZN has incorporated a Dall’s sheep monitoring program in the WMP. The primary objective of the sheep monitoring plan is to determine if mine overflight events have a significant effect on female Dall’s sheep lambing in the study area (defined as a 5 km radius around the mine site and airstrip). This plan will need to be further developed, including the final determination of survey methodology; however, if a significant impact to over-flights is observed, the Flight Impact Management Plan will be modified for the lambing period to minimize impacts in lambing locations.

d) Describe how results from monitoring programs will be integrated into decision making and the process in which mitigations will be determined.

The Draft WMP is based on the principles of adaptive management. Adaptive management is a structured, iterative process of decision making over time as experience is gained and new information is obtained. The objective of adaptive management is to reduce uncertainty through monitoring, or 'learning by doing'. In the case of the Project, the 'doing' is the wildlife monitoring program outlined in the Draft WMP and the 'learning' is continual improvements to the Draft WMP. As such, results of wildlife monitoring will be periodically reviewed by CZN and others, focusing on identifying any areas in which mitigation measures are failing to minimize project effects to wildlife or wildlife habitats, or areas where project impacts to wildlife or wildlife habitat are exceeding predictions identified in the *Vegetation and Wildlife Assessment Report*. This review process will, therefore, provide real time, effective data upon which to base decisions with respect to wildlife incidents and measures for reducing risks to wildlife and to workers.

e) Comment on the use of additional research and adaptation of monitoring programs to determine efficacy of mitigation measures.

The results of the operational wildlife monitoring program will be reviewed and assessed annually to determine whether mitigation policies are minimizing Project-related effects and producing the desired outcome. If Project-related effects to wildlife are detected by the monitoring program, the most suitable course of action will be determined by CZN, in consultation with the local communities and the appropriate regulatory agencies. If review determines that project effects are exceeding expected impacts outlined in the *Vegetation and Wildlife Assessment Report*, revision of mitigation processes may be required. The suitability of monitoring programs in terms of mitigation processes and the determination of project effects will also be considered. The Draft WMP will be flexible enough to incorporate comments, suggestions, and information based both on science and local ecological and traditional knowledge. The Draft WMP, therefore, is a dynamic document that will be further developed and evaluated as the Project proceeds.

Where CZN believes sufficient information exists (e.g., Dall's sheep) provide a full assessment of data in the context of the above questions to help describe how adaptive management would be applied as proposed.

Anecdotal information suggests that Dall's sheep at the Prairie Creek Mine site are relatively tolerant of human presence and equipment noise for much of the year, but the lambing period is a key life cycle period when disturbance can be problematic for sheep. Previous surveys in the area identified potential lambing areas to the west and east of the Fast Creek-Prairie Creek confluence and in the Folded Mountain area. However, the numbers of sheep lambing in immediate proximity to the mine site has not been documented. Therefore, CZN has incorporated a Dall's sheep monitoring program in the Draft WMP. This plan will need to be further developed, including the identification of appropriate monitoring methodology; however, the primary objective of the sheep monitoring plan is to determine if mine overflight events have a significant effect on female Dall's sheep lambing in the study area (defined as a 5 km radius around the mine site and airstrip). If a significant impact to over-flights is observed, the Flight Impact Management Plan will be modified for the lambing period to minimize impacts in lambing locations.

2.0 IR PARKS CANADA 2-8 – ROAD IMPACTS ON WILDLIFE

Parks Canada states that the Developer's Assessment Report (DAR) does not provide a sufficient amount of information to determine the impact of winter operation of the access road on wildlife, and in particular, on woodland caribou, or to determine appropriate mitigation and monitoring programs.

Request:

1. *Describe the potential impacts on woodland caribou from the road routing and road operation during winter.*

Response:

The original Prairie Creek Mine access road has been in existence since 1980. Approximately 63 km of realignments are proposed in the first winter of operation, and will result in a total road length of 174 km. This will be accomplished with equipment working along the alignment during November to early January, with construction of the ice bridge across the Liard River in December – January and connection to the Liard Transfer Facility and the Liard Highway.

The Tetcela Transfer Facility (TTF; 2.0 ha in area) and the Liard Transfer Facility (LTF; 2.8 ha in area) will operate from December to early March, and year-round apart from break-up and fall wet periods, respectively. The Cat Camp is located along the access road to the east of the Mackenzie Mountains and is a small existing facility (less than 1 ha) consisting of trailers and small fuel storage tanks.

Potential impacts on caribou associated with the road routing and road operation during winter include:

- *Sensory Disturbance*

If wintering occurs close to the access road, caribou have the potential to be affected through sensory disturbance related to operation of heavy equipment and transport trucks. Historical data also indicate that caribou occur in small numbers in the area east of the Nahanni Range (likely boreal caribou). The proposed realignment of the access road section to the eastern foot of the Nahanni Range would result in a lower potential for effects on boreal caribou from operation of heavy equipment and transport trucks.

- *Movements*

Access road operation may affect caribou movements between the Mine site and through the Mackenzie Mountains while individuals are on their winter range. Access road operation may also affect caribou movements east of the Mackenzie Mountains and toward the Nahanni Range to the terminus of the road at the LTF, where boreal caribou are more likely to be encountered in winter.

- *Direct Mortality*

Small bands of caribou may be encountered in proximity to the access road between Prairie Creek and the Liard River and may be subject to collisions with trucks. Wintering caribou are only expected occasionally along the access road, so the risk is limited.

- *Loss of Habitat*

Vegetation removal that will occur as part of the access road realignment and the development of the two transfer facilities will occur during the first year only and will remove potential caribou habitat. However, the 63 km footprint associated with the access road realignment in addition to the 4.8 ha footprint associated with the two transfer facilities is a relatively small area in the context of the vegetative habitats that occur in the area, and the known size of woodland caribou home ranges in the region.

- *Indirect Mortality*

It is possible that the access road may assist some hunters in accessing previously inaccessible land, thereby possibly increasing caribou harvest in the region, particularly in the Second Gap area. Dead wildlife along the access road may also attract carnivores to the area, which increase predation pressure on caribou. Disturbance from recreation activities (*e.g.,* snowmobiles) may also cause increased energy expenditure leading to an increase in predation risk.

Request:

2. Describe the associated mitigation for these impacts.

Response:

Canadian Zinc committed to undertaking winter surveys for caribou and other wildlife in proximity to the Mine site and access road (Undertaking #18) in late 2010 and early 2011. A two-scale survey approach was developed for the Project area and includes 1) a sub-regional caribou occupancy survey of approximately 9,000 km^2 around the mine site and access road, and 2) a reconnaissance survey of the mine access road alignment. This approach was reviewed by PCA, who issued a Research and Collection Permit for the portion of the surveys conducted in the NNPR to Golder (on behalf of CZN). The sub-regional survey is based on an occupancy survey methodology described in the primary scientific literature. The objective of the sub-regional occupancy survey is to determine the extent of winter habitat use by caribou in the defined study area and identify areas of high probability of caribou occupancy. The objective of the access road survey is to identify possible caribou road crossing locations and identify areas where vehicle-caribou conflict might occur.

In addition to the winter caribou surveys currently underway in the Project area, CZN has proposed a number of specific caribou monitoring activities outlined in the Draft WMP. These monitoring activities include:

- Conducting on-going ground-based surveys of the access road, mine infrastructure sites, and the airstrip to assess caribou presence and identify caribou aggregations;
- Implementing a radio call-in procedure so that observations of caribou along the access road can immediately be relayed to the Road Operations Supervisor so that traffic alerts can be issued; and
- Implementing a procedure so that caribou observations made by aircraft during transport of crews and materials will be reported to mine environmental staff.

Although a range of potential results is possible in terms of caribou landscape occupancy, as obtained from the winter wildlife surveys, CZN has proposed a number of mitigation strategies to provide for protection of caribou and other wildlife during winter hauling activities along the access road (December to March). It is important to note that concentrate hauling along the access road will not be conducted during the most sensitive time-periods in the caribou life cycle (*e.g.,* calving [May/June], post-calving [June to August], and rutting [September/October]).

The mitigation strategies outlined in the Draft WMP that are applicable to caribou along the access road include:

- Education of vehicle operators on potential areas of human-caribou conflict;
- Prohibition of hunting by site employees and contractors;
- Proper management of dead wildlife encountered along the access road that may attract predatory wildlife species and increase caribou predation risk;
- Instituting a highly visible signage system at the mine site and at the south-eastern terminus of the access road to alert drivers of “caution zones” and recent caribou activity along the access road;
- Instituting a temporary (movable) signage system along the access road to inform vehicle operators of temporary vehicle/caribou conflict areas
- Positing lower traffic speeds in the vicinity of sensitive caribou areas along the access road, such as areas of high probability of occupancy by caribou and known crossing locations identified during the winter aerial surveys and the ongoing monitoring program;
- Ensuring that vehicle operators yield right-of-way to caribou and take all reasonable measures to avoid vehicle-caribou incidents (including reducing speeds to zero if caribou are observed on the access road and until caribou move off and away from the road, or are no longer visible);
- Ensuring that snow removal practices along the access road do not create snow banks that block driver sightlines (> 1 m) and impede caribou movement across and away from the roadway; and
- Implementing various road control procedures to deter public use of the road and use by out-of-region hunters.

As part of an adaptive management strategy, if the above-noted caribou monitoring indicates a lack of success of mitigation actions, then mitigation actions will be modified and additional protection measures may be implemented following consultation with First Nations, GNWT ENR, and Parks Canada.

3.0 CLOSING

We trust that this addresses the present Parks Canada Agency Information Requests. Please contact the undersigned if you have any questions or require further clarification with respect to these responses.

Yours very truly,

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

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APPENDIX I

Access Road Spill Risk Assessment

APPENDIX I
SPILL ASSESSMENT AND CONTINGENCY PLANNING

1.0 PREAMBLE

CZN recognizes the importance of developing an appropriate and comprehensive Spill Contingency Plan ("SCP") prior to commencement of operations at the Prairie Creek Mine site. Such plans would include spill notifications, response team training and preparedness, appropriate actions for specific types of spills, definition of responsibilities, and reporting. In addition, the variation of terrain conditions and their inherent sensitivities and challenges relating to any possible spill should be taken into consideration. Issues CZN believe are appropriate for consideration during environmental assessment are:

- commitments by the proponent to produce such plans with an acceptable overall content and subject to agency/third party review; and,

- assessment of the risks of spills occurring, mitigation considerations and contingency planning.

The remainder of this document focuses on these issues.

2.0 COMMITMENTS

CZN commits to producing a Spill Contingency Plan suitable for operations at the Mine and along the access road for all reportable spills. CZN accepts that such a plan must be in place before operations commence. We recommend that this be a condition of operating permits. This condition can include provision for agency and third party review and comment, and necessary approval of a suitable plan by the Mackenzie Valley Land and Water Board before operations can proceed. Following approval, the Plan will be formally circulated to INAC, Parks Canada and the GNWT.

In preparing an appropriate SCP, CZN will consult and refer to relevant guidelines, such as INAC's 2007 "Guidelines for Spill Contingency Planning", and will reference in the plan where this has been done. The SCP will address all potentially hazardous substances used at the Mine or transported along the road. The substances considered will include all materials that have the potential to impact the environment or human health, and will include fuel, water treatment chemicals and mineral concentrates. The locations and quantities of all of the substances considered at the mine site, along the access road, and at the transfer stations will be detailed, and locations of storage shown on accompanying maps. Particular attention will be paid to substances that occur in liquid form and significant volumes, such as fuel and sulphuric acid, due to the risk of rapid migration and impact. Worst case scenarios will be considered in greater detail, specifically for those sections of the road considered more sensitive than others. While an inventory of Material Safety Data Sheets for all substances will be maintained at the mine, the SCP will include 'fast fact' sheets in an appendix to the plan which will cover information such as safety measures, first aid, specific emergency response requirements and physical and chemical properties of the substance. This information will be in plain language more easily understood by all responders.

The SCP will identify the location of spill kits and materials along the road. At a minimum, spill kits will be maintained at the Transfer Facilities and at Cat Camp. An additional spill kit location will be established approximately mid-distance between the Transfer Facilities so that spill response equipment is available no more than 50 km from any spill site. Additional spill kit locations are discussed below in Section 4. It does not make sense to place kits at every location that may be determined to be “higher risk” as manpower will be required to deploy the resources, and that has to come from an operating location. There is also the matter of security and regular inspection and inventorying of each equipment cache. Well equipped spill and readily transportable response equipment (e.g. trailers) stationed at selected locations would provide flexibility

For a spill on the access road, the plan will define the procedures that should be followed regarding immediate notifications and actions, how equipment and resources would be mobilized to the site of the spill, and what mitigation measures could be adopted in addition to the spill response. Guidance will also be given regarding which components of the spill kit should be used for a given type of spill and spilled substance.

The SCP will include details of spill responses for all types of ground conditions. At the Mine, this will include frozen and non-frozen ground and snow cover. Along the access road, frozen ground both with and without snow cover will be considered. Opportunities for the rapid spread of contaminants in certain landforms will also be considered, such as in the karst area in the Ram Plateau area along the road.

The SCP will discuss how to manage contaminated media that may result from a spill response. Such media may consist of soil, snow, water or ice. Contaminants are most likely to be either hydrocarbons or metals, although others are possible. Soil contaminated with hydrocarbons can be taken to the bioremediation cell proposed for the Mine site. This may include gravel and rocks rather than attempt to separate these at the spill site. This material would not be included in samples to verify completion of remediation, and would remain on site and be incorporated into the Waste Rock Pile. Soil contaminated with metals could be processed through the Mill, provided the soil does not contain any material that could interfere with the Mill process. Representative samples would be tested to verify the appropriate remedial approach. The SCP will also specify the appropriate level of treatment considering future land use. Water contaminated with hydrocarbons can be processed through an activated carbon vessel at the Mine site. Water contaminated with metals can be treated at the Mine site Water Treatment Plant.

Depending on the nature of a spill, it may be necessary to investigate spill impacted areas after a spill response. Procedures will be provided in the SCP for initial sampling to determine whether further follow-up is necessary. In a worst case, this sampling may indicate a need to conduct a more comprehensive environmental site assessment, and ultimately the development and implementation of a remedial action plan.

CZN will maintain a trained spill response team at the Mine. The general composition of the team will be detailed in the Plan. Operators stationed at the Transfer Facilities will also receive appropriate spill response training. Response training will include classroom study, equipment deployment instruction and spill exercises. Training for individual employees/contractors would be commensurate with the duties each is to perform in their day to day functions plus basic spill response procedures. It is envisaged that this would cover responses to Level 1 and smaller Level 2 incidents (see Section 4.3 below for level definitions). Training for Spill Response Team members will be of a much higher order, up to and including large Level 3 events.

Response training will include spill exercises where attendees will take appropriate actions and deploy suitable equipment and materials to combat a specifically designed, realistic, spill scenario. The simulated spill will involve a test medium which poses no environmental hazard but behaves like those requiring a response if spilled. Spill exercises will be undertaken in summer (initial training) and winter (final training) conditions, and in locations representing the range of environmental conditions that will exist on the road. Spill simulations will include the use of the bags to be used to transport concentrates on the road. Popcorn, puffed wheat or a heavier inert substance will be used to simulate the “spill”.

Spill response training will likely be done at the Mine site. However, if any exercises are contemplated within the NNPR, park staff will be notified first and if the plans are approved, invited to observe or participate. Parks staff will also be consulted regarding the rendering of additional resources and assistance for responding to a spill, although CZN would not rely on this.

The SCP will contain information that clearly states who is responsible for spill response and clean-up. Because nearly all incoming materials will be trans-shipped at the Liard Transfer Facility, CZN will be responsible for nearly all of the loads. The only exceptions might be dedicated trucks for acid and explosive chemicals delivery. In this case, the deliverer may be responsible, but CZN would provide assistance in the event of a spill. In addition, CZN will stipulate in contracts with 3rd party contractors building or using the access road, or working at the Mine site, that a copy of the SCP will be provided and that their staff must be fully familiar with its contents and their duties and responsibilities. Copies of relevant portions of the contracts will be made available for public review. CZN’s oversight of road and mine operations will include checks on contractor adherence to the contracts with respect to spill contingency. Details of this oversight will be provided in the SCP.

In addition CZN, will endeavour to contract a bulk fuel service company located in the region, preferably close to the haul route, which has an established mobile spill response unit that would be available 24 hours a day. The company would assist CZN in its response to any large bulk fuel spill along the access road or highways during the operation of the winter road. This service company may also provide training on spill cleanups to CZN employees and contractors, but this and all other items would be defined in the contract.

3.0 SPILL RISK ASSESSMENT

An SCP exists for the Mine site which will be subject to review and update for operations. Spills that might occur at the Mine site are not the subject of this document. However, while such spills pose some risk to the environment, this risk is limited by the fact that most Mine facilities are located inside a large flood protection berm separating the site from Prairie Creek, personnel trained for spill response will be on hand for rapid response, and the release of spilled material to the environment can be prevented by temporarily suspending all site discharge, if necessary. The assessment of spill risks below focuses on access road operations where the circumstances noted above for the Mine site that limit the risks from spills may not exist.

3.1 Road Alignment

The attached drawings show the proposed road alignment in plan and section. The plan view shows the proposed alignment and the existing alignment where this departs from the proposed route. Three main re-alignments are proposed: Km 48 to 56 by-passing the Poljes; Km 102 to 121 avoiding wetlands; and, Km 126 to 180, also avoiding wetlands. The section from Km 94 to 101 will also be revised to open out switch-backs and reduce grade. The Polje re-alignment avoids two tight switchbacks at Km 49-50, and steep grades at Km 49-50 and Km 54-57. In summary, the proposed road alignment will be markedly safer than the current one which was used extensively over two winter seasons.

3.2 Road Operating Period

Annual road operations are expected to occur in the following general fashion:

- Km 0 (the mine) to Km 82.5 (the Tetcela Transfer Facility (TTF))
    - Dec. 1 – Jan. 15: 50,000 tonnes of concentrates to TTF (empty return)

- Km 82.5 to Km 180 TTF to Liard Transfer Facility (LTF)
    - Jan. 15 – Mar. 31: 50,000 tonnes of concentrates to LTF

- Km 0 to Km 180
    - Jan. 15 – Mar. 31: 70,000 tonnes of concentrates to LTF
    - Jan. 15 – Mar. 31: Operating supplies to the mine

The indicated operating periods may vary by several weeks each way depending on weather conditions.

3.3 Materials being Hauled

Table 1 provides a summary of materials of environmental significance being hauled outbound from and inbound to the Prairie Creek mine. Details are given regarding the form of the material, package size, package type, number of packages per load, and number of loads per season. Bulk liquid hauls are considered to pose the greatest risk because of the potential for rapid migration in the event of a spill. Sulphuric acid and diesel fuel are the main bulk liquids being hauled. The largest quantity of material to be moved is concentrates (see Section 4.4 for mitigating factors).

Most of the road route will consist of frozen muskeg or gravely soil covered by snow. The migration of any spills will be retarded by snow absorption, facilitating spill response and recovery. Where snow is absent, spilled fuel will pond on the frozen ground and would be collected. A follow-up investigation would occur to confirm no significant seepage has occurred, and if it has, remedial action would be required.

Given the time of year, watercourses will usually be frozen, at least on the surface. There is the potential for warm spells during the winter period, and the possibility of open water near the road. If a spill occurred into open water, an open water containment and recovery strategy would be employed.

Areas where permeable bedrock is close to surface and not covered by soil are prone to a greater risk from fuel spills. Significant rock exposure occurs in the Ram Plateau. However, the road with the proposed re-alignments traverses karst with varying thicknesses of soil cover. Rock exposures are absent. As above, migration of any spilled liquid will be limited by snow cover and frozen ground, facilitating clean-up. A certain amount of absorption by frozen soil may occur, requiring remediation, but the risk of significant groundwater contamination from a fuel spill will be effectively mitigated by the frozen conditions.

Significant stream crossings would be susceptible to contamination, whether they are frozen or not. The Liard and Tetcela River crossings are prone in this regard. However, these crossings are relatively broad with shallow banks, and the potential for an accident is much less. A span-type bridge crossing is proposed for Polje Creek. This creek may flow in winter because it is fed by groundwater. However, crossing approaches will also be shallow and set back from the stream banks, posing a low risk for accidents and entry of any spill into the watercourse.

Sulphuric acid will be transported into the mine by dedicated tanker trucks. Drivers for these trucks are specially trained in driving safety and spill response for this chemical. At a minimum, drivers will have the following knowledge:

- Existence and content of appropriate sections of the SCP
- Route familiarity, including identification of higher risk areas, signage, strict adherence to speed limits and communications protocols
- Properties and hazards of the materials (sulphuric acid & the vehicle’s diesel fuel)
- Composition and use of the vehicle’s on board spill response kit and requirement for all responders actively involved in the response to wear appropriate personal protective equipment (PPE)
- Notification procedures in the event of an incident and details to be communicated

In the event of an acid spill, an industry recommended approach is to use soda ash to neutralize the acid, and then recover any sludge and contaminated soil/water for disposal in an approved manner. A spill into a waterbody will be harder to neutralize, and response strategies will need to be devised on a case by case basis, employing strategically located control points (more on this is given in Section 4).

3.4 Spill Risk

A matrix for the risk of spills for different sections of the access road is given in Table 2. Proximity to water is indicated as well as the ground composition. Grade refers to elevation change along the road, and alignment to the sinuosity of the road. Containment refers to the opportunity to collect spilled material in a reasonable timeframe (a few hours) without entry to the nearest water body. A risk level is then assigned to the road section based on a combination of these factors. Next, a consequence level is assigned based on the potential severity of impacts if a spill actually occurred. Individual road sections are discussed below. Mitigation is discussed in Section 4.

Prairie/Fast Creek Section

The road from the Mine to Km 7 parallels Prairie Creek and Fast Creek. There are sections that are immediately adjacent to the creek. Spills in these locations would be problematic because it may not be possible to prevent part of a spill entering the creek. The consequence if a spill did occur would be potentially high for these sections, depending on the material spilled (see Sections 4.1 and 4.2 for mitigation). However, the risk of a spill is low because the road grade is flat and the alignment is generally quite straight. Prairie Creek over this reach is considered to be migration habitat for bull trout. While migration is unlikely to be occurring in winter, fish may be over-wintering in deep pools. There is one location (over a distance of approximately 10 m) where a deep pool abuts the road bank. Therefore, any spills entering the creek pose a possible but limited risk to over-wintering fish. Rapid response would be necessary.

During the early winter period, only concentrates will be hauled over this reach. A spill of concentrates should not pose a high risk provided there is no loss of concentrates from the bags, or the spilled material does not enter the creek. The bags are designed to be resilient and will be new (one use only), and the concentrates will be frozen during transport. The presence of ice and snow cover on the water surface will also facilitate a response. Ice and snow thickness will be greater in mid-January when the back-haul of supplies commences.

Funeral Creek Section

Between Km 7 and Km 16.7, the road parallels Funeral Creek. Conditions are similar to the Prairie Creek section except the grade is steeper. The consequence is also higher because of the presence of a spawning bull trout population, which may be resident in winter. The road is not proximal to the creek from approximately Km 11.7 onwards where the grade steepens. The section considered to pose the highest risk is from Km 13 to Km 16. A spill over this section would be considered a ‘worst-case’ scenario because of the road grade and grade separation between road and creek below. The section starts with a switch-back crossing of a Funeral Creek tributary. This switch-back will be ‘opened-out’ to make turning easier, and the crossing will be a broad span structure. The section has a steep grade and crosses a steep side slope. In the event of a spill, it would be difficult to access the area below the road and the speed of spill response may also be affected. Specific mitigation strategies for this risk are discussed in Sections 4.1-4.3 (in particular Section 4.3, see ‘control points’).

Sundog Creek Section

The first section of Sundog Creek to Km 22.7 poses a low risk because road conditions are good and the headwaters of the creek will be dry in winter. An incised tributary of Sundog Creek exists at Km 22.7-23. The road ramps down into the bed and out again. The ramps are steep. However, while there may be some groundwater seepage in this area, there are no fish because of the high falls at Km 24. Nevertheless, any spilled material in the crossing area could enter the bed gravels and would pose a risk to possible fish presence downstream during the spring migration (grayling). Should a spill occur in this area, a response can be mounted between Km 23 and the falls at Km 24. Further, the creek bed is likely to be dry in winter to Km 29 where the gravel outwash plain starts, further reducing risks and providing additional opportunities for spill recovery if any has evaded upstream capture.

From Km 23 to 29, the road crosses scree slopes in places and there is grade separation from the creek below. The risk of a spill is not high, but response would be difficult if one occurred. Grayling migrate up the creek in the spring, but either retreat or are stranded as flows recede through the summer. Some have been noted in deep pools near Cat Camp. However, it is unlikely that fish are present upstream of Km 30-35 in the winter. The road bed is good and broad between Km 29 and Km 39. Spill risk is low. However, any spill would require an immediate and complete response because of the road location on the creek floodplain. Spilled liquid could seep into the alluvial gravels. If this has deemed to have occurred, a backhoe will be mobilized to dig a cut-off trench immediately downstream. The trench will allow monitoring to take place, and recovery using sorbents, skimmers and a vacuum truck. Additional trenches would be dug as needed.

Sundog Tributaries Section

From Km 39 to Km 52, spill risk is low because of good road conditions. Consequence is also low because the road is not proximal to water apart from small tributary creeks to Sundog Creek. Spills, if they occurred, could be readily responded to with complete clean-up. From Km 52 to Km 55, risk is slightly greater because of an increase in road grade and the fact that the road crosses karst terrain. Polje Creek is quite narrow at the crossing location and the road would be good at the approaches. To the east, the road grade increases to climb onto the karst plateau. Soil cover overlying limestone, together with snow cover, will readily limit the migration of any spills until such time as a spill response occurs.

Tetcela River and Fishtrap Creek Section

From Km 55 to Km 83, road conditions are good and the road is not proximal to water bodies. Travelling east to Km 93, the Tetcela and Fishtrap valleys are crossed, including extensive wetlands. The consequence of a spill would be high, but the risk of a spill is low because the valleys are broad and road conditions are good. Also, apart from the water crossings, frozen ground and snow should facilitate containment and response should a spill occur. Note that the portion of the road crossing these valleys is only expected to be open from mid-winter onwards, providing assurance that well frozen conditions will exist with significant snow cover.

Km 94 to Km 101 is a difficult piece of road climbing the Silent Hills because of the switchbacks and grade. Improvements are planned in the form of switchback modifications and grade reduction. The revised route has reduced grades in this area to approximately 7%. This is considerably better than the current grades. However, the road will still be difficult. The consequence of a spill is moderate because this section is at least a few hundred metres from Fishtrap Creek. Spill response in the wooded area would be difficult but feasible before spilled materials could migrate significantly. Additional mitigation strategies are discussed in Sections 4.1 and 4.2.

Wolverine Pass to Grainger Gap Section

From Km 101 to Km 123, the original road route crossed another extensive wetland. The proposed re-alignment moves the road out of this area, avoiding wetlands completely to the Grainger Gap. The new route will also be flat and straight, posing a low risk of spills. Surveys of the road route during the summer over the last few years have noted the common presence of a pair of trumpeter swans in a pond just north of Km 121. Swans have not been seen in other locations along the route. The revised alignment takes the road approximately 1 km away from this pond.

Grainger Gap to Liard River Section

The headwaters of the Grainger River in the Grainger Gap area will be frozen at the time of road use. The road bed is flat and straight and spill risks are low. The revised road route towards Nahanni Butte will also have a low risk due to good road conditions.

Liard Ice Bridge and Old Logging Road

The consequence of a spill at the Liard crossing would be potentially high if the spill penetrated the ice, but the risk of a spill should be low. The old logging road to the Nahanni access road is set back from the river and is flat and generally straight.

4.0 MITIGATION

4.1 Road Design to Minimize Risks

CZN has evaluated the access road to make modifications that promote greater safety and reduce the risk of accidents and, therefore, spills. The focus of evaluations has been the elimination of tight hairpin turns and reduction in road grades. From west to east, the proposed polje re-alignment will eliminate two hairpins and some steep grades, and will also take the road away from the poljes and associated groundwater sources. A re-design of the road up to Wolverine Pass has reduced the tightness of the switch-back turns and reduced grades so that there is no gradient exceeding 8%. This is the lowest grade possible given the elevation change from valley to pass, and the width of the corridor of stable ground available. The re-alignment east of the Silent Hills moves the road out of wetlands onto firmer terrain with few watercourses and water bodies. The re-alignment east of Grainger Gap is similar in that the Grainger lowlands are avoided in favour of the lower slopes of the Front Range where only headwater streams exist which will be dry and frozen in winter.

The risk assessment noted higher risks in areas where the road is proximal to creeks running parallel, and where grades are higher, especially where there is a grade separation with a creek below. To mitigate these risks, CZN intends to investigate and implement the placement of barriers along the outer edge of the road way to reduce the risk of trucks leaving the road. One option is an earthen berm. However, in many of the areas noted, the inside of the road way is bounded by a slope, making it difficult to construct a road wide enough to allow room for a berm. Where room is not sufficient for a berm, other barrier options will be considered. Large boulders could be placed, although this is dependent on suitable boulder sources. Another option is to place hollow plastic road barriers and fill them with gravel. An option suitable for the specific location will be chosen.

The mountainous portion of the road has sections of steady grade where it would be difficult for trucks to come to a stop safely in the event of a break failure. Specific sections where this may be an issue are Km 11-16 and 19-22. CZN proposes to investigate suitable locations for the construction of run-away lanes.

4.2 Road Operational Procedures to Minimize Risks

Operational procedures will be adopted to minimize the risk of spills along the access road and at the Mine. Speed limits will be set by the road operations supervisor for all sections of the road, and will be posted. These will take into account safe driving speeds for the section in question, and the risks and consequences for spills as determined above. Before the road is opened for traffic, the operations supervisor will drive the road and note appropriate speeds and locations where additional warning is required. Following this, signs will be made and posted along the road. Consideration will be given to sections of the road where the risks from spills are greater. Specific speed limits may be set for specific types of trucks and loads through sensitive sections. The route will be defined by markers that will be visible during adverse winter conditions. Road conditions will be monitored at all times, and temporary closures will occur if visibility is deemed to be too poor. Truck speeds will also be monitored by road operations staff on patrol.

All drivers using the road will be required to have suitable driving training and experience for the conditions. In addition, all drivers will be expected to know the following:

- Existence and content of the appropriate sections of the SCP
- Properties and hazards associated with the cargo(s) being carried and also the vehicle fuel.
- Composition and use of the on-board spill response kit and requirement to wear personal protective equipment (PPE)
- Required notification procedures to be employed in the event of an incident and details to be communicated

Drivers will also receive an orientation package describing the road and specific sections/conditions before driving the road for the first time, and they will be required to read it.

Because drivers will check in and out, and be in communication with control during the journey, a need to keep a driving log is not considered justified. A system of digital recordings is preferred over paper. However, this approach will be reviewed in the first few months of operations. The digital system will also record the truck and driver, date and time of travel. The road operations supervisor will place limits on hours of driving over a prescribed period with the intent of providing drivers with a necessary rest period before starting a new journey.

For vehicle communications with a coordinator and between vehicles, one option is to have radio repeaters all along the right of way, although there may still be blank spots. A satellite-based phone system is another option, but may also have limitations in tight steep canyons. A blend of the two approaches might work best and will be investigated. Repeater towers may be required. The intent will be to have communications coverage for the entire road. This is for safety and operations reasons. The drivers will need to communicate with control and each other to plan passing at turn outs. CZN would also like to have a GPS-based tracking system that tracks the progress of all trucks on the road, and displays this on multiple screens in different locations.

CZN will adopt a journey management system (JMS). This will comprise of the following:

- All vehicles are serviceable and carry a first aid kit, fire extinguisher, survival kit, spill kit, global positioning system beacon, and have working communications. Those in the vehicle must all have suitable winter clothing;
- All drivers are trained and briefed on the route, road conditions, existing and forecast weather conditions, problem areas, any observations of wildlife, and are instructed on and given a copy of the communications protocols;
- A journey plan is kept by the JMS Coordinator which includes the name of all persons in the vehicle, the assigned radio call sign, ETD and ETA, destination, type and quantity of the cargo and confirmation of vehicle fuel level;
- The plan is opened by radio upon departure and closed by radio upon arrival at destination with the JMS Coordinator;
- Progress is monitored by the Coordinator and radio check-ins are required at specific intervals, probably based on kilometre markers;
- Vehicles on the road track nearby traffic through the radio. Drivers coordinate their passing locations. Vehicles may travel in convoy to reduce radio workloads. An approaching vehicle warning system will also be considered;
- The Coordinator will track all traffic and initiates a radio call if a vehicle check in is overdue. A response is initiated if traffic passing through the area within a very short period of time cannot confirm the non-reporter has radio problems or other valid reason for missing a check in.

The road will be regularly inspected and maintained during the operating season to ensure optimal performance and minimize risks from poor road bed conditions. Vehicle traction will be paramount, especially on the grade sections. CZN has two strategies in this regard:

- Gravel surfacing may need to be laid over snow and ice accumulations on the road periodically (except near creek crossings); and,

- Trucks will be required to use chains from Km 0 to Km 29. This section of the road contains most of the grades and chains will not damage the surface for winter operations (gravel bed). Km 29 could be a chain-up/removal area as it is broad and flat, and would also serve as a tire pressure and breaks check location for in-bound vehicles.

4.3 Spill Response Planning

Response System

An incident management system will be used to respond to spills. CZN proposes to adopt the Incident Command System (ICS) that is widely used by governments and industry. This lets trained regulators, contractors and other external resources quickly integrate with and augment the spill management team. Selected ICS documentation will be incorporated into the Spill Contingency Plan.

A spill classification system will also be used that is in wide use in industry, as follows:

Level 1 A **minor** event that is confined to the Company property and can be handled by CZN/available contractor personnel using the response resources, manpower and equipment, at hand. Employee safety is not significantly affected and public safety and property is not endangered. The Incident Commander is the Shift Supervisor.

Level 2 A **moderate** event where an incident has occurred or spread beyond Company property, or employee safety is endangered or external resources such as fire, police or ambulance or contractors/external resources are required, but public safety is not endangered. The Incident Commander is the Mine Manager or his delegate.

Level 3 A **major** event where public safety or property is endangered or major off-site environmental impacts have occurred or could occur, and external resources are required. The Incident Commander is the Mine Manager or a Vice President.

Responders

The spill response team will consist of 6 personnel: 1 Supervisor, 1 Safety Watch, and 4 responders, one of which will be a mechanic. The responders will work on the buddy system in teams of two. Any required increase in the number of responders will also be in teams of 2. The Supervisor is responsible for all communications off the spill site, and directs and documents operations in a chronological log. Communications will be relayed via the JMS Co-ordinator. Road traffic would likely be halted until the emergency phase of the spill response is completed. The JMS Co-ordinator would relay information to mine management for necessary external communications with regulators and local stakeholders.

The Safety Watch will be an experienced employee with intimate knowledge of the operations and safe operating procedures. The Safety Watch's primary responsibility will be to police safety and coach the responders. The Safety Watch may also help unload or deploy equipment in the early stages of a response or assist from time to time if required, but safety policing is the priority.

As mechanical equipment such as pumps and skimmers could be involved, the inclusion of a mechanic with his tools is appropriate. The team would be supported by other units delivering additional equipment, as necessary.

Spill Equipment

When a spill occurs, there is a potential for spilled material to enter a water body and flow either above or below any ice cover. Flow can also occur in a dry watercourse. Contaminants can be carried away from the spill site. In the route assessment above, a number of areas were indicated where a spill could enter a watercourse. Sensitive areas were indicated along Prairie and Funeral Creeks, especially the upper section of Funeral Creek, Sundog Creek, and the Tetcela and Fishtrap Creek crossings. CZN intends to establish "control points". These are pre-determined locations from which spill containment and recovery operations could be mounted to limit the migration of a spilled substance from an upstream location. Establishment of control points along Prairie and Funeral Creeks would be challenging because the road parallels the creeks and the creeks may have significant flows of water. However, a silt or other form of curtain will be stored approximately mid-point between the mine and Funeral Creek ready for deployment to reduce flow in part of Prairie Creek adjacent to a spill. The curtain would not be intended to contain a spill, but rather would assist spill response by providing a more quiescent environment. The Funeral Creek stream width is likely to be quite narrow in winter. Absorbents will be available for placement along the bank between the stream and the road, and/or across the stream itself temporarily, as necessary.

The upper section of Funeral Creek consists of two tributaries adjacent to the road which are unlikely to be fish-bearing during the road operating season. However, the creek downstream is sensitive because of the possible presence of over-wintering fish. This section of the road is considered the most challenging in terms of mounting a response in the event of a spill because of the steep terrain and grade separation between the road and creek. Consequently, control points will be established on these tributaries. Control equipment, including material to create temporary dams and absorbents, will be stored adjacent to the tributaries ready to be quickly deployed. The intent is to prevent migration downstream of the control point of any substance spilled in the upstream catchment. Similar control points will also be established on Sundog Creek in two locations (one just above the main falls and one just before the creek flows onto the fluvial outwash plain), and downstream of the Tetcela River and Fishtrap Creek crossings.

Control point equipment will include booms and absorbents in addition to board weirs, sand bags and other inert materials that would be available for temporary use to prevent the migration of contaminants.

Spill kits will be carried on vehicles with materials appropriate for the loads (i.e. type of sorbent). Trucks transporting fuel will carry sorbent specific to hydrocarbons. Trucks carrying acid will be dedicated trucks with specially trained drivers, and spill kits specific to acid. Comprehensive spill kits will be maintained at the mine site, Cat Camp, the Tetcela Transfer Facility, Grainger Gap, and the Liard Transfer Facility. An option that will be given serious consideration is the supply of custom built and stocked road trailers dedicated to spill response, containing equipment, materials and tools. The trailer(s) would be stationed at one or more of the above noted locations and could be readily hooked up and towed to a spill site. The trailers would be stationed at regular intervals along the road to be proximal to all possible spill locations. There is no need to locate the trailers in high risk locations because responders will still need to travel to the spill location, collecting the nearest trailer on the way. Trailer use would be restricted to preventative maintenance, training and spill response activities.

Non-dedicated equipment such as backhoes, dozers, crane trucks, dump trucks, vacuum trucks etc would be called to spill sites on a priority basis in the event of need. The mine and the transfer stations will have heavy equipment. This would be made available instantly in the event of need.

4.4 Specific Potential Spills

Concentrates

Externally clean 3,000 kg bags of concentrates will leave the mine site strapped to flat beds. The concentrates retain approximately 8% moisture after bagging, and are therefore expected to be frozen blocks at the time of loading and transport. The 'oldest' bags will be transported first to ensure sufficient time for freezing in the non-heated storage shed. In the event of an accident along the road, some of the bags could fall from the vehicle. There is a risk of these breaking open. Spill exercises addressing this potential occurrence were discussed above. A back hoe may be required to pick up the material, and re-bagging at the spill location would occur. Contaminated soil would also be recovered and re-processed in the mill. If bags were to roll down a steep grade after an accident and split apart in an area where no heavy machinery access is possible, then shovels and manpower will be required to recover the material. A crane truck or helicopter may be required in the recovery.

Bulk Fuel

Diesel fuel will be brought into the mine via 10,000 litre tanks. Each mine haul truck will have one such tank anchored to the flat bed. Approximately 800 such loads are expected. Control Point locations would be designed to stop the migration of spills of diesel fuel. Response equipment and material would be appropriate for the possible quantity of a spill. A worst case discharge would be the total cargo on a vehicle. The dedicated road trailers noted above could be stocked with the necessary response material for the spill of a full tank.

Bulk Acid

Sulphuric acid will be brought into the mine via 20,000 litre dedicated tankers. Approximately 22 such loads are expected. These loads likely pose the greatest risk of impact because of the substance and load quantity. A different set of road use criteria would be applied for such loads, including reduced speeds, especially over the higher risk sections noted. Also because of the limited number of loads, there will be some flexibility to schedule the deliveries during periods of optimal road and weather conditions, and convoys could be used and other traffic reduced or stopped temporarily for passage of the convoy.

Despite the above precaution, a small risk of a spill would still exist. The Control Points would also be selected with the aim of limiting, as far as possible, the migration of the acid spill. Response equipment and material would again be appropriate for the possible quantity of a spill, and the dedicated road trailers could be appropriately stocked. Caches of soda ash might also be stored at the high risk locations, although these would need to be in animal-proof containers (salt is an attractant to ungulates), and removed seasonally (to avoid caking in wet conditions).

Shoulder Season Conditions

During late fall/early winter construction from the mine to the Tetcela Transfer Faclity at Km 84, there may be open water, specifically along Prairie Creek and lower Funeral Creek, and in Polje Creek (although a span crossing is proposed for this location). All other creeks are expected to be dry or completely frozen. Prairie Creek may still not be frozen over when road operations commence in December. Road design and operations measures (berms, use of chains etc.) to minimize the risks of spills in these locations has been discussed above. Spill response crews will be trained and prepared for open water response situations. The crews will be prepared and equipped for rapid response given that open water conditions may potentially mean that a spilled substance could migrate more quickly than in frozen conditions. As noted above, a silt or other form of curtain will be stored approximately mid-point between the mine and Funeral Creek ready for deployment to control flow in a creek adjacent to a spill. Control points and dedicated road trailers were also discussed above.

During the road operating period, there may be brief periods of warm temperatures leading to melting adjacent to the road. This is more likely as the end of the road season approaches. Again, spill response crews will be trained and prepared/equipped for open water response situations.

TABLE 1: MATERIALS FOR ROAD HAUL

MATERIAL	FORM	PACKAGE	CONTENTS	TONNES PER LOAD	UNITS PER LOAD (max)	NO. LOADS	TOTAL LOADS
Outbound							4005
Mineral concentrates	Solid	bag (kg)	3,000		10	4000	
Hazardous waste	Various	drum (litres)	205	10	49	5	
Inbound							1133
Fuel and Oil							
Diesel	Liquid	Tanker (litres)	10,000		1	800	
Mineral Oil (Explosives)	Liquid	Tanker (litres)	10,000		1	3.5	
Petroleum fluids	Liquid	drum (litres)	205	20	98	4	807
Mill Supplies and Reagents							
Jaw Crusher Liners	Solid	Pallets (Kg)	250	15	60	0.6	
Cone Crusher Liners	Solid	Pallets (Kg)	250	15	60	1.2	
Ball Mill Liners	Solid	Pallets (Kg)	250	15	60	0.9	
Grinding Balls	Solid	drum (litres)	250	15	60	6.9	
Ferro Silicon	Solid	bag (kg)	1000	20	20	7.2	
Glycol	Liquid	drum (litres)	205	20	98	1.0	
Flocculant	Solid	bag (kg)	200	10	50	0.1	
DF067	Liquid	drum (litres)	205	20	98	0.4	
SIBX	Solid	bag (kg)	1000	20	20	1.6	
MIBC	Liquid	drum (litres)	205	20	98	0.0	
Soda ash	Solid	bag (kg)	1000	20	20	21.1	
P82	Solid	bag (kg)	1000	20	20	1.9	
AQ4	Solid	bag (kg)	1000	20	20	7.3	
Copper sulphate	Solid	bag (kg)	1000	20	20	19.0	
3894	Liquid	drum (litres)	205	20	98	0.2	
RTR3	Solid	bag (kg)	1000	20	20	0.2	
SIL N	Solid	bag (kg)	1000	20	20	5.0	
Sodium sulphide	Solid	bag (kg)	1000	20	20	8.7	
Backfill Cement	Solid	bag (kg)	1000	30	30	170.7	254
Water Treatment Reagents							
Sulphuric acid	Liquid	Tanker (litres)	20,000	20	1	21.6	
Sodium sulphide	Solid	bag (kg)	1000	0	0	2	
Ferric sulphate (Ferix 3)	Solid	bag (kg)	1000	20	20	3	
Lime	Solid	bag (kg)	1000	20	20	12	39
Mine Supplies							
Mine operating supplies	Solid	Pallets (Kg)	500	15	30	33.3	33
Explosives Components							
Sensitizer	Solid	boxes (Kg)	152	10	66	6	
Sodium nitrate	Solid	bag (kg)	25	15	600	6	
Ammonium nitrate	Solid	bag (kg)	1000	30	30	10.5	23

TABLE 2: ASSESSMENT OF SPILL RISK AND CONSEQUENCE ALONG ACCESS ROAD

Km from Mine From	To	Proximity to Water	Ground Type	Grade	Alignment	Containment	Risk	Consequence	Comment
Prairie/Fast Creek									
0	3.5	30-80	Silty sand	Flat	Broad curves	Readily contained	Low	Low	Creek or channel not near road
3.5	4.0	0	Sandy gravel	Flat	Broad curves	No containment	Low	High	
4.0	4.9	30-50	Sandy gravel	Flat	Broad curves	Can be contained	Low	Moderate	Creek or channel not near road
4.9	5.1	0	Sandy gravel	Flat	Straight	No containment	Low	High	
5.1	5.3	20-100	Silty sand	Flat	Straight	Can be contained	Low	Moderate	Saddle with ditches
5.3	7.0	10-50	Sandy gravel	Flat	Straight	No containment	Low	High	
Funeral Creek									
7.0	11.7	0-50	Silty sand	Gentle	Broad curves	No containment	Moderate	High	
11.7	16.7	0-30	Sandy gravel	Steep	Straight	No containment	High	High	Km 13 hairpin. Steep slopes inhibite response
Sundog Creek									
16.7	22.7	0-30	Sandy gravel	Gentle	Straight	Can be contained	Low	Moderate	Creek not fish-bearing year round
22.7	23.0	0-50	Sandy gravel	Steep	Straight	No containment	High	Moderate	1.5 km from falls and possible seasonal fish
23.0	28.8	0-20	Sandy gravel	Gentle	Straight	No containment	Moderate	High	Steep slopes inhibiting response
28.8	39.2	0	Gravel	Flat	Straight	No containment	Low	High	Low accident risk but high consequence
Sundog Creek tributaries									
39.2	52.0	0-1000	Silt/organic	Flat	Straight	Readily contained	Low	Low	Except for small triburary crossings
52.0	55.0	300-1000	Silt/organic	Gentle	Straight	Readily contained	Moderate	Moderate	Except for Polje Creek. Karst features
Tetcela & Fishtrap									
55.0	83.0	100-1000	Silt/organic	Gentle	Straight	Readily contained	Low	Moderate	
83.0	93.0	0-1000	Silt/organic	Flat	Straight	Can be contained	Low	High	Extensive wetlands
93.0	101.0	300-2000	Silt/organic	Steep	Curves	Difficult containment	High	Moderate	Wooded slope
Wolverine Pass to Grainger Gap									
101.0	123.0	1000-2000	Silt/organic	Flat	Straight	Readily contained	Low	Low	
Grainger Gap to Liard									
123.0	126.0	0-100	Silty sand	Flat	Straight	Can be contained	Low	Moderate	Grainger River headwaters
126.0	156.0	>2000	Silty sand	Flat	Straight	Readily contained	Low	Low	Except for small triburary crossings
Liard Ice Bridge									
156.0	157.0	0	Ice	Flat	Straight	No containment	Low	High	
Old Logging Road									
157.0	170.0	200-1000	Silt	Flat	Straight	Can be contained	Low	Moderate	

APPENDIX J

Terms of Reference

Technical Advisory committee

APPENFIX J
DRAFT TERMS OF REFERENCE - TECHNICAL ADVISORY COMMITTEE

An existing Parks Canada/CZN/Dehcho Technical Committee currently meets approximately every 4 months to discuss issues of mutual interest. CZN proposes that this committee be replaced by a Technical Advisory Committee (TAC) for mine operations and include local Band representation. Meetings will be held in locations proximal to the project and communities.

This document is a draft terms of reference for the TAC.

Location and Frequency of Meetings

We propose that 3 meetings be held each year. A winter meeting (January) would be held in Nahanni Butte. Travel to the community will be possible by road and ice bridge. The Mine access road will also be open and in operation, affording an opportunity for TAC meeting attendees to observe activities. A spring meeting (May) would be held in Fort Simpson, and a summer meeting (August) held at the Mine site which would include a site tour and inspection.

Committee Composition and Attendance

CZN proposes that the meetings be co-chaired by representatives from CZN and Parks Canada. This is meant to be a procedural function. These representatives will also be responsible for meeting arrangements, circulation of agendas and meeting minutes. The Nahanni Butte Dene Band and Lidlii Kue First Nation will be asked to nominate a representative for meeting attendance. However, the meetings will be open to other Bands and the general public.

The meetings will also be open to regulatory representatives. Regulators will be encouraged to attend the Fort Simpson meeting as this would be the main annual meeting at which monitoring data would be reviewed and discussed.

Scope of the Committee

The intention is for the meetings to be an appropriate forum to review operations, consider monitoring data, and decide on any need for adaptive changes. Band members and the public can ask questions and raise concerns. Regulators can do the same, and also be available to answer questions from the Bands and public.

The TAC is not intended to replace established regulatory systems and responsibilities. Rather, it is intended as a forum to discuss results and issues, and consider operational changes. It is also a forum for community members to see environmental management and regulatory processes at work, and to allow individuals to make comments.

The formation of a TAC is partly based on the recognition that there are multiple interests in the region, including CZN's interest in the Mine, Parks Canada's interest in the NNPR, and NBDB and LKFN interest in their traditional lands. The TAC provides an opportunity for all parties to meet and discuss issues of mutual interest, given that there is a shared management approach to the region's natural resources.

For the most part, Mine staff will be responsible for collecting and reporting monitoring data, and for undertaking studies directly related to the Mine operation. From time to time, the TAC may decide that additional monitoring or studies are warranted. At that time, consideration will be given to responsibilities and cost sharing depending on the nature, scope and focus of the work. If the decision is made that an external party (e.g. a consultant) should be hired to undertake the work, the TAC will consider candidates and agree on a selection that is acceptable to all parties.

APPENDIX K

Draft Wildlife Mitigation and Monitoring Plan

February 23, 2011

DRAFT WILDLIFE MANAGEMENT PLAN

Canadian Zinc Corporation Prairie Creek Mine, Northwest Territories

Submitted to:
Canadian Zinc Corporation
Suite 1710, 650 West Georgia Street
Vancouver, BC
V6B 4M9

REPORT

Report Number: 09-1422-5007/1000/1030

Distribution:

1 Copy - Canadian Zinc Corporation

2 Copies - Golder Associates Ltd.

Golder Associates

Executive Summary

This report presents an outline of a draft Wildlife Management Plan (WMP) prepared on behalf of Canadian Zinc Corporation (CZN) for its Prairie Creek Mine located in the Northwest Territories (the Project). The current mine development includes surface buildings and mine infrastructure as well as underground workings that extend into the adjacent slopes of the Prairie Creek valley. Current access to the mine site is by air to an airstrip located 1.5 km north of the mine site. A previously used access route connects the mine site with the Liard Highway east of Nahanni Butte. Several realignments to the route have been proposed to avoid difficult ground conditions and more sensitive environmental areas. The Prairie Creek Mine is located on land surrounded by the Nahanni National Park Reserve (NNPR), which includes approximately 80 km of the western portion of the 174 km access road.

A “Vegetation and Wildlife Assessment Report” was prepared by Golder Associates Ltd. (Golder) in 2010, which was included with CZN’s Developers Assessment Report (DAR) and submitted to the Mackenzie Valley Environmental Impact Review Board (MVEIRB) in 2010. Subsequent to a review of the DAR, a series of Information Requests (IRs) were sent to the MVEIRB and subsequently to CZN for response. Technical Meetings were held in October 2010 wherein additional comments were provided by federal government agencies, specifically Parks Canada Agency (PCA) and Environment Canada (EC). Several of the IRs centered on additional information being provided by CZN on aspects related to mitigation and management of potential impacts on wildlife from operation of the mine and access road.

An important component of any WMP is to develop effective mitigation and monitoring programs and incorporate monitoring results into wildlife management, in order to minimize impacts and measure if project-related effects exceed predicted impacts. This WMP is based on adaptive management principles and consists of two major components: Project *mitigation* that guides mine and access road operation, and Project *monitoring* that measures the effectiveness of mitigation measures.

The purpose of the WMP is to ensure that effects of the Mine and access road on wildlife are minimized. The *Mitigation* section outlines practices and procedures aimed at preventing, minimizing or mitigating potential adverse effects of the project on wildlife and wildlife habitats. The *Monitoring* section outlines the steps considered necessary to ensure that mitigation measures are effectively minimizing effects of the Mine, access road, and associated infrastructure on wildlife and wildlife habitats in the Project Area. The WMP must be flexible enough to incorporate comments, suggestions, and information based both on science and local ecological and traditional knowledge. The WMP is a dynamic document that will be further developed and evaluated as the Project proceeds.

Study Limitations

This Draft Wildlife Management Plan was prepared by Golder Associates Ltd. for Canadian Zinc Corporation and is intended as a framework for implementing mitigation and management practices related to potential impacts on wildlife from the Prairie Creek Mine project. The Draft Wildlife Management Plan outlined herein is based on the principle of adaptive management whereby approaches to management of potential impacts on wildlife will be modified over the years of mine operation, on the basis of new information provided through monitoring of the mine and access road operation. The material in this report reflects Golder's best judgment in light of information available to it at the time of preparation, with the understanding that the procedures and practices will change over time.

Any use which a third party makes of this report or any reliance on or decisions to be made based on it, are at the sole risk and responsibility of such third party. Golder accepts no responsibility for damages, if any, suffered by any third party as a result of decision made or action based on this report.

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1.0 INTRODUCTION

1.1 Project Background

Canadian Zinc Corporation (CZN), based in Vancouver, British Columbia (BC), has proposed to reopen the Prairie Creek Mine for production (the Project). The mine is located at approximately 61^{o} 33' north latitude and 124^{o} 48' west longitude adjacent to Prairie Creek, a tributary of the South Nahanni River, Northwest Territories (NT). Prairie Creek flows into the South Nahanni River approximately 43 km downstream of the Prairie Creek Mine.

The current mine development includes surface buildings and mine infrastructure as well as underground workings that extend into the adjacent slopes of the Prairie Creek valley. Current access to the mine site is by air to an airstrip located 1.5 km north of the mine site. A previously used access route connects the mine site with the Liard Highway. The access route is to be reinstated with several realignments to avoid difficult ground conditions and more sensitive environmental areas. The length of the realigned access road is approximately 174 km. The Prairie Creek Mine is located on land surrounded by the Nahanni National Park Reserve (NNPR). Approximately 80 km of the western portion of the 174 km access road crosses the NNPR.

Golder Associates Ltd. (Golder) prepared a baseline data summary and assessment of the potential effects of reopening the access route and bringing the mine to full production capacity on vegetation and wildlife. This report was incorporated by CZN into its Developer's Assessment Report (DAR) for the proposed mine reopening. Golder (2010) reviewed the potential effects associated with full operation of the mine site on wildlife, and concluded that for most species, significant effects from mining, processing ore to concentrate, and transporting the concentrates out on the access road are not expected to occur. However, sensory disturbance and human presence may result in avoidance of the mine site by some wildlife species or attraction and resulting interaction, notably by caribou (*Rangifer tarandus*), Dall's sheep (*Ovis dallli*), wolverine (*Gulo gulo*), gray wolf (*Canis lupus*), and grizzly bear (*Ursus arctos*).

An assessment of project-related effects on wildlife and wildlife habitat results in predicted outcomes. Therefore, it is important to develop effective mitigation and monitoring programs and incorporate monitoring results into wildlife management in order to minimize impacts and measure if project-related effects exceed predicted impacts. This Wildlife Management Plan (WMP) is based on adaptive management principles and consists of two major components: Project *Mitigation* that guides mine and access road operation, and Project *monitoring* that measures the effectiveness of mitigation measures.

1.2 Objectives

The WMP for the Prairie Creek Mine is designed as a comprehensive plan that incorporates site activities, reviews potential site impacts and outlines adaptive management measures to mitigate potential effects. The purpose of the WMP is to ensure that effects of the Mine and access road on wildlife are minimized. The *Mitigation* section outlines practices and procedures aimed at preventing, minimizing or mitigating potential adverse effects of the project on wildlife and wildlife habitats. The *Monitoring* section outlines the steps considered necessary to ensure that mitigation measures are effectively minimizing effects of the Mine, access road, and associated infrastructure on wildlife and wildlife habitats in the Project Area.

1.3 Adaptive Management Approach

The WMP is based on the principles of adaptive management. Adaptive management is a structured, iterative process of decision making over time as experience is gained and new information is obtained. The objective of adaptive management is to reduce uncertainty through monitoring, or ‘learning by doing’. In the case of the Project, the ‘doing’ is the wildlife monitoring program and the ‘learning’ is continual improvements to the WMP. This requires the WMP to be adaptive and flexible. As such, the results of wildlife monitoring will be periodically reviewed, focusing on identifying any areas in which mitigation measures are failing to minimize project effects to wildlife or wildlife habitats, or areas where project impacts to wildlife or wildlife habitat are exceeding predictions.

The WMP must also be flexible enough to incorporate comments, suggestions, and information based both on science and local ecological and traditional knowledge. Feedback and suggestions from employees will be a key element in wildlife interaction prevention analysis. If Project-related effects to wildlife are detected by the monitoring program, the most suitable course of action will be determined by CZN, in consultation with the local communities and the appropriate regulatory agencies. The WMP is a dynamic document that will be further developed and evaluated as the Project proceeds.

2.0 PROJECT DESCRIPTION

The Prairie Creek Mine site has been in place since 1982, including all surface facilities required for full scale mining operations, with the exception of the 6 ha waste rock storage area that will be needed at mine start-up. Once fully operational, the mine will encompass approximately 65.5 ha, a relatively small and compact area of disturbance. Mine facilities are located immediately adjacent to the underground portal and mine shops, including the camp, fuel storage, and water storage pond (WSP), while the airstrip is located 1.5 km north of the mine site.

The original Prairie Creek Mine access road has been in existence since 1980. Proposed improvements to the access road, including 63 km of realignments in the first winter of operation, will result in a total length of 174 km. This will be accomplished with equipment working along the alignment from November to mid-January. The new route will cross the Liard River via an ice bridge in the vicinity of Swan Point. After crossing the ice bridge, the route joins an old logging road which follows the east side of the Liard River to join into the existing Nahanni Butte all season road to its junction with the Liard Highway. The Liard ice bridge will be available for concentrate haulage traffic on average from mid-January to the end of March.

Canadian Zinc will operate two transfer facilities along the access road: one near the mid-point of the road called the Tetcela Transfer Facility (TTF; 2.0 ha in area) and one near the junction of the Liard Highway, called the Liard Transfer Facility (LTF; 2.8 ha in area). The TTF will operate from December to early March each year. The haul of concentrates by the Mine truck fleet will commence from the Mine once the portion of the road from the Mine to the TTF is open, which is expected to be in early December. When the remainder of the road opens, which is expected to be by mid-January, contractor trucks will collect the concentrates in storage and truck them out to the LTF, with an expected completion by early March. The Cat Camp is presently located along the access road to the east of the Mackenzie Mountains and consists of trailers and small fuel storage tanks (less than 1 ha in total).

3.0 SCOPE OF THE WMP

3.1 Background

The WMP is intended to provide a blueprint for wildlife impact mitigation and monitoring at the Prairie Creek Mine site and along the access road. This document applies to everyone working, visiting or inspecting the mine site and operation of the Project, regardless of their relationship to CZN. Ultimately, the WMP will have two audiences: the community and government stakeholders who have concerns about Project effects to wildlife; and mine environmental staff who carry out the monitoring. This document should provide background rationale and information on data collection and analysis to assess if the plan will adequately monitor project effects to wildlife.

The WMP will attempt to:

- Provide information to assess anticipated project impacts;
- Outline mitigation to reduce the risks and disturbance to wildlife and wildlife habitat;
- Determine the effectiveness of wildlife mitigation;
- Meet regulatory requirements and corporate commitments for monitoring as outlined in the DAR and subsequent correspondence during the EA review period;
- Design studies and data collection protocols that are consistent with initiatives for impact mitigation and monitoring in the region;
- Propose thresholds and adaptive management triggers that can be used as early warning signs for reviewing and considering the implementation of additional wildlife mitigation measures;
- Describe a process for regularly reviewing Project operation, mitigation, monitoring and management;
- Outline a means to provide results to communities, governments, and the public; and
- Receive and incorporate input from First Nations and government agencies.

3.2 Study Area

The study area for the WMP includes the Prairie Creek Mine site footprint, the airstrip, and the access road. The Prairie Creek Mine site is located in the Mackenzie Mountains that locally comprise low mountains with moderate to steep sides and intervening valley bottoms. The mine site is located within the Spruce/Lichen vegetation unit (Beak 1981) at an elevation of approximately 850 m. Above the mine site, this unit grades into the Sub-alpine Shrub zone (dwarf birch and willow with scattered, stunted black spruce), which in turn grades into the Alpine Tundra zone at higher elevations. As is typical of this region, the sparse tree and shrub cover associated with the lower valley slopes is due to cold air drainage within valley bottoms, which limits growth of trees.

The access road crosses a number of vegetation units as described by Beak (1981). From the Mine site in the Mackenzie Mountains, the access road traverses Spruce/Lichen, Sub-alpine Shrub, Alpine Tundra, Black Spruce Parkland, Riparian Alluvial, Pine Parkland, Mixed Coniferous-Deciduous, Black Spruce Muskeg, Grainger Tillplain, Floodplain/Tillplain, and finally Aspen-Liard Floodplain at the Liard River.

3.3 Valued Components

The WMP, while covering the broad range of species occurring within the Project area, focuses on wildlife Valued Components (VCs) that were identified in the supplemental *Vegetation and Wildlife Assessment Report* to the DAR. Wildlife VCs represent species and species habitats considered to be important to local First Nation, social, cultural, economic, or aesthetic values and scientific community concerns. Factors considered when selecting VCs included the following:

- First Nation concern with respect to traditional use;
- Required by or compatible with regulatory requirements and existing initiatives (*e.g.,* wildlife listed under the NWT Status Ranks, Schedule 1 of the Species at Risk Act, and wildlife assessed by the Committee on the Status of Endangered Wildlife in Canada [COSEWIC]);
- Known to be important to residents, managers, and regulators (*e.g.,* harvested species);
- When taken together, reflect overall environmental and social conditions; and
- Can be easily measured or described with one or more practical indicators (*i.e.,* measurement endpoints).

An important aspect of the VC selection process is that it reflects concerns raised by First Nations and government agencies. The following table (Table 1) presents identified VCs and the rationale for their inclusion.

Table 1: Wildlife Valued Components (VCs) identified in the Prairie Creek Mine and Access Road Project Area

VC	Rationale for Inclusion	SARA Listing	COSEWIC Listing	GNWT Listing
Woodland caribou (*Rangifer tarandus*)	*Northern Mountain Ecotype* ■ Confirmed present in the Project area during winter. ■ Designated as Special Concern under SARA. ■ Designated as Special Concern under COSEWIC. ■ Highlighted by GNWT as at-risk for access road related mortality during winter hauling operations. ■ Species of local economic importance to hunters/outfitters.	Special Concern	Special Concern	Secure
	Boreal Ecotype ■ Confirmed present at the eastern portion of the Project area. ■ Designated as Threatened under SARA. ■ Designated as Threatened under COSEWIC. ■ Highlighted by GNWT as at-risk for access road related mortality during winter hauling operations.	Threatened	Threatened	Sensitive

VC	Rationale for Inclusion	SARA Listing	COSEWIC Listing	GNWT Listing
Grizzly Bear (*Ursus arctos*)	■ Confirmed present in the Project area. ■ Designated as Special Concern under COSEWIC. ■ Highlighted by GNWT as at-risk for wildlife encounters at mine site during spring, summer, and fall.	None	Special Concern	Sensitive
Wolverine (*Gulo gulo*)	■ Confirmed present in the Project area. ■ Designated as Special Concern under COSEWIC. ■ Highlighted by GNWT as at-risk for wildlife encounters at mine site during all seasons.	None	Special Concern	Sensitive
Wood Bison (*Bos bison athabascae*)	■ Confirmed present in the Project area. ■ Designated as Threatened under SARA. ■ Designated as Threatened under COSEWIC. ■ Designated as At Risk under GNWT General Status Ranks of Wild Species. ■ Highlighted by GNWT as at-risk for access road related mortality during winter hauling operations.	Threatened	Threatened	At Risk
Dall's sheep (*Ovis dalli*)	■ Confirmed present in the Project area. ■ Highlighted by GNWT as at-risk for aircraft related disturbance at the mine site during the spring lambing season. ■ Species of local economic importance to hunters/outfitters.	None	None	Secure
Moose (*Alces alces*)	■ Confirmed present in the Project area. ■ Highlighted by GNWT as at risk for access road related mortality during winter hauling operations. ■ Identified as important to First Nations as traditional food source. ■ Source of local economic importance to hunters/outfitters.	None	None	None
Raptors	■ Peregrine falcon (*Falco peregrines anatum*) designated as Threatened under SARA. ■ Short-eared owl (*Asio flammeus*) designated as Special Concern under SARA and COSEWIC.			
Waterfowl	■ Horned grebe (*Podiceps auritus*) designated as Special Concern under COSEWIC.			
Passerines	■ Rusty blackbird (*Euphagus carolinus*) designated as Special Concern under SARA and COSEWIC, designated as May Be At Risk under GNWT Status Ranks. ■ Olive-sided flycatcher (*Contopus cooperi*) designated as Threatened under SARA and COSEWIC.			
Non-passerines	■ Common nighthawk (*Chordeiles minor*) designated as Threatened under SARA and COSEWIC.			

4.0 PROJECT ISSUES AND CONCERNS

The WMP considers the potential for effects to wildlife associated with mine site and access road activities during Project operation. The WMP considers impacts to wildlife habitat, movement, behaviour, and abundance. Direct impacts to wildlife habitat include any Project activities that may compromise, create or alter habitat or result in wildlife mortality. Indirect impacts alter wildlife movement, behaviour, or abundance through sensory disturbance. Impacts can result from Project activities or features that:

- Attract wildlife;
- Disrupt, impede or reduce movement;
- Alter behaviour; or
- Cause direct or indirect wildlife mortality.

The impacts and associated mitigation strategies described herein are applicable to a broad range of wildlife. Potential Project-related impacts to wildlife include:

- Direct and indirect effects to wildlife health and mortality;
- Changes in behaviour from attraction or avoidance by wildlife from adjacent areas;
- Direct and indirect wildlife mortality due to an increase in trapping and hunting activities associated with the access road (related to improved access and increased effectiveness of those activities);
- Impediment, disruption, or reduction of movement for individuals in local populations along traditional travel routes;
- Alteration in wildlife behaviour or wildlife mortality from human, vehicle, or aircraft interactions and collisions; and
- Disturbance related (*e.g.*, noise) and physical barriers from access roads.

Detailed descriptions of impact pathways and potential effects on wildlife are found in Golder 2010. It is not the intent of this document to provide an impact assessment, but to provide a plan to manage and reduce risks to wildlife.

5.0 WILDLIFE MITIGATION

Mitigation aims to prevent adverse impacts from occurring and keeping those that do occur within an acceptable level. The elements of mitigation are generally organized into a hierarchy of actions, including:

- Avoidance of adverse impacts as much as possible by use of preventative measures; and
- Minimizing adverse impacts to “as low as practicable” levels.

The mitigation practices outlined below will be implemented to accommodate the natural behaviours of wildlife where possible; and where not possible, to deter wildlife from actively using Project sites. The protection of human life must be paramount; however the preservation of wildlife health and natural behaviours (patterns of migration, reproduction, *etc*.) is also important.

5.1 General Procedures and Practices

General mitigation includes rules and procedures for employees and contractors necessary to ensure worker safety and limit attraction and disturbance of wildlife. The Government of Northwest Territories has developed guidelines to protect wildlife during resource development activities. For this project, guidelines found in the “Safety in Grizzly and Black Bear Country” document will be followed to prevent and mitigate bear-human interactions. In addition, the following general mitigation strategies are intended to reduce or avoid effects to wildlife and wildlife habitat during Project operation:

- All relevant observations of wildlife (particularly of Dall’s sheep, caribou, grey wolf, wolverine and grizzly bear) will be reported to mine environmental staff;
- If a bird nest is found on site and eggs are present, monitoring will be conducted and efforts will be made to avoid the area. Any raptor nesting activity observed within 1.5 km of the Project will be reported to GNWT ENR;
- An effective Waste Management Plan will be implemented, particularly as it relates to the disposal of food waste;
- Hunting, trapping, harvesting, and fishing by site employees and contractors will be prohibited;
- Non-mine vehicles, including all terrain vehicles (ATVs) and snowmobiles will be prohibited on site;
- Pets will be prohibited on site; and
- The appropriate regulatory agencies (*i.e.,* GNWT ENR and Parks Canada) will be contacted to receive additional direction regarding new issues that arise.

5.2 On-Site Education

To limit impacts to wildlife, an education strategy will be implemented that consists of a detailed site orientation session for all site personnel and visitors. The orientation session will include a general wildlife education component in addition to Project-specific rules related to wildlife right-of-way, traffic management, and minimizing employee-wildlife interactions. Prior to participation in field activities associated with the Project, site personnel and visitors must attend the detailed orientation session and must review all operating procedures appropriate to their tasks and responsibilities.

The following will be incorporated into an employee education and awareness program:

- On-site personnel will receive basic bear awareness and safety training, including information on bear behaviour, how to avoid bear encounters, and how to respond to bears in the case of an encounter. The existing bear management plan should be reviewed to ensure it includes the following elements:
  - A designated system for reporting and recording bear sightings at and near the mine site and access road. All bear observations will be recorded with geographic locations and entered into a database;
  - A bear warning system to instantly warn workers of the presence of bears in the immediate vicinity of the mine site (*e.g.*, two-way radio broadcast, loudspeakers);
  - A structure for reporting bear-human encounters and resulting incidents to inform mine management and GNWT ENR staff;
  - A protocol for dealing with problem bears, with a designated chain of responsibilities for ensuring worker safety and efficient and speedy resolution of incidents; and
  - Annual reporting of bear observations, movements, incidents and how incidents were resolved.
- On-site personnel will be educated on the applicable policies and practices contained within this WMP and other Project commitments, particularly waste management practices;
- On-site personnel will be educated on wildlife issues and monitoring activities in the Project area and will be able to identify and report any of the animal species listed in Table 1; and
- On-site personnel will be discouraged from using areas outside of immediate work sites.

5.3 Wildlife-Human Conflict Management

A key concern in all aspects of the Prairie Creek Mine project is the protection of humans and wildlife. General wildlife-human conflict management policies are aimed at minimizing or preventing wildlife problems through the training of employees, treatment of problem animals, the management of food and garbage, and the establishment of procedures and policies on wildlife management.

5.3.1 Employee Safety

- On-site personnel will be provided with access to bear deterrents, such as air horns, bear spray and/or bear bangers. Personnel working in remote areas should carry personal bear deterrents and two-way radios at all times. Pilots must be informed when transporting personal bear deterrents by aircraft and the transport of such materials must be in accordance with Transport Canada requirements. Noise devices should not be used unnecessarily to avoid unwarranted disturbance to other wildlife;
- Personnel working outside will be made aware of visual or auditory barriers that may contribute to surprising bears and other wildlife (*e.g.*, noise of running water, high winds, *etc.*);
- If an employee encounters an animal exhibiting signs of aggression or if the employee feels that the animal represents a legitimate threat to their health and safety, employees will immediately vacate the area and immediately report the incident to the Mine Manager; and
- If a wildlife threat is identified in an area (*e.g.*, a problem bear), warnings will be broadcast by two-way radio, loudspeaker and signage will be posted at specific sites to inform personnel of the potential risk.

5.3.2 Prevention and Treatment of Problem Animals

- Wildlife sightings in proximity to the Mine site and access road will be recorded in a wildlife log (see Section 6.2);
- The appropriate regulatory agencies (*e.g.*, GNWT ENR and Parks Canada) will be informed of any incidents with problem bears or other wildlife prior to action, unless imminent worker safety is at risk (see Section 6.2);
- Bear use of habitats near mining infrastructure (*e.g.* spring foraging by bears in disturbed areas) will be documented (see Section 6.2). Additional monitoring and mitigation measures may be developed in response to this information;
- Several on-site employees will be trained in methods of deterring and moving animals away from hazardous areas (such as roads, camp, and other mine infrastructure). At least one trained employee will be on-site at all times. All deterrent actions taken will start with the least intrusive method, and then increase in intensity until wildlife may need to be relocated or destroyed (see Section 7.0). Each deterrent action will stop as soon as the animal moves away from the potentially hazardous site or activity. Records of deterrent action will be included in a wildlife incident report that will be forwarded to the appropriate regulatory agencies;
- Only designated on-site personnel will be authorized to carry firearms, which may be employed if human life is at risk; however non-lethal management techniques aimed at avoiding the destruction of wildlife will be employed first whenever possible (see section 7.0);
- Dead wildlife encountered in proximity to the mine site and access road will be recorded and geo-referenced (see Section 7.5). Mine environmental staff will alert GNWT ENR and Parks Canada, and at their discretion, carcasses will be transferred to Nahanni Butte, or incinerated;

- All buildings and stairs will be skirted to discourage their use by small wildlife; and
- The storage of soda ash on site will be secured and contained so that spillage does not occur. Dall's sheep are presently attracted to this source and this will be prevented in the future.

5.3.3 Waste Management and Camp Infrastructure Organization

Waste management is a key element of effective wildlife conflict management. A Waste Management Plan provides a framework for minimizing and disposing of attractants such as garbage, food wastes, and other edible and aromatic substances. A Waste Management Plan outlined in the DAR provided an outline of measures to reduce the attractants of bears and wolverines to the mine site and transfer stations, with active management of food materials and food and other camp wastes. The overall Waste Management Plan should be based on the following key principles:

- Health and safety of all site employees, visitors, and environment;
- Reduction, reuse, and recycling of waste materials;
- Proactive management of wastes that may attract wildlife or result in the interaction between humans and wildlife; and
- Environmental awareness and waste management training.

The existing Waste Management Plan will be updated and will incorporate the following:

- A Solid Waste Facility that will consist of four different cells: belts and tires; incinerator; hydrocarbon contaminated material; and, sewage sludge. Of these, only the sewage sludge is expected to be an attractant to wildlife. This cell will be fenced, chain link, non-electrified with a minimum 6 foot height. The fence will include solid, reinforced posts. The fence will be placed along the centre-line of a containment berm (see Figure 6-16 in the DAR), and there will be a gate of similar height on wheels to allow for truck entry. The elevated location of the fence and low annual snow depth will keep out bears in snow free seasons and wolves and wolverine in the winter;
- Food waste will be collected and incinerated on a daily basis. This is done at present, and no animal attraction issues have been encountered to date. Limited food supplies will be stored inside the Transfer Stations, and waste will also be collected for transfer to the Mine. As noted above, the road construction and operating period will be within the period of bear hibernation. These measures will follow northern industry practices;
- A no littering policy, specifically with respect to food materials;
- A no feeding of wildlife policy;
- Separation of food waste and non-food waste at source;
- Not permitting food and beverages and their containers in any outdoor areas;

- Assigning designated contained areas for lunch and coffee breaks;
- Storing all food and garbage in bear-proof areas or bear-proof containers;
- Storing all grease, oils, fuels or antifreeze in bear-proof areas or containers; and
- Storing incinerator spare parts on-site to prevent lengthy breakdowns and subsequent extended waste storage.

5.4 Management of Toxic Substances

Management measures that are or will be in place with respect to potential contaminated substances include:

- Appropriate materials management systems to minimize the risk of accidental spills or leakage of concentrate, diesel fuel, other hydrocarbons, and other hazardous materials being shipped to/from the mine site;
- The existing Spill Management Plan will be reviewed and improved as necessary prior to full operation of the Prairie Creek Mine. This plan will include provision for rapid deployment of cleanup crews and for containment and clean up of spilled material and contaminated surfaces;
- Fuel storage at the mine site will be in tanks and within a bermed area to contain any potential spill or leak (already on site since 1981). Fuel will be brought to the mine along the access road from the Liard Highway and will be shipped on backhauls by the concentrate haul fleet;
- Other hydrocarbons (*e.g.,* lubricants, oils, solvents) will be transported in approved drums or other containers and stored at the mine site in such approved containers and within designated locations for hydrocarbon storage. Spill containment will be implemented and spill contingency plans will be established. Minor spillage of hydrocarbons may occur on an infrequent basis but mostly inside at the mine shops, and occasionally outside in the mine and camp complex;
- Chemicals used in the ore milling process, explosives manufacture or for shop or maintenance purposes will be transported and stored in approved containers and will be handled with care to prevent loss of material to outside areas (*e.g.,* the mill, warehouse and shops);
- Explosives used will be emulsions produced in an on-site plant. Storage of explosives in the plant area will be strictly controlled to prevent accidental detonation. Only authorized personnel will be allowed to transfer explosives, and in a dedicated truck only;
- Sewage sludge will be stored at the waste rock pile area in a dedicated solid waste facility. The sludge cell will be fenced to deter wildlife entry;
- A contaminated soil land-farm will also be established in the solid waste facility to bio-remediate contaminated soil and will not constitute an attractant to wildlife;
- Used lead batteries and other batteries used for mining, ore milling, shops, or camp activities will be collected at the hazardous waste storage location and will be returned by surface shipment to a recycle facility on an annual basis;

- Concentrate from the ore milling process will be bagged in a bagging plant with dust control. Bagging will be in a dedicated location. Bags will be stored in a concentrate shed until the winter haul period; and
- Measures aimed at reducing the number of birds that use the water storage pond (WSP) will be implemented. Measures may involve the use of scare tactics to dissuade birds from landing on the WSP, such as fake raptors or markers (streamers, flags, long stringers of flagging, *etc*.). Noise deterrents (*e.g*., scare cannons, pyrotechnics, *etc*.) will be used as a last resort, as they could disrupt other wildlife in the area. All observations of birds at the WSP will be reported to mine environmental staff. Information on species, number, age, activity, and success of scare tactics will be recorded. The results of the monitoring will be summarized in reports and submitted to the appropriate regulatory agencies (see section 6.2).

5.5 Management of Sensory Disturbance

The mine site is compact, and there are limited opportunities to reduce equipment use, vehicle traffic, surface light sources, or other activities associated with the Prairie Creek Mine. Management measures that are or will be in place with respect to sensory disturbances to wildlife include:

- Power generating equipment will be fitted with industry standard muffler systems;
- Where feasible, lighting sources will be designed to minimize fugitive light emissions onto adjacent wildlife habitat;
- To reduce noise along the access road, the use of “Jake” brake engine retarders will be discouraged;
- Flight paths to and from the mine will be considered according to the recommended guidelines for flying in caribou country (MPERG 2008), where feasible and within topographic and safety constraints;
- Flights paths to and from the mine will be considered according to recommended guidelines for flying in sheep country (MERG 2002), where feasible and within topographic and safety constraints; and
- A Dall’s sheep monitoring program will be implemented to ensure that Project-related effects on sheep are minimized (see Section 6.2). Based on results of the sheep monitoring program, the existing Flight Impact Management Plan will be updated to develop operational flight guidelines that can be safely implemented.

5.6 Vehicle Procedures and Practices

Vehicle-wildlife collisions can result in injury or mortality to people and/or wildlife, as well as damage to vehicles. The following mitigation strategies will be used to reduce the potential for negative interactions.

5.6.1 Traffic Management

- The airstrip will be checked and cleared of wildlife prior to aircraft landing or taking off;
- Emergency procedures to remove wildlife from the airstrip or access road will be developed;
- Maximum traffic speeds for all sections of the access road will be implemented accounting for road grade, curvature, adjacent sensitivities and sight-lines. Lower maximum speeds may be posted in the vicinity of sensitive wildlife areas, such as areas of high probability of occupancy by caribou and known crossing locations identified during the winter aerial surveys and the ongoing monitoring program;
- Vehicle operators will yield right-of-way to wildlife and will take all reasonable measures to avoid vehicle-wildlife incidents. When VC species listed as “May Be at Risk” or “At Risk” under the NWT Status Ranks or “Special Concern”, “Threatened”, or “Endangered” on Schedule 1 of SARA) are visible on the road (see Table 1 for species ranks), vehicle activity will cease (*i.e.,* speeds reduced to zero) until the animals have moved a safe distance away or are no longer visible;
- A highly visible signage system will be installed at the mine site and the south-eastern terminus of the access road to alert drivers of “caution zones” and recent wildlife activity along the access road. The Wildlife Monitor will ensure that signage is updated as new wildlife observations and incidents are reported. Caribou activity will be highlighted on these signs;
- A temporary (movable) signage system will be employed along the access road to inform vehicle operators of temporary vehicle/wildlife conflict areas (information on which would also be provided to drivers before their journeys);
- All vehicles will be equipped with two-way radios. Relevant wildlife sightings along the access road will be geo-referenced (according to the posted road km markers) and reported immediately to road supervisors who will issue travel alerts to drivers. The report will include the species, number, geographic location and approximate road km marker; and
- Snow removal along the access road should ensure that high banks (> 1 m) are avoided to provide adequate sightlines for drivers and so wildlife do not become “trapped” on the roadway as vehicles approach. In locations where build up of snow is an issue for wildlife, lower snow banks and the creation of gaps/push-outs every 100 m will be beneficial so that wildlife can readily move off the roadway. This can be confirmed during the first year of operation of the access road, specifically with respect to locations where wildlife has been recorded crossing the access road.

5.6.2 Access Road Use Control

- Use of recreational vehicles will be prohibited;
- Signage at the south-eastern terminus of the access road will be installed to inform the public of the high utilization status of the road by heavy vehicles and to deter non-mine related use;
- Non-mine road traffic, including ATVs and snowmobiles will be deterred from using the road by installing a check-point and screening station near the south-eastern terminus of the access road, manned by representatives from the Nahanni Butte Dene Band;
- Public use of the access road and evidence of land use, such as hunting, fishing, camping, or firewood harvesting will be noted and reported to road and mine management staff and the appropriate regulatory agencies; and
- The south-eastern end of the access road will be blocked at specified locations after each hauling season with gates, berms, pits and/or boulders to discourage use.

6.0 WILDLIFE MONITORING

Wildlife monitoring and reporting is important to limit human-wildlife interactions. Effective monitoring and reporting can be used so that wildlife attractant issues are resolved, nuisance animals are dealt with effectively, and adaptive management may be applied to reduce the risk of future problems. The objectives of the monitoring portion of this WMP are to:

- Determine the effectiveness of mitigation implemented through the WMP;
- Present data collection techniques that contribute to understanding and managing Project-related effects to wildlife; and
- Establish action levels or triggers for early warning signs to implement adaptive management where appropriate.

6.1 Wildlife Monitor and Qualifications

CZN will retain wildlife monitors to conduct ground surveillance during the initial mine start up and production period. The Wildlife Monitor will be responsible for wildlife matters on the mine site and access road, and will have specific responsibilities for implementing the WMP and communicating wildlife-related issues to CZN, First Nations, GNWT ENR and Parks Canada. It is expected that environmental staff on shift at the mine site would take on the Wildlife Monitor role, in addition to other duties. More than one person would be trained for the Wildlife Monitor position so that at least one monitor is available on site.

The mine site Wildlife Monitors must have the following qualifications and experience:

- Knowledge of regional wildlife life history and habitat relationships (particularly listed wildlife species and other VC species described in the *Vegetation and Wildlife Assessment Report*);
- Knowledge of regional wildlife behaviour (particularly listed wildlife species and other VC species described in the *Vegetation and Wildlife Assessment Report*), including seasonal feeding habits and movement patterns during the breeding, pregnancy, birthing, post-natal, and winter periods;
- Ability to observe, record, and report on wildlife activity and habitat use in the Project area and vicinity;
- Experience working with contractors in an industrial setting and knowledge of how heavy equipment is used on industrial construction sites; and
- Ability to communicate and resolve issues of concern with contractors, equipment operators, supervisory staff, and general workers.

It will be the responsibility of the Wildlife Monitors to assist with the following:

- Reduce the risk to workers from potential wildlife encounters;
- Routinely inspect physical wildlife deterrent practices and designs;
- Encourage wildlife to leave potentially dangerous locations, or when interfering with emergency operations;
- Guide field supervisors in limiting the impact of the Project on wildlife and wildlife habitat; and
- Maintain records of wildlife sightings and incidents in a computer database system.

The mine site Wildlife Monitors will be provided with:

- Equipment such as, high-visibility vests, two-way radios, binoculars, a 12-gauge shotgun (with scare cartridges, rubber bullets, bean bags), launchers with bangers, screamers signal flares, bear spray, and a field first aid kit;
- Specialized training on the safe use of firearms, launchers, and bear spray; and
- First aid and bear awareness safety training.

The Wildlife Monitors will have access to all project activities, will interact daily with mine staff to plan activities, and will be in position to report back to the First Nations community, GNWT ENR, and Parks Canada on the effectiveness of mitigation and monitoring.

6.2 Wildlife Incidents and Reporting

A general wildlife monitoring program is proposed to identify the species, numbers and locations where interactions with wildlife occur, to identify risks to wildlife or work crews, and to describe Project-related effects to wildlife.

An "Observe, Record, and Report" policy for wildlife observations, wildlife incidents, and near misses will be implemented. For the purposes of this WMP, a *wildlife incident* is defined as an interaction between an animal and human or human property where either:

- The animal is harmed;
- The person is harmed;
- The person is threatened; or
- Significant property damage occurs.

6.2.1 Monitoring

It will be the responsibility of the Wildlife Monitors to observe and record information on wildlife presence within and adjacent to the Project area, including wildlife interactions with mine infrastructure, observations of birds on the WSP, and caribou occurrence at the mine site and along the access road (aided by road operations supervisors and sightings by truckers). The Wildlife Monitor will be mobile and proactive in investigating wildlife activity (*e.g.*, direct observations, recent tracks or feces). This will be ground-based unless aircraft are available for occasional spot checks.

Incident forms and a wildlife observation log will be made available to all mine personnel. It will be the responsibility of all mine staff to document and report wildlife observations, wildlife incidents, and near misses to the Wildlife Monitors. The purpose of a reporting and observation logging process is to assist in monitoring local wildlife populations and to aid in identifying potential problems or areas of conflict between wildlife and project components (*e.g.*, vehicles, humans, *etc.*).

It will be the responsibility of the Wildlife Monitors to collect and enter information from wildlife observations, wildlife incident forms and near misses into a tracking database. Specific attention will be given to observations of listed wildlife species and wildlife VCs at the mine site and along the access road. For each relevant wildlife observation or incident, the following information will be reported by Project personnel, and recorded by the Wildlife Monitors:

- Date and time of the observation;
- Location of the observation, with UTM coordinates where possible;
- Species and apparent physical condition of individuals;
- Number and age of individual wildlife observed;
- Activity of animals (*e.g.,* direction of movement, birthing, feeding);
- Any other potentially relevant information, including any noticeable responses to Project activities; and
- Deterrent action taken (if any).

6.2.1.1 Caribou Monitoring

6.2.1.1.1 Background

Woodland caribou in this region include both the “Northern Mountain” and “Boreal” ecotypes. Northern Mountain caribou inhabit the Mackenzie Mountains and have distinct seasonal migrations from summer to winter ranges. The available information suggests that woodland caribou of the Prairie Creek area are of the Northern Mountain ecotype, but their population affinity is not clear (*i.e.,* they may be part of the Nahanni or the Redstone population). Boreal caribou are different in that they do not occur in discrete herds but live in small, dispersed, and relatively sedentary bands east of the Mackenzie Mountains.

Surveys conducted on behalf of Cadillac Explorations in the early 1980's indicated that caribou concentrations were not found in proximity to the access road (Beak 1981). Information from outfitters based in Nahanni Butte suggests that Northern Mountain caribou congregate in the Prairie Creek drainage well to the north of the road in the fall, and migrate east to winter range.

To examine current caribou distribution in the Project area, CZN has committed to undertaking three winter surveys for caribou and other wildlife in proximity to the Mine site and access road. A two-scale survey approach was developed for the Project area and includes 1) a sub-regional caribou occupancy survey of approximately 9,000 km^2 around the mine site and access road and 2) a reconnaissance survey of the mine access road alignment. The objective of the sub-regional occupancy survey is to determine the extent of winter habitat use by caribou in the defined study area. The objective of the access road survey is to identify possible caribou road crossing locations and identify areas where vehicle-caribou conflict might occur.

In addition to the above noted caribou surveys, specific caribou monitoring activities will be implemented to provide the following real-time information during year-round mine operations and winter hauling activities:

- Information on caribou numbers, frequency of occurrence, and distribution in the Project area;
- Location of caribou and caribou aggregations in close proximity to mine infrastructure and the airstrip; and
- Location of caribou and caribou aggregations in close proximity to the access road during winter concentrate hauling operations.

6.2.1.1.2 Approach

CZN will implement the following on-going wildlife monitoring procedures specific to caribou:

- The Wildlife Monitors will conduct ground-based surveys of the access road (during winter operation), mine infrastructure sites, and the airstrip to assess caribou presence and identify caribou aggregations in the Project area.
- A radio call-in procedure will be implemented so that observations of caribou along the access road can immediately be relayed to the Road Operations Supervisor so that traffic alerts can be issued. Observations recorded by drivers during hauling will provide information about caribou crossing patterns and movement corridors along the access road.
- A procedure will be implemented so that caribou observations made by aircraft pilots during transport of crews and materials will be reported to the Wildlife Monitors. Observation recorded during air transport will provide additional information about presence of caribou in the vicinity of the mine site and access road.

As part of an adaptive management strategy, if the above-noted caribou monitoring indicates a lack of success of mitigation actions, then mitigation actions will be reassessed and modified following consultation with First Nations, GNWT ENR, and Parks Canada.

6.2.1.2 *Dall's Sheep Monitoring*

6.2.1.2.1 Background

Ungulates may expend energy when disturbed by aircraft overflights or other human activities (MacArthur *et al.* 1982, Harrington and Veitch 1992, Stankowich 2008), which may potentially impact populations. Anecdotal information suggests that Dall's sheep at the Prairie Creek Mine site are relatively tolerant of human presence and equipment noise for much of the year, but the lambing period is a key life cycle period when disturbance can be problematic for sheep. Beak (1981) identified potential lambing areas to the west and east of the Fast Creek-Prairie Creek confluence and the Folded Mountain area (refer to Figure 1 in Golder 2010). Generally, female Dall's sheep demonstrate a high degree of fidelity to their lambing ranges (Geist 1971).

The numbers of sheep lambing in immediate proximity to the mine site has not been documented. Since sheep have been attracted to the immediate mine site area by the presence of salt on site, it is possible that sheep may be lambing in proximity to the mine site and airstrip (*i.e.,* the slopes above and to the east of the WSP). Frid (2003) reported that direct aircraft over-flights by fixed-wing aircraft caused fleeing behaviour and disrupted resting of Dall's sheep in the Yukon. However, there is no specific documentation of potential consequential effects on female habitat use during the lambing period. Therefore, the purpose of the Dall's sheep monitoring program is to:

- Determine the distribution, habitat use, and movements of sheep in the study area during the parturition period;
- Determine if female sheep use specific lambing areas in the study area;
- Determine the timing of lambing in the study area; and
- Describe and compare sheep activity, behaviour, and movements in relation to the frequency and proximity of mine-related air traffic.

6.2.1.2.2 Approach

Monitoring of Dall's sheep will be conducted by a qualified wildlife biologist. The biologist must have prior experience conducting extensive behavioural monitoring studies of wildlife. In addition, the biologist must be able to recognize and record sheep behaviour. The Dall's sheep monitoring program will need to be further developed; however a general approach to monitoring is outlined below.

6.2.1.2.3 Study Area

- The study area for monitoring mine-related over-flight disturbance effects on Dall's sheep is defined by a 5-km radius around the mine site, airstrip, and airstrip approach to provide a broader picture than just the immediate Mine footprint.

6.2.1.2.4 Aerial Reconnaissance Surveys

- Prior to mine start-up, a reconnaissance-level Dall's sheep survey will be conducted by qualified personnel during the parturition period (typically mid-April to mid-June) to document sheep distribution and habitat use in the defined study area.
- The survey will be conducted by helicopter according to methods previously used in the region to document sheep distribution and lambing success (Larter and Allaire 2005). Briefly, a spaghetti-type survey technique will be used to survey all cliffs in the designated study area, keeping a height of at least 100-150 m above terrain. According to Larter and Allaire (2005), this survey technique is the most efficient way to cover mountainous terrain, reduce the probability of counting sheep herds twice, and limit stress to sheep.
- The location of sheep observed during the survey will be geo-referenced using a Global Positioning System (GPS). Observed sheep will be classified by sex and age based on relative size and horn characteristics.
- During the first year of mine operation, a follow-up survey will be conducted during the lambing period to confirm the use of previously identified lambing habitat and to search for additional lambing areas that may have been missed during the initial survey.

6.2.1.2.5 Ground-based Reconnaissance Surveys

- Prior to mine start-up (and in addition to reconnaissance-level aerial survey), a ground-based reconnaissance survey will be conducted by a Wildlife Monitor during the parturition period (typically mid-April to mid-June) to document sheep distribution and habitat use in the defined study area.

If no lambing areas are identified in the study area during the reconnaissance level aerial survey and complementary ground survey, then no further mitigation measures would be implemented for mine-related overflight activity.

6.2.1.2.6 Ground-based Behavioural Surveys (if necessary)

- If sheep are recorded in the study area during the reconnaissance level aerial or ground surveys, a more extensive and detailed ground-based behavioural observation survey plan will be implemented to document sheep movements, activity, and behaviour in relation to aircraft activity for the duration of the parturition period. The survey needs to extend into the post-lambing period as females with lambs remain on lambing grounds for 3-4 weeks after birth (Geist 1971).
- Ground-based observation surveys will be conducted using binoculars and spotting scopes from designated observation points (distances of ≥ 1 km to avoid disturbance to animals).
- Observations will focus on determining if overflight events have significant impacts on Dall's sheep behaviour.

- If no significant impact is observed from overflight events during the first year of production, then no further mitigation measures would be implemented for mine-related overflight activity.
- If a significant impact to overflights is observed, the Flight Impact Management Plan will be modified for the parturition period to minimize low overflights in lambing locations for the duration of mine operation.

The primary purpose of a Dall's sheep monitoring program is to track changes in sheep behaviour and location in relation to aircraft traffic over time. If disturbance is evident, then monitoring is expected to undergo modification over the years and should be seen as an evolving program. This requires the monitoring program to be adaptive and flexible. One possible outcome is that no effects from flights are indicated, in which case the monitoring program will stop. The monitoring program must also be flexible enough to incorporate comments, suggestions, and information based both on science and local knowledge. Adaptive management may lead to several changes to the monitoring program if an impact is detected. If negative effects are detected, the options available include:

- Increasing the monitoring effort;
- Implementing new monitoring programs to further understand Project-related effects; and
- Implementing changes to the Flight Impact Management Plan to ensure that Project-related effects on Dall's sheep are minimized.

6.2.2 Incident Management Strategy and Contacts

Historical survey data indicate that listed wildlife species and other wildlife VCs occurring in the area are not proximal to the mine or access road, with occasional exceptions. As a result, the impact assessment concluded that significant effects on listed wildlife species and other wildlife VCs are unlikely. This will be confirmed primarily by collecting and logging wildlife sightings and interactions, followed by review by a wildlife biologist.

In the case of an incident or potential incident involving direct contact with a listed wildlife species or wildlife VC, the Wildlife Monitor will ensure that the appropriate government agencies are contacted to inform them of the incident, and to prepare a plan of action. Table 2 lists suggested contacts for wildlife incidents.

Table 2: Wildlife Incident Contacts for Prairie Creek Mine Project

Name	Company/Agency	Title	Phone Number	Email
Wildlife Emergency Line	GNWT ENR (Ft. Simpson)	-	1-867-695-7433	-
Wildlife Emergency Line	GNWT ENR (Yellowknife)	-	1-867-873-7181	-
24 Hour Spill Report Line	GNWT ENR	-	1-867-920-8130	-
Report a Poacher	GNWT ENR	-	1-866-762-2437	-
Nic Larter	GNWT ENR	Dehcho Regional Biologist	1-867-695-7475	Nic_Larter@gov.nt.ca
Doug Tate	Parks Canada	Conservation Biologist	1-867-695-3151	Doug.Tate@pc.gc.ca
Mike Suitor	Parks Canada	Ecologist	1-867-695-3151	Mike.Suitor@pc.gc.ca

6.2.3 Data Analysis and Reporting

Regular reporting and analysis of the wildlife monitoring program is a component of the adaptive management process, whereby the Wildlife Monitor will review wildlife observations and incidents on a weekly basis. As a component of this review, the data will be analyzed for issues or potential problems such as seasonal concentration areas or sections along the access road that have a high incidence of collisions or near miss occurrences. The Wildlife Monitors will contribute to a detailed quarterly report of wildlife observations and incidents that occurred during the monitoring period. In addition to this quarterly report, caribou observations and incidents at the mine site and along the access road will be summarized in a monthly report. All wildlife reports will be submitted to First Nations, GNWT ENR, and Parks Canada to solicit review of the effectiveness of mitigation measures and, following discussion in Technical Advisory Committee meetings, to suggest modifications to mitigation and monitoring plans, as necessary.

6.2.4 Adaptive Management Process

Monitoring results will be reviewed and assessed annually to determine whether mitigation policies are having the expected results and are minimizing project effects. If review determines that project effects are exceeding expected impacts, revision of mitigation processes may be required. Revision of monitoring programs may also be required if mitigation processes are changed or if the review process finds the current monitoring activities are insufficient in determining project effects. This review and revision process will include:

- Periodic review of monitoring reports by a qualified wildlife biologist that will assess results of monitoring programs to determine whether any thresholds (see section 8.0) have been crossed or whether monitoring results indicate a problem;
- If thresholds are crossed or if monitoring programs detect a significant impact to a particular species or group of species, mitigation measures relating to the species and project activities involved will be reviewed and revised to correct the problem and minimize project effects; and
- If at any time, those involved in the monitoring process notice that a project threshold has been crossed, they should immediately bring it to the attention of the appropriate personnel. This should trigger a review of the threshold and revision of mitigation measures.

7.0 WILDLIFE ENCOUNTERS

Wildlife encounters are usually inadvertent, caused by wildlife disorientation or curiosity, or by improper waste management at a project site. However, if encounters and problem wildlife persist, deterrent actions or further mitigation may become necessary. For wildlife deterrents to be effective there must be:

- Knowledgeable personnel who are able to select deterrent actions on a case by case basis for each unique wildlife situation;
- The consistent application of deterrent actions for similar situations;
- An evaluation of every encounter and deterrent action taken to determine the root causes and effectiveness of response; and
- Documentation of all deterrent actions prepared by the Wildlife Monitor and forwarded to GNWT ENR and Parks Canada upon request, and in the annual monitoring report.

7.1 Response to Bear Encounters

There is a potential for workers to encounter both black bears and grizzly bears. Bears may be active from April through to October in and near project activities. In order to properly mitigate human-bear interactions it is important to differentiate between grizzly bears and black bears. Both species may appear similar in size and can vary in colour from black or brown to cinnamon or blonde. The response procedures below are provided as background only. For detailed directions on the most appropriate responses to grizzly bear and black bear encounters, refer to “Safety in Grizzly and Black Bear Country”, available from GNWT ENR.

7.1.1 Response to a Bear at a Distance

If any worker observes a bear from a distance (more than 30 m away), the worker shall:

- Stop work immediately and walk slowly towards the nearest building or vehicle and prepare to take refuge, if it becomes necessary; and
- Alert the Wildlife Monitor and all other workers in the vicinity by two-way radio and inform the Mine Manager of the situation.

The distances noted in this section and those that follow are guidelines only and each encounter is to be evaluated based on time and site specific considerations. Mine personnel are expected to use their judgment to decide what a safe distance is in a particular situation.

7.1.2 Response to a Bear at Close Range

If any worker observes a bear at close range (within 30 m), the worker shall:

- Stop work immediately;
- Slowly back away from the bear, while observing its behaviour (aggressive or non-aggressive) and allow the bear to leave the area, and walk slowly towards the nearest building or vehicle and prepare to take refuge;
- Alert the Wildlife Monitor and all other workers in the vicinity; and, if a bear appears aggressive, workers should make themselves appear as large as possible and make noise to deter the bear from coming closer (as well as to alert nearby workers of the situation). Talking to the bear in a firm voice can also help the bear to identify humans; and
- Notify the Mine Manger immediately to arrive at a course of action. The Mine Manager will have ultimate authority in dealing with life threatening situations.

7.1.3 Response to "Bear in Camp" Scenario

For detailed directions on the most appropriate responses to grizzly bear and black bear encounters or bears in camp, refer to "Safety in Grizzly and Black Bear Country", available from GNWT ENR. The response to a bear encounter at camp will be as follows:

- A camp siren designated for emergencies will be sounded and a radio alert will be sent out to all workers at the camp and nearby worksites;
- The Mine Manager or designate will consult with the Wildlife Monitors to determine an appropriate response with the use of wildlife deterrents. The use of lethal force will be avoided to the extent possible as there may be a risk of injury (from gunfire) to workers taking shelter in the various camp buildings; and
- A post-incident analysis will be undertaken to identify any factors contributing to the 'bear in camp' situation and how well the response worked. These factors will be addressed as soon as possible to limit the potential for a reoccurrence of the incident.

7.1.4 Response of the Wildlife Monitor to an Incident

Upon arriving on the incident scene, the Wildlife Monitor will undertake the following actions:

- Assess the bear for signs of aggressive behaviour;
- Advise the Mine Manager and nearby workers of the potential threat and how to respond;
- Use non-lethal deterrents, as appropriate to prevent the bear from approaching to within 30 m of any worker;
- If the bear approaches to within 30 m, shows clear signs of aggression and the worker(s) is/are unable to retreat to a safer location, lethal force may be used to protect the safety of workers;

- Record details of the incident and take photographs, as appropriate, and report the incident to NWT ENR and Parks Canada; and
- Incidents involving human injury and/or destruction of bears are to be reported to NWT ENR, Parks Canada and RCMP immediately.

7.2 Wildlife Deterrent Procedures

Whenever numerous and frequent signs of wildlife are observed near areas of human activity, the potential causes should be investigated. If an animal has gained access to shelter, a potential hazard, or food source, immediate action will be taken to secure the site from re-entry by wildlife.

Generally, wildlife should be left undisturbed. However, if the presence of an animal presents a risk to the animal or to humans, or causes material damage, deterrent action should be considered. If an animal is showing clear signs of being rabid, the animal should be killed. The Wildlife Monitors will contact GNWT ENR and Parks Canada who may want to take tissue samples and dispose of the carcass.

7.2.1 Projectile Deterrents

The use of Projectile deterrents should be a rare event, as the preferred method of addressing wildlife encounters will be to avoid confrontation and to allow wildlife to disperse from an area voluntarily. Options available to wildlife monitors to encourage wildlife to disperse are discussed below.

7.2.2 Wildlife Herding Procedures

In general:

- Wildlife will be given the “right-of-way”. If wildlife are crossing or attempting to cross the access road, site roads or airstrip, traffic will stop and wait for the animal(s) to cross; and
- Wildlife will not be blocked from crossing roadways and efforts will be made to accommodate natural movement patterns across the access road.

The Mine Manager and/or the Wildlife Monitors may authorize deterrent actions if an animal endangers itself or humans near roadways, mine infrastructure, or the airstrip. Deterrent actions to be taken will begin at the lowest level indicated below and may increase to higher levels, as appropriate to the situation. The objective is to have wildlife voluntarily move away from potentially hazardous situations without causing unnecessary stress or possible injury.

Herding strategies used by the Wildlife Monitors and the reactions of wildlife will be documented and included in the wildlife incident report. This record will also include information surrounding the incident, such as weather conditions, date/time, and justification for actions taken. GNWT ENR and Parks Canada should be provided with an incident report upon request.

The protocols listed below may need to be adapted or refined further before implementation based on feedback from regulatory agencies.

7.2.2.1 Level 1

Approach the animal(s) from inside a vehicle while announcing your presence:

- If the animal does not respond to the vehicle, the Wildlife Monitor may slowly approach the animal on foot (if it is safe to do so), while maintaining a safe distance. Do only what is necessary to encourage the animal to move;
- Approach no closer than 50 m. If the animal starts to move off, stop the approach;
- If the animal stops moving, continue the approach;
- If the animal does not respond to an approach on foot, it may be necessary to increase the disturbance to the animal. Clap and/or shout to alert the animal to your presence; and
- If clapping and shouting do not cause the animal to move off, use an air horn; and when the animal leaves the area, continue to monitor until it has moved approximately 100 m away from the road, mine infrastructure, or airstrip.

7.2.2.2 Level 2

- If the Wildlife Monitor approaches to within approximately 50 m of the animal(s) and it still remains, the Wildlife Monitor will stop their approach;
- Noise-making or explosive deterrents may be used to try and scare off the animal. If it is after dusk, use a noise maker that also emits light. This helps to illuminate the animal and provides another level of deterrence;
- If the animal is not responding to noise-making deterrents at a distance, move to less than 50 m and use the appropriate deterrent given the distance between the monitor and animal (refer to Table 2);
- When the animal begins to move away, stop the deterrent action;
- If the animal stops moving, resume the deterrent action; and
- If the animal moves off, continue to monitor until it has moved approximately 100 m away from the road, mine infrastructure, or airstrip.

7.2.2.3 Level 3

- If the animal does not respond to the approach of people and deterrents, the animal may have become habituated to people or may be sick;
- If the animal does not respond to noise making deterrents, use other non-lethal projectiles. Select the type of non-lethal projectile based on the distance between the monitor and animal (refer to Table 3);
- When the animal starts to move away, stop deterrent actions;
- If the animal stops moving, resume the deterrent actions using non-lethal Projectiles or noise makers;
- If the animal moves off, continue to monitor until it is approximately 100 m away from the road, mine infrastructure, or airstrip; and
- If the animal refuses to move after an extended period of time or becomes aggressive, it may be necessary to kill the animal for safety reasons.

Table 3: Guidelines for Use of Non-lethal Projectiles to Deter Wildlife (Adapted from Dolson 2002)

Projectile	Accuracy	Description
		15 mm pistol launcher
Bangers	25 m	Provide a very good noise stimulus and have a consistent range. The disadvantages are that they are slow to reload and cumbersome in low light conditions.
Screamers	75 m	Produce a loud screeching noise through complete travel, with a visual effect in low light. They can have an inconsistent range and be very unpredictable. They provide a very good noise stimulus but share the same disadvantages as the bangers.
		12 gauge shotgun
Bean Bags	25 m	Designed for close range encounters and should be fired from a distance of approximately 5 m.
Shell Crackers	75 m	Shell Crackers are consistent in range and accuracy. They explode with a loud bang at the end of travel.
Rubber Slugs	75 m	They are very accurate; however, there is the possibility of penetration if used at a distance of less than 25 m. Follow up shots can be made quickly.

7.3 Dealing With an Injured Animal

Upon encountering an injured animal:

- Stop work immediately and retreat to a safe distance;
- Alert the Wildlife Monitor and Mine Manager; and
- Visually assess the type of injury (predator, vehicle impact).

7.3.1 Prey Injuries

If the injuries appear to be caused by a carnivore:

- Assume that a bear is present in the vicinity until otherwise determined (this is the worst case scenario from a human safety perspective);
- Alert all workers in the vicinity; and
- Follow protocols for Bear Encounters in Section 7.1.

7.3.2 Injuries Caused by Human Activity

If the injures are the result of human activity:

- The Wildlife Monitor will visually assess the extent of injuries;
- Where the injuries are deemed critical, the animal may be killed for compassionate reasons; and
- A detailed report will be made to GNWT ENR and Parks Canada, as soon as possible.

7.4 Dealing with a Carcass

Carcasses are an indication that a predator may be nearby, so never approach a fresh kill. Also be cautious of loose piles of dirt, branches and vegetation, as predators sometimes cache carcasses.

Upon the discovery of a wildlife carcass:

- Alert the Wildlife Monitor and Mine Manager; and
- Avoid the immediate area until the Wildlife Monitor advises that it is safe to return.

The Wildlife Monitor shall:

- Assess the stage of decay and signs indicating a probable cause of death (predator kill, disease, drowning);
- Examine the immediate area for other evidence of recent wildlife activity;
- Collect biological samples, if requested by GNWT ENR and Parks Canada;
- Record the details of the incident, take photographs, and provide this information to the Mine Manager; and
- If necessary and with the assistance of workers, collect the carcass and incinerate it or transfer it to GNWT ENR, Parks Canada, or Nahanni Butte.

8.0 ADAPTIVE MANAGEMENT TRIGGERS AND RESPONSES

In order to gauge the extent to which mitigation and management objectives have been achieved, threshold values or statements have been set for specific indicators which, if reached, will trigger specific management responses.

8.1 Mortality Thresholds

Wildlife mortality thresholds for the project were developed based on the findings of the supplemental *Vegetation and Wildlife Assessment Report* to the DAR. Wildlife mortality thresholds apply to VC species listed as "May Be at Risk" or "At Risk" under the NWT Status Ranks or "Special Concern", "Threatened", or "Endangered" on Schedule 1 of SARA. Should any of the wildlife mortality thresholds be crossed, an immediate review of the incident will be triggered. The review will examine the cause of the mortality and will re-evaluate the applicable mitigation measures to determine why and how they failed to prevent the mortality. Based on the results of the review, changes may be made to existing mitigation measures or new mitigation measures may be created to prevent further mortalities.

The following species-specific mortality thresholds will be used for the Prairie Creek Mine Project, including mine site operation and access road operation:

- Caribou, wood bison, grizzly bear, wolverine, peregrine falcon, short-eared owl, horned grebe, rusty blackbird, olive-sided flycatcher, and common nighthawk – mortality threshold is zero. Any mortality directly relating to the operation of the mine site or access road will trigger a review of mitigation strategies.

Project-related mortality of other VC wildlife species at the mine site or along the access road will be reviewed on a case-by-case basis, including the mortality of waterfowl and water birds relating to the WSP, and the mortality of important VCs such as moose and Dall's sheep. As outlined in section 6.2 of this document, all Project-related mortality will be included in a report submitted to First Nations, GNWT ENR, and Parks Canada. If review determines that project effects are exceeding expected impacts, revision of mitigation processes may be required and additional species mortality thresholds may be implemented under the adaptive management process.

8.2 Non-fatal Disturbance

In addition to direct mortality, activities at the mine site and along the access road may disturb wildlife behaviour and alter patterns of use of the local land base by wildlife. While no clear thresholds have been identified for disturbance effects on wildlife, the reporting of wildlife incidents and observations by mine staff will be important in the analysis of wildlife incident trends and in minimizing wildlife conflicts through the adaptive management process. If the results of the monitoring program indicate that Project-related effects are consistent with impact predictions outlined in the *Vegetation and Wildlife Assessment Report*, adaptive management will not be triggered. However, if monitoring reveals important new information, such as locations of caribou calving areas near the access road, locations of Dall's sheep lambing areas in proximity to the mine airstrip, or locations of wildlife movements that cross the mine site or access road, then adaptive management actions would be triggered to mitigate site-specific risks to wildlife.

Adaptive management of wildlife disturbance other than mortality will be developed on a case-by-case basis. Management responses could include some of the measures outlined in Table 4.

Table 4: Possible Adaptive Management Triggers and Responses for Wildlife Monitoring

Monitoring Strategies	Adaptive Management Trigger	Potential Adaptive Management Response
Incident Monitoring	■ Identification of new habitat use by VC species. ■ Identification of VC species in areas previously undetected. ■ Identification of new VC species movement routes. ■ Frequent wildlife-human interaction sites, times, or seasons.	■ Ensure proper education of mine staff and truckers. ■ Post appropriate signage at Mine site and along access road (where necessary). ■ Ensure proper management of access road traffic (speed restrictions). ■ Ensure proper snow removal along access road to prevent the entrapment of animals. ■ Review Mine Waste Management Plan and attraction of wildlife to mine site.
Incidental Observation Tracking	■ Identification of increased incidence of predation or disease. ■ Apparent shifts in a VC species habitat use/distribution across the landscape. ■ Identification of previously undetected VC species in Project area.	■ Additional investigations into causes for these changes if a discernable cause is suspected (*e.g.,* attraction of predators to mine site by food waste).
Ground-based and Aerial Observations by Mine Staff and Others	■ Apparent shifts in a VC species habitat use/distribution across the landscape. ■ Identification of declines in a VC species numbers.	■ Additional investigations into causes for these changes if a discernable cause is suspected (*e.g.,* increased vehicle mortality, aircraft disturbance).

9.0 CLOSURE

We trust the information contained in this report is sufficient for your present needs. Should you have any additional questions regarding the project, please do not hesitate to contact the undersigned at 604-296-4200.

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

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10.0 REFERENCES

Beak Consultants Limited. 1981. Prairie Creek Project Vegetation & Wildlife Studies, 1981. Report prepared for Cadillac Explorations Ltd. September 1981. Prepared by Beak Consultants Limited, Richmond, BC.

Dolson, S. 2002. A guidebook: Non-lethal black bear management. J.J. Whistler Bear Society. Whistler, BC.

Frid, A. 2003. Dall's sheep response to overflights by helicopter and fixed-wing aircraft. Biological Conservation 110:387-389.

Geist, V. 1971. Mountain sheep: A Study in Behaviour and Evolution. The University of Chicago Press, Chicago, IL, USA.

Harrington, F.H., and A.M. Veitch. 1992. Calving success of woodland caribou exposed to low-level jet fighter overflights. Arctic 45:213-218.

Larter, N.C., and D.G. Allaire. 2005. Sheep surveys of the Liard Range, Nahanni Range, and Ram Plateau in the Mackenzie Mountains, August 2003. Manuscript Report No. 166. Department of Environment and Natural Resources, Government of the Northwest Territories, Fort Simpson, NT.

MacArthur, R.A., Geist, V., and R.H. Johnston. 1982. Cardiac and behavioral responses of mountain sheep to human disturbance. The Journal of Wildlife Management: 46:351-358.

Mining and Petroleum Environmental Research Group (MPERG). 2008. Flying in caribou country: How to minimize disturbance from aircraft. Prepared by EDI Environmental Dynamics Inc., Whitehorse, YK.

Mining Environment Research Group (MERG). 2002. Flying in sheep country: How to minimize disturbance from aircraft. Prepared by Laberge Environmental Services, Whitehorse, YK.

Stankowich, T. 2008. Ungulate flight responses to human disturbance: A review and meta-analysis. Biological Conservation: 141:2159-217.

Working Group on General Status of NWT Species. 2006. NWT Species 2006-2010 – General Status Ranks of Wild Species in the Northwest Territories. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT.

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APPENDIX L

Mixing Analysis

Northwest Hydraulics Co.

9819 – 12 Avenue SW | Edmonton, AB T6X 0E3 | 780.436.5868 | www.nhcweb.com

nhc
northwest hydraulic consultants

Ref. No. 16987

February 11, 2011

Canadian Zinc Corporation
Suite 1710 - 650 West Georgia Street
Vancouver, BC
V6B 4N9

Attention: David Harpley

Via email: david@canadianzinc.com

Re: Mixing analysis for exfiltration trench outfall to Prairie Creek - DRAFT

Dear Mr. Harpley:

1.0 INTRODUCTION

The water management plan proposed by Canadian Zinc Corporation (CZN) for operation of the Prairie Creek mine involves treating mine drainage water and mill process water to reduce metal concentrations, then discharging excess treated water to Prairie Creek. A NHC letter report dated September 9, 2010 presented a preliminary review of outfall alternatives. A diffuser was ruled out because of the lack of a suitably deep channel. NHC recommended a simple pipe outlet from the bank of Prairie Creek in order to minimize construction impacts.

The results of mixing analysis for this pipe outfall presented in a letter dated October 22, 2010 and subsequent discussions with regulators resulted in the abandonment of the pipe outfall alternative and the selection of an exfiltration trench outfall as a more viable alternative. A preliminary design of this exfiltration trench outfall was presented in a letter report dated December 22, 2010. The design of the exfiltration trench was refined in the course of the present mixing analysis presented herein.

This report presents the results of a mixing analysis performed to quantify mixing in Prairie Creek in the reach downstream of the outfall. The exfiltration trench will discharge the treated water over an 8 m width of stream bed to increase mixing in the near field or vertical mixing zone. Once vertical mixing is complete further mixing occurs laterally in the far field or transverse mixing zone. The results from this report are presented as dimensionless concentrations and dilutions relative to initial outfall concentrations and are intended to be utilized by others to assess various water quality parameters to ensure that they meet water quality instream targets.

2.0 CHANNEL HYDRAULIC CHARACTERISTICS

Figure 1 shows Prairie Creek below the outfall location based on a 1994 orthophoto at the mine site and 1:50,000 scale topographic map developed from aerial photos taken in 1969. Photos 1 and 2 show the location of the proposed outfall and downstream reach as observed in 2010. These photos show the stream conditions for a discharge of 12 m^3/s, which is similar to the mean open water flow.

Channel hydraulic characteristics for the reach downstream of the outfall were estimated using a HEC-RAS hydraulic model. Available survey information consists of channel cross sections, thalweg and water surface profiles surveyed in August 1980 and in August 2010. The 2200 m reach length surveyed in August 1980 ends about 1000 m downstream of the Harrison Creek confluence and provides good information on the overall channel profile and representative channel sections. The 350 m reach length surveyed upstream of the Harrison Creek confluence in August 2010 provides current cross section information in the reach where the outfall is proposed, and confirmation that the current water surface slope is consistent with the slope surveyed in 1980. Representative cross sections surveyed in 1980 and 2010 were transposed to the locations shown in Figure 1 reach based on the general channel profile and the location of riffle sections as seen in the 2010 photographs.

The HEC-RAS model was run to determine channel hydraulic conditions for both open-water and ice-cover conditions. Open-water conditions typically occur from May to October and ice-cover conditions typically occur from November to April. Three monthly discharges (maximum, mean and minimum) were selected to represent the range of hydraulic characteristics for each of these conditions. Discharges were determined by analysis of monthly flow data from Water Survey of Canada (WSC) records for Prairie Creek at Cadillac Mine for the period October 1974 through December 1990. These WSC discharges were increased by a factor of 2% to account for the difference in drainage area between the WSC gauge and the reach downstream of the outfall. The hydraulic characteristics at the outfall for the six selected stream discharges are listed in Table 1.

Table 1 Summary of hydraulic characteristics at outfall

Flow Condition	Discharge (m^3/s)	Top Width (m)	Mean Velocity (m/s)	Mean Depth (m)	Maximum Depth (m)
Open-water (May-Oct)					
Maximum Monthly	38.2	60.1	1.97	1.00	0.37
Mean Monthly	10.2	24.0	1.16	0.64	0.37
Minimum Monthly	1.57	12.3	0.65	0.31	0.20
Ice-cover (Nov-Apr)					
Maximum Monthly	4.43	22.8	0.62	0.31	0.57
Mean Monthly	0.71	11.8	0.36	0.17	0.27
Minimum Monthly	0.039	6.4	0.10	0.06	0.12

3.0 OUTFALL CHARACTERISTICS

Figure 2 shows the proposed location and extent of the exfiltration trench within Prairie Creek. Figure 3 shows design details of the 8 m long discharge section of the exfiltration trench will be located under the low flow channel to facilitate full rapid mixing of the effluent with stream flows under low flow conditions.

The outfall will discharge a mixture of treated process water and mine drainage water. The release of treated process water is proposed to be managed on the basis of the flow in Prairie Creek and its corresponding dilution capacity to meet the instream objectives. 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. Four alternate effluent discharge scenarios were considered to evaluate a range of possible mine drainage conditions. These scenarios include the best (most likely) estimate of outfall discharge, low and high estimates of groundwater flow into the mine and an extreme scenario of with high groundwater flow which includes flow from the Prairie Creek aquifer. The effluent discharge rates were determined by Canadian Zinc and are summarized on a monthly basis in Table 2.

Table 2 Summary of monthly outfall discharge scenarios

Month	Outfall Discharge Scenario			
	Low Estimate (m^3/s)	Best Estimate (m^3/s)	High Estimate (m^3/s)	Extreme Estimate (m^3/s)
Jan	0.0055	0.0080	0.0110	0.1010
Feb	0.0020	0.0020	0.0060	0.0800
Mar	0.0020	0.0020	0.0060	0.0800
Apr	0.0085	0.0135	0.0185	0.1455
May	0.0500	0.0765	0.1055	0.2205
Jun	0.0610	0.0925	0.1685	0.2295
Jul	0.0610	0.0925	0.1745	0.2345
Aug	0.0610	0.0925	0.1685	0.2285
Sep	0.0550	0.0835	0.1480	0.2330
Oct	0.0275	0.0465	0.0735	0.1905
Nov	0.0140	0.0205	0.0295	0.1495
Dec	0.0080	0.0115	0.0165	0.1015

4.0 VERTICAL MIXING

The exfiltration trench design will produce significant mixing in the near field zone where vertical mixing processes dominate, because the effluent will be discharged evenly over an 8 m width of the channel with shallow turbulent flow. Vertical mixing analysis was carried out analytically for all six stream discharge scenarios presented in Section 2 combined with the four outfall discharge scenarios. Each set of four outfall discharges were selected from the monthly outfall discharges in Table 2 based on the month in which corresponding stream discharge would most likely to occur. These discharges are summarized in Table 3 along with the computed vertical mixing lengths and vertical dilutions for each scenario.

The vertical mixing length was defined as the distance downstream of the exfiltration trench where vertical variations in concentration would be less than ±2%. Vertical mixing lengths tend to increase with increased flow depth. Vertical mixing lengths varied from a minimum of 1.6 m during low flow ice-covered conditions to a maximum of 31 m during high flow open-water conditions.

Dilutions at the end of the vertical mixing zone were calculated assuming that the effluent concentration mixed completely with the percentage of the stream discharge flowing directly over top of the 8 m long perforated pipe section of the exfiltration trench. The percentage of the stream discharge flowing over the exfiltration trench was determined from the distribution of unit discharge across the channel for the various stream discharges. These unit discharge distributions were calculated by multiplying the local velocities by the local depths and were estimated using cross section 20, located just downstream of the proposed outfall as shown in Figure 2. The lowest dilution of 5.8 was found to occur during low flow ice-covered conditions with the extreme outfall discharge even though the vertical mixing zone included 98% of the stream discharge.

Table 3 Summary of mixing characteristics for various discharge scenarios

Discharge Scenario	Open Water Monthly Maximum	Open Water Monthly Mean	Open Water Monthly Minimum	Ice Cover Monthly Maximum	Ice Cover Monthly Mean	Ice Cover Monthly Minimum
Prairie Creek						
Discharge (m^3/s)	38.2	10.2	1.57	4.43	0.71	0.039
Discharge in vertical mixing zone (%)	43%	59%	82%	63%	85%	98%
Vertical mixing length (m)	30.6	22.1	10.2	16.1	7.4	1.6
Month of most likely occurrence	June	July	October	April	December	March
Low Estimate Outfall Discharge						
Outfall Discharge (m^3/s)	0.0610	0.0610	0.0275	0.0085	0.0080	0.0020
Dilution after vertical mixing	270.5	98.7	47.6	326.7	75.9	20.2
Dilution after transverse mixing	627.2	168.2	58.1	522.2	89.8	20.5
Best Estimate Outfall Discharge						
Outfall Discharge (m^3/s)	0.0925	0.0925	0.0465	0.0135	0.0115	0.0020
Dilution after vertical mixing	178.5	65.3	28.5	206.0	53.0	20.2
Dilution after transverse mixing	414.0	111.3	34.8	329.1	62.7	20.5
High Outfall Discharge						
Outfall Discharge (m^3/s)	0.1685	0.1745	0.0735	0.0185	0.0165	0.0060
Dilution after vertical mixing	98.2	34.9	18.3	150.5	37.2	7.4
Dilution after transverse mixing	227.7	59.5	22.4	240.5	44.0	7.5
Extreme Outfall Discharge						
Outfall Discharge (m^3/s)	0.2295	0.2345	0.1905	0.1455	0.1015	0.0080
Dilution after vertical mixing	72.2	26.1	7.6	19.7	6.8	5.8
Dilution after transverse mixing	167.4	44.5	9.2	31.4	8.0	5.9

5.0 TRANSVERSE MIXING

The dilutions resulting from complete transverse mixing of effluent concentrations were calculated for all the scenarios presented in Table 3. Very little increase in dilutions occurred for the minimum ice-covered discharge scenarios because mixing was already 98% complete in the vertical mixing zone.

Transverse mixing analyses were performed with the TRSMIX transverse mixing numerical model to determine the length of the transverse mixing zone and the distribution of concentrations within this zone. This model was developed at the University of Alberta to simulate mixing in natural streams with variable channel characteristics such as Prairie Creek. Model inputs include outfall characteristics and the stream hydraulic characteristics, as well as mixing characteristics.

Mixing characteristics are defined by dimensionless mixing coefficients. Dimensionless mixing coefficients in natural channels tend to range from 0.4 to 0.8, however values higher than 1.0 have been measured in some rivers. A value of 0.8 was selected for Prairie Creek. This value, on the high side of the normal range, was selected because the available hydraulic characteristics of the reach were limited to representative sections that would not capture all of the observed variability in the flow field.

Best estimate outfall discharges for the mean open-water and ice-covered flow conditions were selected for simulation with the transverse mixing model. These two scenarios represent the conditions which will occur most likely and most frequently. The minimum ice-covered discharge scenario was not simulated because transverse mixing would be almost complete at the end of the vertical mixing zone. As well, the minimum open-water discharge scenario was not simulated because the initial conditions were relatively similar to the mean ice-covered discharge scenario. Maximum discharge scenarios were not simulated because both near field and far field dilution rates are more than double the rates for the mean flow scenarios.

Figures 4 and 5 show the distributions of dimensionless concentrations obtained from the mixing model for the two mean flow scenarios. These dimensionless concentrations are the defined as the fraction of concentration relative to the initial outfall concentration and are the inverse of dilution. Transverse distances are shown relative to the local stream width for ease of presentation. The following information is presented in each figure:

- Chart A shows the distribution of dimensionless concentration over a 2000 m reach downstream of the outfall.
- Chart B shows transverse sections of the plume as it spreads across the channel with increasing distance downstream from the outfall.
- Chart C shows the reduction in maximum concentration and concentration along each bank with distance downstream from the outfall.

The maximum concentration is within 2% of the mean concentration about 1700 m downstream of the outfall for the scenario with mean ice-covered discharge and the best estimate of outfall discharge. For the scenario with mean open-water discharge discharge and the best estimate of outfall discharge, the maximum concentration is still 10% greater than the mean concentration at the end of the modeling reach 2000 m downstream of the outfall.

The mixing length required for any particular water quality constituent to meet the instream target levels can be determined by combining the mixing model dimensionless concentrations with the design concentrations in the effluent discharge and the background concentrations in the receiving water.

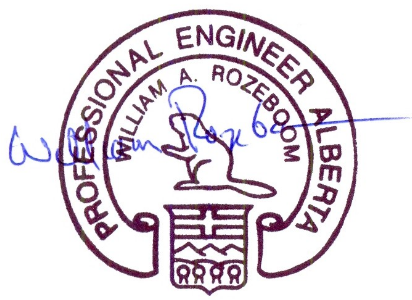
6.0 CLOSURE

This report presents the results of a mixing analysis performed to quantify mixing in Prairie Creek in the reach downstream of the proposed exfiltration trench outfall. The results from this report are presented as dimensionless concentrations and dilutions relative to initial outfall concentrations and are intended to be utilized by others to assess various water quality parameters to ensure that they meet water quality in-stream targets.

We trust that the above assessment meets your immediate needs; please do not hesitate to call if there are any questions.

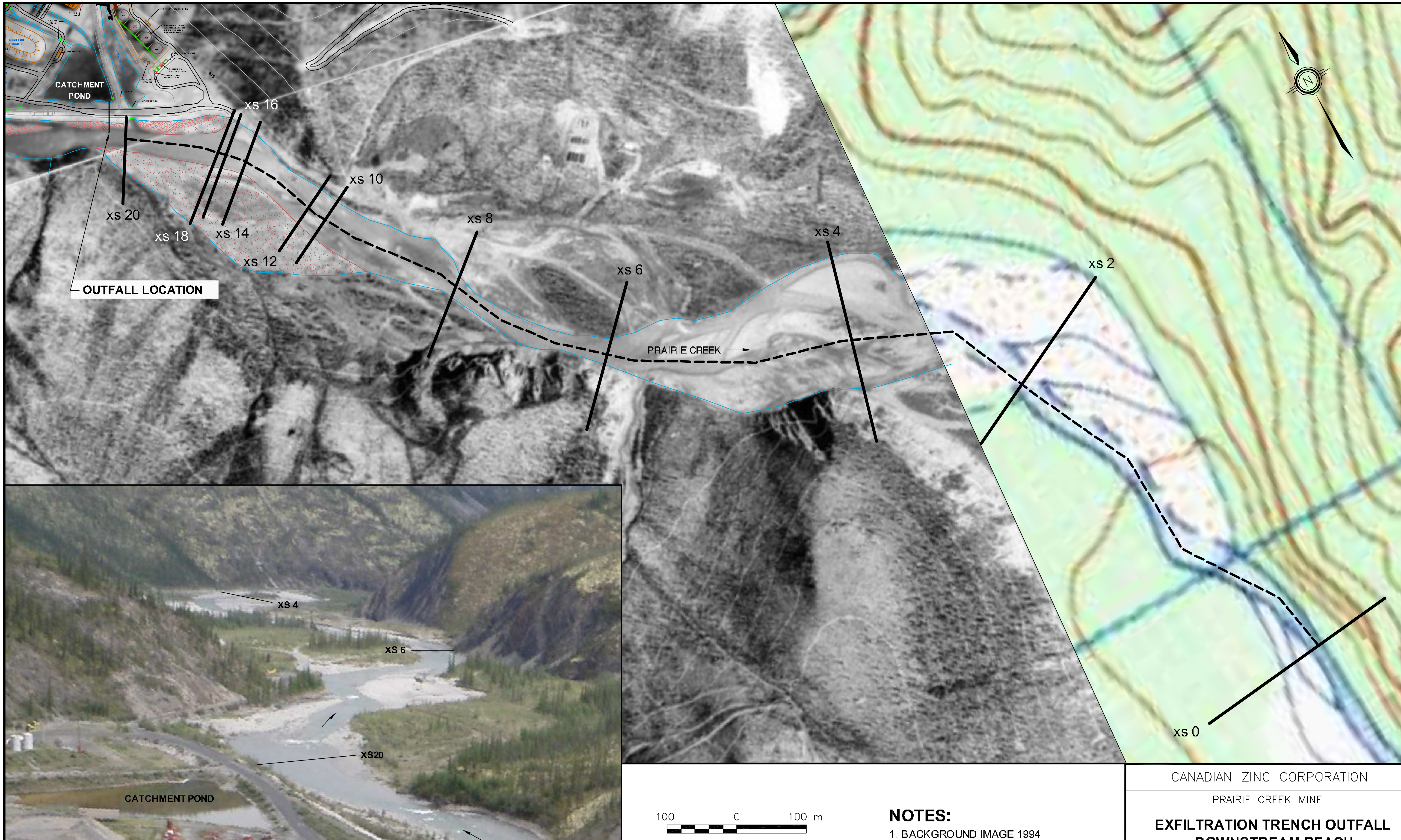
Respectfully submitted,

northwest hydraulic consultants



W.A. (Bill) Rozeboom, M.B.A., P.Eng.
Senior Hydrologist

Gary Van Der Vinne, M.Sc., P.Eng.
Principal



VIEW DOWNSTREAM TO PRAIRIE CREEK MIXING ZONE REACH, AUGUST 2010.

100 0 100 m

SCALE 1:5,000

NOTES:

1. BACKGROUND IMAGE 1994
2. MAP SOURCE: NTS 95F10, EDITION 1

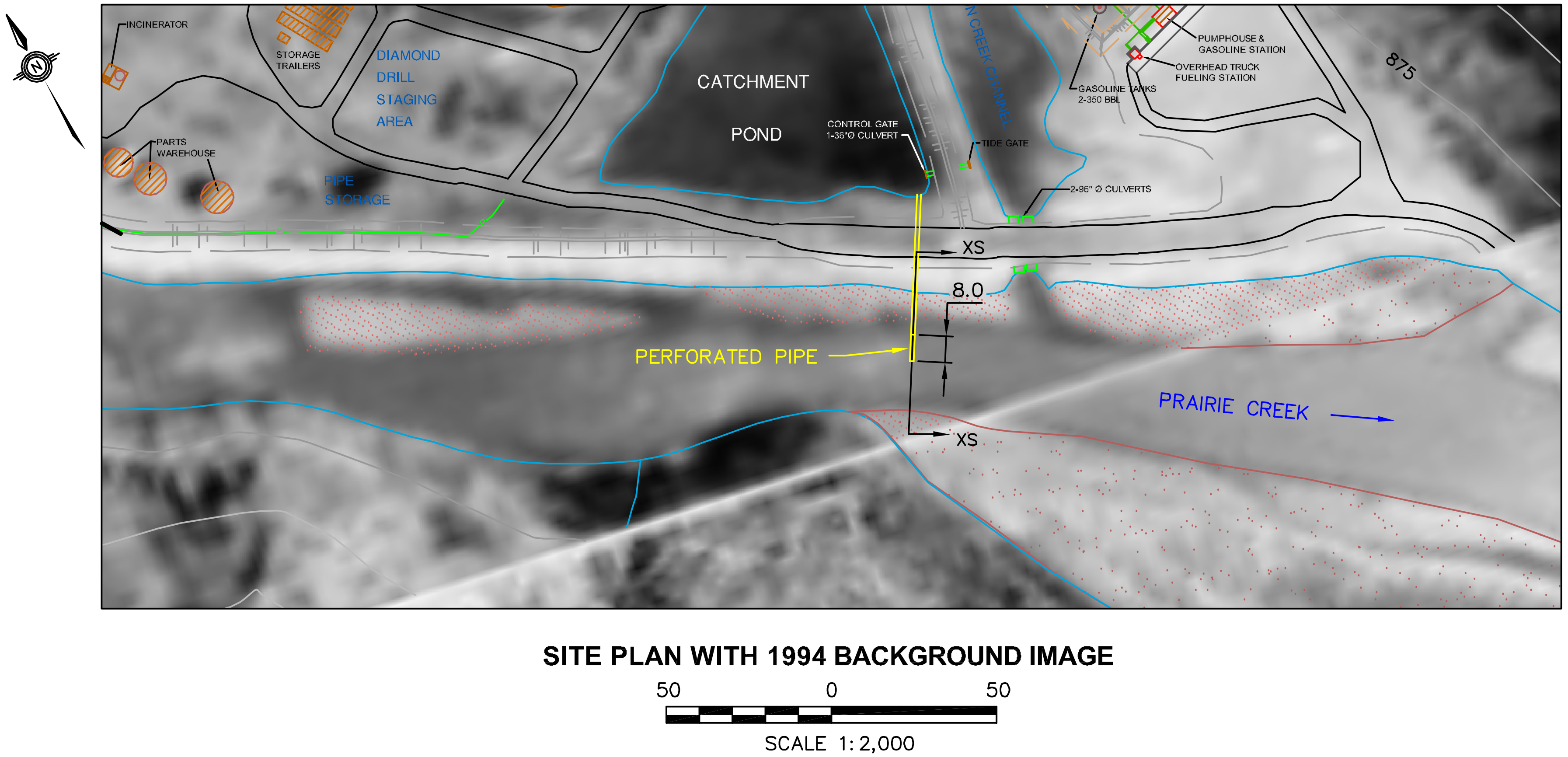
CANADIAN ZINC CORPORATION

PRAIRIE CREEK MINE

EXFILTRATION TRENCH OUTFALL DOWNSTREAM REACH

Dwg. 6987-003-R1	9 Feb 2011	**Figure 1**

northwest hydraulic consultants



SITE PLAN WITH 1994 BACKGROUND IMAGE

PHOTO 1. VIEW DOWNSTREAM
PHOTO DATE: AUGUST 9, 2010

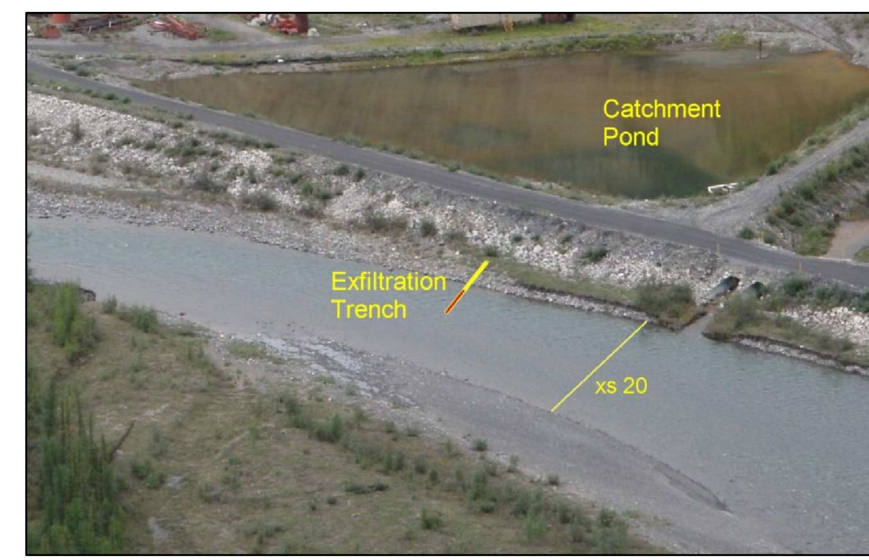
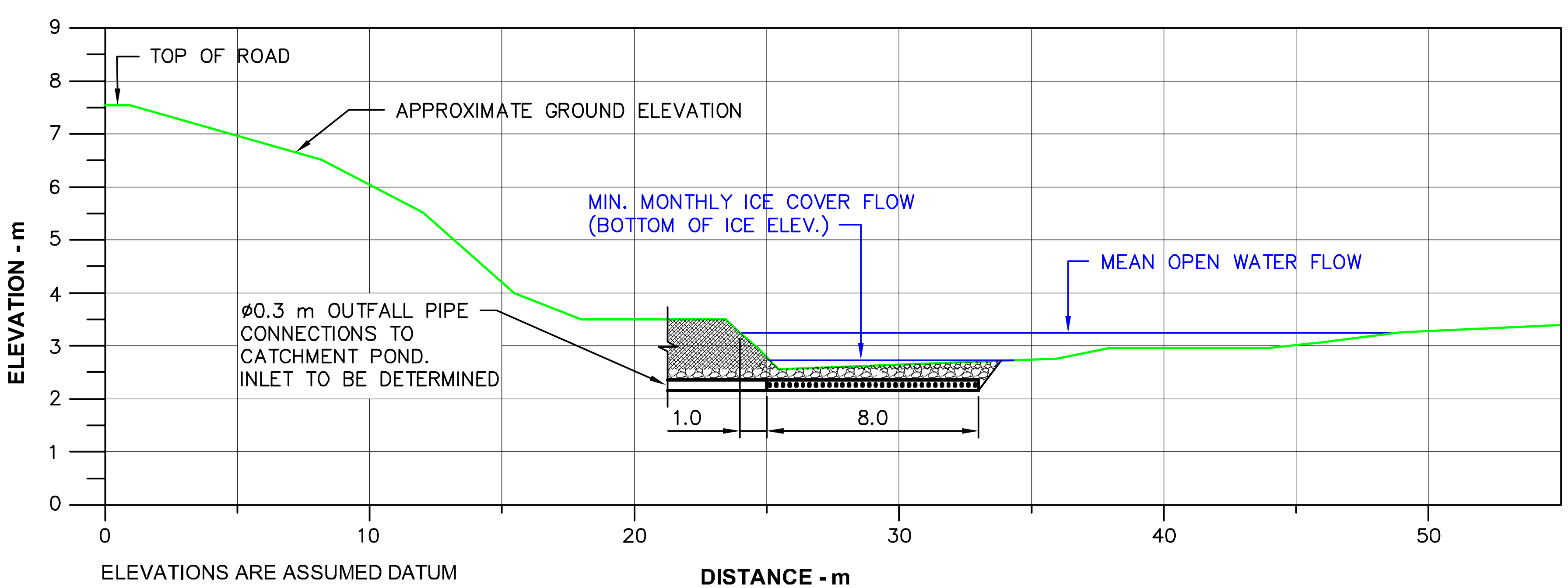


PHOTO 2. EXFILTRATION TRENCH LOCATION
PHOTO DATE: AUGUST 9, 2010

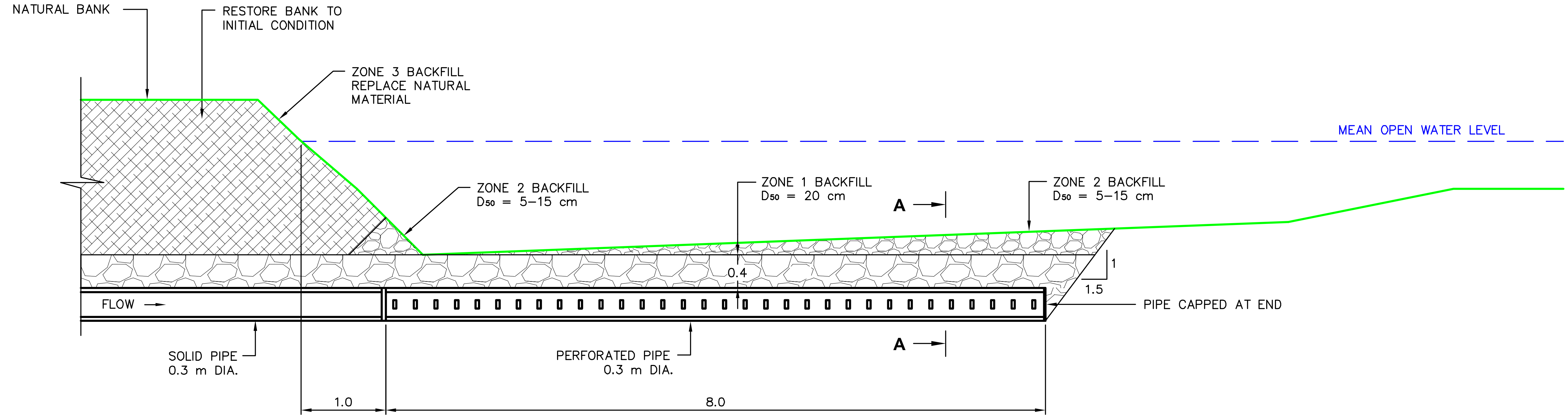


ELEVATIONS ARE ASSUMED DATUM

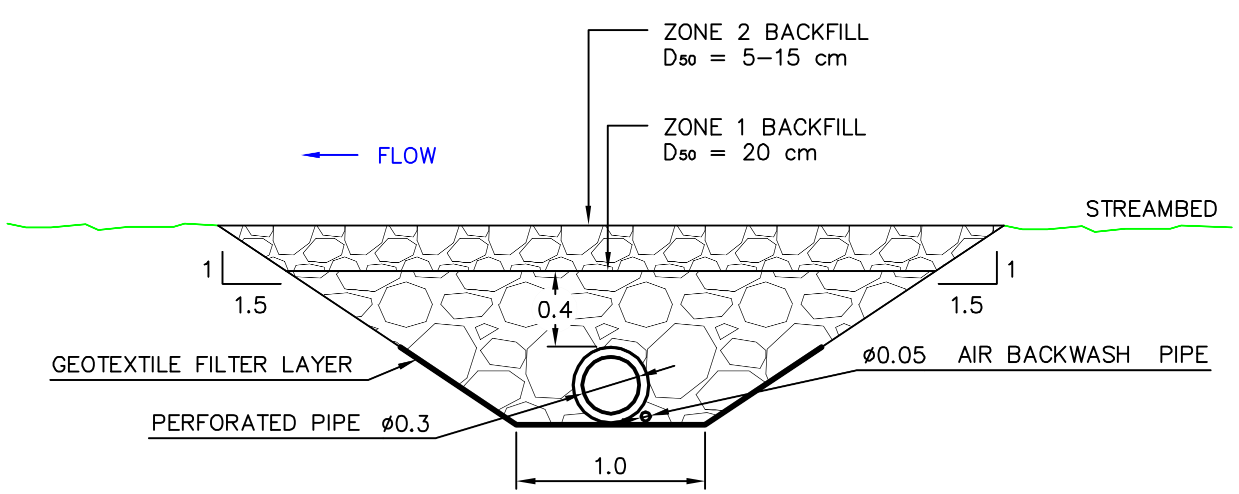
CROSS SECTION AT OUTFALL
(VIEWING DOWNSTREAM)

NOT FOR CONSTRUCTION

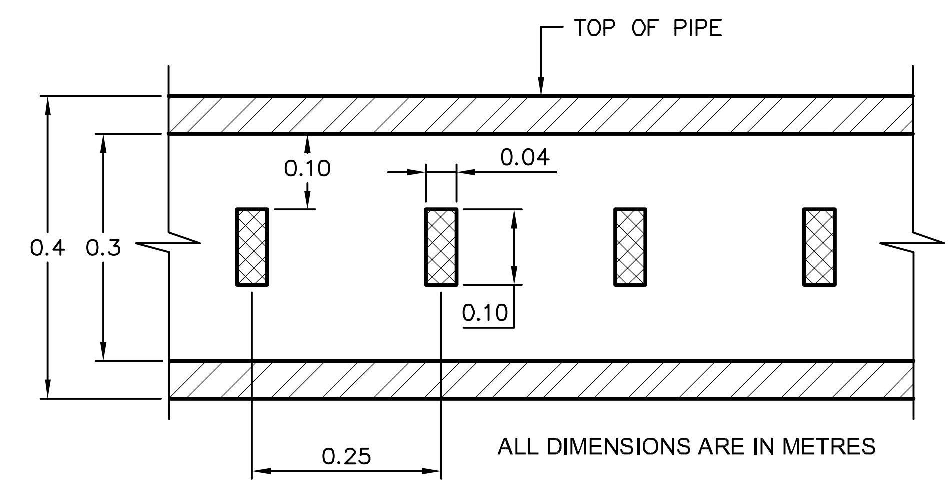
CANADIAN ZINC CORPORATION		
PRAIRIE CREEK MINE		
EXFILTRATION TRENCH OUTFALL CONCEPTUAL DESIGN		
Dwg. 6987–006–R1	9 Feb 2011	**Figure 2**
northwest hydraulic consultants		



DETAIL 1
EXFILTRATION TRENCH
HORIZONTAL SCALE 1:50
VERTICAL SCALE 1:25



A-A
SCALE 1:40



ALL DIMENSIONS ARE IN METRES

DETAIL 2
PERFORATED PIPE ELEVATION
SCALE 1:10

CANADIAN ZINC CORPORATION		
PRAIRIE CREEK MINE		
EXFILTRATION TRENCH OUTFALL DETAILS		
Dwg. 6987–006–R1	9 Feb 2011	**Figure 3**
northwest hydraulic consultants		

CHART A
CONCENTRATION CONTOUR PLAN

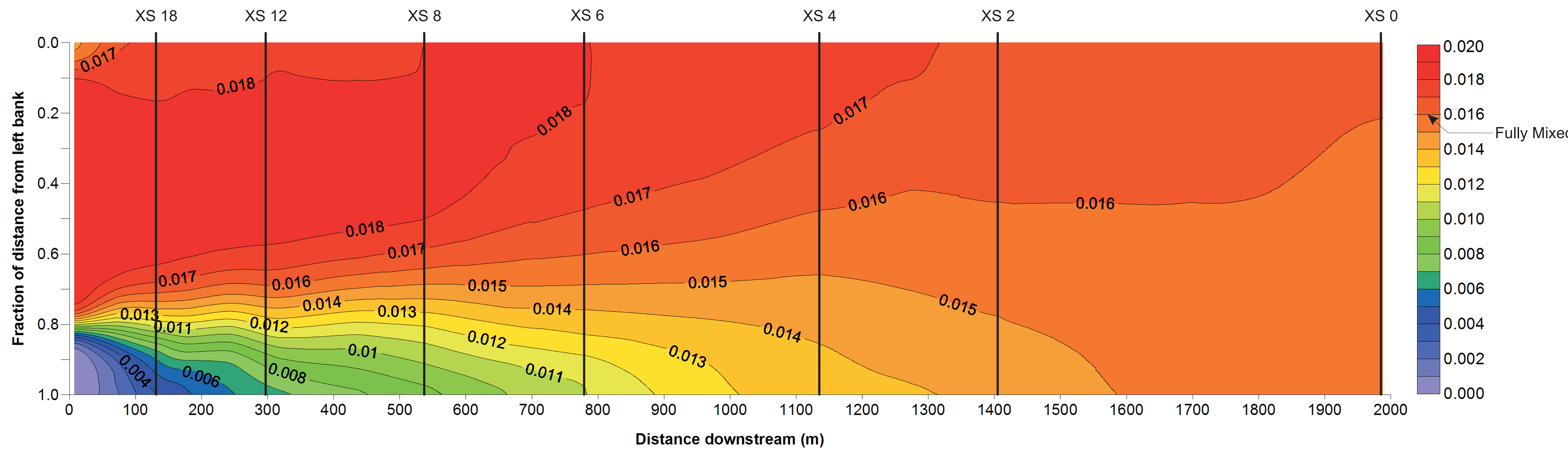


CHART B
TRANSVERSE CONCENTRATION PROFILES

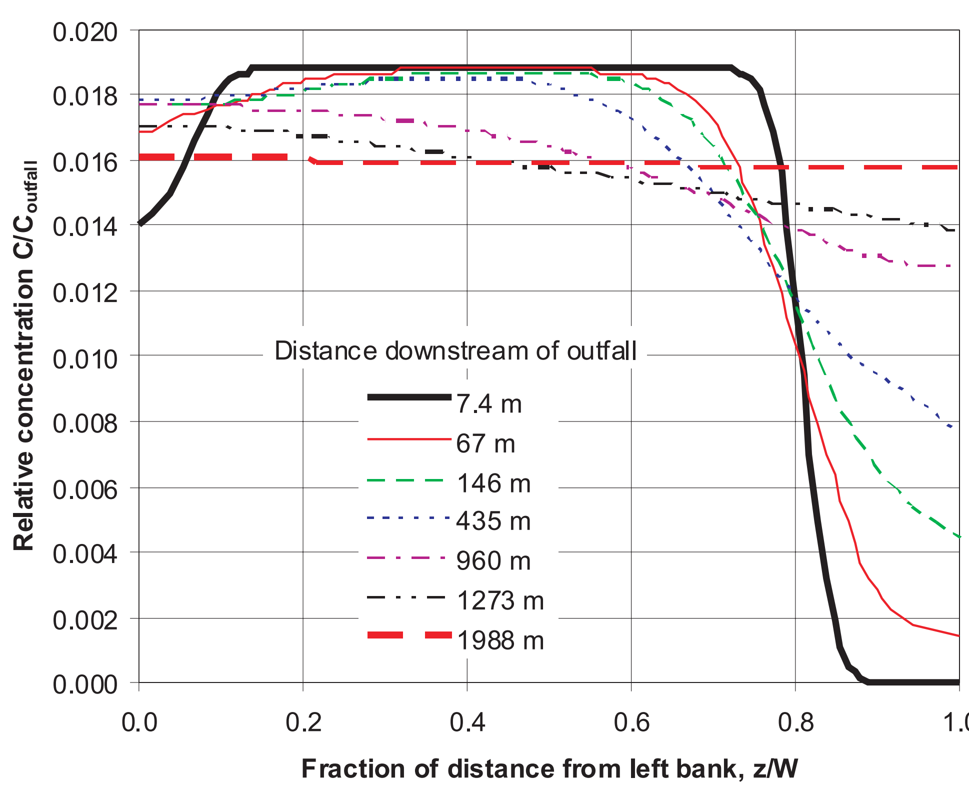
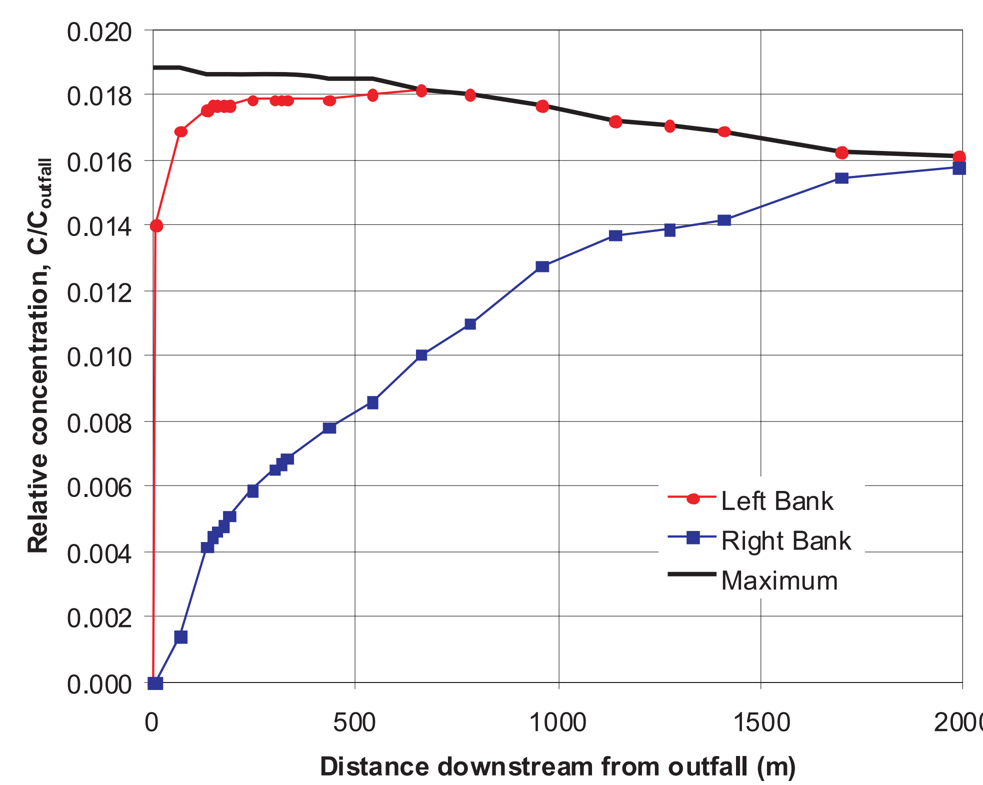


CHART C
LONGITUDINAL CONCENTRATION PROFILES



Prairie Creek Discharge	0.71 m^3/s
Outfall Discharge	0.0115 m^3/s
Vertical Mixing Length	7.1 m
Fully-mixed Dilution	62.7

CANADIAN ZINC CORPORATION

PRAIRIE CREEK MINE

EXFILTRATION TRENCH OUTFALL CONCENTRATION DISTRIBUTIONS FOR MEAN ICE-COVERED CONDITIONS

Project 16987	11 Feb 2011	**Figure 4**

northwest hydraulic consultants

CHART A
CONCENTRATION CONTOUR PLAN

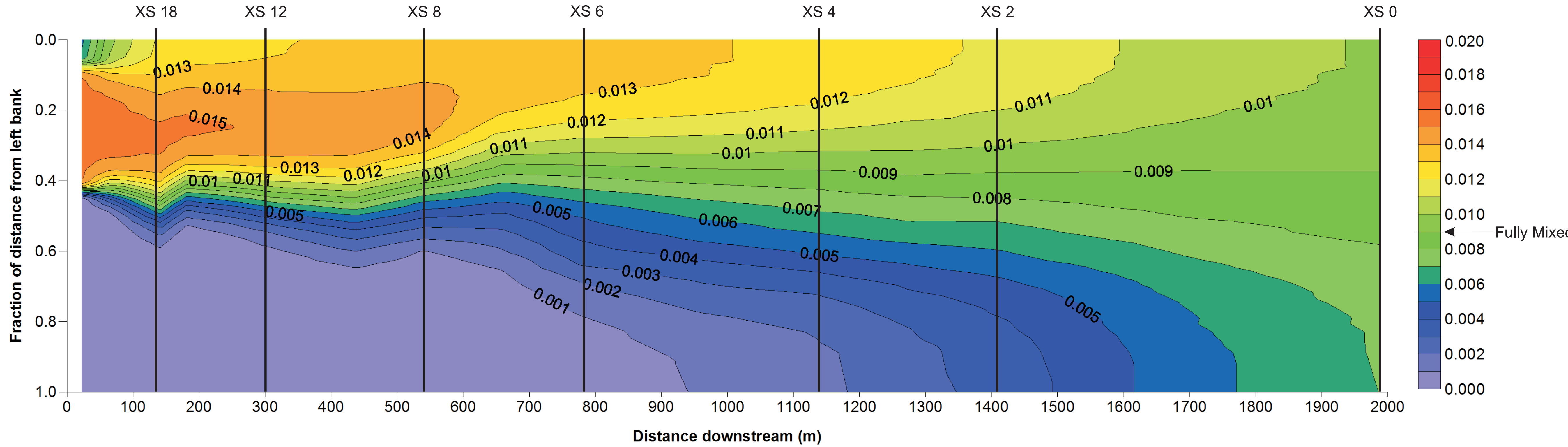


CHART B
TRANSVERSE CONCENTRATION PROFILES

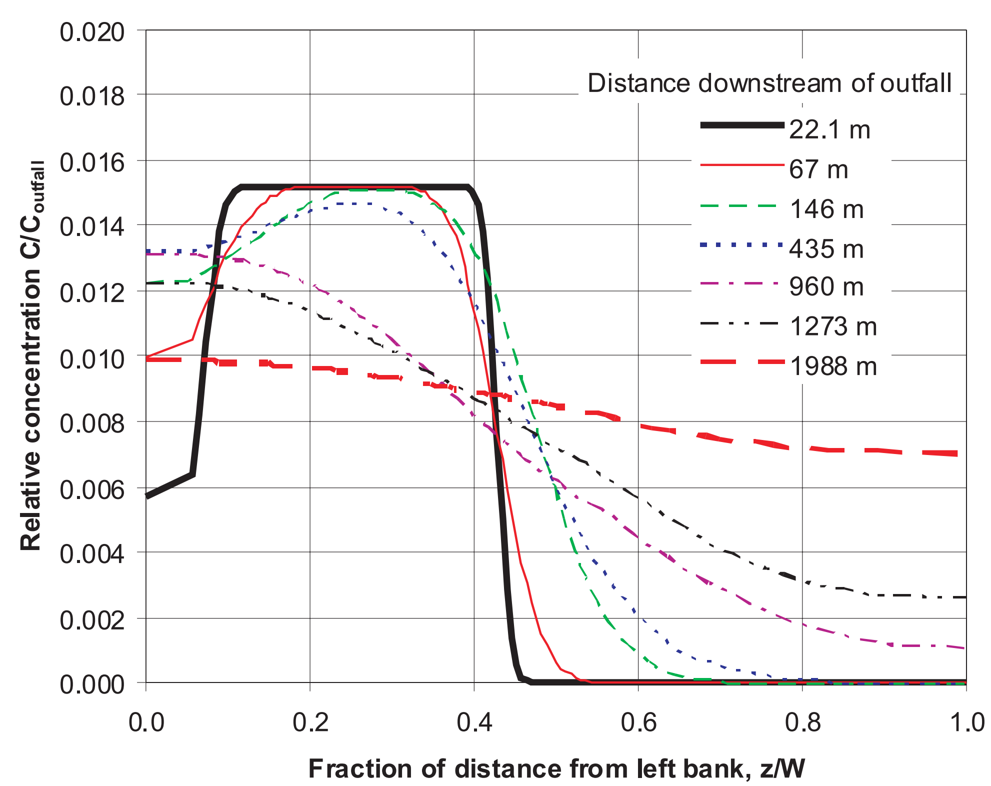
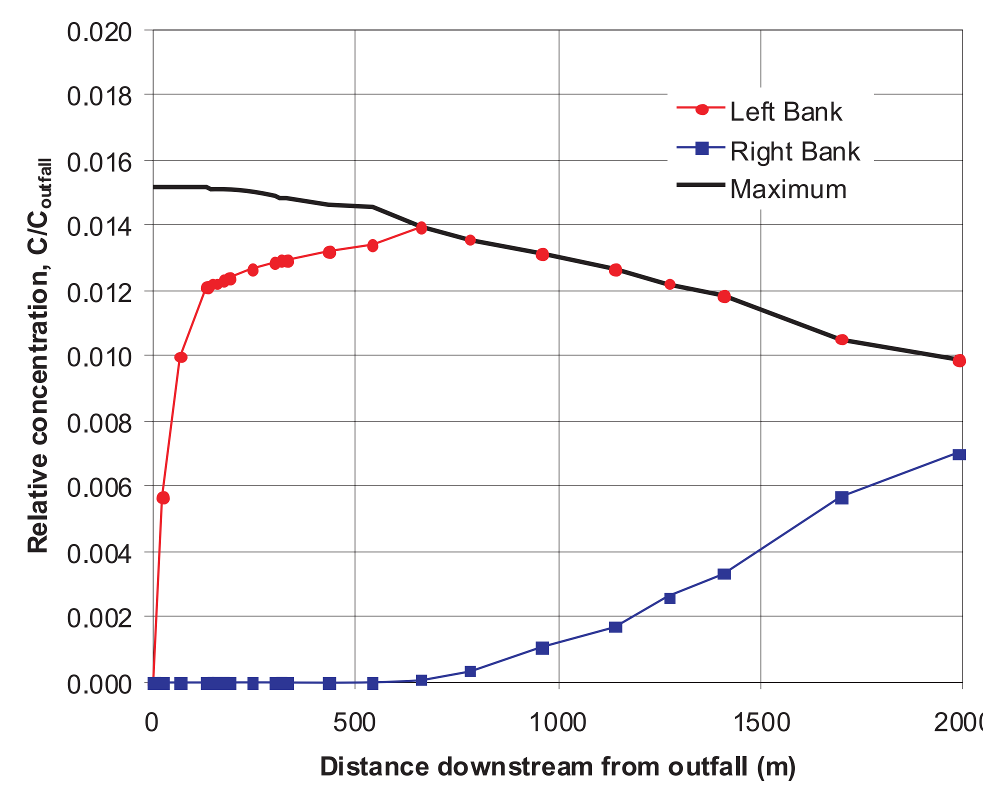


CHART C
LONGITUDINAL CONCENTRATION PROFILES



Prairie Creek Discharge	10.2 m^3/s
Outfall Discharge	0.0925 m^3/s
Vertical Mixing Length	22.1 m
Fully-mixed Dilution	111.3

CANADIAN ZINC CORPORATION

PRAIRIE CREEK MINE

EXFILTRATION TRENCH OUTFALL CONCENTRATION DISTRIBUTIONS FOR MEAN OPEN-WATER CONDITIONS

Project 16987	11 Feb 2011	**Figure 5**

northwest hydraulic consultants

APPENDIX M

Analysis of Stream Flow Trends

Northwest Hydraulics Co.

9819 – 12 Avenue SW | Edmonton, AB T6X 0E3 | 780.436.5868 | www.nhcweb.com

nhc
northwest hydraulic consultants

Ref. No. 16987

October 25, 2010

Canadian Zinc Corporation
Suite 1710 - 650 West Georgia Street
Vancouver, BC
V6B 4N9

Attention: David Harpley

Via email: david@canadianzinc.com

Re: Regional Streamflow Time Series Trend Analysis

Dear Mr. Harpley:

This letter has been prepared to document a time series trend analysis of long-term streamflow records in the Prairie Creek mine vicinity. A trend analysis of the flow data had been requested by Natural Resources Canada (NRC) staff during technical meetings organized by the Mackenzie Valley Review Board for the Prairie Creek Mine Environmental Assessment.

The objectives of the trend analysis were twofold: (1) to assess if there are any obvious long-term trends in annual peak or mean flows in the region, and (2) to assess the representativeness of flows during the 1975 to 1990 period when the Prairie Creek at Cadillac Mine stream gauge was operated by the Water Survey of Canada (WSC).

A time series trend analysis on annual average flows and annual daily maximum flows was made using WSC flow data for the four gauges listed below. Most of the gauges have short periods of missing record within the period indicated above as having continuous record. For the Liard River gauge, missing flows during the winters of 1981 and 1982 were estimated on the basis of typical winter values to complete the period of record that is coincident with the Prairie Creek gauge.

Name	Gauge #	Basin Area, km^2	Record start	Notes
Prairie Creek at Cadillac Mine	10EC002	495	Oct 1974	Record ends after Dec 1990
Flat River near the Mouth	10EA003	8560	Oct 1960	Continuous records start 1973
South Nahanni River above Virginia Falls	10EB001	14500	Oct 1962	Continuous records start 1972
Liard River at Fort Liard	10ED001	222000	Oct 1943	Continuous records start 1965

To facilitate the assessment of the regional data and also the representativeness of the 1975 to 1990 period, the flow data were normalized using 1975 to 1990 average values. For each gauge, mean annual flows were normalized by dividing by the average of the 1975 to 1990 mean flows. Peak annual flows were normalized by dividing by the average of the 1975 to 1990 peak flow values.

Figure 1 shows a time series plot of normalized annual runoff for each station together with 10-year running average runoff amounts for the Liard and South Nahanni River stations. The ten year running average is the average over the prior period, for example the 2009 value reflects the mean runoff for years 2000 through 2009. Normalized flows above 1.0 are greater than the average 1975-1990 value; normalized flows less than 1.0 are less than the average 1975-1990 value.

There is no obvious long term trend in the annual mean flows. The 10-year mean values show oscillations that are commonly found in hydrologic records and which are sometimes associated with cyclic variability in the Pacific Decadal Oscillation and other indices.

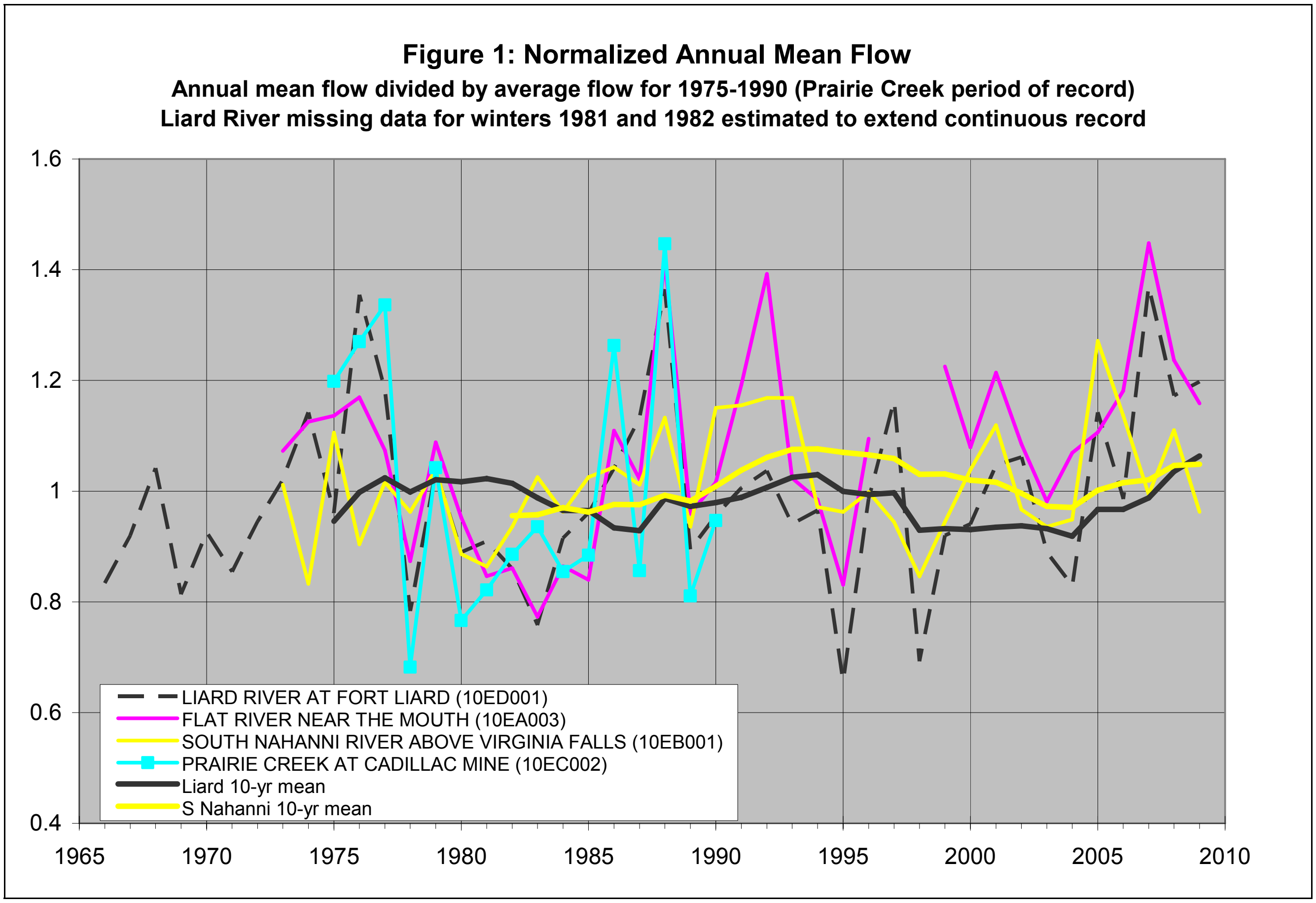
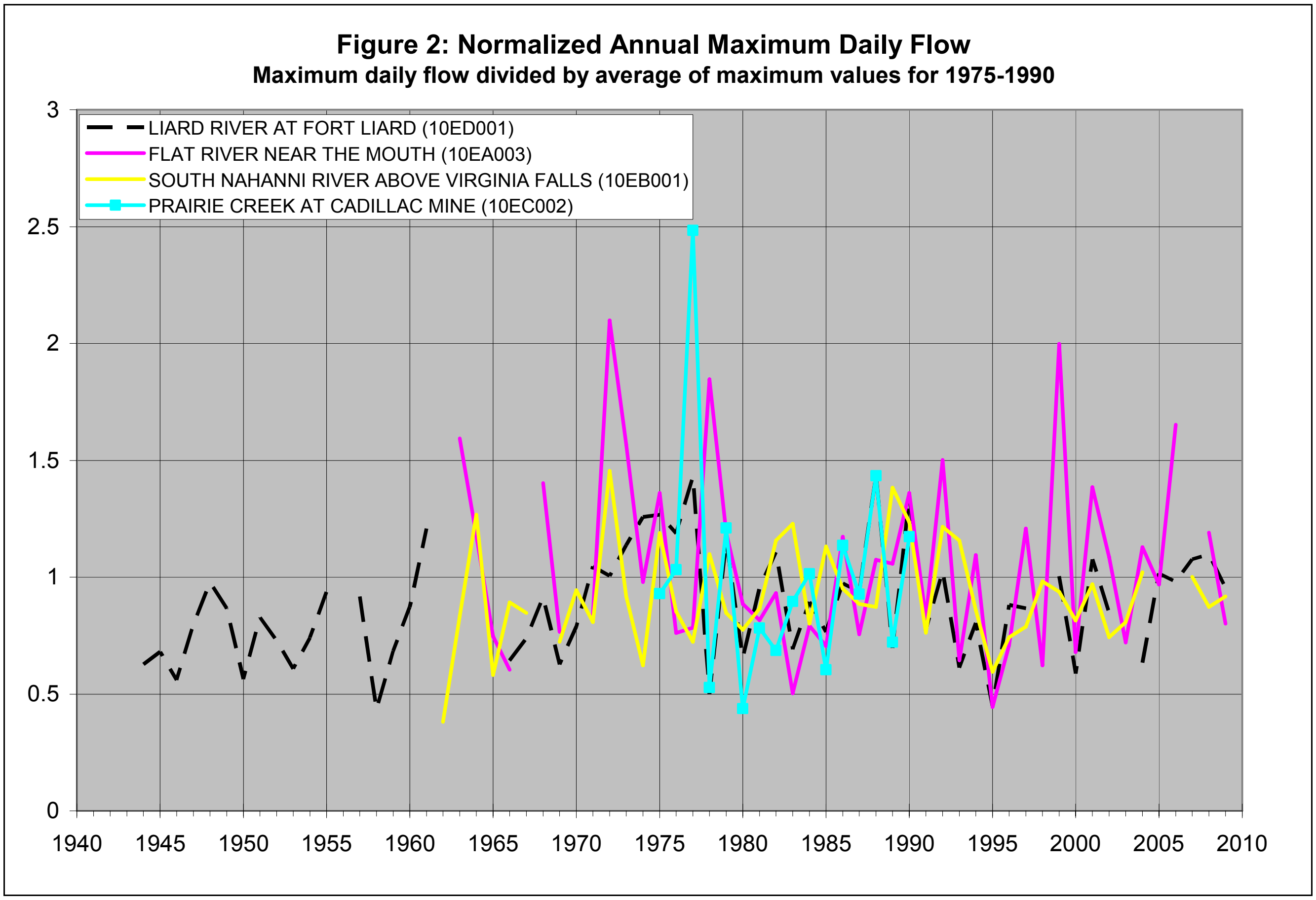


Figure 2 shows a time series plot of normalized annual maximum daily flow for each station. Normalized flows above 1.0 are greater than the average 1975-1990 value; normalized flows less than 1.0 are less than the average 1975-1990 value. The plot does not include 10 year running mean values because of gaps in the post-1997 peak flow records at all of the gauges.

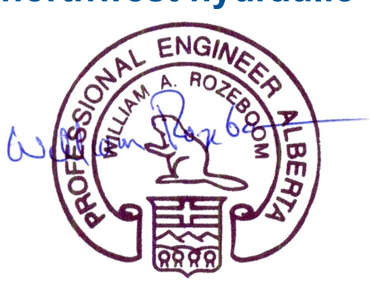
There is no obvious long term trend in the annual peak flows. The normalized Prairie Creek peak flow for 1977 is the highest of all stations for all years of record, but this may be due in part to the relatively small size of the Prairie Creek basin. It is noted that the same year (1977) had the highest flow in the Liard River record but below-average peak flows in the Flat and South Nahanni Rivers.



In conclusion, there are no obvious trends in either the annual mean or annual peak flows at gauged streams in the Prairie Creek region. The 1975 -1990 record for Prairie Creek appears to be reasonably representative of average conditions considering the longer-term flow records at the regional stations. Also, the Prairie Creek record appears to include wet and dry years with runoff near both the upper and lower bounds of the range of variability seen in the other stations.

Respectfully submitted,

northwest hydraulic consultants



W.A. (Bill) Rozeboom, M.B.A., P.Eng.
Senior Hydrologist

APPENDIX N

Groundwater IR Replies

Robertson Geoconsultants

ROBERTSON GEOCONSULTANTS INC. A Robertson Group Company

Consulting Engineers and GeoScientists for the Mining Industry

Suite 640, 580 Hornby St., Vancouver BC, Canada V6C 3B6
Phone (604) 684-8072 Fax (604) 684-8073
www.robertsongeoconsultants.com

March 3, 2011
RGC Project No: 148002/5

Canadian Zinc Corporation

Suite 1710 – 650 West Georgia Street
Vancouver, B.C.
V6B 4N9

Attention: Dave Harpley

RE: RGC Responses to Second Round of Information Requests, Prairie Creek Mine, NWT - REV 0

Dave,

This letter report summarizes our responses to the Second Round of Information Requests (IRs) submitted by INAC to the Mackenzie Valley Review Board for the Prairie Creek Mine Environmental Assessment. As requested, only those IRs directly related to hydrogeological aspects of the proposed development are addressed in this letter report.

1 Information Requests from Indian & Northern Affairs – Water Resources Division

1.1 IR: INAC02-03: Receiving Water Quality – Post-closure

Request 1: Provide predicted in-stream parameter concentrations post-mine closure for 'all' parameters potentially affected by mining operations, including mercury.

Additional mixing calculations have been completed for the following trace metals potentially affected by mining operations not presented in earlier reports: arsenic, (As), antimony (Sb), iron (Fe), mercury (Hg) and silver (Ag) The additional mixing calculations included conservative mixing calculations as well as sensitivity analyses to evaluate the influence of geochemical controls on predicted trace metal concentrations in Prairie Creek (see Appendix A for more details).

Tables 1 and 2 summarize the updated conservative predictions of pre-mining and post-closure in-stream concentrations in Prairie Creek at Harrison Creek (station SPN3-11) and at the Park Boundary, respectively. Tables 3 and 4 summarize the predicted in-stream concentrations below Harrison Creek SNP station 3-11) and at the Park Boundary for various reactive mixing calculations, assuming various potential geochemical controls, including:

- surface complexation reactions and sorption of trace metals by co-precipitation along a flow path prior to mixing in the creeks, and
- The effects of the development of a reducing environment in the post-closure flooded backfilled mine voids;

For the purposes of identifying potential exceedances, the site specific objectives as provided by Hatfield (2011) have been used.

Conservative mixing calculations suggest that only zinc (Zn) and mercury (Hg) potentially exceed the proposed site-specific objectives (Tables 1 and 2). Zinc is only predicted to exceed the site-specific objectives under extreme low flow conditions, i.e. for winter base flow conditions (Jan – Mar) assuming a very dry year ("minimum flows"), similar to conditions estimated for pre-mining conditions (see Tables 1 and 2). Mercury is predicted to exceed the site-specific objective for most of the year under both average and minimum flows.

It should be emphasized, however, that the water quality predictions shown in Tables 1 and 2 are based on the assumption of conservative mixing. While these calculations are a good initial screening tool for identifying potential contaminants of concern, they likely significantly over-predict concentrations of trace metals (including Cd, Cu, Pb, Sb, and Hg) known to be reactive in the aquatic environment and subject to attenuation along the flow path.

As discussed in more detail in Appendix A, the discrepancy between predicted and observed water quality is particularly evident in the case of mercury. Mercury concentrations observed in current mine water discharge from the 870 Portal (station 3-7) have shown consistently non-detectable Hg concentrations (<0.02 ug/L). Even the highly mineralized mine water collected from the Prairie Creek mine (at XC-4) has shown no detectable Hg concentrations. Similarly, groundwater in the highly mineralized shallow MQV (at MW09-15) did not show any detectable Hg concentrations.

The mobility of mercury is known to be greatly inhibited in alkaline environments and in reducing conditions due to mineral precipitation (see Levinson, 1980, Steinnes, 1995). Our geochemical analyses using site-specific data support this general finding (see Appendix A). Thermodynamic modelling indicates that assuming moderately reducing conditions currently observed in the mine water and local bedrock aquifer (and expected to re-establish post-closure), mercury concentrations in the backfilled mine water will be greatly reduced (see Appendix A for more details). Our reactive mixing calculations indicate that under such moderately reducing conditions, mercury concentrations in Prairie Creek would not exceed the site-specific objectives (see Tables 3 and 4). Based on the loading calculations presented in Appendix A and summarized in Tables 1 to 4, we conclude that the only likely exceedances post-closure in Prairie Creek (at station SNP 3-11) will be zinc in the winter months for minimum flow conditions, similar to what is occurring currently.

A more detailed review of the available literature and/or attenuation studies are recommended over the mine operating period to further evaluate the mobility of the principal trace metals of concern (i.e. Zn, Cd, Pb, Sb and Hg) in the local groundwater system at Prairie Creek, and to enable reliable monitoring and response plans to be developed for the post-closure period.

Request 2: What are predicted in-stream parameter concentrations during early post-closure? How long will the early post-closure conditions last?

No specific attempt was made in our water quality predictions to distinguish between early and long-term post-closure concentrations, but to provide a conservative estimate of the closure condition. Source concentrations used for "backfilled mine water" in the post-closure scenarios (see Tables A5 to A8 in Appendix A) were calculated based on kinetic test results (standard humidity cell testwork) of oxygenated samples. This approach assumes that all the mass of reactive rock and backfill introduces a load to the waters when groundwater contacts the rock mass. This most likely represents the early post-closure and reflooding stage.

The original predictions did not take into account the anticipated reduction of metal release once the water table has rebounded. Predictions included in the sensitivity analysis provided in Appendix A (and summarized in Table 3) result in water qualities that are generally similar to current conditions in Prairie Creek and would represent a longer-term post-closure condition (i.e. after the establishment of appropriately reducing conditions).

Note that the period of early post-closure is estimated to be of relatively short duration. According to information provided by CZN, the final void space in the mine after completion of all backfilling is estimated to be about 1%, or approximately 18,000 m3. Assuming an annual average groundwater flow through the backfilled mine of 2.1 L/s, it would take about 100 days to "flush" the groundwater initially stored in the backfilled mine. Taking into consideration the effects of incomplete mixing and dispersion along the flow path this "first flush" may impact local groundwater discharging towards Harrison Creek (and ultimately Prairie Creek) for a few years (say 3-5 years).

Request 3: Given that concentrations of several metals are predicted to exceed in-stream objectives after closure, identify potential mitigation measures that could be implemented to reduce the concentrations to below in-stream concentrations?

As discussed earlier, only zinc is predicted to exceed in-stream objectives in Prairie Creek (at station 3-11) after closure and flooding of the Prairie Creek Mine . Continued monitoring of water levels and water quality before and during mine development will be conducted and used to review, and revise as required, these initial water quality predictions. Note that elevated zinc concentrations post-closure are expected because this occurred prior to mining and is a natural phenomenon.

In the event that these revised water quality predictions suggest that in-stream concentrations of selected trace metals (excluding zinc) in Prairie Creek may not meet specified criteria, then the following potential mitigation measures could be considered:

- Maintain partially dewatered mine workings plus
    - controlled (seasonal) release and/or
    - pump & treat
- Full flooding plus seepage interception using
    - Pumping wells in MQV/Vein fault
    - Pumping wells in HCAA, and/or
    - Pumping wells in PCAA

The first mitigation option available would be to maintain a partially dewatered mine by active pumping (from one or several centrally located pumping wells equipped with submersible pumps). The flood level in the partially flooded mine workings would be maintained at an elevation below that of Prairie Creek (i.e. < 865m amsl). This would prevent the migration of potentially impacted mine water towards Harrison Creek and Prairie Creek.

If required, the collected mine water could be treated until such time that the mine water pool has improved sufficiently that full flooding can be allowed. Based on observed and modelled mine inflows, water treatment could potentially be a seasonal operation. The relatively small mine inflows predicted for the winter months (~1 to 2 L/s) could potentially be stored in the underground workings and treated during the summer months.

If the mine water collected at the Portal is only marginally impacted it could potentially be allowed to discharge to Prairie Creek without treatment.

During the period of active post-closure mine water treatment, the flood level and the water quality in the flooded mine would have to be monitored. Once water quality in the partially flooded mine has reached acceptable levels, the mine could be allowed to flood to its natural post-closure level.

An alternative mitigation approach would be to allow complete flooding of the (sealed) mine workings and use seepage interception systems at the down-gradient discharge points to prevent discharge of mine-impacted groundwater into the Harrison Creek Alluvial Aquifer (HCAA) and/or Prairie Creek Alluvial Aquifer PCAA), and from there into Prairie Creek.

Potential options for seepage interception systems would include pumping wells screened in the highly permeable MQV/Vein Fault structure (e.g. near MW09-15) or in the alluvial sediments of the HCAA and/or the PCAA. The advantage of this approach is that it allows the mine to flood earlier which will speed-up the on-set of reducing conditions and stabilization of metal release.

The disadvantages of both approaches is they would require seasonal occupancy of the site on a prolonged basis, supplies would need to be brought in (fuel, reagents, fuel), and there would be on-going vehicle and air traffic. We stress that the described mitigation, while available, may not be required, but this will be confirmed during operations and verified by post-closure monitoring.

1.2 IR: INAC02-07: Hydrogeology – Potential Groundwater Inflows, Mine water Management

Request 1: Identify mitigation measures that are available to handle significantly higher mine in-flows.

Additional sensitivity runs were completed using the existing groundwater flow model to determine the magnitude of seasonal mine inflows (see Appendix B). Table 5 shows a summary of predicted monthly mine inflows for different scenarios. The last column shows the estimated probability of occurrence (see Appendix B for more details).

The main parameter controlling mine in-flow into the dewatered mine is the transmissivity of the highly permeable Vein Fault. Our highest estimate into the active mine workings (of about 200 L/s) assumes a fracture width of ~10 m and a hydraulic conductivity of $1*10^{-4}$ m/s, resulting in a transmissivity value of $1*10^{-3}$ m^2/s. These estimates of K (and T) are about two-fold greater than our best estimates (based on model calibration). Note also that our model predictions (conservatively) assumed that the Vein Fault is highly permeable to the full depth of proposed mining (around 600 m amsl).

Finally, it should be noted that these maximum predicted inflows (of about 200 L/s) cannot be sustained year-round, even under the most conservative assumption of a highly permeable Vein Fault extending into the Prairie Creek Alluvial Aquifer. Sensitivity runs described in Appendix B illustrate that during winter conditions, when Harrison Creek is frozen and recharge from the HCAA is assumed to be negligible, seepage from the PCAA would represent the main source of recharge to the active mine workings (assuming, of course, that the Vein Fault intersects the PCAA). Under those conditions, seepage from the PCAA would still be less than 100 L/s (Appendix B).

In summary, the upper limit of inflows to the Prairie Creek Mine are predicted to range from ~100 L/s during the winter months to ~200 L/s in the summer months with an annual average of about 160 L/s.

1.3 IR: INAC02-12: Current Groundwater Conditions

Request 1: INAC requests that Canadian Zinc confirm the extent of the Vein Fault in the vicinity of Prairie Creek valley and describe the implications of the Vein Fault being connected to Prairie Creek on flow within the creek itself, and on mine inflows.

Note: Comments on geological evidence are given by CZN in the text of the IR response document.

Additional sensitivity runs were completed using the existing groundwater flow model to determine the potential impact of the permeable Vein Fault intersecting the Prairie Creek Alluvial Aquifer on mine inflows (see Appendix B). Table 6 summarizes predicted inflows to the dewatered Prairie Creek Mine and contributions from the PCAA in the four different steady-state scenarios. The predicted total inflow to the dewatered Prairie Creek Mine is not predicted to change significantly, even if the permeable Vain fault extends into the PCAA (< 1% increase in flow).

These sensitivity runs further indicate that significant seepage from PCAA into the mine workings is only expected under the following conditions:

(i) Vein Fault extends into the PCAA;

(ii) Vein Fault has a high transmissivity ($T=1*10^{-3}$ m^2/s); and

(iii) HCAA does not provide adequate recharge (i.e. assuming winter conditions when Harrison Creek dries up/freezes)

Assuming that the Vein Fault extends into the PCAA, seepage from the PCAA (and ultimately from Prairie Creek) is predicted to be 2 to 9 L/s for the low flow scenario (Fault K = $1*10^{-5}$ m/s) and 14 to 89 L/s for the high flow scenario (Fault K = $1*10^{-4}$ m/s).

Note that seepage rates from the PCAA would be higher during the winter months when Harrison Creek freezes up and does not provide adequate recharge to the HCAA. The highest predicted seepage rates from PCAA (~90 L/s) would result in local drawdown in the PCAA and would likely induce seepage ("leakage") from Prairie Creek. Even under this highly conservative scenario, stream-flow in Prairie Creek would still be about 75% of its lowest mean winter baseflow (i.e. 350 L/s in March).

Request 2: Provide additional information on the existing dissolved metal groundwater plume(s) throughout the full vertical extent of all of the hydrostratigraphic units as well as along the width and length of the plume flow paths. Hydrostratigraphic units of concern include Prairie Creek Alluvial Aquifer (>45m, deepest monitoring well is 5.8m deep), Harrison Creek Alluvial Aquifer 20m thick, deepest monitoring well is 12.7m deep), MQV Vein Fault, and shallow and deep bedrock units. CZN should explain how the characterization of groundwater flow and connectivity within the PCAA and the HCAA is determined with confidence given that the existing monitoring wells do not penetrate the full depth of the aquifer.

In late 2009, five additional monitoring wells (MW-09 series) were installed in the Harrison Creek and mill site areas with the specific purpose of assessing the source of elevated zinc concentrations in this area (see Appendix B of RGC 2010a). These wells were first sampled in November 2009 and again in July and October of 2010. In addition, three historic wells located in the mill site area and screened in the PCAA (MSW series) were sampled to better delineate the extent of the zinc plume in the PCAA.

A full summary of all groundwater quality results for the 2010 surveys is provided in Appendix C. Figures 1 to 4 show the observed concentrations at the various well locations for four trace metals of concern at the Prairie Creek site, i.e. zinc, cadmium, copper and lead.

The following conclusions can be drawn with respect to the chemical nature and spatial extent of the metal plume(s) in this area:

- Zinc concentrations exceed 2,000 ug/L in fractured bedrock and 1,000 ug/L in the PCAA; several other trace metals (Cd, Cu, Pb, and Se) also exceed CCME guidelines but their concentrations in groundwater are generally at least two to three orders of magnitude lower than zinc;
- The highest metal concentrations are observed in the bedrock wells MW09-15 (screened in the shallow MQV) and MW09-12 (screened in non-mineralized fractured bedrock); the chemical composition and trace metal concentrations in these two wells is very similar suggesting a common source of metal contamination; groundwater gradients suggest that this common source is natural discharge of mineralized groundwater from the MQV which outcrops in the Harrison Creek valley; however, leakage of mine water from the 870 tunnel may also contribute to the elevated metal concentrations;
- Metal concentrations in the wells screened in the HCAA (MW09-14 and MW09-12) generally showed much lower metal concentrations than in the underlying bedrock (in particular zinc), suggesting significant dilution of the mineralized groundwater discharging from the bedrock into the alluvial sediments; note that MW09-12 and MW09-14 showed very similar seasonal dilution trends in 2009/2010 supporting our contention that they are both screened in the same alluvial aquifer system (i.e. HCAA);
- Metal concentrations in the wells screened in the PCAA showed significant variation in space and time:
    - the water supply well (PW-01 or SNP 3-1) and the other mill site wells (screened to a depth of approximately 18 m) generally showed very low metal concentrations suggesting that the PCAA reach up-gradient of Harrison Creek is not significantly impacted;
    - the shallow well MW09-11 located immediately down-gradient of the existing Coarse Ore Stockpile (and screened in relatively low permeability sediments of the PCAA) showed moderately elevated metal concentrations; note that zinc concentrations in this PCAA well are similar to those observed in the mill seeps (MS-1 and MS-2) but higher than in the HCAA (MW09-12),
    - the shallow well MW08-01 located down-gradient of the Harrison Creek valley (and screened in highly permeable sediments of the PCAA) showed consistently elevated metal concentrations (in particular zinc); note that the metal concentrations observed at MW08-01 are significantly higher

than in the other alluvial wells screened in the HCAA and PCAA (and in the underlying bedrock) suggesting that mineralized groundwater from bedrock (likely from the MQV) is contributing metal loading to this well;

The new groundwater monitoring data collected in 2010 are generally consistent with earlier monitoring data described in RGC (2010a). The existing information suggests that the zinc plume in the PCAA is limited to the reach down-gradient of Harrison Creek. The zinc plume is very likely limited to the northern side of the valley (i.e. north of Prairie Creek) where most, if not all, metal loading (the sources) is assumed to occur (see below). The Prairie Creek valley narrows significantly within about 200 m down-gradient of MW08-1. It is likely that groundwater in the PCAA is discharging to Prairie Creek in this narrow section of the valley. The fact that zinc concentrations in Prairie Creek decrease along this reach (i.e. between PC2 and PC3) suggests that the zinc plume in the PCAA does not reach beyond this narrow section of the PCAA.

INAC's statement that the existing monitoring wells do not penetrate the full depth of the aquifer, warrants some clarifications. The MQV/Vein fault system is screened at two different depth intervals: (i) in a shallow, highly mineralized section from 18 to 24 m bgs (at MW09-15) and (ii) in a deeper, less mineralized section from 51 to 79 m bgs (MW08-3). This nested pair of piezometers suggests that shallow groundwater shows higher trace metal concentrations than deeper groundwater in the MQV/Vein fault. Shallow bedrock is typically also more permeable (due to weathering and lower lithostratic stresses. Hence a bias towards screening shallow bedrock (as done in most other bedrock holes) is considered prudent and likely conservative with respect to estimating contaminant loads in bedrock.

The two monitoring wells screened in the HCAA were screened within a relatively short distance of the overburden-bedrock contact. MW09-14 is essentially screened across the entire depth of the HCAA (from 6.6 to 12.7m bgs) with an estimated depth to bedrock of about 15 m bgs at this location based on drilling at MW09-15. Monitoring well MW09-12 is only screened in the upper half of the HCAA (screen from 2.9 to 7.4 m bgs with a depth to bedrock of about 13 m). However, water quality in this partially penetrating well is very similar to the water quality in the fully penetrating well MW09-14 located further up-gradient, suggesting limited vertical variation in water quality in the HCAA.

The recently installed monitoring wells in the PCAA specifically targeted the shallow depth interval of the PCAA because of the presence of potential sources of contamination at surface (i.e. Coarse Ore Stockpile at MW09-11) and the likelihood of upward gradients in the PCAA (at MW08-3) and hence discharge of shallow groundwater to Prairie Creek. Upward hydraulic gradients have since been confirmed between the shallow bedrock and the shallow alluvium at MW08-3. Note, however, that several historic pumping and monitoring wells are screened at significantly greater depth in the PCAA (to a depth of 18 m). Earlier hydrogeological studies suggest that the PCAA is subdivided into an upper and lower aquifer unit separated by a thick clay layer from about 16 to 26 m bgs (KPA, 1980). It is likely that these wells fully screen the upper portion of the PCAA. Recent sampling of these historic wells indicated very limited groundwater contamination in these deeper PCAA wells (see above).

In summary, the existing network of monitoring wells is considered adequate for the purposes of this current environmental assessment. We recognize that there is currently a bias towards monitoring of the shallow groundwater system (in particular in the PCAA); however, we believe that this bias is justified and does not significantly influence our ability to interpret the groundwater flow system and contaminant loading to Prairie Creek.

Additional hydrogeological characterization work is planned for the operational period of this project to ensure data is collected to allow prediction of hydrogeological behaviour after mine closure with a high degree of confidence. This characterization work would include detailed monitoring of the response of the groundwater system to (i) dewatering of the mine workings in preparation for mining and (ii) year-round collection and treatment of mine water without the possibility of discharge from the 870 portal area.

Request 3: Information on any aquifer hydraulic testing within the hydrostratigraphic units of the PCAA, HCAA, MQV/Vein fault, shallow bedrock and deep bedrock conducted by CZN. If no information has been collected describe how groundwater movement in these zones has been predicted and provide the level of confidence that exists in the assessment of groundwater flow rates and plume migration rates.

The hydraulic testing completed to date is summarized in Section 3.3 and Table 3-2 of RGC (2010a). For more details on hydraulic testing, the reader is referred to Appendix C of RGC (2010a).

Groundwater flow in the bedrock system surrounding the underground workings of the Prairie Creek Mine (MQV/Vein fault and surrounding bedrock) was predicted using a transient flow model (see RGC 2010b). Sensitivity analyses using steady-state and transient model simulations were completed to determine the level of confidence in these flow predictions (see Appendix B). The range of uncertainty in predicted flows is reflected in the scenarios of predicted mine inflows.

Groundwater flow in the alluvial aquifers (HCAA and PCAA) was predicted using Darcy calculations with observed hydraulic gradients and assuming reasonable upper and lower bounds of K and saturated cross-sections (see Section 4.2 and Table 4-4 in RGC 2010a). Again, the low and high flow estimates for the alluvial aquifers provided in Table 3-2 of RGC (2010a) reflect our estimate of the range of uncertainty in these flows.

Regarding predictions of migration of the current plume in the groundwater system, it was conservatively assumed that any impacted groundwater would discharge into Prairie Creek in the reach between SNP station 3-6 (Harrison Creek) and station SPN3-11 located about 1,000 m down-gradient of the Prairie Creek Mine and Harrison Creek, as it is likely doing at present and as it has done since initial development of the mine prior to the 1980's. Future changes are described in the responses above.

Request 4: Additional information on changes to groundwater seepage rates into Prairie Creek and Harrison Creek during low flow and high flow conditions.

Appendix D shows updated water level readings in all monitoring wells at the Prairie Creek Mine site, including water level surveys conducted in June, July and late October 2010. The following conclusions can be drawn with respect to changes in groundwater flow rates in HCAA and PCAA:

- Groundwater levels in HCAA above the mill (in MW09-14) show significant seasonal variations, ranging from a high of 5.6 m below top of casing (bTOC) under high flow (July 2010) to 9.2 m bTOC under low flow (November 2009); in other words, the saturated thickness of the sediments in the HCAA varied from ~7 m during high flow to ~3 m during low flow; these fluctuations suggest that groundwater flow rates in HCAA vary significantly throughout the year (by at least a factor of 2);
- Groundwater levels in HCAA at the confluence with PCAA (in MW09-12) showed a maximum range of about 1 m between high and low flow periods suggesting a much more modest range of seasonal variation in groundwater flow (likely less than 10%);
- Groundwater levels in PCAA in the mill area (in MW09-11 and MSW wells) and down-gradient of Harrison Creek (in MW08-1) showed only minor fluctuations of about 0.2 m throughout the open water season; this suggests that groundwater flow in PCAA does not vary significantly throughout the year.

Previous investigations had identified two potential sources for the current metal plume in the PCAA:

- Mine water by-passing collection and treatment at the 870-level portal and
- Groundwater discharging from the MQV/Vein Fault into Harrison Creek and Alluvial Aquifer and Prairie Creek Alluvial Aquifer.

Note that discharge of groundwater from the mineralized MQV is believed to be a natural source of metal loading (in particular zinc) to the system. In contrast, mine water by-passing treatment at the 870-level portal is a “legacy” of historic mine development in the 1980s. Untreated mine water is known to discharge into the PCAA via two pathways: (i) year-round leakage of mine water from the 870 tunnel (the tunnel floor is fractured and leaks based on observations of water loss from a sump), and (ii) winter/spring leakage of (untreated) mine water that collects in (or behind) an ice plug at the 870 portal, also contribute to metal loading in the PCAA.

Note that mine water discharging from the 870 Portal shows higher concentrations of most trace metals (including zinc, cadmium, copper, lead, and antimony) than groundwater in the MQV/Vein fault. The elevated concentrations of Cd, Cu, Pb and Sb observed in the Mill seeps (MS-1 and MS-2) and the Camp Ditch (MS-3) suggest that shallow groundwater in this area is impacted primarily by untreated mine water (note that a seep used to exist in the area where the Polishing Pond was built, and the seepage drained into the Mill Ditch). The fact that higher trace metal concentrations were observed early in the year (i.e. in June 2010) suggests that recharge of mine water during the early spring runoff season (when the “ice plug” is melting) is a significant source of metal loading to the PCAA.

Several synoptic flow and water quality surveys were completed in 2009/2010 to estimate seasonal variations in flow and contaminant loads of various sources including the Polishing Pond (SNP3-4) representing treated mine water, and the mill seeps representing impacted groundwater discharging to the Catchment Pond. Table 7 summarizes the observed flows and zinc concentrations and the estimated zinc loads. These detailed surveys suggest that zinc loads from the mill seeps range from 120 to 270 kg/yr during the open water season (no mill seep flows were observed after freeze-up). The observed range of zinc loading in the mill seeps can be explained by a small amount of leakage of mine water (about 0.5 to 1.1 L/s) into the alluvial groundwater. For comparison, zinc loading from the MQV to HCAA is estimated to be about 114 kg/yr (assuming 1.7 L/s at 2,120 ug/L). These loading calculations suggest that untreated mine water from the 870-

level and discharge from the MQV both contribute to the current metal loading in the PCAA (in the mill area).

More detailed monitoring of groundwater quality and hydraulic gradients in the mill area over the course of a full open water season (including the early period of snowmelt) would be required to better quantify the relative proportions of those contaminant sources to PCAA. However, it should be emphasized that both potential sources of current metal loading to PCAA would be eliminated during active operation of the Prairie Creek Mine. Prior to and during active mining, the mine workings would be dewatered and all mine water collected would be pumped to surface for treatment. This would eliminate any leakage or seasonal seepage of mine water from the 870-portal as mine water would be collected year-round. Furthermore, dewatering of the mine workings would reverse hydraulic gradients in the permeable MQV/Vein fault which would greatly reduce, if not eliminate, discharge of mineralized groundwater from the MQV/Vein fault into HCAA and PCAA.

1.4 IR_INAC02-13: Groundwater Conditions during Active Mining

Request 1: Assess and describe the potential magnitude of effects on Prairie Creek flows assuming worst-case connectivity between Prairie Creek and the MQV/Vein fault.

See response to INAC02-12 Request 1.

Request 2: Assess the impacts from the dissolved metal groundwater plume(s) discharging into Harrison Creek and Prairie Creek, using the measured hydraulic and chemical properties of the flow systems and considering the seasonal fluctuations in stream flow rates and effluent discharge.

As outlined in our response to IR INAC02-12 (Request 3), the source of the current metal plume (primarily zinc) in the HCAA and PCAA (ultimately discharging into Prairie Creek) will be removed during active mining due to (i) dewatering of the mine workings (which will capture flow in the Vein Fault) and (ii) year-round collection and treatment of all mine water (which will eliminate the 870 level tunnel/adit as a source). The removal of these sources of metal loading to the alluvial aquifers is predicted to cause the plume to dissipate as a source of metal concentrations to Harrison Creek and Prairie Creek.

The residual loading of metals to Prairie Creek (after start of mine dewatering and year-round mine water collection) will depend on:

(i) Residual metal loading from naturally mineralized bedrock not within the radius of influence of mine dewatering; and

(ii) The time required to flush any residual metal plume from HCAA and PCAA.

As a first approximation, the time required to flush any residual metal plume can be estimated using estimates of travel time in the HCAA and PCAA aquifer. Using the hydraulic parameters for HCAA listed in Table 4-4 of RGC (2010a) and further assuming a porosity of 25%, it would take about 40-80 days for any residual metal plume to travel the 300 m distance from the MQV/Vein Fault (near MW09-15) to the confluence with the PCAA (near MW09-12). Similarly, it is estimated that it would take about 1-3 years for any residual metal plume residing in the PCAA to travel the estimated maximum distance (say 1,000 m) of discharge into Prairie Creek.

Once the residual metal plume is flushed, the only remaining metal loading (other than from treated mine water discharge) would be natural loading from mineralized bedrock outside the cone of depression of the dewatered mine. Based on existing information, it can be assumed that all of the highly mineralized MQV and most of the surrounding Vein Fault extending into Harrison Creek valley will be within the cone of the dewatered mine. Hence the only mineralized groundwater potentially contributing metal loading to HCAA and PCAA (and ultimately into Prairie Creek) during active mining would originate from a small section of moderately mineralized bedrock in the lower portion of the Harrison Creek valley.

The magnitude of groundwater flow from mineralized bedrock by-passing the cone of depression of the actively dewatered mine is roughly estimated to range from <10% to 25% of current discharge of MQV flow to Harrison Creek, or <0.1 to 0.25 L/s. Groundwater quality observed in MW08-03 is considered representative of groundwater in such moderately mineralized bedrock. It can be shown that this small loading from moderately (naturally) mineralized bedrock would result in significantly lower in-stream concentrations in Prairie Creek (at station SNP 3-11) than observed today and even than predicted for pre-mining conditions (see Table 1).

1.5 IR_INAC02-14: Post-closure Groundwater Conditions

Request 1: Re-evaluate predictions of post-closure groundwater impacts on Harrison Creek and Prairie Creek by incorporating the following:

- **Worst-case scenario assumptions regarding connectivity (i.e. Vein fault connects to Prairie Creek), mine water inflows and concentrations**
- **Re-evaluation using any new additional information regarding the mixing contributions of groundwater from the MQV within the Vein fault/contributions of groundwater from the MQV within the Vein fault MQV system.**
- **An evaluation of the aquifer's attenuative capacity for metals of concern**
- **Inclusion of antimony, arsenic, iron, mercury, and silver predictions on in-stream concentrations, in addition to cadmium, copper, lead, selenium, zinc, and sulphate.**

In the preamble to their information request INAC02-14, INAC suggested that the level of groundwater characterization at the mine site presented in the DAR is insufficient to determine with certainty the source of the existing dissolved metal groundwater plume.

In the author's opinion, the existing groundwater characterization clearly indicates that the current metal groundwater plume is caused by a combination of untreated mine water and natural groundwater discharging from the MQV/Vein fault. For each source, reasonable ranges of flows and associated metal loads (including zinc) have been estimated based on the existing site characterization work, water level and water quality monitoring data and numerical modeling of groundwater flow. In our opinion, the current site characterization work is adequate for the purposes of the current environmental assessment.

In their preamble, INAC also suggested that our predictions of post-closure water quality in Prairie Creek are not consistent with current trends of water quality in Prairie Creek. Specifically, INAC pointed out that the zinc concentration in Prairie Creek observed on September 29, 2008 at station PC-2 (27 ug/L) was higher than our predicted zinc concentration for post-closure conditions in Prairie Creek at SNP station 3-11 (i.e. 7.7 ug/L for September flows). In our opinion, this comparison is flawed and current trends of water quality in Prairie Creek are indeed consistent with our post-closure water quality predictions as outlined below.

Sampling station PC-2 is located just down-gradient of the Catchment Pond and hence is strongly influenced by the release of treated mine water from the Catchment Pond. SNP monitoring data indicate that zinc concentrations in the effluent from the Catchment Pond ranged from 309 to 380 ug/L in late September 2008. SNP monitoring data for station 3-4 indicate that the zinc concentrations in treated mine effluent from the Polishing Pond ranged from 773 to 873 ug/L in late September 2008. This treated mine effluent represents a zinc load of about 250 to 350 kg/yr (with flows of 10-13 L/s). Clearly, such treated mine effluent would not be present post-closure.

Note also that the sample for PC-2 was taken only about 150 m down-gradient of the effluent discharge (on the north side) and does not represent a well-mixed sample of Prairie Creek. This is evident from the significant decrease in zinc concentrations observed in Prairie Creek samples taken on the same day at sampling station PC-3 located about 600 m downstream of PC-2, in a reach where no significant surface inflow to Prairie Creek occurs. Sampling station PC-3 is also considered to be a more representative sampling station because it is located in a relatively narrow riffle zone of the PC stream channel which enhances mixing of the effluent plume from the north side of the channel.

The zinc concentration observed at PC-3 on September 29, 2008 was only 10 ug/L, despite the documented release of treated mine effluent into Prairie Creek (see above). It can be shown that the removal of the treated mine effluent load (250 to 350 kg/yr) for post-closure conditions would further reduce zinc concentrations at PC-3 to as low as 7 ug/L. We conclude that the observed water quality in Prairie Creek in late September 2008 is entirely consistent with our post-closure predictions.

Recent seasonal water quality monitoring at station SNP 3-11 is also consistent with our predictions of post-closure water quality. Zinc concentrations at station 3-11 typically ranged from 10 ug/L during summer high flow to 30 ug/L in early spring runoff (May/early June). The elevated zinc concentrations observed during early spring runoff are likely caused by the seepage and discharge of untreated mine water at that time of year. From a closure perspective, the most representative flow period is mid-winter when stream flow is the lowest and metal concentrations in Prairie Creek are predicted to be highest. A recent winter base-flow survey conducted on January 28, 2010 showed a zinc concentration of 21 ug/L at SNP station 3-11, which is also consistent with our predictions of post-closure water quality in Prairie Creek during winter base-flow.

In conclusion, current water quality observations in Prairie Creek (at station SNP 3-11) are entirely consistent with our post-closure water quality predictions for Prairie Creek. In fact, our water quality predictions are likely conservative since current PC water quality is clearly influenced by treated mine effluent discharge which will be eliminated post-closure due to sealing of the 870 tunnel.

As requested by INAC, we have re-evaluated and updated our predictions of post-closure groundwater impacts on Prairie Creek for a wider range of trace metals (see Appendix A for more details). Tables 1 to 3 provide a summary of predicted water quality in Prairie Creek (at Station SNP 3-11) for this extended list of trace metals and a range of scenarios. The conservative mixing calculations presented in Tables 1 and 2 have been discussed in our response to INAC02-03.

Here we focus on the discussion of the scenarios specifically requested by INAC, i.e., a worst-case flow scenario and several scenarios considering natural attenuation (see Table 3).

For this worst-case flow scenario, we assumed an increase in groundwater flow through the backfilled/flooded mine and MQV/Vein fault by a factor of 2. In other words, mean annual flow through the backfilled mine was assumed to be 4.2 L/s and additional flow through the MQV/Vein fault structure was assumed to be 5.7 L/s (for a combined flow of 9.9 L/s). Furthermore, we assumed no dilution in our source term concentrations for this worst-case scenario (note that this is a very conservative assumption as higher flows through the flooded/backfilled mine workings are expected to dilute the source term concentrations).

Results are summarized in Table 3 for Prairie Creek just below Harrison Creek. Even under this very conservative worst-case flow scenario, all trace metals except mercury remain below the site-specific criteria proposed by Hatfield (2011). Only mercury (Hg) is predicted to exceed site specific objectives (Hatfield, 2011) for all months other than May and June. However, in the authors' opinion, there are reactive mechanisms that will control the concentrations of mercury and other parameters well below those concentrations predicted assuming conservative mixing. These mechanisms are evaluated further in the sensitivity analyses discussed below.

As discussed in Appendix A and our earlier response to INAC02-03, the mobility of mercury is known to be greatly inhibited in alkaline environments and in reducing conditions due to mineral precipitation (see Levinson, 1980, Steinnes, 1995). Our geochemical analyses using site-specific data support this general finding (see Appendix A). Thermodynamic modelling indicates that, assuming moderately reducing conditions currently observed in the mine water and local bedrock aquifer (and expected to re-establish post-closure), mercury concentrations in the backfilled mine water will be greatly reduced (see Appendix A for more details).

Our reactive mixing calculations indicate that assuming moderately reducing conditions prevail in the flooded mine workings, mercury concentrations in Prairie Creek would not exceed the site-specific objective, even for the worst-case flow scenario described above.

2 Closure

We trust that the information provided in this letter report meets your requirements.

Please contact the undersigned if you have any questions regarding the content of this report or require further information.

Best Regards,

ROBERTSON GEOCONSULTANTS INC.

Prepared by:

ORGINAL SIGNED

Dr. Christoph Wels, M.Sc., P.Geo.

Principal and Senior Hydrogeologist

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TABLES

Table 1. Predicted In-Stream Concentrations of Main Metals for Pre-Mining and Post Closure
Prairie Creek at Harrison Creek (SPN3-11)

	Pre-Mining - Average Flows										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Jan	0.052	0.57	0.35	1.19	15.81	0.14	0.147	5.2	0.02	0.02	93.2
Feb	0.053	0.57	0.36	1.19	17.66	0.14	0.151	5.2	0.02	0.02	96.9
Mar	0.055	0.58	0.38	1.19	21.26	0.14	0.158	5.2	0.02	0.02	100.0
Apr	0.051	0.57	0.32	1.18	11.36	0.13	0.138	5.2	0.02	0.02	80.7
May	0.049	0.56	0.29	1.18	6.78	0.13	0.129	5.2	0.02	0.02	36.4
Jun	0.049	0.56	0.29	1.18	6.72	0.13	0.129	5.2	0.02	0.02	45.7
Jul	0.049	0.57	0.29	1.18	7.05	0.13	0.130	5.2	0.02	0.02	54.5
Aug	0.049	0.57	0.29	1.18	7.32	0.13	0.130	5.2	0.02	0.02	60.1
Sep	0.049	0.56	0.23	1.14	7.47	0.13	0.122	4.9	0.02	0.02	63.2
Oct	0.050	0.57	0.31	1.18	9.10	0.13	0.134	5.2	0.02	0.02	85.4
Nov	0.050	0.57	0.31	1.18	10.20	0.13	0.136	5.2	0.02	0.02	87.5
Dec	0.051	0.57	0.33	1.19	13.03	0.13	0.142	5.2	0.02	0.02	90.9
	Post-Closure - Average Flows										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Jan	0.077	0.62	0.46	1.19	15.33	0.16	0.271	5.3	**0.15**	0.02	93.0
Feb	0.087	0.64	0.51	1.20	17.00	0.17	0.320	5.3	**0.20**	0.02	96.6
Mar	0.094	0.65	0.55	1.20	20.50	0.18	0.354	5.4	**0.23**	0.02	99.6
Apr	0.065	0.60	0.38	1.19	11.08	0.15	0.210	5.3	**0.10**	0.02	80.5
May	0.058	0.59	0.30	1.19	7.01	0.13	0.176	5.2	0.03	0.02	36.4
Jun	0.055	0.58	0.30	1.19	6.87	0.13	0.162	5.2	0.03	0.02	45.7
Jul	0.055	0.58	0.31	1.19	7.09	0.13	0.160	5.2	**0.04**	0.02	54.5
Aug	0.056	0.58	0.31	1.19	7.34	0.14	0.167	5.2	**0.04**	0.02	60.1
Sep	0.058	0.58	0.26	1.14	7.48	0.14	0.166	4.9	**0.05**	0.02	63.2
Oct	0.074	0.62	0.34	1.20	9.47	0.15	0.255	5.2	**0.06**	0.02	85.4
Nov	0.066	0.60	0.37	1.19	10.04	0.15	0.216	5.2	**0.09**	0.02	87.4
Dec	0.069	0.60	0.41	1.19	12.69	0.15	0.229	5.3	**0.11**	0.02	90.7
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
	Pre-Mining - Minimum Flows										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Jan	0.056	0.58	0.39	1.19	23.46	0.14	0.162	5.2	0.02	0.02	94.2
Feb	0.067	0.60	0.55	1.20	**49.75**	0.16	0.214	5.2	0.02	0.02	101.0
Mar	0.073	0.61	0.64	1.20	**64.43**	0.17	0.242	5.3	0.02	0.02	105.3
Apr	0.059	0.59	0.44	1.19	31.90	0.15	0.179	5.2	0.02	0.02	83.5
May	0.049	0.56	0.29	1.18	6.70	0.13	0.129	5.2	0.02	0.02	36.3
Jun	0.049	0.56	0.29	1.18	6.66	0.13	0.129	5.2	0.02	0.02	45.7
Jul	0.049	0.57	0.29	1.18	7.04	0.13	0.130	5.2	0.02	0.02	54.5
Aug	0.049	0.57	0.29	1.18	7.24	0.13	0.130	5.2	0.02	0.02	60.1
Sep	0.049	0.56	0.23	1.14	7.30	0.13	0.122	4.9	0.02	0.02	63.2
Oct	0.049	0.57	0.30	1.18	8.82	0.13	0.133	5.2	0.02	0.02	85.3
Nov	0.050	0.57	0.31	1.18	9.38	0.13	0.134	5.2	0.02	0.02	87.4
Dec	0.053	0.57	0.36	1.19	17.29	0.14	0.150	5.2	0.02	0.02	91.4
	Post-Closure - Minimum Flows										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Jan	0.100	0.67	0.59	1.20	22.58	0.18	0.387	5.4	**0.26**	0.02	93.8
Feb	0.196	0.85	1.14	1.25	**47.22**	0.28	0.865	5.8	**0.70**	0.03	99.7
Mar	0.225	0.91	1.33	1.26	**61.45**	0.32	1.009	6.0	**0.83**	0.03	103.8
Apr	0.133	0.73	0.78	1.22	30.46	0.22	0.550	5.6	**0.41**	0.02	82.8
May	0.056	0.58	0.30	1.19	6.88	0.13	0.166	5.2	0.03	0.02	36.4
Jun	0.054	0.58	0.30	1.19	6.78	0.13	0.155	5.2	0.03	0.02	45.7
Jul	0.055	0.58	0.31	1.19	7.08	0.13	0.160	5.2	**0.04**	0.02	54.5
Aug	0.055	0.58	0.31	1.19	7.26	0.14	0.163	5.2	**0.04**	0.02	60.1
Sep	0.056	0.58	0.25	1.14	7.31	0.14	0.159	4.9	**0.04**	0.02	63.2
Oct	0.071	0.62	0.34	1.20	9.15	0.14	0.242	5.2	**0.06**	0.02	85.4
Nov	0.062	0.59	0.35	1.19	9.25	0.14	0.197	5.2	**0.07**	0.02	87.3
Dec	0.081	0.63	0.48	1.20	16.73	0.16	0.293	5.3	**0.17**	0.02	91.1
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table 2. Predicted In-Stream Concentrations of Main Metals for Pre-Mining & Post-Closure
Prairie Creek at Park Boundary

	Pre-Mining - Average Flows										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Jan	0.052	0.57	0.33	1.18	14.86	0.14	0.144	5.2	0.02	0.02	93.1
Feb	0.053	0.57	0.34	1.18	16.51	0.14	0.148	5.2	0.02	0.02	96.8
Mar	0.054	0.58	0.36	1.19	19.76	0.14	0.154	5.2	0.02	0.02	99.8
Apr	0.050	0.57	0.31	1.18	10.86	0.13	0.136	5.2	0.02	0.02	80.6
May	0.049	0.57	0.29	1.18	6.73	0.13	0.128	5.2	0.02	0.02	36.4
Jun	0.049	0.57	0.28	1.18	6.69	0.13	0.128	5.2	0.02	0.02	45.7
Jul	0.049	0.57	0.29	1.18	6.98	0.13	0.129	5.2	0.02	0.02	54.5
Aug	0.049	0.57	0.29	1.18	7.23	0.13	0.129	5.2	0.02	0.02	60.1
Sep	0.049	0.56	0.23	1.14	7.36	0.13	0.122	4.9	0.02	0.02	63.2
Oct	0.049	0.57	0.30	1.18	8.82	0.13	0.132	5.2	0.02	0.02	85.3
Nov	0.050	0.57	0.30	1.18	9.81	0.13	0.134	5.2	0.02	0.02	87.5
Dec	0.051	0.57	0.32	1.18	12.36	0.13	0.139	5.2	0.02	0.02	90.8
	Post-Closure - Average Flows										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Jan	0.074	0.62	0.43	1.19	14.42	0.16	0.256	5.3	**0.14**	0.02	92.9
Feb	0.083	0.63	0.48	1.19	15.92	0.17	0.299	5.3	**0.18**	0.02	96.5
Mar	0.089	0.64	0.52	1.20	19.08	0.17	0.330	5.3	**0.21**	0.02	99.5
Apr	0.063	0.59	0.37	1.19	10.61	0.14	0.201	5.2	**0.09**	0.02	80.5
May	0.057	0.59	0.29	1.19	6.94	0.13	0.170	5.2	0.03	0.02	36.4
Jun	0.054	0.58	0.29	1.19	6.82	0.13	0.158	5.2	0.03	0.02	45.7
Jul	0.054	0.58	0.30	1.18	7.01	0.13	0.156	5.2	0.03	0.02	54.5
Aug	0.055	0.58	0.31	1.18	7.24	0.14	0.162	5.2	**0.04**	0.02	60.1
Sep	0.057	0.58	0.25	1.15	7.37	0.14	0.161	4.9	**0.05**	0.02	63.2
Oct	0.071	0.62	0.33	1.20	9.15	0.14	0.241	5.2	**0.06**	0.02	85.4
Nov	0.064	0.60	0.36	1.19	9.67	0.14	0.206	5.2	**0.08**	0.02	87.4
Dec	0.066	0.60	0.39	1.19	12.05	0.15	0.218	5.2	**0.10**	0.02	90.6
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
	Pre-Mining - Minimum Flows										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Jan	0.055	0.58	0.38	1.19	21.74	0.14	0.158	5.2	0.02	0.02	94.0
Feb	0.065	0.60	0.52	1.19	**45.47**	0.16	0.204	5.2	0.02	0.02	100.4
Mar	0.071	0.61	0.60	1.20	**58.77**	0.17	0.231	5.2	0.02	0.02	104.6
Apr	0.058	0.58	0.42	1.19	**29.34**	0.15	0.173	5.2	0.02	0.02	83.1
May	0.048	0.57	0.28	1.18	6.67	0.13	0.128	5.2	0.02	0.02	36.3
Jun	0.048	0.57	0.28	1.18	6.63	0.13	0.128	5.2	0.02	0.02	45.7
Jul	0.049	0.57	0.29	1.18	6.97	0.13	0.129	5.2	0.02	0.02	54.5
Aug	0.049	0.57	0.29	1.18	7.16	0.13	0.129	5.2	0.02	0.02	60.1
Sep	0.049	0.56	0.23	1.14	7.21	0.13	0.122	4.9	0.02	0.02	63.2
Oct	0.049	0.57	0.30	1.18	8.57	0.13	0.132	5.2	0.02	0.02	85.3
Nov	0.050	0.57	0.30	1.18	9.07	0.13	0.133	5.2	0.02	0.02	87.4
Dec	0.053	0.57	0.34	1.18	16.19	0.14	0.147	5.2	0.02	0.02	91.3
	Post-Closure - Minimum Flows										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Jan	0.095	0.66	0.56	1.20	20.95	0.18	0.360	5.4	**0.23**	0.02	93.6
Feb	**0.182**	0.83	1.05	1.24	**43.19**	0.27	**0.792**	5.8	**0.64**	0.03	99.3
Mar	**0.208**	0.88	**1.22**	1.25	**56.08**	0.30	**0.922**	5.9	**0.75**	0.03	103.3
Apr	0.124	0.71	0.72	1.21	**28.05**	0.21	0.507	5.5	**0.37**	0.02	82.5
May	0.055	0.58	0.29	1.19	6.83	0.13	0.161	5.2	0.02	0.02	36.4
Jun	0.053	0.58	0.29	1.18	6.73	0.13	0.152	5.2	0.03	0.02	45.7
Jul	0.054	0.58	0.30	1.18	7.01	0.13	0.156	5.2	**0.03**	0.02	54.5
Aug	0.055	0.58	0.30	1.18	7.17	0.13	0.159	5.2	**0.04**	0.02	60.1
Sep	0.055	0.58	0.25	1.15	7.22	0.13	0.156	4.9	**0.04**	0.02	63.2
Oct	0.069	0.61	0.33	1.20	8.87	0.14	0.229	5.2	**0.05**	0.02	85.3
Nov	0.061	0.59	0.34	1.19	8.96	0.14	0.189	5.2	**0.07**	0.02	87.3
Dec	0.078	0.62	0.46	1.19	15.69	0.16	0.276	5.3	**0.16**	0.02	91.0
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***

Note: bold values exceed the in-stream criterion proposed by SRC

Table 3. Summary of Sensitivity Analyses for Predicted Post Closure Water Quality for Prairie Creek At Harrison Creek (at SPN 3-11)

Month	Parameter	Units	Hatfield	Average Flow Conditions					Minimum Flow Conditions			
				Conservative Loading (Table A5)	Worst Case Scenario Flows (Table A9)	Surface Complexation of Source Terms (UG and WRP) (Table A11)	Same as in Table A9 Using Half Detection Limit Values (Table A13)	Reducing Conditions of Backfilled UG (Table A15)	Conservative Loading (Table A6)	Surface Complexation of Source Terms (UG and WRP) (Table A12)	Same as in Table A9 Using Half Detection Limit Values (Table A14)	Reducing Conditions of Backfilled UG (Table A16)
Jan	Cadmium (Cd)	ug/L	*0.38*	0.077	0.105	0.074	0.074	0.050	0.100	0.095	0.095	0.052
Feb				0.087	0.124	0.083	0.083	0.050	0.196	0.183	0.183	0.059
Mar				0.094	0.138	0.089	0.089	0.052	0.225	0.210	0.210	0.064
Apr				0.065	0.081	0.062	0.062	0.049	0.133	0.125	0.125	0.054
May				0.058	0.059	0.056	0.056	0.056	0.056	0.054	0.054	0.054
Jun				0.055	0.056	0.054	0.054	0.053	0.054	0.052	0.052	0.052
Jul				0.055	0.058	0.053	0.053	0.051	0.055	0.053	0.053	0.051
Aug				0.056	0.061	0.054	0.054	0.051	0.055	0.054	0.054	0.051
Sep				0.058	0.063	0.056	0.056	0.051	0.056	0.055	0.055	0.051
Oct				0.074	0.082	0.071	0.071	0.065	0.071	0.068	0.068	0.063
Nov				0.066	0.080	0.064	0.064	0.051	0.062	0.060	0.060	0.051
Dec				0.069	0.088	0.066	0.066	0.049	0.081	0.078	0.078	0.051
Jan	Copper (Cu)	ug/L	*4*	0.62	0.68	0.56	0.56	0.56	0.67	0.56	0.56	0.56
Feb				0.64	0.71	0.56	0.56	0.56	0.85	0.57	0.57	0.57
Mar				0.65	0.74	0.56	0.56	0.56	0.91	0.58	0.58	0.58
Apr				0.60	0.63	0.56	0.56	0.56	0.73	0.56	0.56	0.56
May				0.59	0.59	0.55	0.55	0.57	0.58	0.55	0.55	0.57
Jun				0.58	0.58	0.55	0.55	0.57	0.58	0.55	0.55	0.56
Jul				0.58	0.58	0.55	0.55	0.56	0.58	0.55	0.55	0.56
Aug				0.58	0.59	0.55	0.55	0.56	0.58	0.55	0.55	0.56
Sep				0.58	0.59	0.55	0.55	0.56	0.58	0.55	0.55	0.56
Oct				0.62	0.64	0.55	0.55	0.60	0.62	0.55	0.55	0.59
Nov				0.60	0.63	0.55	0.55	0.56	0.59	0.55	0.55	0.56
Dec				0.60	0.64	0.56	0.56	0.56	0.63	0.56	0.56	0.56
Jan	Lead (Pb)	ug/L	*7*	0.46	0.62	0.32	0.32	0.32	0.59	0.35	0.35	0.35
Feb				0.51	0.72	0.33	0.33	0.33	1.14	0.45	0.45	0.45
Mar				0.55	0.81	0.35	0.35	0.34	1.33	0.52	0.52	0.52
Apr				0.38	0.48	0.30	0.30	0.30	0.78	0.38	0.38	0.38
May				0.30	0.30	0.29	0.29	0.29	0.30	0.29	0.29	0.29
Jun				0.30	0.30	0.29	0.29	0.29	0.30	0.29	0.29	0.29
Jul				0.31	0.32	0.29	0.29	0.29	0.31	0.29	0.29	0.29
Aug				0.31	0.34	0.29	0.29	0.29	0.31	0.29	0.29	0.29
Sep				0.26	0.29	0.29	0.29	0.29	0.25	0.29	0.29	0.29
Oct				0.34	0.39	0.30	0.30	0.30	0.34	0.29	0.29	0.30
Nov				0.37	0.45	0.30	0.30	0.30	0.35	0.29	0.29	0.30
Dec				0.41	0.52	0.31	0.31	0.31	0.48	0.33	0.33	0.33
Jan	Selenium (Se)	ug/L	*2.16*	1.19	1.21	1.17	1.17	1.16	1.20	1.18	1.18	1.16
Feb				1.20	1.21	1.18	1.18	1.16	1.25	1.22	1.22	1.16
Mar				1.20	1.22	1.18	1.18	1.16	1.26	1.24	1.24	1.16
Apr				1.19	1.20	1.17	1.17	1.16	1.22	1.20	1.20	1.16
May				1.19	1.19	1.17	1.17	1.17	1.19	1.17	1.17	1.17
Jun				1.19	1.19	1.17	1.17	1.16	1.19	1.16	1.16	1.16
Jul				1.19	1.19	1.16	1.16	1.16	1.19	1.16	1.16	1.16
Aug				1.19	1.19	1.16	1.16	1.16	1.19	1.16	1.16	1.16
Sep				1.14	1.15	1.17	1.17	1.16	1.14	1.16	1.16	1.16
Oct				1.20	1.21	1.18	1.18	1.18	1.20	1.18	1.18	1.17
Nov				1.19	1.20	1.17	1.17	1.16	1.19	1.17	1.17	1.16
Dec				1.19	1.20	1.17	1.17	1.16	1.20	1.17	1.17	1.16
Jan	Zinc (Zn)	ug/L	*35*	15.33	24.10	15.18	15.18	15.20	22.58	22.42	22.42	22.46
Feb				17.00	27.38	16.84	16.84	16.87	47.22	46.98	46.98	47.09
Mar				20.50	34.23	20.34	20.34	20.38	61.45	61.19	61.19	61.33
Apr				11.08	15.71	10.95	10.95	10.96	30.46	30.26	30.26	30.33
May				7.01	7.34	6.88	6.88	6.88	6.88	6.76	6.76	6.76
Jun				6.87	7.15	6.74	6.74	6.74	6.78	6.65	6.65	6.65
Jul				7.09	7.66	6.96	6.96	6.96	7.08	6.95	6.95	6.95
Aug				7.34	8.16	7.21	7.21	7.21	7.26	7.13	7.13	7.13
Sep				7.48	8.61	7.53	7.53	7.54	7.31	7.36	7.36	7.37
Oct				9.47	11.99	9.33	9.33	9.34	9.15	9.02	9.02	9.03
Nov				10.04	13.54	9.90	9.90	9.91	9.25	9.11	9.11	9.12
Dec				12.69	18.90	12.55	12.55	12.57	16.73	16.58	16.58	16.61

Note: Highlighted cells indicate exceedance above site-specific objectives (Hatfield, 2011)

Table 3 cont'd. Summary of Sensitivity Analyses for Predicted Post Closure Water Quality for Prairie Creek At Harrison Creek (at SPN 3-11)

Month	Parameter	Units	Hatfield	Average Flow Conditions					Minimum Flow Conditions			
				Conservative Loading (Table A5)	Worst Case Scenario Flows (Table A9)	Surface Complexation of Source Terms (UG and WRP) (Table A11)	Same as in Table A9 Using Half Detection Limit Values (Table A13)	Reducing Conditions of Backfilled UG (Table A15)	Conservative Loading (Table A6)	Surface Complexation of Source Terms (UG and WRP) (Table A12)	Same as in Table A9 Using Half Detection Limit Values (Table A14)	Reducing Conditions of Backfilled UG (Table A16)
Jan	Arsenic (As)	ug/L	*5*	0.16	0.19	0.15	0.15	0.13	0.18	0.18	0.18	0.14
Feb				0.17	0.21	0.16	0.16	0.13	0.28	0.27	0.27	0.15
Mar				0.18	0.22	0.17	0.17	0.13	0.32	0.30	0.30	0.16
Apr				0.15	0.16	0.14	0.14	0.13	0.22	0.21	0.21	0.14
May				0.13	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Jun				0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Jul				0.13	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Aug				0.14	0.14	0.13	0.13	0.13	0.14	0.13	0.13	0.13
Sep				0.14	0.14	0.13	0.13	0.13	0.14	0.13	0.13	0.13
Oct				0.15	0.16	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Nov				0.15	0.16	0.14	0.14	0.13	0.14	0.14	0.14	0.13
Dec				0.15	0.17	0.15	0.15	0.13	0.16	0.16	0.16	0.13
Jan	Antimony (Sb)	ug/L	*20*	0.27	0.41	0.27	0.26	0.14	0.39	0.38	0.38	0.15
Feb				0.32	0.51	0.31	0.31	0.14	0.87	0.85	0.85	0.18
Mar				0.35	0.57	0.35	0.34	0.15	1.01	1.00	0.99	0.21
Apr				0.21	0.29	0.21	0.20	0.13	0.55	0.54	0.54	0.16
May				0.18	0.18	0.17	0.17	0.17	0.17	0.16	0.16	0.16
Jun				0.16	0.17	0.16	0.15	0.15	0.16	0.15	0.15	0.15
Jul				0.16	0.18	0.16	0.15	0.14	0.16	0.16	0.15	0.14
Aug				0.17	0.19	0.16	0.16	0.14	0.16	0.16	0.16	0.14
Sep				0.17	0.19	0.17	0.17	0.15	0.16	0.17	0.16	0.14
Oct				0.25	0.30	0.25	0.25	0.21	0.24	0.24	0.23	0.21
Nov				0.22	0.29	0.21	0.21	0.15	0.20	0.19	0.19	0.14
Dec				0.23	0.33	0.22	0.22	0.14	0.29	0.29	0.28	0.14
Jan	Iron (Fe)	ug/L	*300*	5.31	5.43	5.08	2.69	5.21	5.41	5.07	2.69	5.31
Feb				5.35	5.52	5.07	2.69	5.25	5.83	5.05	2.70	5.74
Mar				5.38	5.57	5.07	2.69	5.28	5.96	5.06	2.72	5.86
Apr				5.25	5.32	5.08	2.68	5.15	5.55	5.07	2.69	5.46
May				5.19	5.19	5.08	2.68	5.09	5.18	5.08	2.68	5.08
Jun				5.19	5.19	5.08	2.68	5.09	5.18	5.08	2.68	5.09
Jul				5.19	5.21	5.08	2.68	5.09	5.19	5.08	2.68	5.09
Aug				5.20	5.22	5.08	2.68	5.10	5.20	5.08	2.68	5.10
Sep				4.93	4.95	5.08	2.68	5.10	4.92	5.08	2.68	5.10
Oct				5.22	5.26	5.08	2.68	5.12	5.22	5.08	2.68	5.12
Nov				5.24	5.31	5.08	2.68	5.15	5.23	5.08	2.68	5.13
Dec				5.27	5.36	5.08	2.68	5.17	5.32	5.08	2.69	5.23
Jan	Mercury (Hg)	ug/L	*0.034*	0.15	0.28	0.039	0.02	0.02	0.26	0.06	0.028	0.020
Feb				0.20	0.37	0.046	0.02	0.02	0.70	0.12	0.061	0.020
Mar				0.23	0.43	0.051	0.03	0.02	0.83	0.14	0.070	0.020
Apr				0.10	0.17	0.031	0.02	0.02	0.41	0.08	0.039	0.020
May				0.027	0.032	0.021	0.010	0.022	0.025	0.020	0.010	0.021
Jun				0.027	0.033	0.021	0.010	0.021	0.026	0.020	0.010	0.021
Jul				0.036	0.051	0.022	0.011	0.020	0.036	0.022	0.011	0.020
Aug				0.043	0.065	0.023	0.012	0.020	0.041	0.023	0.011	0.020
Sep				0.048	0.074	0.024	0.012	0.021	0.044	0.023	0.012	0.020
Oct				0.062	0.100	0.026	0.013	0.024	0.058	0.025	0.013	0.023
Nov				0.089	0.157	0.030	0.015	0.020	0.074	0.028	0.014	0.020
Dec				0.11	0.202	0.03	0.017	0.020	0.17	0.042	0.021	0.020
Jan	Silver (Ag)	ug/L	*0.103*	0.021	0.022	0.021	0.010	0.020	0.022	0.022	0.011	0.020
Feb				0.022	0.023	0.021	0.011	0.020	0.027	0.026	0.013	0.020
Mar				0.022	0.024	0.022	0.011	0.020	0.028	0.027	0.014	0.020
Apr				0.021	0.021	0.020	0.010	0.020	0.024	0.023	0.012	0.020
May				0.020	0.020	0.020	0.010	0.020	0.020	0.020	0.010	0.020
Jun				0.020	0.020	0.020	0.010	0.020	0.020	0.020	0.010	0.020
Jul				0.020	0.020	0.020	0.010	0.020	0.020	0.020	0.010	0.020
Aug				0.020	0.020	0.020	0.010	0.020	0.020	0.020	0.010	0.020
Sep				0.021	0.022	0.020	0.010	0.020	0.021	0.020	0.010	0.020
Oct				0.021	0.021	0.020	0.010	0.020	0.021	0.020	0.010	0.020
Nov				0.021	0.021	0.020	0.010	0.020	0.021	0.020	0.010	0.020
Dec				0.021	0.022	0.020	0.010	0.020	0.021	0.021	0.011	0.020
Jan	Sulphate (SO_4)	mg/L	*200*	93	94	91	91	91	94	92	92	92
Feb				97	98	95	95	94	100	98	98	97
Mar				100	101	98	98	97	104	102	102	101
Apr				81	81	79	79	79	83	81	81	81
May				36	36	36	36	36	36	36	36	36
Jun				46	46	45	45	45	46	45	45	45
Jul				54	55	53	53	53	54	53	53	53
Aug				60	60	59	59	59	60	59	59	59
Sep				63	63	62	62	62	63	62	62	62
Oct				85	86	84	84	84	85	84	84	84
Nov				87	88	86	86	86	87	86	86	86
Dec				91	91	89	89	89	91	89	89	89

Note: Highlighted cells indicate exceedance above site-specific objectives (Hatfield, 2011)

Table 4. Summary of Sensitivity Analyses for Predicted Post Closure Water Quality for Prairie Creek At Park Boundary

Month	Parameter	Units	Hatfield	Average Flow Conditions					Minimum Flow Conditions			
				Conservative Loading (Table A7)	Worst Case Scenario Flows (Table A10)	Surface Complexation of Source Terms (UG and WRP) (Table A11b)	Same as in Table A11b Using Half Detection Limit Values (Table A13b)	Reducing Conditions of Backfilled UG (Table A15b)	Conservative Loading (Table A8)	Surface Complexation of Source Terms (UG and WRP) (Table A12b)	Same as in Table A9 Using Half Detection Limit Values (Table A14b)	Reducing Conditions of Backfilled UG (Table A16b)
Jan	Cadmium (Cd)	ug/L	*0.38*	0.074	0.100	0.072	0.072	0.051	0.095	0.090	0.091	0.053
Feb				0.083	0.117	0.080	0.080	0.051	0.182	0.167	0.170	0.059
Mar				0.089	0.129	0.086	0.086	0.052	0.208	0.191	0.195	0.063
Apr				0.063	0.078	0.062	0.062	0.050	0.124	0.116	0.118	0.055
May				0.057	0.058	0.056	0.056	0.056	0.055	0.054	0.054	0.054
Jun				0.054	0.056	0.054	0.054	0.053	0.053	0.052	0.053	0.052
Jul				0.054	0.057	0.054	0.054	0.051	0.054	0.053	0.053	0.051
Aug				0.055	0.059	0.055	0.055	0.051	0.055	0.053	0.054	0.051
Sep				0.057	0.061	0.056	0.056	0.052	0.055	0.054	0.055	0.051
Oct				0.071	0.078	0.069	0.069	0.064	0.069	0.066	0.067	0.063
Nov				0.064	0.077	0.063	0.063	0.052	0.061	0.059	0.060	0.051
Dec				0.066	0.084	0.065	0.065	0.050	0.078	0.074	0.076	0.051
Jan	Copper (Cu)	ug/L	*4*	0.62	0.67	0.57	0.57	0.57	0.66	0.56	0.57	0.57
Feb				0.63	0.70	0.57	0.57	0.57	0.83	0.57	0.58	0.58
Mar				0.64	0.72	0.57	0.57	0.57	0.88	0.58	0.59	0.59
Apr				0.59	0.62	0.57	0.57	0.57	0.71	0.56	0.57	0.57
May				0.59	0.59	0.57	0.57	0.58	0.58	0.56	0.57	0.58
Jun				0.58	0.58	0.57	0.57	0.58	0.58	0.56	0.57	0.57
Jul				0.58	0.58	0.57	0.57	0.57	0.58	0.56	0.57	0.57
Aug				0.58	0.59	0.57	0.57	0.57	0.58	0.56	0.57	0.57
Sep				0.58	0.59	0.57	0.57	0.57	0.58	0.56	0.57	0.57
Oct				0.62	0.63	0.57	0.57	0.60	0.61	0.56	0.57	0.60
Nov				0.60	0.62	0.57	0.57	0.57	0.59	0.56	0.57	0.57
Dec				0.60	0.64	0.57	0.57	0.57	0.62	0.56	0.57	0.57
Jan	Lead (Pb)	ug/L	*7*	0.43	0.58	0.32	0.32	0.32	0.56	0.34	0.35	0.34
Feb				0.48	0.67	0.32	0.32	0.32	1.05	0.43	0.43	0.45
Mar				0.52	0.76	0.34	0.34	0.34	1.22	0.49	0.50	0.52
Apr				0.37	0.45	0.30	0.30	0.30	0.72	0.37	0.37	0.39
May				0.29	0.30	0.28	0.28	0.29	0.29	0.28	0.28	0.29
Jun				0.29	0.30	0.28	0.28	0.29	0.29	0.28	0.28	0.29
Jul				0.30	0.31	0.28	0.28	0.29	0.30	0.28	0.28	0.29
Aug				0.31	0.33	0.29	0.29	0.29	0.30	0.28	0.29	0.29
Sep				0.25	0.28	0.29	0.29	0.29	0.25	0.28	0.29	0.29
Oct				0.33	0.37	0.29	0.29	0.30	0.33	0.29	0.29	0.30
Nov				0.36	0.43	0.29	0.29	0.30	0.34	0.29	0.29	0.30
Dec				0.39	0.49	0.31	0.31	0.31	0.46	0.32	0.32	0.33
Jan	Selenium (Se)	ug/L	*2.16*	1.19	1.20	1.19	1.19	1.18	1.20	1.18	1.20	1.18
Feb				1.19	1.21	1.19	1.19	1.18	1.24	1.22	1.24	1.18
Mar				1.20	1.21	1.20	1.20	1.18	1.25	1.23	1.25	1.18
Apr				1.19	1.19	1.19	1.19	1.18	1.21	1.19	1.21	1.18
May				1.19	1.19	1.19	1.19	1.19	1.19	1.17	1.19	1.19
Jun				1.19	1.19	1.19	1.19	1.19	1.18	1.16	1.18	1.18
Jul				1.18	1.19	1.18	1.18	1.18	1.18	1.16	1.18	1.18
Aug				1.18	1.19	1.18	1.18	1.18	1.18	1.16	1.18	1.18
Sep				1.15	1.15	1.19	1.19	1.18	1.15	1.16	1.18	1.18
Oct				1.20	1.20	1.20	1.20	1.20	1.20	1.18	1.20	1.19
Nov				1.19	1.19	1.19	1.19	1.18	1.19	1.17	1.19	1.18
Dec				1.19	1.20	1.19	1.19	1.18	1.19	1.17	1.19	1.18
Jan	Zinc (Zn)	ug/L	*35*	14.42	22.32	14.40	14.40	14.42	20.95	20.55	20.91	20.95
Feb				15.92	25.27	15.90	15.90	15.92	43.19	42.35	43.08	43.19
Mar				19.08	31.45	19.04	19.04	19.08	56.08	55.02	55.96	56.08
Apr				10.61	14.76	10.59	10.59	10.61	28.05	27.50	27.99	28.05
May				6.94	7.24	6.94	6.94	6.94	6.83	6.71	6.83	6.83
Jun				6.82	7.07	6.81	6.81	6.82	6.73	6.61	6.73	6.73
Jul				7.01	7.52	7.01	7.01	7.01	7.01	6.88	7.00	7.01
Aug				7.24	7.98	7.23	7.23	7.24	7.17	7.04	7.16	7.17
Sep				7.37	8.38	7.53	7.53	7.53	7.22	7.24	7.37	7.38
Oct				9.15	11.42	9.14	9.14	9.15	8.87	8.71	8.86	8.87
Nov				9.67	12.81	9.65	9.65	9.67	8.96	8.79	8.95	8.96
Dec				12.05	17.63	12.04	12.04	12.05	15.69	15.39	15.66	15.68

Note: Highlighted cells indicate exceedance above site-specific objectives (Hatfield, 2011)

Table 4 cont'd. Summary of Sensitivity Analyses for Predicted Post Closure Water Quality for Prairie Creek At Park Boundary

Month	Parameter	Units	Hatfield	Average Flow Conditions					Minimum Flow Conditions			
				Conservative Loading (Table A7)	Worst Case Scenario Flows (Table A10)	Surface Complexation of Source Terms (UG and WRP) (Table A11b)	Same as in Table A11b Using Half Detection Limit Values (Table A13b)	Reducing Conditions of Backfilled UG (Table A15b)	Conservative Loading (Table A8)	Surface Complexation of Source Terms (UG and WRP) (Table A12b)	Same as in Table A9 Using Half Detection Limit Values (Table A14b)	Reducing Conditions of Backfilled UG (Table A16b)
Jan	Arsenic (As)	ug/L	*5*	0.16	0.18	0.15	0.15	0.13	0.18	0.17	0.17	0.14
Feb				0.17	0.20	0.16	0.16	0.13	0.27	0.25	0.26	0.15
Mar				0.17	0.21	0.17	0.17	0.14	0.30	0.28	0.28	0.16
Apr				0.14	0.16	0.14	0.14	0.13	0.21	0.20	0.20	0.14
May				0.13	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Jun				0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Jul				0.13	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Aug				0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Sep				0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13
Oct				0.14	0.15	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Nov				0.14	0.16	0.14	0.14	0.13	0.14	0.14	0.14	0.13
Dec				0.15	0.17	0.15	0.15	0.13	0.16	0.16	0.16	0.13
Jan	Antimony (Sb)	ug/L	*20*	0.26	0.38	0.25	0.25	0.14	0.36	0.35	0.35	0.15
Feb				0.30	0.47	0.30	0.29	0.14	0.79	0.77	0.78	0.18
Mar				0.33	0.53	0.33	0.32	0.15	0.92	0.90	0.91	0.20
Apr				0.20	0.27	0.20	0.20	0.13	0.51	0.49	0.50	0.16
May				0.17	0.18	0.17	0.17	0.17	0.16	0.16	0.16	0.16
Jun				0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15	0.15
Jul				0.16	0.17	0.16	0.15	0.14	0.16	0.15	0.15	0.14
Aug				0.16	0.18	0.16	0.16	0.14	0.16	0.16	0.15	0.14
Sep				0.16	0.19	0.17	0.16	0.15	0.16	0.16	0.16	0.14
Oct				0.24	0.28	0.24	0.24	0.21	0.23	0.22	0.22	0.20
Nov				0.21	0.27	0.21	0.20	0.15	0.19	0.19	0.18	0.14
Dec				0.22	0.31	0.22	0.21	0.14	0.28	0.27	0.27	0.14
Jan	Iron (Fe)	ug/L	*300*	5.27	5.39	5.16	2.71	5.27	5.37	5.07	2.72	5.37
Feb				5.31	5.46	5.15	2.71	5.31	5.75	5.05	2.73	5.75
Mar				5.34	5.52	5.16	2.72	5.34	5.87	5.05	2.74	5.87
Apr				5.23	5.29	5.16	2.71	5.23	5.50	5.06	2.72	5.50
May				5.17	5.17	5.16	2.71	5.17	5.17	5.07	2.71	5.17
Jun				5.17	5.17	5.16	2.71	5.17	5.17	5.07	2.71	5.17
Jul				5.17	5.19	5.16	2.71	5.17	5.17	5.07	2.71	5.17
Aug				5.18	5.20	5.16	2.71	5.18	5.18	5.07	2.71	5.18
Sep				4.93	4.96	5.16	2.71	5.18	4.93	5.07	2.71	5.18
Oct				5.20	5.23	5.16	2.71	5.20	5.19	5.07	2.71	5.19
Nov				5.22	5.28	5.16	2.71	5.22	5.21	5.07	2.71	5.21
Dec				5.24	5.32	5.16	2.71	5.24	5.29	5.07	2.71	5.29
Jan	Mercury (Hg)	ug/L	*0.034*	0.14	0.25	0.038	0.019	0.020	0.23	0.05	0.026	0.020
Feb				0.18	0.34	0.044	0.022	0.020	0.64	0.11	0.057	0.020
Mar				0.21	0.39	0.048	0.024	0.020	0.75	0.13	0.065	0.020
Apr				0.09	0.16	0.030	0.015	0.020	0.37	0.07	0.036	0.020
May				0.026	0.031	0.021	0.011	0.022	0.025	0.020	0.010	0.021
Jun				0.027	0.032	0.021	0.011	0.021	0.025	0.020	0.010	0.021
Jul				0.034	0.048	0.022	0.011	0.021	0.034	0.022	0.011	0.021
Aug				0.040	0.060	0.023	0.012	0.021	0.039	0.022	0.011	0.021
Sep				0.045	0.068	0.024	0.012	0.021	0.042	0.023	0.012	0.021
Oct				0.058	0.092	0.026	0.013	0.024	0.054	0.025	0.013	0.023
Nov				0.082	0.143	0.029	0.015	0.021	0.069	0.027	0.014	0.021
Dec				0.10	0.184	0.03	0.016	0.020	0.16	0.040	0.020	0.020
Jan	Silver (Ag)	ug/L	*0.103*	0.021	0.022	0.021	0.011	0.020	0.022	0.022	0.011	0.020
Feb				0.022	0.023	0.022	0.011	0.020	0.026	0.025	0.013	0.020
Mar				0.022	0.024	0.022	0.011	0.020	0.027	0.027	0.013	0.020
Apr				0.021	0.021	0.021	0.010	0.020	0.023	0.023	0.012	0.020
May				0.020	0.020	0.020	0.010	0.020	0.020	0.020	0.010	0.020
Jun				0.020	0.020	0.020	0.010	0.020	0.020	0.020	0.010	0.020
Jul				0.020	0.020	0.020	0.010	0.020	0.020	0.020	0.010	0.020
Aug				0.020	0.020	0.020	0.010	0.020	0.020	0.020	0.010	0.020
Sep				0.021	0.021	0.020	0.010	0.020	0.021	0.020	0.010	0.020
Oct				0.021	0.021	0.021	0.010	0.020	0.021	0.020	0.010	0.020
Nov				0.021	0.021	0.021	0.010	0.020	0.021	0.020	0.010	0.020
Dec				0.021	0.022	0.021	0.010	0.020	0.021	0.021	0.011	0.020
Jan	Sulphate (SO_4)	mg/L	*200*	93	94	93	93	93	94	92	94	93
Feb				96	97	96	96	96	99	98	99	98
Mar				99	101	99	99	99	103	102	103	102
Apr				80	81	80	80	80	82	81	83	82
May				36	36	36	36	36	36	36	36	36
Jun				46	46	46	46	46	46	45	46	46
Jul				54	55	54	54	54	54	54	54	54
Aug				60	60	60	60	60	60	59	60	60
Sep				63	63	63	63	63	63	62	63	63
Oct				85	86	85	85	85	85	84	85	85
Nov				87	88	87	87	87	87	86	87	87
Dec				91	91	91	91	90	91	89	91	91

Note: Highlighted cells indicate exceedance above site-specific objectives (Hatfield, 2011)

Table 5. Predictions of Mine Inflow Rates for Active Mining (L/sec).

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.	Estimated Probability of Occurrence (%)
Low Estimate (K Fault =1E-5 m/s)	15	15	15	15	21	32	47	38	31	29	25	20	25.2	10%
Best Estimate (Nm15Tr w/ K Fault = 5E-5 m/s)	15	15	15	15	41.3	61.7	90.3	74.3	60.5	55.3	25	20	40.7	70%
High Estimate (K Fault =1E-4 m/s)	15	15	15	15	83	123	181	149	121	111	25	20	72.7	15%
High Estimate with Vein Fault-PCAA Connection	100	100	100	150	207	207	207	207	207	207	150	100	162	5%

flow reduced to account for limited recharge of HCAA during winter freeze-up

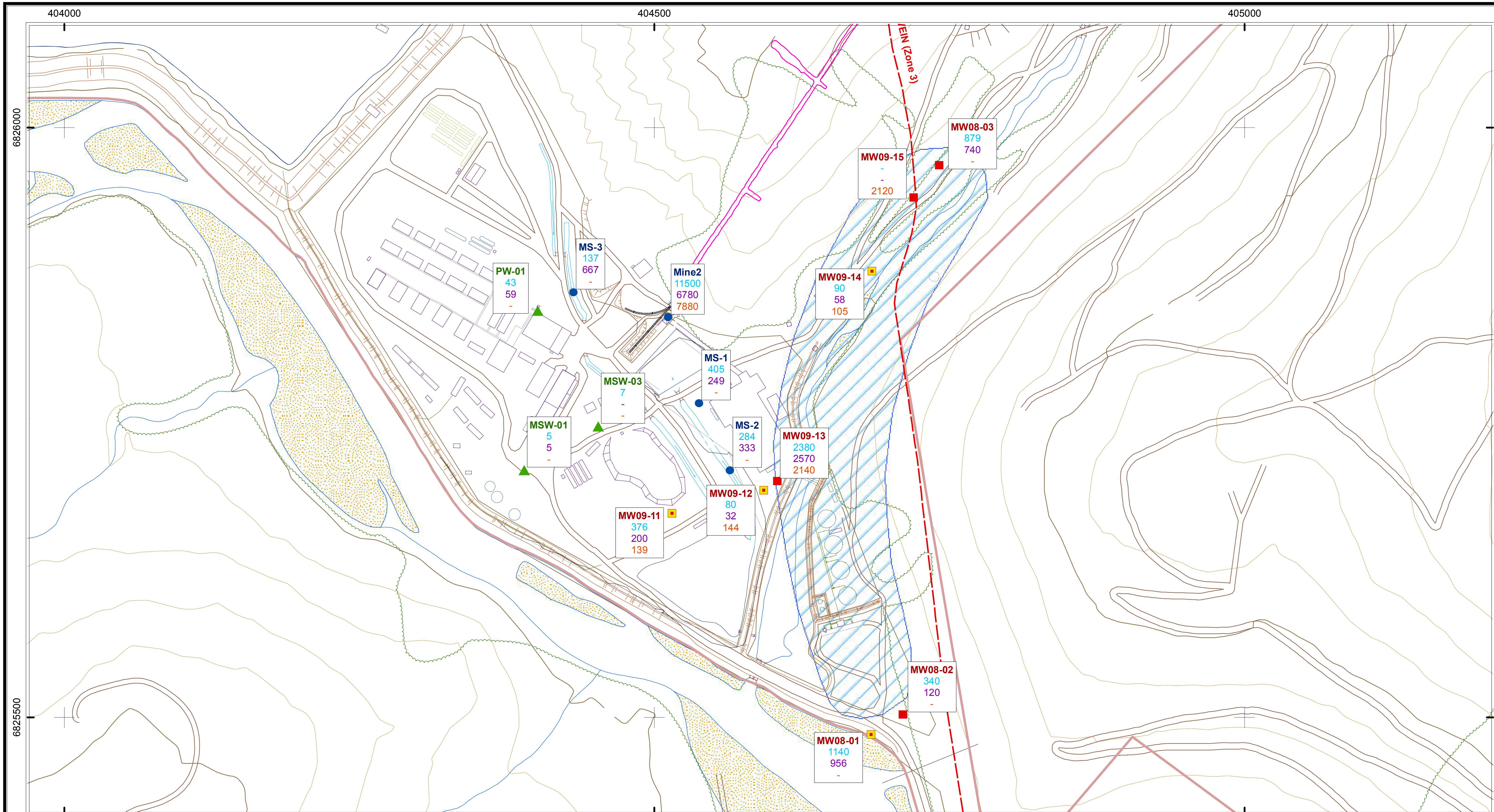
Table 6. Results of Sensitivity Analysis on Southern Extent of Permeable Vein Fault.

	Low Flow Scenario (Fault K=1E-5 m/s)			High Flow Scenario (Fault K=1E-4 m/s)		
Description	Low Flow Estimate (RGC, 2010a)	AM13 w/ Vein Fault extended to PCAA	AM13a w/o recharge from HCAA	Low Flow Estimate (RGC, 2010a)	AM13 w/ Vein Fault extended to PCAA	AM13a w/o recharge from HCAA
Run	AM13	AM13a		AM13	AM13a	
Mine Inflow (L/s)	28.8	28.9	18.3	205.1	206.2	105.4
Seepage from PCAA (L/s)	0.0	1.7	9.1	0.0	13.3	88.8

Table 7. Estimated zinc loads from treated mine water and mill seeps.

	Treated Mine Water (SNP 3-4)			Mill Seeps		
	Flow	[Zn] conc	Zn Load	Flow	[Zn] conc	Zn Load
Date	L/s	ug/L	kg/yr	L/s	ug/L	kg/yr
Sep-29-2008	13.6	31	13	20	316	199
Jul-3-2009	8.3	275	72	12	317	120
Jan-28-2010	0	0	0	0	0	0
Jun-9-2010	6	6780	1,283	12	333	126
Sep-9-2010	16.9	784	418	30	284	269
Average	9	1574	357	15	250	143
Notes:	black values observed					
	red values estimated					

FIGURES



LEGEND

- ▲ MSW - Mill Site Well
- ■ Monitoring Well - Bedrock
- ▣ Monitoring Well - Alluvium/Unconsolidated
- ● Surface Water Collection Site/MS - Mill Seep
- ▨ Groundwater Discharge Zone (from MQV)

23 Zinc Concentrations (µg/L) - September/October 2010
105 Zinc Concentrations (µg/L) - June/July 2010
21 Zinc Concentrations (µg/L) - November 2009

PROJECTION: UTM
ZONE: 10
DATUM: NAD 83
UNITS: Meters

CONTOUR INTERVAL: 25m

Dissolved Zn Concentrations in Groundwater & Surface Water

Prairie Creek Mine Site (Camp Area)

SCALE

0 50 100 150 200 Meters

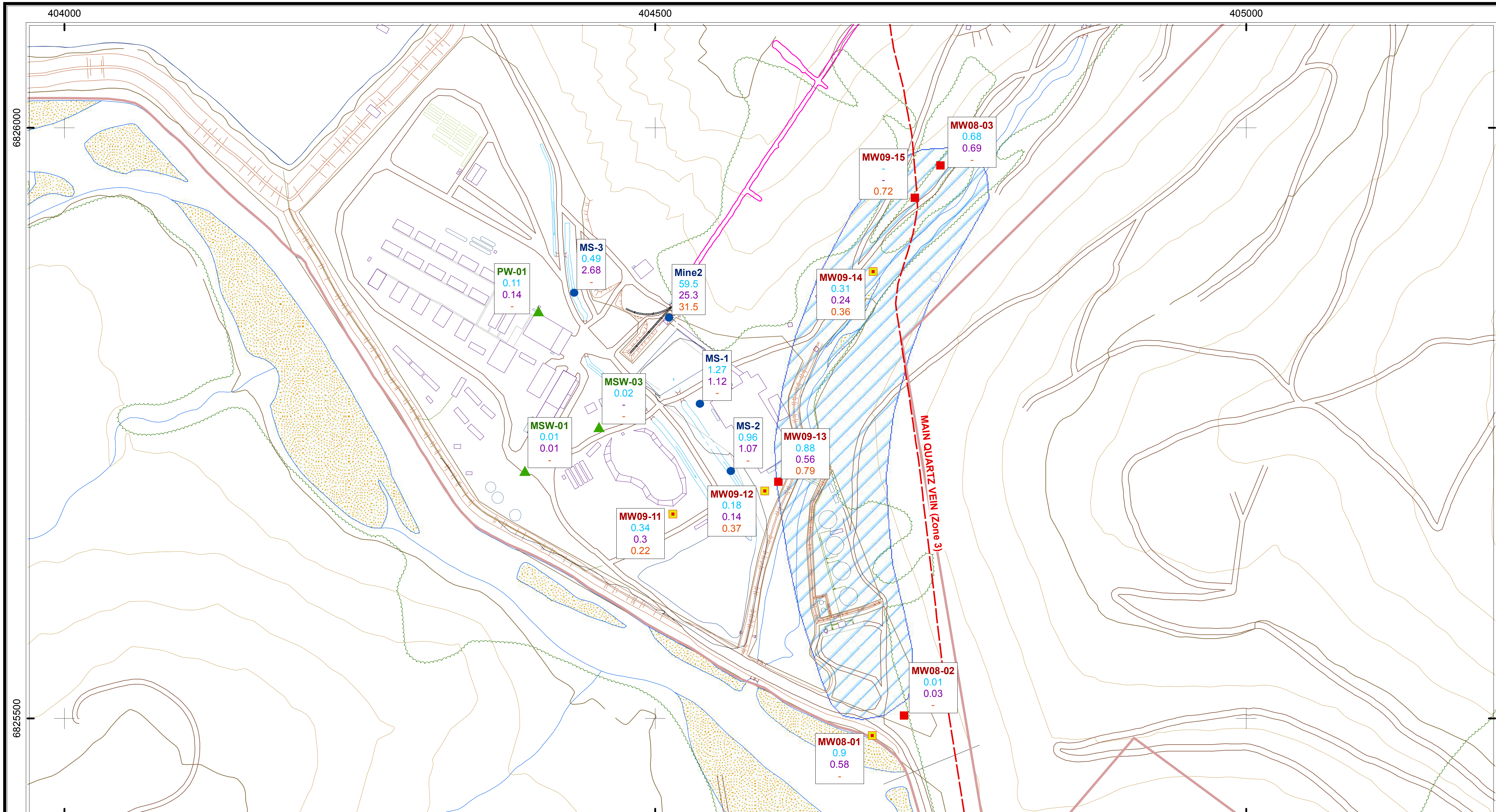
CANADIAN ZINC CORPORATION

ROBERTSON GEOCONSULTANTS INC.
Consulting Geotechnical and Environmental Engineers

CLIENT: Canadian Zinc Corporation
PROJECT: Prairie Creek DAR
PROJECT No: RGC 148002
LOCATION: NT, Canada

FIGURE: 1

DATE:02/24/2011 DRAWN BY:OM FILE:PrairieCr_LocationPlan(CampArea)_Zinc_2011.mxd



LEGEND

- MSW - Mill Site Well
- Monitoring Well - Bedrock
- Monitoring Well - Alluvium/Unconsolidated
- Surface Water Collection Site/MS - Mill Seep
- Groundwater Discharge Zone (from MQV)

0.34 Cd Concentrations (µg/L) - September/October 2010
0.30 Cd Concentrations (µg/L) - June/July 2010
0.22 Cd Concentrations (µg/L) - November 2009

PROJECTION: UTM
ZONE: 10
DATUM: NAD 83
UNITS: Meters

CONTOUR INTERVAL: 25m

Cd Concentrations in Groundwater & Surface Water

Prairie Creek Mine Site (Camp Area)

SCALE

0 50 100 150 200 Meters

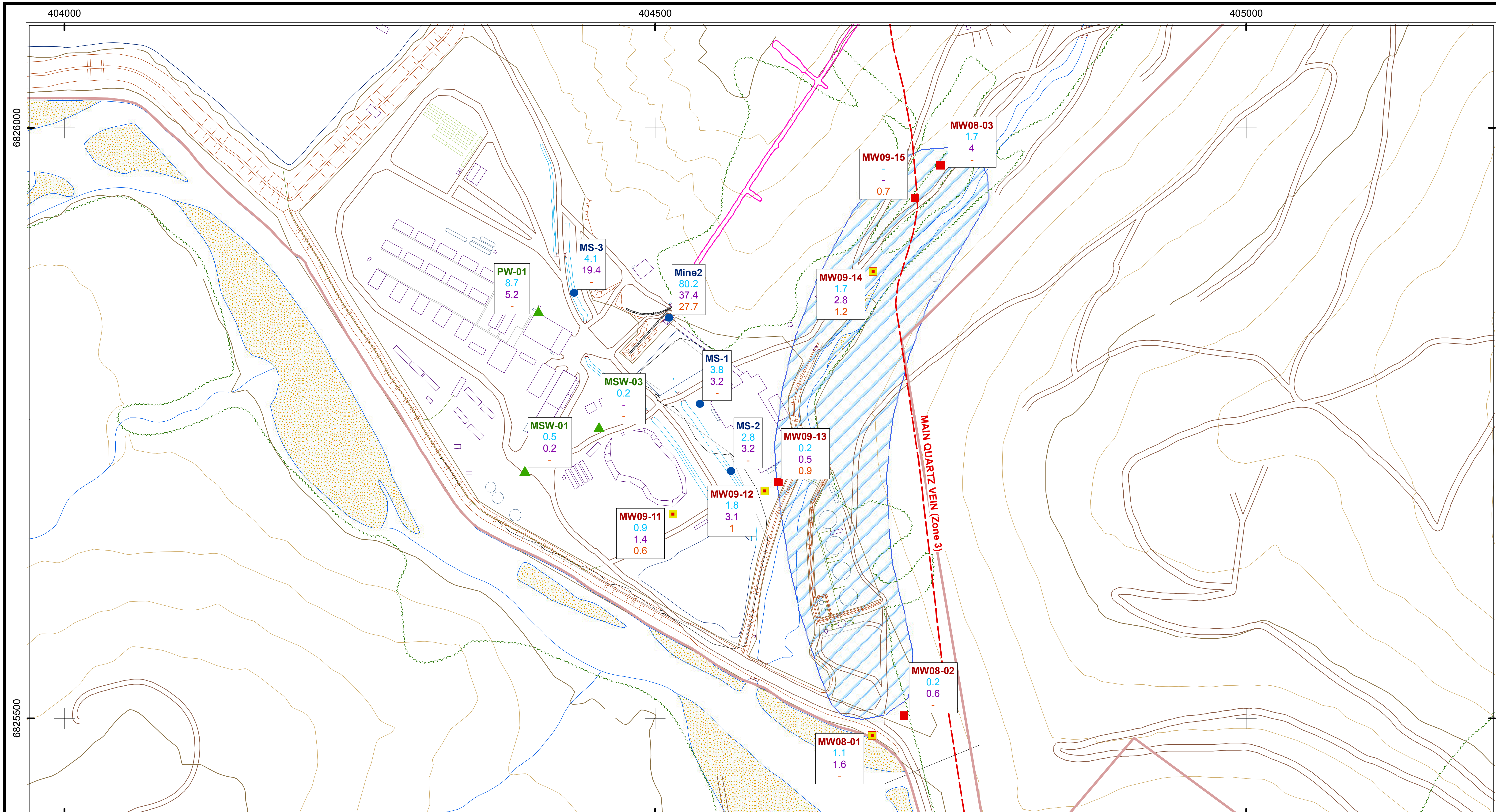
CANADIAN ZINC CORPORATION

ROBERTSON GEOCONSULTANTS INC.
Consulting Geotechnical and Environmental Engineers

CLIENT: Canadian Zinc Corporation
PROJECT: Prairie Creek DAR
PROJECT No: RGC 148002
LOCATION: NT, Canada

FIGURE: 2

DATE:02/24/2011 DRAWN BY:OM FILE:PrairieCr_LocationPlan(CampArea)_Cd_2011.mxd



LEGEND

- MSW - Mill Site Well
- Monitoring Well - Bedrock
- Monitoring Well - Alluvium/Unconsolidated
- Surface Water Collection Site/MS - Mill Seep
- Groundwater Discharge Zone (from MQV)

0.9 Cu Concentrations (µg/L) - September/October 2010
1.4 Cu Concentrations (µg/L) - June/July 2010
0.6 Cu Concentrations (µg/L) - November 2009

PROJECTION: UTM
ZONE: 10
DATUM: NAD 83
UNITS: Meters

CONTOUR INTERVAL: 25m

Cu Concentrations
in Groundwater & Surface Water

Prairie Creek Mine Site (Camp Area)

SCALE

0 50 100 150 200 Meters

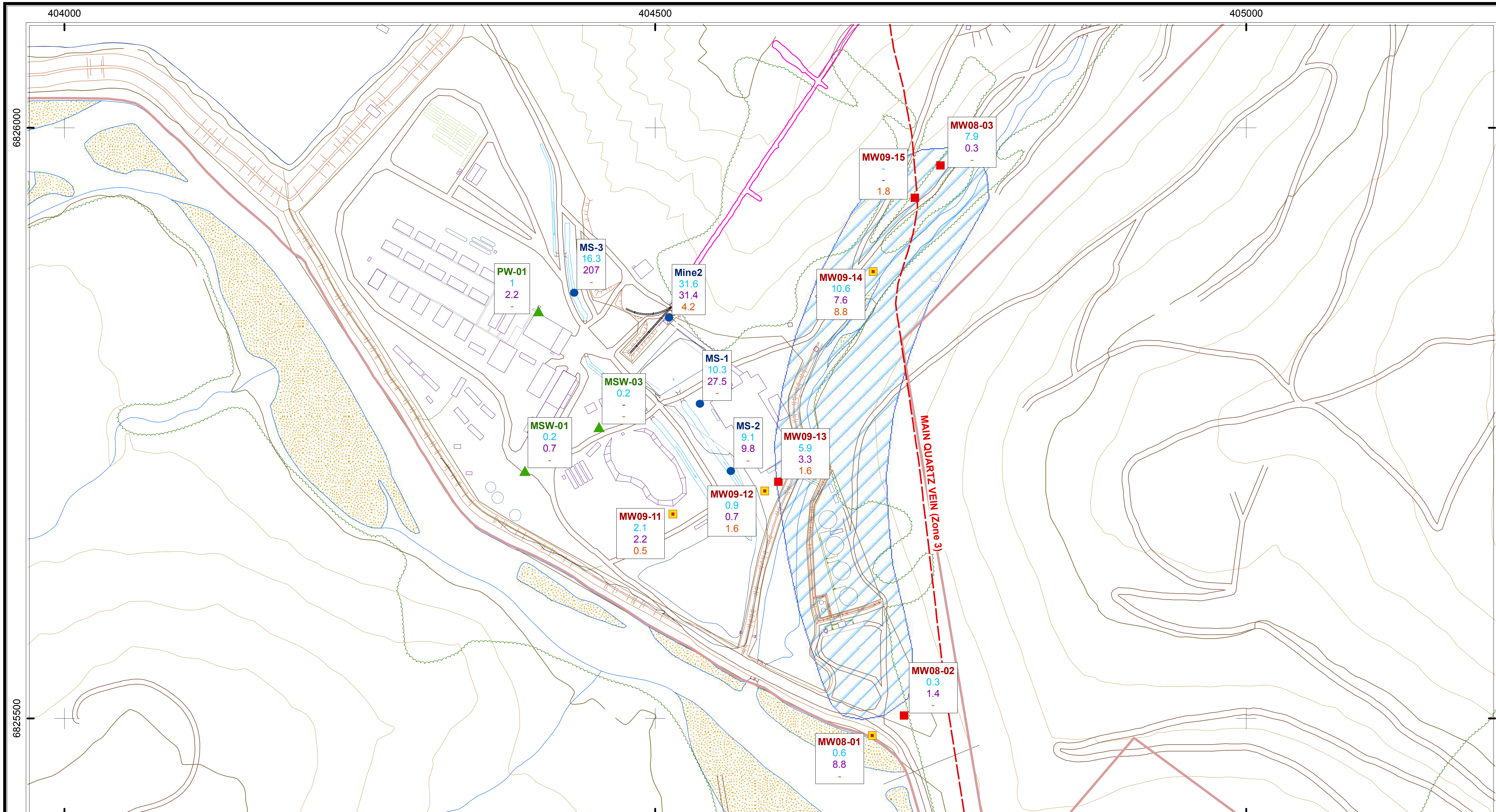
CANADIAN ZINC CORPORATION

ROBERTSON GEOCONSULTANTS INC.
Consulting Geotechnical and Environmental Engineers

CLIENT: Canadian Zinc Corporation
PROJECT: Prairie Creek DAR
PROJECT No: RGC 148002
LOCATION: NT, Canada

FIGURE: 3

DATE:02/24/2011 DRAWN BY:OM FILE:PrairieCr_LocationPlan(CampArea)_Cu_2011.mxd



LEGEND

- MSW - Mill Site Well
- Monitoring Well - Bedrock
- Monitoring Well - Alluvium/Unconsolidated
- Surface Water Collection Site/MS - Mill Seep
- Groundwater Discharge Zone (from MQV)

2.1 Pb Concentrations (µg/L) - September/October 2010
2.2 Pb Concentrations (µg/L) - June/July 2010
0.5 Pb Concentrations (µg/L) - November 2009

PROJECTION: UTM
ZONE: 10
DATUM: NAD 83
UNITS: Meters

CONTOUR INTERVAL: 25m

Pb Concentrations in Groundwater & Surface Water

Prairie Creek Mine Site (Camp Area)

SCALE

0 50 100 150 200 Meters

CANADIAN ZINC CORPORATION

ROBERTSON GEOCONSULTANTS INC.
Consulting Geotechnical and Environmental Engineers

CLIENT: Canadian Zinc Corporation
PROJECT: Prairie Creek DAR
PROJECT No: RGC 148002
LOCATION: NT, Canada

FIGURE: 4

DATE:02/24/2011 DRAWN BY:OM FILE:PrairieCr_LocationPlan(CampArea)_Pb_2011.mxd

APPENDIX A

ADDENDUM - Updated Predictions of Post-Closure Water Quality in Prairie Creek, Prairie Creek Mine, NWT REV0

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March 3, 2011
RGC Project No: 148002

Canadian Zinc Corporation
Suite 1710 – 650 West Georgia Street
Vancouver, B.C.
V6B 4N9

Attention: Dave Harpley

RE: ADDENDUM - Updated Predictions of Post-Closure Water Quality in Prairie Creek, Prairie Creek mine, NWT REV0

Dave,

The purpose of this memo is to provide additional predictions of post-closure water quality in Prairie Creek for a wider range of selected trace metals than originally reported in RGC (2010a,b). In addition, the effects of surface complexation (or sorption) as well as the development of reducing conditions were considered where appropriate for the prediction of post-closure water quality. This update has been prepared jointly by Robertson GeoConsultants Inc. (RGC) and pHase Geochemistry Inc. (pHase).

1 Scope of Water Quality Predictions

CZN has proposed to backfill the mine workings and tunnels with a mixture of cemented tailings and rock float (dense media separation) and include strategically-placed bulkheads to allow re-flooding of the mine. Groundwater flow modelling of those post-closure conditions suggests that the primary metal load to Prairie Creek from the re-flooded mine workings will occur via groundwater flow along the MQV/Vein Fault system (which discharges into Harrison Creek alluvium and/or Harrison Creek itself and then Prairie Creek), whereas seepage from the waste rock pile (to be placed in a side valley of Harrison Creek) represents a secondary load.

Conservative mixing calculations have been completed to estimate the resulting in-stream concentrations in Prairie Creek (at station SPN3-11 just downstream of Harrison Creek). For a detailed description of the methods and assumptions of these loading calculations, including determination of appropriate “source terms” (i.e. concentrations of selected parameters of concern for various source waters), the reader is referred to RGC (2010a, b).

In the earlier loading calculations (RGC, 2010a,b), in-stream concentrations were estimated for the following parameters of concern: cadmium (Cd), copper (Cu), lead (Pb), selenium (Se), zinc (Zn) and sulphate (SO_4).

In the second round of information requests, INAC requested that these loading calculations be completed for ‘all’ parameters potentially affected by mining operations, including Hg (INAC02-03). Hence, in-stream concentrations in Prairie Creek using the same conservative load balance approach were estimated for the following additional metals of interest: arsenic (As), antimony (Sb), iron (Fe), mercury (Hg), and silver (Ag).

This revision also includes a series of sensitivity runs that evaluate:

- Higher flows from the backfilled underground and the MQV vein structure (considered worst case flows),
- The effects of surface complexation reactions and sorption of trace metals by co-precipitation along a flow path prior to mixing in the creeks,
- The effect of using half the detection limit for values below detection for the calculations, and
- The effects of the development of a reducing environment in the post flooded backfilled mine voids.

2 Updated Conservative Water Quality Predictions

Conservative mixing calculations previously completed were updated to estimate in-stream concentrations of selected trace metals (and sulphate) in Prairie Creek for the following scenarios:

- Pre-mining
- Post-closure

For each scenario, in-stream concentrations were estimated for “average flow conditions” and “minimum flow conditions”. The reader is referred to RGC (2010a,b) for a detailed rationale and description of those two flow scenarios.

In-stream concentrations reported here were calculated for two locations:

1. Prairie Creek just downstream of Harrison Creek (at station SPN3-11).
2. Prairie Creek at the Park Boundary.

Appendix A summarizes the results of these conservative mixing calculations. For each scenario, the assumed source concentrations and seasonal (monthly) flow rates and the predicted in-stream concentrations in Prairie Creek are shown. Note that red values indicate source concentrations which were assumed to be equal to the detection limit to allow a (conservative) estimation of resulting in-stream water quality in Prairie Creek.

In all tables, the current CCME guidelines and site-specific RCA objectives proposed by SRC (2010) are shown for reference. Also shown are the in-stream criteria proposed by Hatfield (2011) for the Prairie Creek Mine site. For the purposes of identifying potential exceedances, the site specific objectives as provided by Hatfield have been used.

2.1 Pre-mining

Groundwater discharge from the mineralized MQV/Vein fault can be expected to have influenced Prairie Creek water quality long before start of mine development at the Prairie Creek mine site. To the best of our knowledge, no reliable historic water quality records are available for Prairie Creek. Hence, pre-mining water quality was estimated using conservative mixing calculations.

For the purpose of estimating pre-mining water quality in Prairie Creek, we assumed conservative mixing of three end-members: (i) Prairie Creek above the mine, (ii) Harrison Creek and (iii) groundwater from the mineralized MQV/Vein Fault structure. The reader is referred to RGC (2010a,b) for a more detailed discussion of these source terms. Recall that groundwater in the MQV/Vein fault was assumed to consist of a 2:1 mixture of groundwater from a less mineralized section of the Vein Fault (at MW08-3) and groundwater from a highly-mineralized zone of the MQV (at MW09-15) (RGC, 2010a,b).

Tables A1 and A2 show the estimated in-stream concentrations of selected trace metals and sulphate in Prairie Creek at Harrison Creek prior to any mine development. Note that average and minimum monthly flows were assumed in Tables A1 and A2, respectively.

The estimated in-stream concentrations for all parameters evaluated here (including the new parameters As, Sb, Fe, Hg and Ag) are below the proposed site specific objectives for average and minimum flows. The only exception is zinc, which is estimated to exceed the site-specific objectives for extremely low flows during winter freeze-up (i.e. minimum flows in January to April, see also RGC, 2010b).

The corresponding in-stream concentrations for Prairie Creek at the Park Boundary are shown in Tables A3 and A4. Note that stream flow at the Park Boundary were estimated to be about 14% higher than flows at the WSC station just upstream of the Prairie Creek mine (based on the incremental catchment area). Also note that trace metal and sulphate concentrations observed in Prairie Creek just upstream of the mine (at station SPN3-10) were assumed to be representative of all additional stream flow contributions in this incremental reach of Prairie Creek.

Estimated in-stream concentrations in Prairie Creek at the Park Boundary are only marginally more dilute than at Harrison Creek.

2.2 Post-Closure

For the post-closure scenario, we assumed conservative mixing of five end-members: (i) Prairie Creek above the mine, (ii) Harrison Creek, (iii) seepage from backfilled mine workings, (iv) groundwater from the mineralized MQV/Vein Fault structure (not impacted by mine backfill) and (v) seepage from the waste rock pile (WRP).

Recall that sulphate and metals concentrations for seepage from the backfilled mine (includes wall rock and paste backfill) and till-covered WRP are based on geochemical predictions of source terms initially developed in pHase (2010a) and updated in pHase (2010b). The reader is referred to RGC (2010a,b) and the original geochemical reports prepared by pHase for a more detailed discussion on the source terms used for this post-closure scenario.

Tables A5 and A6 show the predicted in-stream concentrations of selected trace metals and sulphate for post-closure conditions in Prairie Creek at Harrison Creek assuming average and minimum monthly flows, respectively. The corresponding predicted in-stream concentrations at the Park Boundary are shown in Tables A7 and A8, respectively.

Under average flow conditions, in-stream post-closure concentrations for all parameters evaluated here remained below the proposed objectives except for mercury (Hg). Predicted mercury concentrations are above the objective for all months except for May and June.

As reported earlier, Cd, Pb and Zn exceed their respective RCA objective for the driest months of the year (Feb-Mar) under minimum flow conditions (RGC, 2010b). Note, however, that Cd and Pb are predicted to stay below the site-specific objectives proposed by Hatfield (2011). Of the additional parameters evaluated here, antimony (Sb) exceeded the RCA criterion under minimum flow conditions in February and March, but remained below the guideline proposed by Hatfield (2011). Similar to average flow conditions, mercury (Hg) is also predicted to exceed the site-specific objective for most of the year during minimum flows.

3 Sensitivity Analyses

As described in Section 1, a series of sensitivity analyses have been completed in this addendum to the earlier load balance calculations. These are presented below.

3.1 Higher Mine and Vein Flows (Worst-Case Post-Closure Scenario)

In their second round of information requests, INAC requested the prediction of post-closure water quality in Prairie Creek for a worst-case scenario in terms of connectivity of the MQV/Vein fault to HCAA and PCAA.

For this worst-case scenario, we assumed an increase in groundwater flow through the backfilled/flooded mine and MQV/Vein fault by a factor of 2. In other words, mean annual flow through the backfilled mine was assumed to be 4.2 L/s and additional flow through the MQV/Vein fault structure was assumed to be 5.7 L/s (for a combined flow of 9.9 L/s). Furthermore, we assumed no dilution in our source term concentrations for this worst-case scenario (note that this is a very conservative assumption as higher flows through the flooded/backfilled mine workings are expected to dilute the source term concentrations).

Results are provided in Tables A9 and A10 for Prairie Creek just below Harrison Creek and at the Park Boundary. Even under this very conservative worst-case scenario, all trace metals except mercury remain below the site-specific criteria proposed by Hatfield (2011). Only mercury (Hg) is predicted to exceed site specific objectives (Hatfield, 2011) for all months other than May and June. However, in the authors' opinion, there are reactive mechanisms that will control the concentrations of mercury and other parameters well below those concentrations predicted assuming conservative mixing. These mechanisms are evaluated further in the sensitivity analyses below.

3.2 Sorption Mechanisms (Surface Complexation of Source Terms)

The results of load balance work presented to date and revised in the sections above only considered conservative mixing models. No consideration was given to surface complexation reactions and sorption of trace metals by co-precipitation. For this revision, with the inclusion of a greater list of parameters, it was deemed necessary to also evaluate surface complexation which is anticipated to represent a significant control on certain trace metals for which predictions were requested, including As, Cd, Mo, Hg, etc. (Bethke, 1996).

The sorption mechanism evaluated here relates to the precipitation of colloids and amorphous oxy-hydroxides that provide surface complexation, or co-precipitation sites for trace metals. The scenario evaluated was for the post closure conditions at SPN-3-11 in Prairie Creek below the confluence with Harrison Creek.

To assess the potential for precipitation of minerals that will form sorption sites, representative full chemistry from the five end-member solutions used in the post closure load balance were mixed in proportion of their contributions as a conservative evaluation basis. Equilibrium speciation of these mixed waters was conducted using PhreeqC Interactive version 2.17 (USGS, 2010). Speciation of the mixed solution indicated a number of supersaturated minerals including diapsore and ferrihydrite; Al and Fe oxy-hydroxides (Appendix B), confirming the anticipated presence of mineral phases with a high propensity for surface complexation.

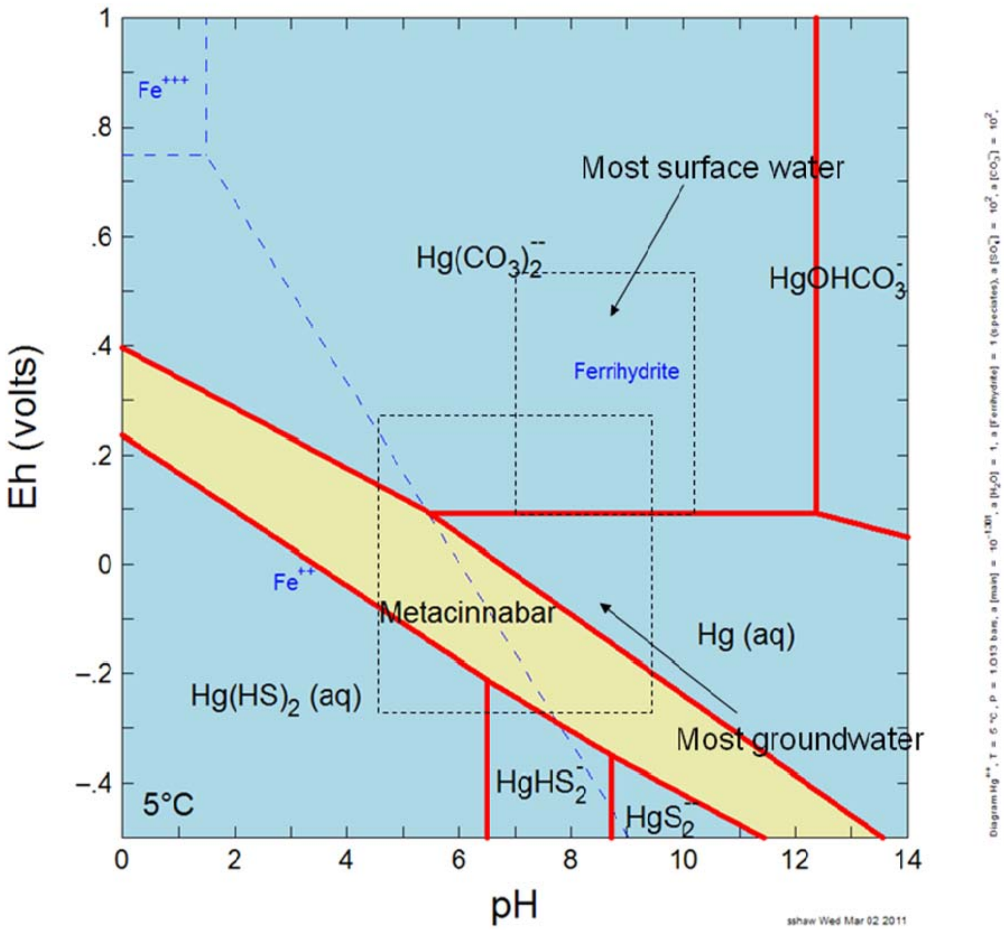


Figure 1. Eh pH Diagram for Mercury in the Presence of Iron, Sulphur and Carbonate Waters.

The Eh-pH diagram for Hg provided in Figure 1 below shows the presence of ferrihydrite within the anticipated post closure conditions in Harrison and Prairie Creeks, specifically near neutral to slightly alkaline pH and oxidizing conditions (current Eh in Prairie Creek is on the order of 0.3 V).

Once the presence of precipitating minerals was confirmed, surface complexation reactions were modelled using Geochemist's Workbench (GWB) version 6.0 (Bethke, 2006), the complexation reactions in which were derived from the Dzombak and Morel (1990) theory. Assumptions on the surface charge for the ferrihydrite precipitate were taken from Bethke (1996) as provided in an example of buffered acid rock drainage solutions in equilibrium with atmospheric oxygen. Results indicate that a number of species sorb to the surfaces of the ferrihydrite in varying degrees, as shown in Figure 2 below (also see Appendix C).

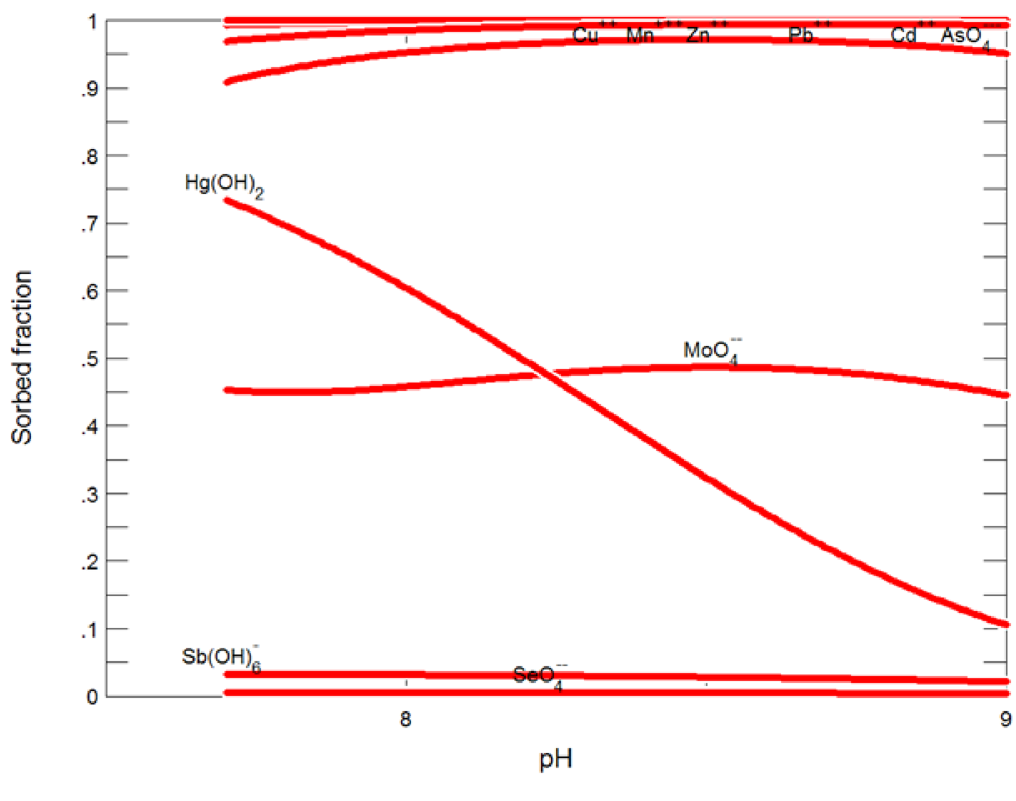


Figure 2. Sorbed Fraction of Selected Parameters Versus pH.

Results of the model allowing for surface complexation of the backfilled mine water and the waste rock pile seepage provided for an assessment of the sorbed fraction of various parameters (Appendix C). These fractions were applied to the source term concentrations and the load balances for average and minimum flow conditions. Results are provided in

Tables A11 and A12 respectively. Based on these evaluations only mercury (Hg) is predicted to exceed the site specific objectives during average flow conditions, as was predicted in the conservative mixing model. However, exceedances are lower and for a shorter proportion of the year (January to March only). During minimum flow conditions mercury (Hg) is predicted to exceed site specific objectives from December through April and zinc (Zn) is predicted to exceed the site specific objectives in February and March as was predicted for pre-mining and conservative mixing models during minimum flow conditions.

3.3 Artifacts of Detection Limits (Using Half DL Values)

It is recognized that for some parameters, many of the end-member solutions use values that are set at the detection limit. This is particularly true for mercury, the parameter resulting in the greatest number of predicted exceedances. As a result, a sensitivity analysis that evaluated the utilization of values representing half the detection limit, a less conservative but accepted standard practice, was conducted.

Results are provided in Tables A13 and A14 and indicate no predicted exceedances during average flow conditions, and exceedances of zinc (February and March) and mercury (February to April) during minimum flows.

3.4 Effects of Reducing Conditions (Reduced Mine Waters)

Over the longer term after closure and reflooding of the backfilled mine, it is likely that more reducing conditions than was assumed for conservative source term predictions will be developed. This supposition is supported by measurements of groundwater samples collected by RGC at Prairie Creek with ORP readings of 30 to 100 mV. These values are within a range presented by Johnson and Younger (2002) for a case study of a mine during reflooding that had values around 50 to 100 mV. The lowest Eh values measured by the authors' were at a flooded Pb-Zn underground mine in Australia (Woodcutters Mine), with reported values of -90mV in the flooded mine workings. For reference, a fully oxidized water has Eh readings around 300 to 400 mV.

Therefore, it was considered appropriate to evaluate the effects of the development of reducing conditions in the reflooded backfilled mine. As shown in Figure 1, the mineral metacinnabar could represent a mineral sink for mercury at very low Eh values (approximately -100 mV). While these conditions could arise as seen in the Australian example, site evidence suggests Eh could be higher. Figure 3 below provides an Eh-pH diagram for mercury showing the mineral HgSe. This mineral, called tiemannite has been found as a secondary sulphide mineral in supergene weathering caps, verified as secondary by isotopic signatures of associated sulphides representing bacterial sulphate reduction processes **(**Belogub et al, 2003**).** The activity diagram showing this mineral suggests that HgSe will precipitate at the pH conditions anticipated when Eh values get to approximately 200 mV, a very feasible scenario.

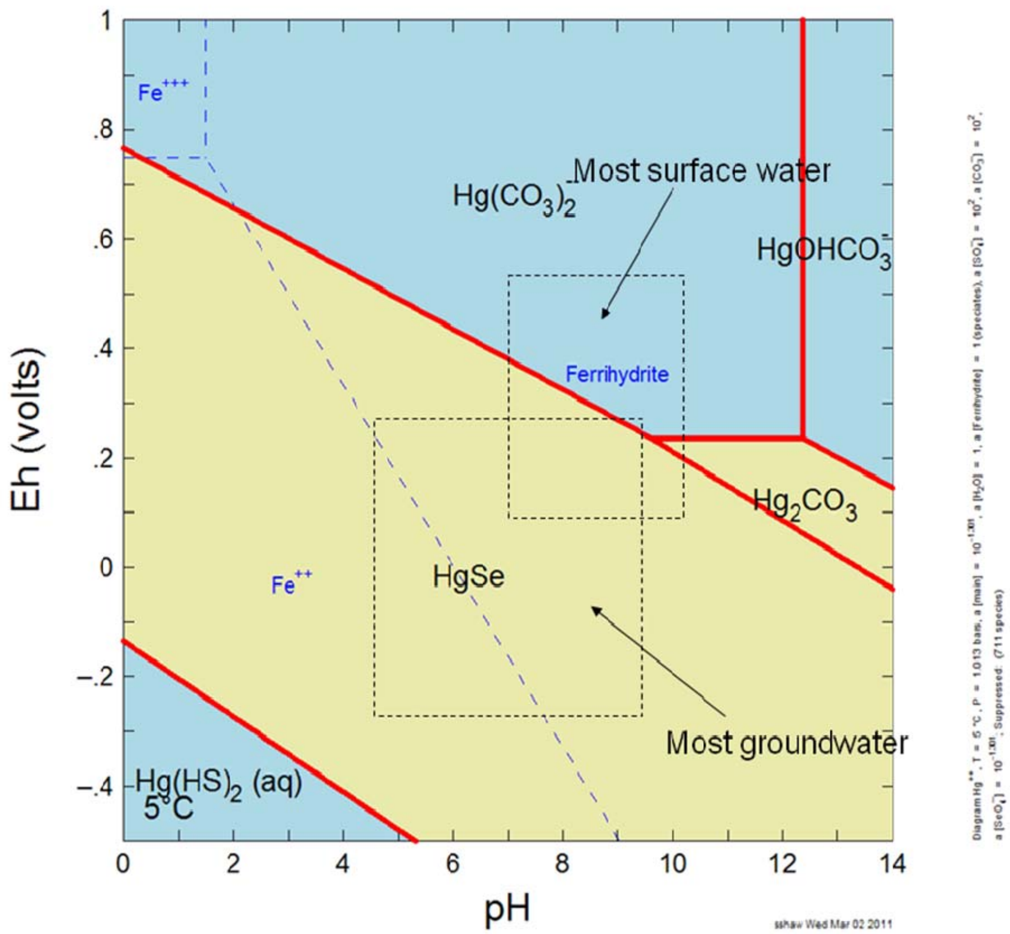


Figure 3. Eh pH Diagram for Mercury in the Presence of Iron, Sulphur, Selenium and Carbonate Waters.

Other minerals that were predicted to precipitate in these Eh-pH conditions included barite, calcite, clausthalite (PbSe) and other selenide minerals. Results presented in Tables A15 and A16 are based on modelled concentrations of the initial source term concentrations equilibrated with key minerals at an Eh of 70 mV (Appendix D).

This evaluation predicts a drastic reduction in mercury concentrations with lowered Eh as a result of tiemmanite precipitation as shown in Figure 4, producing concentrations that are consistent with literature related to the mobility of mercury in reducing conditions. In this scenario, only zinc exceeds site specific objectives during February and March of the minimum flow conditions, consistent with other scenarios.

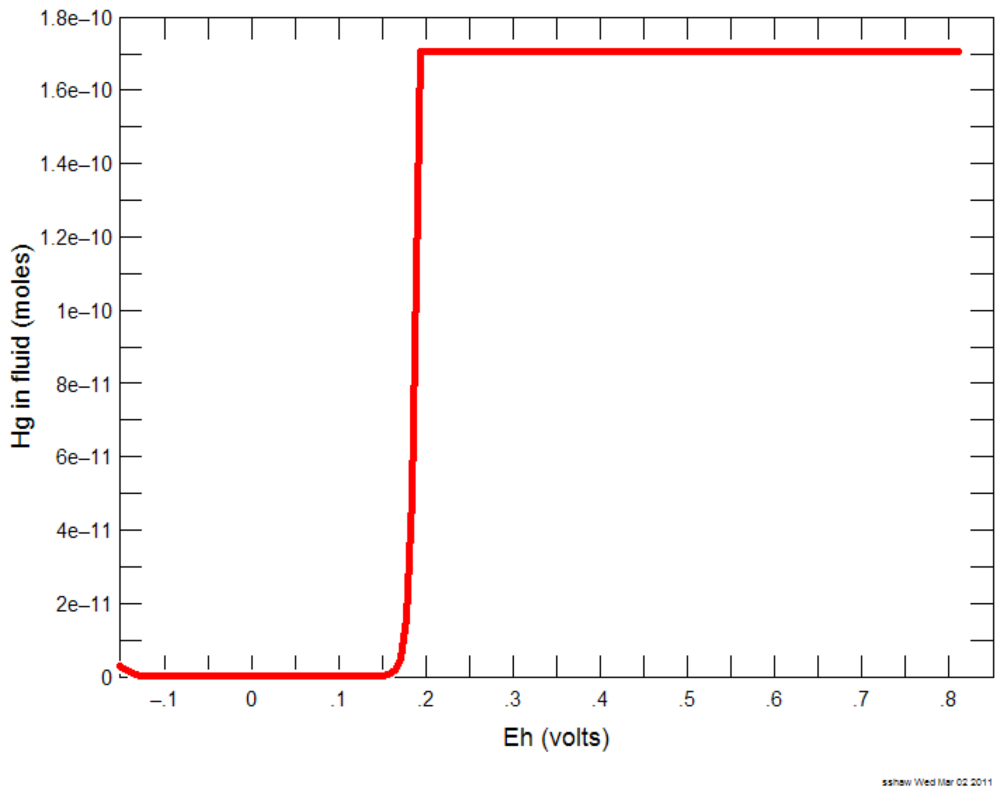


Figure 4. Moles of Mercury in Solution Versus Eh.

4 Discussion

4.1 Comparison of Pre-Mining and Post-Closure Water Quality

Tables 1 and 2 compare in-stream concentrations in Prairie Creek at Harrison Creek and the Park Boundary predicted via conservative mixing for pre-mining and post-closure conditions.

Under average flow conditions, the predicted post-closure concentrations of most trace metals (including Cd, Pb, Zn, Sb and Hg) are slightly higher than for pre-mining conditions. However, only mercury is predicted to exceed the site specific objectives for average flow conditions at Harrison Creek and at the Park Boundary.

Under minimum flow conditions, the influence of seepage from the backfilled mine is predicted to be more evident. Under those flow conditions, post-closure concentrations of several trace metals (including Cd, Pb, Zn, Sb and Hg) are predicted to be higher than estimated pre-mining concentrations. Zinc and mercury may exceed their respective site specific objectives during winter low flow.

4.2 Influences of Conservatism on Predicted Concentrations

It is recognized that the mine water and WRP seepage concentrations predicted represent conservative source terms. In combination with a conservative load balance and the use of detection limit values for those results below detection has likely resulted in overly-conservative values, particularly for parameters such as mercury, the mobility of which is known to be greatly inhibited in alkaline environments and in reducing conditions due to mineral precipitation (see Levinson, 1980, Steinnes, 1995). As a result, sensitivity analyses conducted provide for what we believe are more realistic concentrations. While a large suite of parameters were included in those analyses, discussion focuses on mercury as it is the only trace metal predicted to consistently exceed site specific objectives.

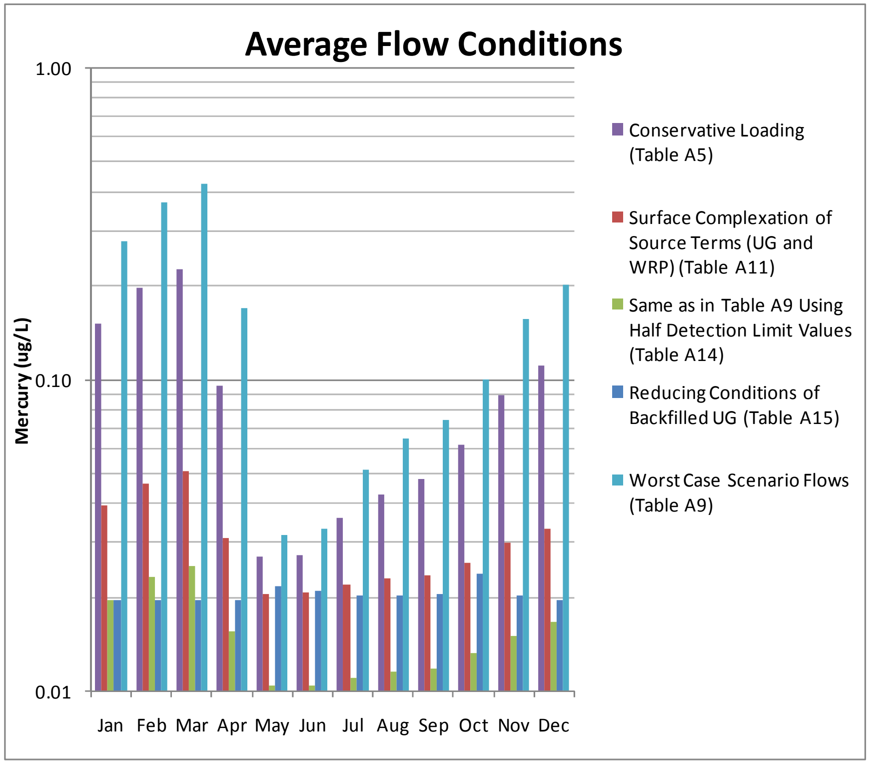
Current site observations indicate total and dissolved mercury in current mine water discharge from the 870-level portal (station 3-7) are consistently non-detectable mercury concentrations (<0.02 ug/L). Even the highly mineralized mine water collected from the Prairie Creek mine (at XC-4) has shown no detectable mercury concentrations. Similarly, groundwater in the highly mineralized shallow MQV (at MW09-15) did not show any detectable mercury concentrations. Observations by MESH Environmental (MESH, 2008) reported that waste rock samples subjected to leach extraction testwork indicated the potential for metal leaching of mercury. However, water samples collected of seepage from that existing waste had values below detection. Mercury concentrations observed to date in mine water collected from the Prairie Creek Mine by RGC and MESH are significantly lower than the mercury concentrations predicted for mine water post closure (i.e. 50 ug/L).

The anticipated source of mobile mercury is from smithsonite as a trace metal substitute for zinc. The lack of any mercury in current mine water may be due to the lack of significant zinc carbonate exposed in the current mine workings. Concentration of this mineral in the 3-con tailings that will be used for paste backfill appears to result in elevated mercury concentrations observed in humidity cell testing of the paste material and is the primary source of elevated mercury in the predicted source term concentrations.

While the observed lack of any mercury in mine water may reflect the current conditions such that they are, i.e. no concentrated source such as the 3-con tailings, it also reflects the poor mobility of mercury in alkaline environments. Natural attenuation of mercury by sorption on mineral surfaces and on organics is predicted to greatly impede the mobility in these conditions. With the sorption mechanism imposed and the use of values equal to half the detection limit for other water inputs, no mercury exceedances are predicted.

Further, over time, the backfilled and reflooded underground system will also likely return to reducing conditions. In these conditions, Hg and many other parameters will become immobile as supported by the sensitivity analysis described in section 3 above and noted in the literature (e.g. Levinson, 1980). Predictions of mercury in this scenario result in values below site specific water quality objectives.

A summary of the results of all the sensitivity results presented here is provided in Table 3 (for Station SNP 3-11 at Harrison Creek) and Table 4 (at Park Boundary) and graphically shown in Figures 5 and 6 for mercury and zinc, respectively.



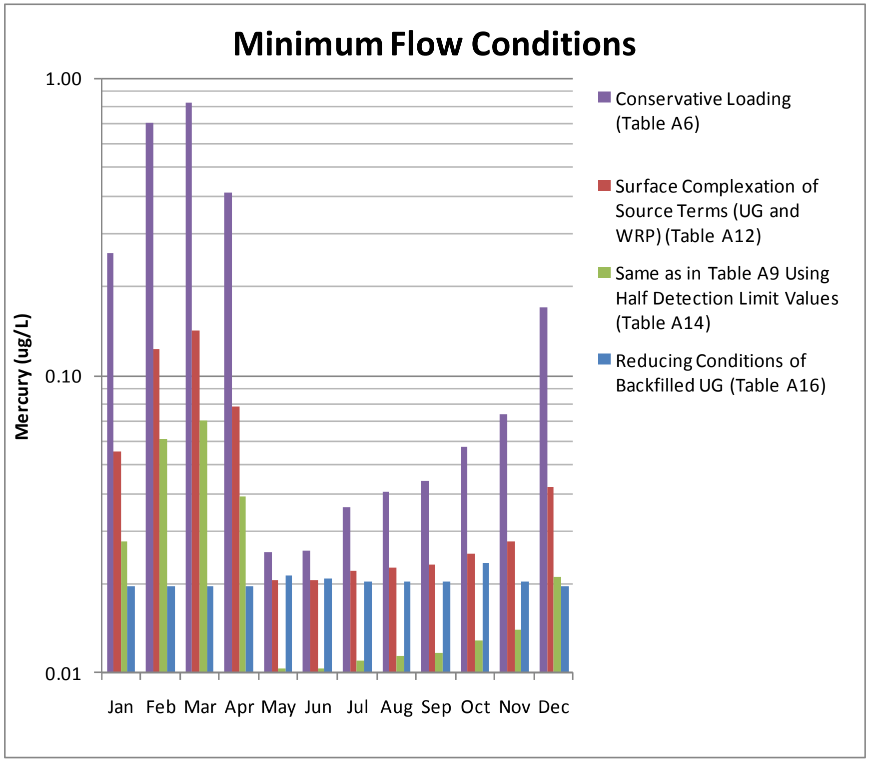
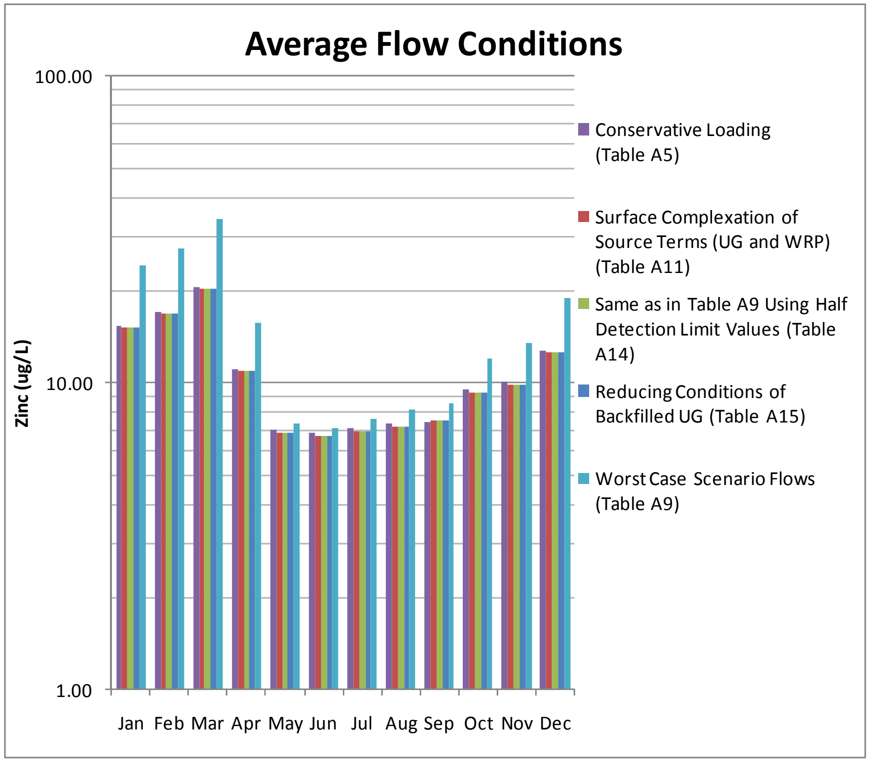


Figure 5. Predicted Monthly Concentrations of Mercury in Various Scenarios for Average and Minimum Flow Conditions.



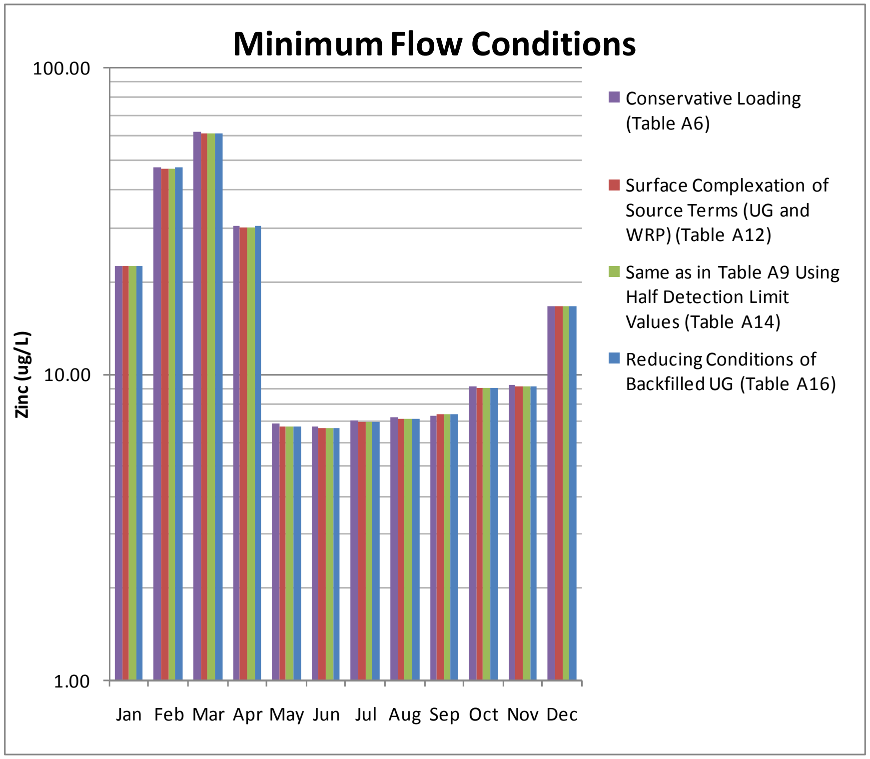


Figure 6. Predicted Monthly Concentrations of Zinc in Various Scenarios for Average and Minimum Flow Conditions.

4.3 Early vs Long-term Post-closure Conditions

In their second round of information requests INAC sought clarification on whether the post-closure predictions of in-stream concentrations in Prairie Creek apply to early or long-term post-closure conditions (see request INAC02-03).

No specific attempt was made in our predictions to distinguish between early and long-term post-closure concentrations, but to provide a conservative estimate of the closure condition. Source concentrations used for “backfilled mine water” in the post-closure scenarios (Tables A5 to A8) were calculated based on kinetic test results (standard humidity cell testwork) of oxygenated samples. This approach assumes that all the mass of reactive rock and backfill introduces a load to the waters when groundwater contacts the rock mass. This most likely represents the early post-closure and reflooding stage.

The original predictions did not take into account the anticipated reduction of metal release once the water table has rebounded. Predictions included in the sensitivity analysis provided here result in water qualities that are generally similar to current conditions in Prairie Creek and would represent a longer-term post closure condition (i.e. after the establishment of appropriately reducing conditions).

Note that the period of early post-closure is estimated to be of relatively short duration. According to information provided by CZN, the final void space in the mine after completion of all backfilling is estimated to be about 1%, or approximately 18,000 m3. Assuming an annual average groundwater flow through the backfilled mine of 2.1 L/s, it would take about 100 days to “flush” the groundwater initially stored in the backfilled mine. Taking into consideration the effects of incomplete mixing and dispersion along the flow path this “first flush” may impact local groundwater discharging towards Harrison Creek (and ultimately Prairie Creek) for a few years (say 3-5 years).

5 Conclusions

This memorandum provides additional predictions of in-stream concentrations in Prairie Creek for the following trace metals of interest not presented in earlier reports: arsenic, (As), antimony (Sb), iron (Fe), mercury (Hg) and silver (Ag). Conservative mixing calculations as previously conducted are updated and a series of sensitivity analyses are presented.

Based on the loading calculations presented in this revision, the authors conclude that the only likely exceedances post closure in Prairie Creek (at station SNP 3-11) will be zinc in the winter months for minimum flow conditions, similar to what occurred pre-mine and is occurring currently.

Conservative mixing calculations suggest that mercury could also potentially exceed the site-specific objectives. However, there is no evidence of elevated mercury concentrations in the current mine water from the Prairie Creek Mine. Both the literature and our site-specific sensitivity analyses suggest that mercury is immobile under the moderately reducing conditions currently observed in the mine water and local groundwater system, and expected to re-establish post-closure.

A more detailed review of the available literature and/or attenuation studies are recommended over the mine operating period to further evaluate the mobility of the principal trace metals of concern (i.e. Zn, Cd, Pb, Sb and Hg) in the local groundwater system at Prairie Creek, and to enable reliable monitoring and response plans to be developed for the post-closure period.

6 Closure

We trust that the information provided in this memo meets your requirements.

Please contact the undersigned if you have any questions regarding the content of this report or require further information.

Best Regards,

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7 References

Belogub, E.V., Novoselov, C.A., Spiro, B., and Yakovleva, B.A. (2003). Mineralogical and S isotopic features of the supergene profile of the Zapadno-Ozernoe massive sulphide and Au-bearing gossan deposit, South Urals. Mineralogical Magazine; April 2003; v. 67; no. 2; p. 339-354

Bethke, C.M. (1996). Geochemical Reaction Modeling, Concepts and Applications. Oxford University Press, New York.

Dzombak, D.A. and Morel, F.M.M. (1990). Surface Complexation Modeling. Wiley, New York.

Hatfield (2011). Prairie Creek Mine – Water Quality Benchmarks and Assessment of Potential Aquatic Effects, Technical memorandum prepared by Hatfield Consultants for Canadian Zinc, March 2, 2011.

Johnson and Younger (2002). Hydrogeological and geochemical consequences of the abandonment of Frazer's Grove carbonate-hosted Pb/Zn fluorspar mine, North Pennines, Uk. In: Mine water Hydrogeology and Geochemistry Eds. P.L. Younger and N.S. Robins, Geological Society Special Publication No. 198, pp.347-364.

Levinson, A. A. (1980). Introduction to Exploration Geochemistry, Second Edition. Applied Publishing Ltd., 924 pp.

pHase Geochemistry (2010a), Source Term Water Quality Predictions, Prairie Creek Project, NWT, Canada, Report prepared for Canadian Zinc, March 2010.

pHase Geochemistry (2010b), Draft Responses to Information Requests, Prairie Creek project, September 6, 2010.

Robertson GeoConsultants Inc. (2010a), Load Balance Calculations for Mine Water and Surface Water, Prairie Creek mine, NWT, Letter Report submitted to Canadian Zinc, March 17, 2010.

Robertson GeoConsultants Inc. (2010b), Updated Predictions of Post-Closure Water Quality in Prairie Creek, Prairie Creek mine, NWT REV0

Saskatchewan Research Council (2010), Development of Site-Specific Water Quality Guidelines for Prairie Creek, NWT, SRC Publication No. 10432-1C10 prepared for Canadian Zinc, February 2010.

Steinnes, E., 1995. Mercury. In Heavy Metals in Soils, 2nd Edition, Ed. Alloway, B.J. Blackie Academic & Professional, London.

Table 1. Predicted In-Stream Concentrations of Main Metals for Pre-Mining and Post Closure
Prairie Creek at Harrison Creek (SPN3-11)

	Pre-Mining - Average Flows										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Jan	0.052	0.57	0.35	1.19	15.81	0.14	0.147	5.2	0.02	0.02	93.2
Feb	0.053	0.57	0.36	1.19	17.66	0.14	0.151	5.2	0.02	0.02	96.9
Mar	0.055	0.58	0.38	1.19	21.26	0.14	0.158	5.2	0.02	0.02	100.0
Apr	0.051	0.57	0.32	1.18	11.36	0.13	0.138	5.2	0.02	0.02	80.7
May	0.049	0.56	0.29	1.18	6.78	0.13	0.129	5.2	0.02	0.02	36.4
Jun	0.049	0.56	0.29	1.18	6.72	0.13	0.129	5.2	0.02	0.02	45.7
Jul	0.049	0.57	0.29	1.18	7.05	0.13	0.130	5.2	0.02	0.02	54.5
Aug	0.049	0.57	0.29	1.18	7.32	0.13	0.130	5.2	0.02	0.02	60.1
Sep	0.049	0.56	0.23	1.14	7.47	0.13	0.122	4.9	0.02	0.02	63.2
Oct	0.050	0.57	0.31	1.18	9.10	0.13	0.134	5.2	0.02	0.02	85.4
Nov	0.050	0.57	0.31	1.18	10.20	0.13	0.136	5.2	0.02	0.02	87.5
Dec	0.051	0.57	0.33	1.19	13.03	0.13	0.142	5.2	0.02	0.02	90.9
	Post-Closure - Average Flows										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Jan	0.077	0.62	0.46	1.19	15.33	0.16	0.271	5.3	**0.15**	0.02	93.0
Feb	0.087	0.64	0.51	1.20	17.00	0.17	0.320	5.3	**0.20**	0.02	96.6
Mar	0.094	0.65	0.55	1.20	20.50	0.18	0.354	5.4	**0.23**	0.02	99.6
Apr	0.065	0.60	0.38	1.19	11.08	0.15	0.210	5.3	**0.10**	0.02	80.5
May	0.058	0.59	0.30	1.19	7.01	0.13	0.176	5.2	0.03	0.02	36.4
Jun	0.055	0.58	0.30	1.19	6.87	0.13	0.162	5.2	0.03	0.02	45.7
Jul	0.055	0.58	0.31	1.19	7.09	0.13	0.160	5.2	**0.04**	0.02	54.5
Aug	0.056	0.58	0.31	1.19	7.34	0.14	0.167	5.2	**0.04**	0.02	60.1
Sep	0.058	0.58	0.26	1.14	7.48	0.14	0.166	4.9	**0.05**	0.02	63.2
Oct	0.074	0.62	0.34	1.20	9.47	0.15	0.255	5.2	**0.06**	0.02	85.4
Nov	0.066	0.60	0.37	1.19	10.04	0.15	0.216	5.2	**0.09**	0.02	87.4
Dec	0.069	0.60	0.41	1.19	12.69	0.15	0.229	5.3	**0.11**	0.02	90.7
SRC criteria	*0.172*	*2.53*	*1.13*	*2.16*	*22.65*	*0.56*	*0.605*	*229*	*0.034*	*0.103*	*119.3*
CCME	*0.017*	*4.0*	*7*	*1*	*30*	*5*	*20*	*300*	*0.026*	*0.1*	*100*
Hatfield	*0.38*	*4.0*	*7*	*2.16*	*35*	*5*	*20*	*300*	*0.034*	*0.103*	*200*
	Pre-Mining - Minimum Flows										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Jan	0.056	0.58	0.39	1.19	23.46	0.14	0.162	5.2	0.02	0.02	94.2
Feb	0.067	0.60	0.55	1.20	**49.75**	0.16	0.214	5.2	0.02	0.02	101.0
Mar	0.073	0.61	0.64	1.20	**64.43**	0.17	0.242	5.3	0.02	0.02	105.3
Apr	0.059	0.59	0.44	1.19	31.90	0.15	0.179	5.2	0.02	0.02	83.5
May	0.049	0.56	0.29	1.18	6.70	0.13	0.129	5.2	0.02	0.02	36.3
Jun	0.049	0.56	0.29	1.18	6.66	0.13	0.129	5.2	0.02	0.02	45.7
Jul	0.049	0.57	0.29	1.18	7.04	0.13	0.130	5.2	0.02	0.02	54.5
Aug	0.049	0.57	0.29	1.18	7.24	0.13	0.130	5.2	0.02	0.02	60.1
Sep	0.049	0.56	0.23	1.14	7.30	0.13	0.122	4.9	0.02	0.02	63.2
Oct	0.049	0.57	0.30	1.18	8.82	0.13	0.133	5.2	0.02	0.02	85.3
Nov	0.050	0.57	0.31	1.18	9.38	0.13	0.134	5.2	0.02	0.02	87.4
Dec	0.053	0.57	0.36	1.19	17.29	0.14	0.150	5.2	0.02	0.02	91.4
	Post-Closure - Minimum Flows										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Jan	0.100	0.67	0.59	1.20	22.58	0.18	0.387	5.4	**0.26**	0.02	93.8
Feb	0.196	0.85	1.14	1.25	**47.22**	0.28	0.865	5.8	**0.70**	0.03	99.7
Mar	0.225	0.91	1.33	1.26	**61.45**	0.32	1.009	6.0	**0.83**	0.03	103.8
Apr	0.133	0.73	0.78	1.22	30.46	0.22	0.550	5.6	**0.41**	0.02	82.8
May	0.056	0.58	0.30	1.19	6.88	0.13	0.166	5.2	0.03	0.02	36.4
Jun	0.054	0.58	0.30	1.19	6.78	0.13	0.155	5.2	0.03	0.02	45.7
Jul	0.055	0.58	0.31	1.19	7.08	0.13	0.160	5.2	**0.04**	0.02	54.5
Aug	0.055	0.58	0.31	1.19	7.26	0.14	0.163	5.2	**0.04**	0.02	60.1
Sep	0.056	0.58	0.25	1.14	7.31	0.14	0.159	4.9	**0.04**	0.02	63.2
Oct	0.071	0.62	0.34	1.20	9.15	0.14	0.242	5.2	**0.06**	0.02	85.4
Nov	0.062	0.59	0.35	1.19	9.25	0.14	0.197	5.2	**0.07**	0.02	87.3
Dec	0.081	0.63	0.48	1.20	16.73	0.16	0.293	5.3	**0.17**	0.02	91.1
SRC criteria	*0.172*	*2.53*	*1.13*	*2.16*	*22.65*	*0.56*	*0.605*	*229*	*0.034*	*0.103*	*119.3*
CCME	*0.017*	*4.0*	*7*	*1*	*30*	*5*	*20*	*300*	*0.026*	*0.1*	*100*
Hatfield	*0.38*	*4.0*	*7*	*2.16*	*35*	*5*	*20*	*300*	*0.034*	*0.103*	*200*

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table 2. Predicted In-Stream Concentrations of Main Metals for Pre-Mining & Post-Closure
Prairie Creek at Park Boundary

	Pre-Mining - Average Flows										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Jan	0.052	0.57	0.33	1.18	14.86	0.14	0.144	5.2	0.02	0.02	93.1
Feb	0.053	0.57	0.34	1.18	16.51	0.14	0.148	5.2	0.02	0.02	96.8
Mar	0.054	0.58	0.36	1.19	19.76	0.14	0.154	5.2	0.02	0.02	99.8
Apr	0.050	0.57	0.31	1.18	10.86	0.13	0.136	5.2	0.02	0.02	80.6
May	0.049	0.57	0.29	1.18	6.73	0.13	0.128	5.2	0.02	0.02	36.4
Jun	0.049	0.57	0.28	1.18	6.69	0.13	0.128	5.2	0.02	0.02	45.7
Jul	0.049	0.57	0.29	1.18	6.98	0.13	0.129	5.2	0.02	0.02	54.5
Aug	0.049	0.57	0.29	1.18	7.23	0.13	0.129	5.2	0.02	0.02	60.1
Sep	0.049	0.56	0.23	1.14	7.36	0.13	0.122	4.9	0.02	0.02	63.2
Oct	0.049	0.57	0.30	1.18	8.82	0.13	0.132	5.2	0.02	0.02	85.3
Nov	0.050	0.57	0.30	1.18	9.81	0.13	0.134	5.2	0.02	0.02	87.5
Dec	0.051	0.57	0.32	1.18	12.36	0.13	0.139	5.2	0.02	0.02	90.8
	Post-Closure - Average Flows										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Jan	0.074	0.62	0.43	1.19	14.42	0.16	0.256	5.3	**0.14**	0.02	92.9
Feb	0.083	0.63	0.48	1.19	15.92	0.17	0.299	5.3	**0.18**	0.02	96.5
Mar	0.089	0.64	0.52	1.20	19.08	0.17	0.330	5.3	**0.21**	0.02	99.5
Apr	0.063	0.59	0.37	1.19	10.61	0.14	0.201	5.2	**0.09**	0.02	80.5
May	0.057	0.59	0.29	1.19	6.94	0.13	0.170	5.2	0.03	0.02	36.4
Jun	0.054	0.58	0.29	1.19	6.82	0.13	0.158	5.2	0.03	0.02	45.7
Jul	0.054	0.58	0.30	1.18	7.01	0.13	0.156	5.2	0.03	0.02	54.5
Aug	0.055	0.58	0.31	1.18	7.24	0.14	0.162	5.2	**0.04**	0.02	60.1
Sep	0.057	0.58	0.25	1.15	7.37	0.14	0.161	4.9	**0.05**	0.02	63.2
Oct	0.071	0.62	0.33	1.20	9.15	0.14	0.241	5.2	**0.06**	0.02	85.4
Nov	0.064	0.60	0.36	1.19	9.67	0.14	0.206	5.2	**0.08**	0.02	87.4
Dec	0.066	0.60	0.39	1.19	12.05	0.15	0.218	5.2	**0.10**	0.02	90.6
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
	Pre-Mining - Minimum Flows										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Jan	0.055	0.58	0.38	1.19	21.74	0.14	0.158	5.2	0.02	0.02	94.0
Feb	0.065	0.60	0.52	1.19	**45.47**	0.16	0.204	5.2	0.02	0.02	100.4
Mar	0.071	0.61	0.60	1.20	**58.77**	0.17	0.231	5.2	0.02	0.02	104.6
Apr	0.058	0.58	0.42	1.19	**29.34**	0.15	0.173	5.2	0.02	0.02	83.1
May	0.048	0.57	0.28	1.18	6.67	0.13	0.128	5.2	0.02	0.02	36.3
Jun	0.048	0.57	0.28	1.18	6.63	0.13	0.128	5.2	0.02	0.02	45.7
Jul	0.049	0.57	0.29	1.18	6.97	0.13	0.129	5.2	0.02	0.02	54.5
Aug	0.049	0.57	0.29	1.18	7.16	0.13	0.129	5.2	0.02	0.02	60.1
Sep	0.049	0.56	0.23	1.14	7.21	0.13	0.122	4.9	0.02	0.02	63.2
Oct	0.049	0.57	0.30	1.18	8.57	0.13	0.132	5.2	0.02	0.02	85.3
Nov	0.050	0.57	0.30	1.18	9.07	0.13	0.133	5.2	0.02	0.02	87.4
Dec	0.053	0.57	0.34	1.18	16.19	0.14	0.147	5.2	0.02	0.02	91.3
	Post-Closure - Minimum Flows										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Jan	0.095	0.66	0.56	1.20	20.95	0.18	0.360	5.4	**0.23**	0.02	93.6
Feb	**0.182**	0.83	1.05	1.24	**43.19**	0.27	**0.792**	5.8	**0.64**	0.03	99.3
Mar	**0.208**	0.88	**1.22**	1.25	**56.08**	0.30	**0.922**	5.9	**0.75**	0.03	103.3
Apr	0.124	0.71	0.72	1.21	**28.05**	0.21	0.507	5.5	**0.37**	0.02	82.5
May	0.055	0.58	0.29	1.19	6.83	0.13	0.161	5.2	0.02	0.02	36.4
Jun	0.053	0.58	0.29	1.18	6.73	0.13	0.152	5.2	0.03	0.02	45.7
Jul	0.054	0.58	0.30	1.18	7.01	0.13	0.156	5.2	**0.03**	0.02	54.5
Aug	0.055	0.58	0.30	1.18	7.17	0.13	0.159	5.2	**0.04**	0.02	60.1
Sep	0.055	0.58	0.25	1.15	7.22	0.13	0.156	4.9	**0.04**	0.02	63.2
Oct	0.069	0.61	0.33	1.20	8.87	0.14	0.229	5.2	**0.05**	0.02	85.3
Nov	0.061	0.59	0.34	1.19	8.96	0.14	0.189	5.2	**0.07**	0.02	87.3
Dec	0.078	0.62	0.46	1.19	15.69	0.16	0.276	5.3	**0.16**	0.02	91.0
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***

Note: bold values exceed the in-stream criterion proposed by SRC

Table 3. Summary of Sensitivity Analyses for Predicted Post Closure Water Quality for Prairie Creek At Harrison Creek (at SPN 3-11)

Month	Parameter	Units	Hatfield	Average Flow Conditions					Minimum Flow Conditions			
				Conservative Loading (Table A5)	Worst Case Scenario Flows (Table A9)	Surface Complexation of Source Terms (UG and WRP) (Table A11)	Same as in Table A9 Using Half Detection Limit Values (Table A13)	Reducing Conditions of Backfilled UG (Table A15)	Conservative Loading (Table A6)	Surface Complexation of Source Terms (UG and WRP) (Table A12)	Same as in Table A9 Using Half Detection Limit Values (Table A14)	Reducing Conditions of Backfilled UG (Table A16)
Jan	Cadmium (Cd)	ug/L	***0.38***	0.077	0.105	0.074	0.074	0.050	0.100	0.095	0.095	0.052
Feb				0.087	0.124	0.083	0.083	0.050	0.196	0.183	0.183	0.059
Mar				0.094	0.138	0.089	0.089	0.052	0.225	0.210	0.210	0.064
Apr				0.065	0.081	0.062	0.062	0.049	0.133	0.125	0.125	0.054
May				0.058	0.059	0.056	0.056	0.056	0.056	0.054	0.054	0.054
Jun				0.055	0.056	0.054	0.054	0.053	0.054	0.052	0.052	0.052
Jul				0.055	0.058	0.053	0.053	0.051	0.055	0.053	0.053	0.051
Aug				0.056	0.061	0.054	0.054	0.051	0.055	0.054	0.054	0.051
Sep				0.058	0.063	0.056	0.056	0.051	0.056	0.055	0.055	0.051
Oct				0.074	0.082	0.071	0.071	0.065	0.071	0.068	0.068	0.063
Nov				0.066	0.080	0.064	0.064	0.051	0.062	0.060	0.060	0.051
Dec				0.069	0.088	0.066	0.066	0.049	0.081	0.078	0.078	0.051
Jan	Copper (Cu)	ug/L	***4***	0.62	0.68	0.56	0.56	0.56	0.67	0.56	0.56	0.56
Feb				0.64	0.71	0.56	0.56	0.56	0.85	0.57	0.57	0.57
Mar				0.65	0.74	0.56	0.56	0.56	0.91	0.58	0.58	0.58
Apr				0.60	0.63	0.56	0.56	0.56	0.73	0.56	0.56	0.56
May				0.59	0.59	0.55	0.55	0.57	0.58	0.55	0.55	0.57
Jun				0.58	0.58	0.55	0.55	0.57	0.58	0.55	0.55	0.56
Jul				0.58	0.58	0.55	0.55	0.56	0.58	0.55	0.55	0.56
Aug				0.58	0.59	0.55	0.55	0.56	0.58	0.55	0.55	0.56
Sep				0.58	0.59	0.55	0.55	0.56	0.58	0.55	0.55	0.56
Oct				0.62	0.64	0.55	0.55	0.60	0.62	0.55	0.55	0.59
Nov				0.60	0.63	0.55	0.55	0.56	0.59	0.55	0.55	0.56
Dec				0.60	0.64	0.56	0.56	0.56	0.63	0.56	0.56	0.56
Jan	Lead (Pb)	ug/L	***7***	0.46	0.62	0.32	0.32	0.32	0.59	0.35	0.35	0.35
Feb				0.51	0.72	0.33	0.33	0.33	1.14	0.45	0.45	0.45
Mar				0.55	0.81	0.35	0.35	0.34	1.33	0.52	0.52	0.52
Apr				0.38	0.48	0.30	0.30	0.30	0.78	0.38	0.38	0.38
May				0.30	0.30	0.29	0.29	0.29	0.30	0.29	0.29	0.29
Jun				0.30	0.30	0.29	0.29	0.29	0.30	0.29	0.29	0.29
Jul				0.31	0.32	0.29	0.29	0.29	0.31	0.29	0.29	0.29
Aug				0.31	0.34	0.29	0.29	0.29	0.31	0.29	0.29	0.29
Sep				0.26	0.29	0.29	0.29	0.29	0.25	0.29	0.29	0.29
Oct				0.34	0.39	0.30	0.30	0.30	0.34	0.29	0.29	0.30
Nov				0.37	0.45	0.30	0.30	0.30	0.35	0.29	0.29	0.30
Dec				0.41	0.52	0.31	0.31	0.31	0.48	0.33	0.33	0.33
Jan	Selenium (Se)	ug/L	***2.16***	1.19	1.21	1.17	1.17	1.16	1.20	1.18	1.18	1.16
Feb				1.20	1.21	1.18	1.18	1.16	1.25	1.22	1.22	1.16
Mar				1.20	1.22	1.18	1.18	1.16	1.26	1.24	1.24	1.16
Apr				1.19	1.20	1.17	1.17	1.16	1.22	1.20	1.20	1.16
May				1.19	1.19	1.17	1.17	1.17	1.19	1.17	1.17	1.17
Jun				1.19	1.19	1.17	1.17	1.16	1.19	1.16	1.16	1.16
Jul				1.19	1.19	1.16	1.16	1.16	1.19	1.16	1.16	1.16
Aug				1.19	1.19	1.16	1.16	1.16	1.19	1.16	1.16	1.16
Sep				1.14	1.15	1.17	1.17	1.16	1.14	1.16	1.16	1.16
Oct				1.20	1.21	1.18	1.18	1.18	1.20	1.18	1.18	1.17
Nov				1.19	1.20	1.17	1.17	1.16	1.19	1.17	1.17	1.16
Dec				1.19	1.20	1.17	1.17	1.16	1.20	1.17	1.17	1.16
Jan	Zinc (Zn)	ug/L	***35***	15.33	24.10	15.18	15.18	15.20	22.58	22.42	22.42	22.46
Feb				17.00	27.38	16.84	16.84	16.87	47.22	46.98	46.98	47.09
Mar				20.50	34.23	20.34	20.34	20.38	61.45	61.19	61.19	61.33
Apr				11.08	15.71	10.95	10.95	10.96	30.46	30.26	30.26	30.33
May				7.01	7.34	6.88	6.88	6.88	6.88	6.76	6.76	6.76
Jun				6.87	7.15	6.74	6.74	6.74	6.78	6.65	6.65	6.65
Jul				7.09	7.66	6.96	6.96	6.96	7.08	6.95	6.95	6.95
Aug				7.34	8.16	7.21	7.21	7.21	7.26	7.13	7.13	7.13
Sep				7.48	8.61	7.53	7.53	7.54	7.31	7.36	7.36	7.37
Oct				9.47	11.99	9.33	9.33	9.34	9.15	9.02	9.02	9.03
Nov				10.04	13.54	9.90	9.90	9.91	9.25	9.11	9.11	9.12
Dec				12.69	18.90	12.55	12.55	12.57	16.73	16.58	16.58	16.61

Note: Highlighted cells indicate exceedance above site-specific objectives (Hatfield, 2011)

Table 3 cont'd. Summary of Sensitivity Analyses for Predicted Post Closure Water Quality for Prairie Creek At Harrison Creek (at SPN 3-11)

Month	Parameter	Units	Hatfield	Average Flow Conditions					Minimum Flow Conditions			
				Conservative Loading (Table A5)	Worst Case Scenario Flows (Table A9)	Surface Complexation of Source Terms (UG and WRP) (Table A11)	Same as in Table A9 Using Half Detection Limit Values (Table A13)	Reducing Conditions of Backfilled UG (Table A15)	Conservative Loading (Table A6)	Surface Complexation of Source Terms (UG and WRP) (Table A12)	Same as in Table A9 Using Half Detection Limit Values (Table A14)	Reducing Conditions of Backfilled UG (Table A16)
Jan	Arsenic (As)	ug/L	*5*	0.16	0.19	0.15	0.15	0.13	0.18	0.18	0.18	0.14
Feb				0.17	0.21	0.16	0.16	0.13	0.28	0.27	0.27	0.15
Mar				0.18	0.22	0.17	0.17	0.13	0.32	0.30	0.30	0.16
Apr				0.15	0.16	0.14	0.14	0.13	0.22	0.21	0.21	0.14
May				0.13	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Jun				0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Jul				0.13	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Aug				0.14	0.14	0.13	0.13	0.13	0.14	0.13	0.13	0.13
Sep				0.14	0.14	0.13	0.13	0.13	0.14	0.13	0.13	0.13
Oct				0.15	0.16	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Nov				0.15	0.16	0.14	0.14	0.13	0.14	0.14	0.14	0.13
Dec				0.15	0.17	0.15	0.15	0.13	0.16	0.16	0.16	0.13
Jan	Antimony (Sb)	ug/L	*20*	0.27	0.41	0.27	0.26	0.14	0.39	0.38	0.38	0.15
Feb				0.32	0.51	0.31	0.31	0.14	0.87	0.85	0.85	0.18
Mar				0.35	0.57	0.35	0.34	0.15	1.01	1.00	0.99	0.21
Apr				0.21	0.29	0.21	0.20	0.13	0.55	0.54	0.54	0.16
May				0.18	0.18	0.17	0.17	0.17	0.17	0.16	0.16	0.16
Jun				0.16	0.17	0.16	0.15	0.15	0.16	0.15	0.15	0.15
Jul				0.16	0.18	0.16	0.15	0.14	0.16	0.16	0.15	0.14
Aug				0.17	0.19	0.16	0.16	0.14	0.16	0.16	0.16	0.14
Sep				0.17	0.19	0.17	0.17	0.15	0.16	0.17	0.16	0.14
Oct				0.25	0.30	0.25	0.25	0.21	0.24	0.24	0.23	0.21
Nov				0.22	0.29	0.21	0.21	0.15	0.20	0.19	0.19	0.14
Dec				0.23	0.33	0.22	0.22	0.14	0.29	0.29	0.28	0.14
Jan	Iron (Fe)	ug/L	*300*	5.31	5.43	5.08	2.69	5.21	5.41	5.07	2.69	5.31
Feb				5.35	5.52	5.07	2.69	5.25	5.83	5.05	2.70	5.74
Mar				5.38	5.57	5.07	2.69	5.28	5.96	5.06	2.72	5.86
Apr				5.25	5.32	5.08	2.68	5.15	5.55	5.07	2.69	5.46
May				5.19	5.19	5.08	2.68	5.09	5.18	5.08	2.68	5.08
Jun				5.19	5.19	5.08	2.68	5.09	5.18	5.08	2.68	5.09
Jul				5.19	5.21	5.08	2.68	5.09	5.19	5.08	2.68	5.09
Aug				5.20	5.22	5.08	2.68	5.10	5.20	5.08	2.68	5.10
Sep				4.93	4.95	5.08	2.68	5.10	4.92	5.08	2.68	5.10
Oct				5.22	5.26	5.08	2.68	5.12	5.22	5.08	2.68	5.12
Nov				5.24	5.31	5.08	2.68	5.15	5.23	5.08	2.68	5.13
Dec				5.27	5.36	5.08	2.68	5.17	5.32	5.08	2.69	5.23
Jan	Mercury (Hg)	ug/L	*0.034*	0.15	0.28	0.039	0.02	0.02	0.26	0.06	0.028	0.020
Feb				0.20	0.37	0.046	0.02	0.02	0.70	0.12	0.061	0.020
Mar				0.23	0.43	0.051	0.03	0.02	0.83	0.14	0.070	0.020
Apr				0.10	0.17	0.031	0.02	0.02	0.41	0.08	0.039	0.020
May				0.027	0.032	0.021	0.010	0.022	0.025	0.020	0.010	0.021
Jun				0.027	0.033	0.021	0.010	0.021	0.026	0.020	0.010	0.021
Jul				0.036	0.051	0.022	0.011	0.020	0.036	0.022	0.011	0.020
Aug				0.043	0.065	0.023	0.012	0.020	0.041	0.023	0.011	0.020
Sep				0.048	0.074	0.024	0.012	0.021	0.044	0.023	0.012	0.020
Oct				0.062	0.100	0.026	0.013	0.024	0.058	0.025	0.013	0.023
Nov				0.089	0.157	0.030	0.015	0.020	0.074	0.028	0.014	0.020
Dec				0.11	0.202	0.03	0.017	0.020	0.17	0.042	0.021	0.020
Jan	Silver (Ag)	ug/L	*0.103*	0.021	0.022	0.021	0.010	0.020	0.022	0.022	0.011	0.020
Feb				0.022	0.023	0.021	0.011	0.020	0.027	0.026	0.013	0.020
Mar				0.022	0.024	0.022	0.011	0.020	0.028	0.027	0.014	0.020
Apr				0.021	0.021	0.020	0.010	0.020	0.024	0.023	0.012	0.020
May				0.020	0.020	0.020	0.010	0.020	0.020	0.020	0.010	0.020
Jun				0.020	0.020	0.020	0.010	0.020	0.020	0.020	0.010	0.020
Jul				0.020	0.020	0.020	0.010	0.020	0.020	0.020	0.010	0.020
Aug				0.020	0.020	0.020	0.010	0.020	0.020	0.020	0.010	0.020
Sep				0.021	0.022	0.020	0.010	0.020	0.021	0.020	0.010	0.020
Oct				0.021	0.021	0.020	0.010	0.020	0.021	0.020	0.010	0.020
Nov				0.021	0.021	0.020	0.010	0.020	0.021	0.020	0.010	0.020
Dec				0.021	0.022	0.020	0.010	0.020	0.021	0.021	0.011	0.020
Jan	Sulphate (SO_4)	mg/L	*200*	93	94	91	91	91	94	92	92	92
Feb				97	98	95	95	94	100	98	98	97
Mar				100	101	98	98	97	104	102	102	101
Apr				81	81	79	79	79	83	81	81	81
May				36	36	36	36	36	36	36	36	36
Jun				46	46	45	45	45	46	45	45	45
Jul				54	55	53	53	53	54	53	53	53
Aug				60	60	59	59	59	60	59	59	59
Sep				63	63	62	62	62	63	62	62	62
Oct				85	86	84	84	84	85	84	84	84
Nov				87	88	86	86	86	87	86	86	86
Dec				91	91	89	89	89	91	89	89	89

Note: Highlighted cells indicate exceedance above site-specific objectives (Hatfield, 2011)

Table 4. Summary of Sensitivity Analyses for Predicted Post Closure Water Quality for Prairie Creek At Park Boundary

Month	Parameter	Units	Hatfield	Average Flow Conditions					Minimum Flow Conditions			
				Conservative Loading (Table A7)	Worst Case Scenario Flows (Table A10)	Surface Complexation of Source Terms (UG and WRP) (Table A11b)	Same as in Table A11b Using Half Detection Limit Values (Table A13b)	Reducing Conditions of Backfilled UG (Table A15b)	Conservative Loading (Table A8)	Surface Complexation of Source Terms (UG and WRP) (Table A12b)	Same as in Table A9 Using Half Detection Limit Values (Table A14b)	Reducing Conditions of Backfilled UG (Table A16b)
Jan	Cadmium (Cd)	ug/L	*0.38*	0.074	0.100	0.072	0.072	0.051	0.095	0.090	0.091	0.053
Feb				0.083	0.117	0.080	0.080	0.051	0.182	0.167	0.170	0.059
Mar				0.089	0.129	0.086	0.086	0.052	0.208	0.191	0.195	0.063
Apr				0.063	0.078	0.062	0.062	0.050	0.124	0.116	0.118	0.055
May				0.057	0.058	0.056	0.056	0.056	0.055	0.054	0.054	0.054
Jun				0.054	0.056	0.054	0.054	0.053	0.053	0.052	0.053	0.052
Jul				0.054	0.057	0.054	0.054	0.051	0.054	0.053	0.053	0.051
Aug				0.055	0.059	0.055	0.055	0.051	0.055	0.053	0.054	0.051
Sep				0.057	0.061	0.056	0.056	0.052	0.055	0.054	0.055	0.051
Oct				0.071	0.078	0.069	0.069	0.064	0.069	0.066	0.067	0.063
Nov				0.064	0.077	0.063	0.063	0.052	0.061	0.059	0.060	0.051
Dec				0.066	0.084	0.065	0.065	0.050	0.078	0.074	0.076	0.051
Jan	Copper (Cu)	ug/L	*4*	0.62	0.67	0.57	0.57	0.57	0.66	0.56	0.57	0.57
Feb				0.63	0.70	0.57	0.57	0.57	0.83	0.57	0.58	0.58
Mar				0.64	0.72	0.57	0.57	0.57	0.88	0.58	0.59	0.59
Apr				0.59	0.62	0.57	0.57	0.57	0.71	0.56	0.57	0.57
May				0.59	0.59	0.57	0.57	0.58	0.58	0.56	0.57	0.58
Jun				0.58	0.58	0.57	0.57	0.58	0.58	0.56	0.57	0.57
Jul				0.58	0.58	0.57	0.57	0.57	0.58	0.56	0.57	0.57
Aug				0.58	0.59	0.57	0.57	0.57	0.58	0.56	0.57	0.57
Sep				0.58	0.59	0.57	0.57	0.57	0.58	0.56	0.57	0.57
Oct				0.62	0.63	0.57	0.57	0.60	0.61	0.56	0.57	0.60
Nov				0.60	0.62	0.57	0.57	0.57	0.59	0.56	0.57	0.57
Dec				0.60	0.64	0.57	0.57	0.57	0.62	0.56	0.57	0.57
Jan	Lead (Pb)	ug/L	*7*	0.43	0.58	0.32	0.32	0.32	0.56	0.34	0.35	0.34
Feb				0.48	0.67	0.32	0.32	0.32	1.05	0.43	0.43	0.45
Mar				0.52	0.76	0.34	0.34	0.34	1.22	0.49	0.50	0.52
Apr				0.37	0.45	0.30	0.30	0.30	0.72	0.37	0.37	0.39
May				0.29	0.30	0.28	0.28	0.29	0.29	0.28	0.28	0.29
Jun				0.29	0.30	0.28	0.28	0.29	0.29	0.28	0.28	0.29
Jul				0.30	0.31	0.28	0.28	0.29	0.30	0.28	0.28	0.29
Aug				0.31	0.33	0.29	0.29	0.29	0.30	0.28	0.29	0.29
Sep				0.25	0.28	0.29	0.29	0.29	0.25	0.28	0.29	0.29
Oct				0.33	0.37	0.29	0.29	0.30	0.33	0.29	0.29	0.30
Nov				0.36	0.43	0.29	0.29	0.30	0.34	0.29	0.29	0.30
Dec				0.39	0.49	0.31	0.31	0.31	0.46	0.32	0.32	0.33
Jan	Selenium (Se)	ug/L	*2.16*	1.19	1.20	1.19	1.19	1.18	1.20	1.18	1.20	1.18
Feb				1.19	1.21	1.19	1.19	1.18	1.24	1.22	1.24	1.18
Mar				1.20	1.21	1.20	1.20	1.18	1.25	1.23	1.25	1.18
Apr				1.19	1.19	1.19	1.19	1.18	1.21	1.19	1.21	1.18
May				1.19	1.19	1.19	1.19	1.19	1.19	1.17	1.19	1.19
Jun				1.19	1.19	1.19	1.19	1.19	1.18	1.16	1.18	1.18
Jul				1.18	1.19	1.18	1.18	1.18	1.18	1.16	1.18	1.18
Aug				1.18	1.19	1.18	1.18	1.18	1.18	1.16	1.18	1.18
Sep				1.15	1.15	1.19	1.19	1.18	1.15	1.16	1.18	1.18
Oct				1.20	1.20	1.20	1.20	1.20	1.20	1.18	1.20	1.19
Nov				1.19	1.19	1.19	1.19	1.18	1.19	1.17	1.19	1.18
Dec				1.19	1.20	1.19	1.19	1.18	1.19	1.17	1.19	1.18
Jan	Zinc (Zn)	ug/L	*35*	14.42	22.32	14.40	14.40	14.42	20.95	20.55	20.91	20.95
Feb				15.92	25.27	15.90	15.90	15.92	43.19	42.35	43.08	43.19
Mar				19.08	31.45	19.04	19.04	19.08	56.08	55.02	55.96	56.08
Apr				10.61	14.76	10.59	10.59	10.61	28.05	27.50	27.99	28.05
May				6.94	7.24	6.94	6.94	6.94	6.83	6.71	6.83	6.83
Jun				6.82	7.07	6.81	6.81	6.82	6.73	6.61	6.73	6.73
Jul				7.01	7.52	7.01	7.01	7.01	7.01	6.88	7.00	7.01
Aug				7.24	7.98	7.23	7.23	7.24	7.17	7.04	7.16	7.17
Sep				7.37	8.38	7.53	7.53	7.53	7.22	7.24	7.37	7.38
Oct				9.15	11.42	9.14	9.14	9.15	8.87	8.71	8.86	8.87
Nov				9.67	12.81	9.65	9.65	9.67	8.96	8.79	8.95	8.96
Dec				12.05	17.63	12.04	12.04	12.05	15.69	15.39	15.66	15.68

Note: Highlighted cells indicate exceedance above site-specific objectives (Hatfield, 2011)

Table 4 cont'd. Summary of Sensitivity Analyses for Predicted Post Closure Water Quality for Prairie Creek At Park Boundary

Month	Parameter	Units	Hatfield	Average Flow Conditions					Minimum Flow Conditions			
				Conservative Loading (Table A7)	Worst Case Scenario Flows (Table A10)	Surface Complexation of Source Terms (UG and WRP) (Table A11b)	Same as in Table A11b Using Half Detection Limit Values (Table A13b)	Reducing Conditions of Backfilled UG (Table A15b)	Conservative Loading (Table A8)	Surface Complexation of Source Terms (UG and WRP) (Table A12b)	Same as in Table A9 Using Half Detection Limit Values (Table A14b)	Reducing Conditions of Backfilled UG (Table A16b)
Jan	Arsenic (As)	ug/L	***5***	0.16	0.18	0.15	0.15	0.13	0.18	0.17	0.17	0.14
Feb				0.17	0.20	0.16	0.16	0.13	0.27	0.25	0.26	0.15
Mar				0.17	0.21	0.17	0.17	0.14	0.30	0.28	0.28	0.16
Apr				0.14	0.16	0.14	0.14	0.13	0.21	0.20	0.20	0.14
May				0.13	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Jun				0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Jul				0.13	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Aug				0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Sep				0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13
Oct				0.14	0.15	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Nov				0.14	0.16	0.14	0.14	0.13	0.14	0.14	0.14	0.13
Dec				0.15	0.17	0.15	0.15	0.13	0.16	0.16	0.16	0.13
Jan	Antimony (Sb)	ug/L	***20***	0.26	0.38	0.25	0.25	0.14	0.36	0.35	0.35	0.15
Feb				0.30	0.47	0.30	0.29	0.14	0.79	0.77	0.78	0.18
Mar				0.33	0.53	0.33	0.32	0.15	0.92	0.90	0.91	0.20
Apr				0.20	0.27	0.20	0.20	0.13	0.51	0.49	0.50	0.16
May				0.17	0.18	0.17	0.17	0.17	0.16	0.16	0.16	0.16
Jun				0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15	0.15
Jul				0.16	0.17	0.16	0.15	0.14	0.16	0.15	0.15	0.14
Aug				0.16	0.18	0.16	0.16	0.14	0.16	0.16	0.15	0.14
Sep				0.16	0.19	0.17	0.16	0.15	0.16	0.16	0.16	0.14
Oct				0.24	0.28	0.24	0.24	0.21	0.23	0.22	0.22	0.20
Nov				0.21	0.27	0.21	0.20	0.15	0.19	0.19	0.18	0.14
Dec				0.22	0.31	0.22	0.21	0.14	0.28	0.27	0.27	0.14
Jan	Iron (Fe)	ug/L	***300***	5.27	5.39	5.16	2.71	5.27	5.37	5.07	2.72	5.37
Feb				5.31	5.46	5.15	2.71	5.31	5.75	5.05	2.73	5.75
Mar				5.34	5.52	5.16	2.72	5.34	5.87	5.05	2.74	5.87
Apr				5.23	5.29	5.16	2.71	5.23	5.50	5.06	2.72	5.50
May				5.17	5.17	5.16	2.71	5.17	5.17	5.07	2.71	5.17
Jun				5.17	5.17	5.16	2.71	5.17	5.17	5.07	2.71	5.17
Jul				5.17	5.19	5.16	2.71	5.17	5.17	5.07	2.71	5.17
Aug				5.18	5.20	5.16	2.71	5.18	5.18	5.07	2.71	5.18
Sep				4.93	4.96	5.16	2.71	5.18	4.93	5.07	2.71	5.18
Oct				5.20	5.23	5.16	2.71	5.20	5.19	5.07	2.71	5.19
Nov				5.22	5.28	5.16	2.71	5.22	5.21	5.07	2.71	5.21
Dec				5.24	5.32	5.16	2.71	5.24	5.29	5.07	2.71	5.29
Jan	Mercury (Hg)	ug/L	***0.034***	0.14	0.25	0.038	0.019	0.020	0.23	0.05	0.026	0.020
Feb				0.18	0.34	0.044	0.022	0.020	0.64	0.11	0.057	0.020
Mar				0.21	0.39	0.048	0.024	0.020	0.75	0.13	0.065	0.020
Apr				0.09	0.16	0.030	0.015	0.020	0.37	0.07	0.036	0.020
May				0.026	0.031	0.021	0.011	0.022	0.025	0.020	0.010	0.021
Jun				0.027	0.032	0.021	0.011	0.021	0.025	0.020	0.010	0.021
Jul				0.034	0.048	0.022	0.011	0.021	0.034	0.022	0.011	0.021
Aug				0.040	0.060	0.023	0.012	0.021	0.039	0.022	0.011	0.021
Sep				0.045	0.068	0.024	0.012	0.021	0.042	0.023	0.012	0.021
Oct				0.058	0.092	0.026	0.013	0.024	0.054	0.025	0.013	0.023
Nov				0.082	0.143	0.029	0.015	0.021	0.069	0.027	0.014	0.021
Dec				0.10	0.184	0.03	0.016	0.020	0.16	0.040	0.020	0.020
Jan	Silver (Ag)	ug/L	***0.103***	0.021	0.022	0.021	0.011	0.020	0.022	0.022	0.011	0.020
Feb				0.022	0.023	0.022	0.011	0.020	0.026	0.025	0.013	0.020
Mar				0.022	0.024	0.022	0.011	0.020	0.027	0.027	0.013	0.020
Apr				0.021	0.021	0.021	0.010	0.020	0.023	0.023	0.012	0.020
May				0.020	0.020	0.020	0.010	0.020	0.020	0.020	0.010	0.020
Jun				0.020	0.020	0.020	0.010	0.020	0.020	0.020	0.010	0.020
Jul				0.020	0.020	0.020	0.010	0.020	0.020	0.020	0.010	0.020
Aug				0.020	0.020	0.020	0.010	0.020	0.020	0.020	0.010	0.020
Sep				0.021	0.021	0.020	0.010	0.020	0.021	0.020	0.010	0.020
Oct				0.021	0.021	0.021	0.010	0.020	0.021	0.020	0.010	0.020
Nov				0.021	0.021	0.021	0.010	0.020	0.021	0.020	0.010	0.020
Dec				0.021	0.022	0.021	0.010	0.020	0.021	0.021	0.011	0.020
Jan	Sulphate (SO_4)	mg/L	***200***	93	94	93	93	93	94	92	94	93
Feb				96	97	96	96	96	99	98	99	98
Mar				99	101	99	99	99	103	102	103	102
Apr				80	81	80	80	80	82	81	83	82
May				36	36	36	36	36	36	36	36	36
Jun				46	46	46	46	46	46	45	46	46
Jul				54	55	54	54	54	54	54	54	54
Aug				60	60	60	60	60	60	59	60	60
Sep				63	63	63	63	63	63	62	63	63
Oct				85	86	85	85	85	85	84	85	85
Nov				87	88	87	87	87	87	86	87	87
Dec				91	91	91	91	90	91	89	91	91

Note: Highlighted cells indicate exceedance above site-specific objectives (Hatfield, 2011)

APPENDIX A

Detailed Mixing Calculations

Table A1. Estimated Pre-mining Water Quality for Prairie Creek at Harrison Creek - Average Flows

Assumed Source Concentrations (constant)

		End-member Concentration									
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	5	0.02	0.02	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.50	14	0.02	0.02	see below
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.02	0.02	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	5	0.02	0.02	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	7	0.02	0.02	244

Note: red values indicate source concentrations assumed equal to lower limit of detection

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	**Mean Monthly Flows (L/s)**		**Predicted Flows (L/s)**		
Month	**PC & HC**	**PC above Mine (SPN 3-10)**	**Harrison Creek**		**MQV/Vein fault (Tr12)**	
Jan	92	530	11		4.3	
Feb	96	381	8		3.7	
Mar	98	309	6		4.0	
Apr	80	819	17		3.5	
May	36	12,358	251		3.8	
Jun	46	17,237	350		4.5	
Jul	54	11,780	239		6.4	
Aug	60	9,336	190		7.3	
Sep	63	6,318	128		6.7	
Oct	85	2,762	56		6.4	
Nov	87	1,294	26		4.2	
Dec	90	838	17		4.8	
Mean	***74***	***5,330***	***108***		***5.0***	

Predicted In-Stream Concentrations (at SPN3-11)

	SPN 3-11 - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.052	0.57	0.35	1.19	15.81	0.14	0.15	5.19	0.02	0.02	93
Feb	0.053	0.57	0.36	1.19	17.66	0.14	0.15	5.20	0.02	0.02	97
Mar	0.055	0.58	0.38	1.19	21.26	0.14	0.16	5.20	0.02	0.02	100
Apr	0.051	0.57	0.32	1.18	11.36	0.13	0.14	5.19	0.02	0.02	81
May	0.049	0.56	0.29	1.18	6.78	0.13	0.13	5.18	0.02	0.02	36
Jun	0.049	0.56	0.29	1.18	6.72	0.13	0.13	5.18	0.02	0.02	46
Jul	0.049	0.57	0.29	1.18	7.05	0.13	0.13	5.18	0.02	0.02	55
Aug	0.049	0.57	0.29	1.18	7.32	0.13	0.13	5.18	0.02	0.02	60
Sep	0.049	0.56	0.23	1.14	7.47	0.13	0.12	4.90	0.02	0.02	63
Oct	0.050	0.57	0.31	1.18	9.10	0.13	0.13	5.18	0.02	0.02	85
Nov	0.050	0.57	0.31	1.18	10.20	0.13	0.14	5.18	0.02	0.02	88
Dec	0.051	0.57	0.33	1.19	13.03	0.13	0.14	5.19	0.02	0.02	91
Mean	***0.050***	***0.57***	***0.31***	***1.18***	***11.1***	***0.13***	***0.14***	***5.2***	***0.02***	***0.02***	***75***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table A2. Estimated Pre-mining Water Quality for Prairie Creek at Harrison Creek - Minimum Flows

Assumed Source Concentrations (constant)

		End-member Concentration									
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	5	0.02	0.02	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.50	14	0.02	0.02	see below
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.02	0.02	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	5	0.02	0.02	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	7	0.02	0.02	244

Note: red values indicate source concentrations assumed equal to lower limit of detection

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	**Min Monthly Flows (L/s)**		**Predicted Minimum Flows (L/s)**		
Month	**PC & HC**	**PC above Mine (SPN 3-10)**	**Harrison Creek**		**MQV/Vein fault (Tr12)**	
Jan	92	145	3		2.2	
Feb	96	48	1		1.9	
Mar	98	38	1		2.0	
Apr	80	78	2		1.8	
May	36	7,840	159		1.9	
Jun	46	10,800	219		2.3	
Jul	54	5,960	121		3.2	
Aug	60	5,120	104		3.6	
Sep	63	3,660	74		3.4	
Oct	85	1,540	31		3.2	
Nov	87	828	17		2.1	
Dec	90	254	5		2.4	
Mean	***74***	***3,026***	***61***		***2.5***	

Predicted In-Stream Concentrations (at SPN3-11)

	SPN 3-11 - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.056	0.58	0.39	1.19	23.46	0.14	0.16	5.20	0.02	0.02	94
Feb	0.067	0.60	0.55	1.20	**49.75**	0.16	0.21	5.24	0.02	0.02	101
Mar	0.073	0.61	0.64	1.20	**64.43**	0.17	0.24	5.27	0.02	0.02	105
Apr	0.059	0.59	0.44	1.19	31.90	0.15	0.18	5.22	0.02	0.02	84
May	0.049	0.56	0.29	1.18	6.70	0.13	0.13	5.18	0.02	0.02	36
Jun	0.049	0.56	0.29	1.18	6.66	0.13	0.13	5.18	0.02	0.02	46
Jul	0.049	0.57	0.29	1.18	7.04	0.13	0.13	5.18	0.02	0.02	54
Aug	0.049	0.57	0.29	1.18	7.24	0.13	0.13	5.18	0.02	0.02	60
Sep	0.049	0.56	0.23	1.14	7.30	0.13	0.12	4.90	0.02	0.02	63
Oct	0.049	0.57	0.30	1.18	8.82	0.13	0.13	5.18	0.02	0.02	85
Nov	0.050	0.57	0.31	1.18	9.38	0.13	0.13	5.18	0.02	0.02	87
Dec	0.053	0.57	0.36	1.19	17.29	0.14	0.15	5.20	0.02	0.02	91
Mean	***0.054***	***0.58***	***0.37***	***1.18***	***20.0***	***0.14***	***0.15***	***5.2***	***0.02***	***0.02***	***76***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table A3. Estimated Pre-mining Water Quality for Prairie Creek at Park Boundary- Average Flows

Assumed Source Concentrations (constant)

		End-member Concentration									
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	5	0.02	0.02	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.50	14	0.02	0.02	see below
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.02	0.02	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	5	0.02	0.02	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	7	0.02	0.02	244

Note: red values indicate source concentrations assumed equal to lower limit of detection

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	Mean Monthly Flows (L/s)		Predicted Flows (L/s)		
Month	**PC & HC**	**PC at Park Boundary**	**Harrison Creek**		**MQV/Vein fault (Tr12)**	
Jan	92	602	11		4.3	
Feb	96	433	8		3.7	
Mar	98	351	6		4.0	
Apr	80	930	17		3.5	
May	36	14,040	251		3.8	
Jun	46	19,584	350		4.5	
Jul	54	13,384	239		6.4	
Aug	60	10,607	190		7.3	
Sep	63	7,178	128		6.7	
Oct	85	3,138	56		6.4	
Nov	87	1,470	26		4.2	
Dec	90	952	17		4.8	
Mean	***74***	***6,056***	***108***		***5.0***	

Predicted In-Stream Concentrations (Prairie Creek at Park Boundary)

	Prairie Creek at Park Boundary - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.052	0.57	0.33	1.18	14.86	0.14	0.14	5.17	0.02	0.02	93
Feb	0.053	0.57	0.34	1.18	16.51	0.14	0.15	5.18	0.02	0.02	97
Mar	0.054	0.58	0.36	1.19	19.76	0.14	0.15	5.18	0.02	0.02	100
Apr	0.050	0.57	0.31	1.18	10.86	0.13	0.14	5.17	0.02	0.02	81
May	0.049	0.57	0.29	1.18	6.73	0.13	0.13	5.16	0.02	0.02	36
Jun	0.049	0.57	0.28	1.18	6.69	0.13	0.13	5.16	0.02	0.02	46
Jul	0.049	0.57	0.29	1.18	6.98	0.13	0.13	5.16	0.02	0.02	54
Aug	0.049	0.57	0.29	1.18	7.23	0.13	0.13	5.16	0.02	0.02	60
Sep	0.049	0.56	0.23	1.14	7.36	0.13	0.12	4.91	0.02	0.02	63
Oct	0.049	0.57	0.30	1.18	8.82	0.13	0.13	5.16	0.02	0.02	85
Nov	0.050	0.57	0.30	1.18	9.81	0.13	0.13	5.17	0.02	0.02	87
Dec	0.051	0.57	0.32	1.18	12.36	0.13	0.14	5.17	0.02	0.02	91
Mean	***0.050***	***0.57***	***0.30***	***1.18***	***10.7***	***0.13***	***0.14***	***5.1***	***0.02***	***0.02***	***74***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table A4. Estimated Pre-mining Water Quality for Prairie Creek at Park Boundary - Minimum Flows

Assumed Source Concentrations (constant)

		End-member Concentration									
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	5	0.02	0.02	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.50	14	0.02	0.02	see below
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.02	0.02	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	5	0.02	0.02	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	7	0.02	0.02	244

Note: red values indicate source concentrations assumed equal to lower limit of detection

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	Min Monthly Flows (L/s)		Predicted Minimum Flows (L/s)		
Month	**PC & HC**	**PC at Park Boundary**	**Harrison Creek**		**MQV/Vein fault (Tr12)**	
Jan	92	165	3		2.2	
Feb	96	55	1		1.9	
Mar	98	43	1		2.0	
Apr	80	89	2		1.8	
May	36	8,908	159		1.9	
Jun	46	12,271	219		2.3	
Jul	54	6,772	121		3.2	
Aug	60	5,817	104		3.6	
Sep	63	4,158	74		3.4	
Oct	85	1,750	31		3.2	
Nov	87	941	17		2.1	
Dec	90	289	5		2.4	
Mean	***74***	***3,438***	***61***		***2.5***	

Predicted In-Stream Concentrations (Prairie Creek at Park Boundary)

	Prairie Creek at Park Boundary - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.055	0.58	0.38	1.19	21.74	0.14	0.16	5.18	0.02	0.02	94
Feb	0.065	0.60	0.52	1.19	**45.47**	0.16	0.20	5.22	0.02	0.02	100
Mar	0.071	0.61	0.60	1.20	**58.77**	0.17	0.23	5.24	0.02	0.02	105
Apr	0.058	0.58	0.42	1.19	29.34	0.15	0.17	5.20	0.02	0.02	83
May	0.048	0.57	0.28	1.18	6.67	0.13	0.13	5.16	0.02	0.02	36
Jun	0.048	0.57	0.28	1.18	6.63	0.13	0.13	5.16	0.02	0.02	46
Jul	0.049	0.57	0.29	1.18	6.97	0.13	0.13	5.16	0.02	0.02	54
Aug	0.049	0.57	0.29	1.18	7.16	0.13	0.13	5.16	0.02	0.02	60
Sep	0.049	0.56	0.23	1.14	7.21	0.13	0.12	4.91	0.02	0.02	63
Oct	0.049	0.57	0.30	1.18	8.57	0.13	0.13	5.16	0.02	0.02	85
Nov	0.050	0.57	0.30	1.18	9.07	0.13	0.13	5.16	0.02	0.02	87
Dec	0.053	0.57	0.34	1.18	16.19	0.14	0.15	5.18	0.02	0.02	91
Mean	***0.054***	***0.58***	***0.35***	***1.18***	***18.6***	***0.14***	***0.15***	***5.2***	***0.02***	***0.02***	***75***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table A5. Predicted Post-closure Water Quality for Prairie Creek at Harrison Creek - Average Flows

Assumed Source Concentrations (constant)

		End-member Concentration									
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	5	0.02	0.02	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.50	14	0.02	0.02	see below
Backfilled Mine (from pHG, 2010b)	10	20	50	5	1,000	10	50	50	50	1	150
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.02	0.02	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	5	0.02	0.02	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	7	0.02	0.02	244
WRP (from pHG, 2010b)	200	500	50	200	6,000	100	1000	50	50	5	1,500

Note: red values indicate source concentrations assumed equal to lower limit of detection

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	Mean Monthly Flows (L/s)		Predicted Flows (L/s)			
Month	**PC & HC**	**PC above Mine (SPN 3-10)**	**Harrison Creek**	**Backfilled Mine (Tr12)**	**MQV/Vein fault (Tr12)**	**WRP (pHG, 2010)**	**Combined Flow**
Jan	92	530	11	1.4	2.9	0.00	545
Feb	96	381	8	1.4	2.3	0.00	392
Mar	98	309	6	1.3	2.7	0.00	319
Apr	80	819	17	1.3	2.2	0.00	839
May	36	12,358	251	1.2	2.5	0.53	12,613
Jun	46	17,237	350	2.1	2.4	0.48	17,592
Jul	54	11,780	239	3.7	2.7	0.19	12,026
Aug	60	9,336	190	4.2	3.1	0.15	9,533
Sep	63	6,318	128	3.4	3.3	0.12	6,453
Oct	85	2,762	56	2.1	4.3	0.24	2,825
Nov	87	1,294	26	1.8	2.4	0.02	1,324
Dec	90	838	17	1.6	3.3	0.00	860
Mean	***74***	***5,330***	***108***	***2.1***	***2.9***	***0.14***	**5443**

Predicted In-Stream Concentrations (at SPN3-11)

	SPN 3-11 - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.077	0.62	0.46	1.19	15.33	0.16	0.27	5.31	**0.15**	0.02	93
Feb	0.087	0.64	0.51	1.20	17.00	0.17	0.32	5.35	**0.20**	0.02	97
Mar	0.094	0.65	0.55	1.20	20.50	0.18	0.35	5.38	**0.23**	0.02	100
Apr	0.065	0.60	0.38	1.19	11.08	0.15	0.21	5.25	**0.10**	0.02	81
May	0.058	0.59	0.30	1.19	7.01	0.13	0.18	5.19	0.03	0.02	36
Jun	0.055	0.58	0.30	1.19	6.87	0.13	0.16	5.19	0.03	0.02	46
Jul	0.055	0.58	0.31	1.19	7.09	0.13	0.16	5.19	**0.04**	0.02	54
Aug	0.056	0.58	0.31	1.19	7.34	0.14	0.17	5.20	**0.04**	0.02	60
Sep	0.058	0.58	0.26	1.14	7.48	0.14	0.17	4.93	**0.05**	0.02	63
Oct	0.074	0.62	0.34	1.20	9.47	0.15	0.25	5.22	**0.06**	0.02	85
Nov	0.066	0.60	0.37	1.19	10.04	0.15	0.22	5.24	**0.09**	0.02	87
Dec	0.069	0.60	0.41	1.19	12.69	0.15	0.23	5.27	**0.11**	0.02	91
Mean	***0.068***	***0.60***	***0.37***	***1.19***	***11.0***	***0.15***	***0.22***	***5.2***	***0.09***	***0.02***	***74***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table A6. Predicted Post-closure Water Quality for Prairie Creek at Harrison Creek - Minimum Flows

Assumed Source Concentrations (constant)

		End-member Concentration									
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	5	0.02	0.02	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.50	14	0.02	0.02	see below
Backfilled Mine (from pHG, 2010b)	10	20	50	5	1,000	10	50	50	50	1	150
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.02	0.02	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	5	0.02	0.02	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	7	0.02	0.02	244
WRP (from pHG, 2010b)	200	500	50	200	6,000	100	1000	50	50	5	1,500

Note: red values indicate source concentrations assumed equal to lower limit of detection

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	**Min Monthly Flows (L/s)**		**Predicted Minimum Flows (L/s)**			
Month	**PC & HC**	**PC above Mine (SPN 3-10)**	**Harrison Creek**	**Backfilled Mine (Tr12)**	**MQV/Vein fault (Tr12)**	**WRP (pHG, 2010)**	**Combined Flow**
Jan	92	145	3	0.7	1.5	0.00	150
Feb	96	48	1	0.7	1.2	0.00	51
Mar	98	38	1	0.7	1.4	0.00	41
Apr	80	78	2	0.6	1.1	0.00	81
May	36	7,840	159	0.6	1.3	0.27	8,001
Jun	46	10,800	219	1.1	1.2	0.24	11,022
Jul	54	5,960	121	1.8	1.4	0.10	6,084
Aug	60	5,120	104	2.1	1.6	0.08	5,228
Sep	63	3,660	74	1.7	1.7	0.06	3,738
Oct	85	1,540	31	1.1	2.1	0.12	1,575
Nov	87	828	17	0.9	1.2	0.01	847
Dec	90	254	5	0.8	1.6	0.00	262
Mean	***74***	**3,026**	**61**	**1.1**	**1.4**	**0.07**	**3090**

Predicted In-Stream Concentrations (at SPN3-11)

	SPN 3-11 - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.100	0.67	0.59	1.20	22.58	0.18	0.39	5.41	**0.26**	0.02	94
Feb	0.196	0.85	1.14	1.25	**47.22**	0.28	0.87	5.83	**0.70**	0.03	100
Mar	0.225	0.91	1.33	1.26	**61.45**	0.32	1.01	5.96	**0.83**	0.03	104
Apr	0.133	0.73	0.78	1.22	30.46	0.22	0.55	5.55	**0.41**	0.02	83
May	0.056	0.58	0.30	1.19	6.88	0.13	0.17	5.18	0.03	0.02	36
Jun	0.054	0.58	0.30	1.19	6.78	0.13	0.16	5.18	0.03	0.02	46
Jul	0.055	0.58	0.31	1.19	7.08	0.13	0.16	5.19	**0.04**	0.02	54
Aug	0.055	0.58	0.31	1.19	7.26	0.14	0.16	5.20	**0.04**	0.02	60
Sep	0.056	0.58	0.25	1.14	7.31	0.14	0.16	4.92	**0.04**	0.02	63
Oct	0.071	0.62	0.34	1.20	9.15	0.14	0.24	5.22	**0.06**	0.02	85
Nov	0.062	0.59	0.35	1.19	9.25	0.14	0.20	5.23	**0.07**	0.02	87
Dec	0.081	0.63	0.48	1.20	16.73	0.16	0.29	5.32	**0.17**	0.02	91
Mean	***0.095***	***0.66***	***0.54***	***1.20***	***19.3***	***0.18***	***0.36***	***5.4***	***0.223***	***0.02***	***75***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table A7. Predicted Post-closure Water Quality for Prairie Creek at Park Boundary- Average Flows

Assumed Source Concentrations (constant)

		End-member Concentration									
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	5	0.02	0.02	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.50	14	0.02	0.02	see below
Backfilled Mine (from pHG, 2010b)	10	20	50	5	1,000	10	50	50	50	1	150
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.02	0.02	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	5	0.02	0.02	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	7	0.02	0.02	244
WRP (from pHG, 2010b)	200	500	50	200	6,000	100	1000	50	50	5	1,500

Note: red values indicate source concentrations assumed equal to lower limit of detection

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	Mean Monthly Flows (L/s)		Predicted Flows (L/s)		
Month	**PC & HC**	**PC at Park Boundary**	**Harrison Creek**	**Backfilled Mine (Tr12)**	**MQV/Vein fault (Tr12)**	**WRP (pHG, 2010)**
Jan	92	602	11	1.4	2.9	0.00
Feb	96	433	8	1.4	2.3	0.00
Mar	98	351	6	1.3	2.7	0.00
Apr	80	930	17	1.3	2.2	0.00
May	36	14,040	251	1.2	2.5	0.53
Jun	46	19,584	350	2.1	2.4	0.48
Jul	54	13,384	239	3.7	2.7	0.19
Aug	60	10,607	190	4.2	3.1	0.15
Sep	63	7,178	128	3.4	3.3	0.12
Oct	85	3,138	56	2.1	4.3	0.24
Nov	87	1,470	26	1.8	2.4	0.02
Dec	90	952	17	1.6	3.3	0.00
Mean	***74***	***6,056***	***108***	***2.1***	***2.9***	***0.14***

Predicted In-Stream Concentrations (Prairie Creek at Park Boundary)

	Prairie Creek at Park Boundary - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.074	0.62	0.43	1.19	14.42	0.16	0.26	5.27	**0.14**	0.02	93
Feb	0.083	0.63	0.48	1.19	15.92	0.17	0.30	5.31	**0.18**	0.02	96
Mar	0.089	0.64	0.52	1.20	19.08	0.17	0.33	5.34	**0.21**	0.02	99
Apr	0.063	0.59	0.37	1.19	10.61	0.14	0.20	5.23	**0.09**	0.02	80
May	0.057	0.59	0.29	1.19	6.94	0.13	0.17	5.17	0.03	0.02	36
Jun	0.054	0.58	0.29	1.19	6.82	0.13	0.16	5.17	0.03	0.02	46
Jul	0.054	0.58	0.30	1.18	7.01	0.13	0.16	5.17	0.03	0.02	54
Aug	0.055	0.58	0.31	1.18	7.24	0.14	0.16	5.18	**0.04**	0.02	60
Sep	0.057	0.58	0.25	1.15	7.37	0.14	0.16	4.93	**0.05**	0.02	63
Oct	0.071	0.62	0.33	1.20	9.15	0.14	0.24	5.20	**0.06**	0.02	85
Nov	0.064	0.60	0.36	1.19	9.67	0.14	0.21	5.22	**0.08**	0.02	87
Dec	0.066	0.60	0.39	1.19	12.05	0.15	0.22	5.24	**0.10**	0.02	91
Mean	***0.066***	***0.60***	***0.36***	***1.19***	***10.5***	***0.15***	***0.21***	***5.2***	***0.09***	***0.02***	***74***

Note: bold values exceed the in-stream criterion proposed by Hatfielc

Table A8. Predicted Post-closure Water Quality for Prairie Creek at Park Boundary - Minimum Flows

Assumed Source Concentrations (constant)

		End-member Concentration									
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	5	0.02	0.02	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.50	14	0.02	0.02	see below
Backfilled Mine (from pHG, 2010b)	10	20	50	5	1,000	10	50	50	50	1	150
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.02	0.02	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	5	0.02	0.02	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	7	0.02	0.02	244
WRP (from pHG, 2010b)	200	500	50	200	6,000	100	1000	50	50	5	1,500

Note: red values indicate source concentrations assumed equal to lower limit of detection

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	Min Monthly Flows (L/s)		Predicted Minimum Flows (L/s)		
Month	**PC & HC**	**PC at Park Boundary**	**Harrison Creek**	**Backfilled Mine (Tr12)**	**MQV/Vein fault (Tr12)**	**WRP (pHG, 2010)**
Jan	92	165	3	0.7	1.5	0.00
Feb	96	55	1	0.7	1.2	0.00
Mar	98	43	1	0.7	1.4	0.00
Apr	80	89	2	0.6	1.1	0.00
May	36	8,908	159	0.6	1.3	0.27
Jun	46	12,271	219	1.1	1.2	0.24
Jul	54	6,772	121	1.8	1.4	0.10
Aug	60	5,817	104	2.1	1.6	0.08
Sep	63	4,158	74	1.7	1.7	0.06
Oct	85	1,750	31	1.1	2.1	0.12
Nov	87	941	17	0.9	1.2	0.01
Dec	90	289	5	0.8	1.6	0.00
Mean	***74***	**3,438**	**61**	**1.1**	**1.4**	**0.07**

Predicted In-Stream Concentrations (Prairie Creek at Park Boundary)

	Prairie Creek at Park Boundary - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.095	0.66	0.56	1.20	20.95	0.18	0.36	5.37	**0.23**	0.02	94
Feb	0.182	0.83	1.05	1.24	**43.19**	0.27	0.79	5.75	**0.64**	0.03	99
Mar	0.208	0.88	1.22	1.25	**56.08**	0.30	0.92	5.87	**0.75**	0.03	103
Apr	0.124	0.71	0.72	1.21	28.05	0.21	0.51	5.50	**0.37**	0.02	82
May	0.055	0.58	0.29	1.19	6.83	0.13	0.16	5.17	0.02	0.02	36
Jun	0.053	0.58	0.29	1.18	6.73	0.13	0.15	5.17	0.03	0.02	46
Jul	0.054	0.58	0.30	1.18	7.01	0.13	0.16	5.17	0.03	0.02	54
Aug	0.055	0.58	0.30	1.18	7.17	0.13	0.16	5.18	**0.04**	0.02	60
Sep	0.055	0.58	0.25	1.15	7.22	0.13	0.16	4.93	**0.04**	0.02	63
Oct	0.069	0.61	0.33	1.20	8.87	0.14	0.23	5.19	**0.05**	0.02	85
Nov	0.061	0.59	0.34	1.19	8.96	0.14	0.19	5.21	**0.07**	0.02	87
Dec	0.078	0.62	0.46	1.19	15.69	0.16	0.28	5.29	**0.16**	0.02	91
Mean	***0.091***	***0.65***	***0.51***	***1.20***	***18.1***	***0.17***	***0.34***	***5.3***	***0.20***	***0.02***	***75***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table A9. Predicted Post-closure Water Quality for Prairie Creek at Harrison Creek - Worst-case Scenario

Assumed Source Concentrations (constant)

	End-member Concentration										
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	5	0.02	0.02	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.50	14	0.02	0.02	see below
Backfilled Mine (from pHG, 2010b)	10	20	50	5	1,000	10	50	50	50	1	150
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.02	0.02	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	5	0.02	0.02	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	7	0.02	0.02	244
WRP (from pHG, 2010b)	200	500	50	200	6,000	100	1000	50	50	5	1,500

Note: red values indicate source concentrations assumed equal to lower limit of detection

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	Mean Monthly Flows (L/s)		Predicted Flows (L/s)			
Month	**PC & HC**	**PC above Mine (SPN 3-10)**	**Harrison Creek**	**Backfilled Mine (Tr12)**	**MQV/Vein fault (Tr12)**	**WRP (pHG, 2010)**	**Combined Flow**
Jan	92	530	11	2.8	5.8	0.00	549
Feb	96	381	8	2.8	4.7	0.00	396
Mar	98	309	6	2.6	5.4	0.00	323
Apr	80	819	17	2.5	4.5	0.00	842
May	36	12,358	251	2.5	5.1	0.53	12,617
Jun	46	17,237	350	4.2	4.8	0.48	17,597
Jul	54	11,780	239	7.4	5.4	0.19	12,032
Aug	60	9,336	190	8.3	6.2	0.15	9,541
Sep	63	6,318	128	6.7	6.7	0.12	6,459
Oct	85	2,762	56	4.3	8.6	0.24	2,832
Nov	87	1,294	26	3.6	4.9	0.02	1,328
Dec	90	838	17	3.1	6.5	0.00	865
Mean	***74***	***5,330***	***108***	***4.2***	***5.7***	***0.14***	**5448**

Predicted In-Stream Concentrations (at SPN3-11)

	SPN 3-11 - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.105	0.68	0.62	1.21	24.10	0.19	0.41	5.43	**0.28**	0.02	94
Feb	0.124	0.71	0.72	1.21	27.38	0.21	0.51	5.52	**0.37**	0.02	98
Mar	0.138	0.74	0.81	1.22	34.23	0.22	0.57	5.57	**0.43**	0.02	101
Apr	0.081	0.63	0.48	1.20	15.71	0.16	0.29	5.32	**0.17**	0.02	81
May	0.059	0.59	0.30	1.19	7.34	0.14	0.18	5.19	0.03	0.02	36
Jun	0.056	0.58	0.30	1.19	7.15	0.13	0.17	5.19	0.03	0.02	46
Jul	0.058	0.58	0.32	1.19	7.66	0.14	0.18	5.21	**0.05**	0.02	55
Aug	0.061	0.59	0.34	1.19	8.16	0.14	0.19	5.22	**0.06**	0.02	60
Sep	0.063	0.59	0.29	1.15	8.61	0.14	0.19	4.95	**0.07**	0.02	63
Oct	0.082	0.64	0.39	1.21	11.99	0.16	0.30	5.26	**0.10**	0.02	86
Nov	0.080	0.63	0.45	1.20	13.54	0.16	0.29	5.31	**0.16**	0.02	88
Dec	0.088	0.64	0.52	1.20	18.90	0.17	0.33	5.36	**0.20**	0.02	91
Mean	***0.083***	***0.63***	***0.46***	***1.20***	***15.4***	***0.16***	***0.30***	***5.3***	***0.16***	***0.02***	***75***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table A10. Predicted Post-closure Water Quality for Prairie Creek at Park Boundary- Worst-case Scenario

Assumed Source Concentrations (constant)

		End-member Concentration									
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	5	0.02	0.02	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.50	14	0.02	0.02	see below
Backfilled Mine (from pHG, 2010b)	10	20	50	5	1,000	10	50	50	50	1	150
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.02	0.02	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	5	0.02	0.02	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	7	0.02	0.02	244
WRP (from pHG, 2010b)	200	500	50	200	6,000	100	1000	50	50	5	1,500

Note: red values indicate source concentrations assumed equal to lower limit of detection

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	Mean Monthly Flows (L/s)		Predicted Flows (L/s)		
Month	**PC & HC**	**PC at Park Boundary**	**Harrison Creek**	**Backfilled Mine (Tr12)**	**MQV/Vein fault (Tr12)**	**WRP (pHG, 2010)**
Jan	92	602	11	2.8	5.8	0.00
Feb	96	433	8	2.8	4.7	0.00
Mar	98	351	6	2.6	5.4	0.00
Apr	80	930	17	2.5	4.5	0.00
May	36	14,040	251	2.5	5.1	0.53
Jun	46	19,584	350	4.2	4.8	0.48
Jul	54	13,384	239	7.4	5.4	0.19
Aug	60	10,607	190	8.3	6.2	0.15
Sep	63	7,178	128	6.7	6.7	0.12
Oct	85	3,138	56	4.3	8.6	0.24
Nov	87	1,470	26	3.6	4.9	0.02
Dec	90	952	17	3.1	6.5	0.00
Mean	***74***	***6,056***	***108***	***4.2***	***5.7***	***0.14***

Predicted In-Stream Concentrations (Prairie Creek at Park Boundary)

	Prairie Creek at Park Boundary - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.100	0.67	0.58	1.20	22.32	0.18	0.38	5.39	**0.25**	0.02	94
Feb	0.117	0.70	0.67	1.21	25.27	0.20	0.47	5.46	**0.34**	0.02	97
Mar	0.129	0.72	0.76	1.21	31.45	0.21	0.53	5.52	**0.39**	0.02	101
Apr	0.078	0.62	0.45	1.19	14.76	0.16	0.27	5.29	**0.16**	0.02	81
May	0.058	0.59	0.30	1.19	7.24	0.14	0.18	5.17	0.03	0.02	36
Jun	0.056	0.58	0.30	1.19	7.07	0.13	0.16	5.17	0.03	0.02	46
Jul	0.057	0.58	0.31	1.19	7.52	0.14	0.17	5.19	**0.05**	0.02	55
Aug	0.059	0.59	0.33	1.19	7.98	0.14	0.18	5.20	**0.06**	0.02	60
Sep	0.061	0.59	0.28	1.15	8.38	0.14	0.19	4.96	**0.07**	0.02	63
Oct	0.078	0.63	0.37	1.20	11.42	0.15	0.28	5.23	**0.09**	0.02	86
Nov	0.077	0.62	0.43	1.19	12.81	0.16	0.27	5.28	**0.14**	0.02	88
Dec	0.084	0.64	0.49	1.20	17.63	0.17	0.31	5.32	**0.18**	0.02	91
Mean	***0.079***	***0.63***	***0.44***	***1.19***	***14.5***	***0.16***	***0.28***	***5.3***	***0.15***	***0.02***	***75***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table A11a. Predicted Post-closure Water Quality for Prairie Creek at Harrison Creek - Average Flows, Surface Complexation at Source

Assumed Source Concentrations (constant)

	End-member Concentration										
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	5	0.02	0.02	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.50	14	0.02	0.02	see below
Backfilled Mine (from pHG, 2010b)	10	20	50	5	1,000	10	50	50	50	0.5	150
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.02	0.02	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	5	0.02	0.02	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	7	0.02	0.02	244
WRP (from pHG, 2010b)	200	500	50	200	6,000	100	1000	50	50	5	1,500

Note: red values indicate source concentrations assumed equal to lower limit of detection

	SPN 3-11 - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Fraction Sorbed	***0.09172***	***0.9967***	***0.9938***	***0.0009768***	***0.008669***	***0.09948***	***0.01308***	***0.999***	***0.8489***		***0.001007***
Backfilled Mine (from pHG, 2010b)	9.0828	0.066	0.31	4.995116	991.331	9.0052	49.346	0.05	8	0.5	150
WRP (from pHG, 2010b)	181.656	1.65	0.31	199.80464	5947.986	90.052	986.92	0.05	8	5	1498

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	Mean Monthly Flows (L/s)		Predicted Flows (L/s)			
Month	**PC & HC**	**PC above Mine (SPN 3-10)**	**Harrison Creek**	**Backfilled Mine (Tr12)**	**MQV/Vein fault (Tr12)**	**WRP (pHG, 2010)**	**Combined Flow**
Jan	92	530	11	1.4	2.9	0.00	545
Feb	96	381	8	1.4	2.3	0.00	392
Mar	98	309	6	1.3	2.7	0.00	319
Apr	80	819	17	1.3	2.2	0.00	839
May	36	12,358	251	1.2	2.5	0.53	12,613
Jun	46	17,237	350	2.1	2.4	0.48	17,592
Jul	54	11,780	239	3.7	2.7	0.19	12,026
Aug	60	9,336	190	4.2	3.1	0.15	9,533
Sep	63	6,318	128	3.4	3.3	0.12	6,453
Oct	85	2,762	56	2.1	4.3	0.24	2,825
Nov	87	1,294	26	1.8	2.4	0.02	1,324
Dec	90	838	17	1.6	3.3	0.00	860
Mean	***74***	***5,330***	***108***	***2.1***	***2.9***	***0.14***	**5443**

Predicted In-Stream Concentrations (at SPN3-11)

	SPN 3-11 - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.075	0.569	0.328	1.195	15.31	0.157	0.269	5.175	**0.040**	0.021	93
Feb	0.084	0.569	0.332	1.199	16.97	0.166	0.317	5.171	**0.047**	0.022	97
Mar	0.090	0.571	0.350	1.202	20.47	0.173	0.351	5.173	**0.051**	0.022	100
Apr	0.063	0.567	0.308	1.190	11.07	0.145	0.209	5.176	**0.031**	0.021	81
May	0.057	0.565	0.291	1.191	7.01	0.134	0.175	5.179	0.021	0.020	36
Jun	0.055	0.565	0.290	1.189	6.86	0.133	0.162	5.179	0.021	0.020	46
Jul	0.054	0.565	0.291	1.187	7.08	0.134	0.160	5.178	0.022	0.020	54
Aug	0.055	0.565	0.291	1.188	7.33	0.135	0.166	5.177	0.023	0.020	60
Sep	0.057	0.565	0.293	1.189	7.66	0.136	0.174	5.177	0.024	0.020	63
Oct	0.071	0.566	0.300	1.203	9.46	0.145	0.253	5.177	0.026	0.021	85
Nov	0.064	0.566	0.302	1.192	10.03	0.144	0.215	5.175	0.030	0.021	87
Dec	0.067	0.567	0.316	1.191	12.68	0.149	0.227	5.176	**0.034**	0.021	91
Mean	***0.066***	***0.57***	***0.31***	***1.19***	***11.0***	***0.15***	***0.22***	***5.2***	***0.031***	***0.02***	***74***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table A12a. Predicted Post-closure Water Quality for Prairie Creek at Harrison Creek - Minimum Flows, Surface Complexation at Source

Assumed Source Concentrations (constant)

	End-member Concentration										
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	5	0.02	0.02	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.50	14	0.02	0.02	see below
Backfilled Mine (from pHG, 2010b)	10	20	50	5	1,000	10	50	50	50	0.5	150
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.02	0.02	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	5	0.02	0.02	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	7	0.02	0.02	244
WRP (from pHG, 2010b)	200	500	50	200	6,000	100	1000	50	50	5	1,500

Note: red values indicate source concentrations assumed equal to lower limit of detection

	SPN 3-11 - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Fraction Sorbed	***0.09172***	***0.9967***	***0.9938***	***0.0009768***	***0.008669***	***0.09948***	***0.01308***	***0.999***	***0.8489***		***0.001007***
Backfilled Mine (from pHG, 2010b)	9.0828	0.066	0.31	4.995116	991.331	9.0052	49.346	0.05	8	0.5	150
WRP (from pHG, 2010b)	181.656	1.65	0.31	199.80464	5947.986	90.052	986.92	0.05	8	5	1498

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	Min Monthly Flows (L/s)		Predicted Flows (L/s)			
Month	**PC & HC**	**PC above Mine (SPN 3-10)**	**Harrison Creek**	**Backfilled Mine (Tr12)**	**MQV/Vein fault (Tr12)**	**WRP (pHG, 2010)**	**Combined Flow**
Jan	92	145	3	0.7	1.5	0.00	150
Feb	96	48	1	0.7	1.2	0.00	51
Mar	98	38	1	0.7	1.4	0.00	41
Apr	80	78	2	0.6	1.1	0.00	81
May	36	7,840	159	0.6	1.3	0.27	8,001
Jun	46	10,800	219	1.1	1.2	0.24	11,022
Jul	54	5,960	121	1.8	1.4	0.10	6,084
Aug	60	5,120	104	2.1	1.6	0.08	5,228
Sep	63	3,660	74	1.7	1.7	0.06	3,738
Oct	85	1,540	31	1.1	2.1	0.12	1,575
Nov	87	828	17	0.9	1.2	0.01	847
Dec	90	254	5	0.8	1.6	0.00	262
Mean	***74***	***3,026***	***61***	***1.1***	***1.4***	***0.07***	**3090**

Predicted In-Stream Concentrations (at SPN3-11)

	SPN 3-11 - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.096	0.572	0.359	1.205	22.54	0.180	0.384	5.172	**0.056**	0.022	94
Feb	0.184	0.581	0.455	1.245	**47.10**	0.271	0.856	5.149	**0.123**	0.027	100
Mar	0.211	0.589	0.527	1.258	**61.31**	0.301	0.998	5.154	**0.141**	0.028	104
Apr	0.126	0.574	0.388	1.218	30.39	0.211	0.544	5.163	**0.079**	0.024	83
May	0.055	0.565	0.290	1.190	6.88	0.133	0.165	5.179	0.021	0.020	36
Jun	0.053	0.565	0.290	1.187	6.77	0.132	0.155	5.179	0.021	0.020	46
Jul	0.054	0.565	0.291	1.187	7.08	0.134	0.159	5.178	0.022	0.020	54
Aug	0.055	0.565	0.291	1.187	7.25	0.134	0.163	5.178	0.023	0.020	60
Sep	0.056	0.565	0.292	1.188	7.49	0.135	0.168	5.178	0.024	0.020	63
Oct	0.069	0.566	0.299	1.201	9.14	0.143	0.240	5.178	0.026	0.021	85
Nov	0.061	0.566	0.299	1.190	9.24	0.141	0.196	5.176	0.028	0.021	87
Dec	0.079	0.569	0.334	1.197	16.71	0.161	0.291	5.175	**0.043**	0.021	91
Mean	***0.092***	***0.57***	***0.34***	***1.20***	***19.3***	***0.17***	***0.36***	***5.2***	***0.051***	***0.02***	***75***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table A11b. Predicted Post-closure Water Quality for Prairie Creek at Park Boundary - Average Flows, Surface Complexation at Source

Assumed Source Concentrations (constant)

		End-member Concentration									
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	5	0.02	0.02	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.50	14	0.02	0.02	see below
Backfilled Mine (from pHG, 2010b)	10	20	50	5	1,000	10	50	50	50	0.5	150
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.02	0.02	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	5	0.02	0.02	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	7	0.02	0.02	244
WRP (from pHG, 2010b)	200	500	50	200	6,000	100	1000	50	50	5	1,500

Note: red values indicate source concentrations assumed equal to lower limit of detection

	Park Boundary - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Fraction Sorbed	***0.09172***	***0.9967***	***0.9938***	***0.0009768***	***0.008669***	***0.09948***	***0.01308***	***0.999***	***0.8489***		***0.001007***
Backfilled Mine (from pHG, 2010b)	9.0828	0.066	0.31	4.995116	991.331	9.0052	49.346	0.05	8	0.5	150
WRP (from pHG, 2010b)	181.656	1.65	0.31	199.80464	5947.986	90.052	986.92	0.05	8	5	1498

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	Mean Monthly Flows (L/s)		Predicted Flows (L/s)			
Month	**PC & HC**	**PC at Park Boundary**	**Harrison Creek**	**Backfilled Mine (Tr12)**	**MQV/Vein fault (Tr12)**	**WRP (pHG, 2010)**	**Combined Flow**
Jan	92	602	11	1.4	2.9	0.00	617
Feb	96	433	8	1.4	2.3	0.00	444
Mar	98	351	6	1.3	2.7	0.00	361
Apr	80	930	17	1.3	2.2	0.00	950
May	36	14,040	251	1.2	2.5	0.53	14,295
Jun	46	19,584	350	2.1	2.4	0.48	19,939
Jul	54	13,384	239	3.7	2.7	0.19	13,630
Aug	60	10,607	190	4.2	3.1	0.15	10,805
Sep	63	7,178	128	3.4	3.3	0.12	7,313
Oct	85	3,138	56	2.1	4.3	0.24	3,201
Nov	87	1,470	26	1.8	2.4	0.02	1,500
Dec	90	952	17	1.6	3.3	0.00	974
Mean	***74***	***6,056***	***108***	***2.1***	***2.9***	***0.14***	**6169**

Predicted In-Stream Concentrations (at Park Boundary)

	Park Boundary - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.072	0.569	0.318	1.191	14.40	0.154	0.254	5.157	**0.038**	0.021	93
Feb	0.080	0.569	0.322	1.195	15.90	0.162	0.297	5.154	**0.044**	0.022	96
Mar	0.086	0.571	0.338	1.198	19.04	0.169	0.328	5.155	**0.048**	0.022	99
Apr	0.062	0.567	0.300	1.187	10.59	0.144	0.200	5.158	0.030	0.021	80
May	0.056	0.565	0.284	1.188	6.94	0.134	0.170	5.161	0.021	0.020	36
Jun	0.054	0.565	0.284	1.186	6.81	0.133	0.158	5.160	0.021	0.020	46
Jul	0.054	0.565	0.285	1.184	7.01	0.133	0.156	5.160	0.022	0.020	54
Aug	0.055	0.565	0.285	1.185	7.23	0.134	0.162	5.159	0.023	0.020	60
Sep	0.056	0.565	0.286	1.186	7.53	0.136	0.168	5.159	0.024	0.020	63
Oct	0.069	0.566	0.293	1.199	9.14	0.144	0.240	5.159	0.026	0.021	85
Nov	0.063	0.566	0.295	1.188	9.65	0.143	0.205	5.157	0.029	0.021	87
Dec	0.065	0.568	0.308	1.188	12.04	0.147	0.217	5.158	0.032	0.021	91
Mean	***0.064***	***0.57***	***0.30***	***1.19***	***10.5***	***0.14***	***0.21***	***5.2***	***0.030***	***0.02***	***74***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table A12b. Predicted Post-closure Water Quality for Prairie Creek at Park Boundary - Minimum Flows, Surface Complexation at Source

Assumed Source Concentrations (constant)

	End-member Concentration										
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	5	0.02	0.02	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.50	14	0.02	0.02	see below
Backfilled Mine (from pHG, 2010b)	10	20	50	5	1,000	10	50	50	50	0.5	150
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.02	0.02	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	5	0.02	0.02	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	7	0.02	0.02	244
WRP (from pHG, 2010b)	200	500	50	200	6,000	100	1000	50	50	5	1,500

Note: red values indicate source concentrations assumed equal to lower limit of detection

	SPN 3-11 - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Fraction Sorbed	***0.09172***	***0.9967***	***0.9938***	***0.0009768***	***0.008669***	***0.09948***	***0.01308***	***0.999***	***0.8489***		***0.001007***
Backfilled Mine (from pHG, 2010b)	9.0828	0.066	0.31	4.995116	991.331	9.0052	49.346	0.05	8	0.5	150
WRP (from pHG, 2010b)	181.656	1.65	0.31	199.80464	5947.986	90.052	986.92	0.05	8	5	1498

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	Min Monthly Flows (L/s)		Predicted Flows (L/s)			
Month	**PC & HC**	**PC at Park Boundary**	**Harrison Creek**	**Backfilled Mine (Tr12)**	**MQV/Vein fault (Tr12)**	**WRP (pHG, 2010)**	**Combined Flow**
Jan	92	165	3	0.7	1.5	0.00	170
Feb	96	55	1	0.7	1.2	0.00	57
Mar	98	43	1	0.7	1.4	0.00	46
Apr	80	89	2	0.6	1.1	0.00	92
May	36	8,908	159	0.6	1.3	0.27	9,069
Jun	46	12,271	219	1.1	1.2	0.24	12,492
Jul	54	6,772	121	1.8	1.4	0.10	6,896
Aug	60	5,817	104	2.1	1.6	0.08	5,925
Sep	63	4,158	74	1.7	1.7	0.06	4,236
Oct	85	1,750	31	1.1	2.1	0.12	1,784
Nov	87	941	17	0.9	1.2	0.01	960
Dec	90	289	5	0.8	1.6	0.00	296
Mean	***74***	***3,438***	***61***	***1.1***	***1.4***	***0.07***	**3502**

Predicted In-Stream Concentrations (at Park Boundary)

	Park Boundary - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.090	0.562	0.340	1.180	20.55	0.172	0.351	5.065	**0.051**	0.022	92
Feb	0.167	0.570	0.425	1.216	**42.35**	0.253	0.770	5.047	**0.111**	0.025	98
Mar	0.191	0.578	0.490	1.228	**55.02**	0.279	0.897	5.053	**0.127**	0.027	102
Apr	0.116	0.564	0.366	1.192	27.50	0.199	0.493	5.058	**0.072**	0.023	81
May	0.054	0.555	0.279	1.166	6.71	0.131	0.158	5.070	0.020	0.020	36
Jun	0.052	0.555	0.279	1.164	6.61	0.130	0.149	5.070	0.020	0.020	45
Jul	0.053	0.555	0.280	1.163	6.88	0.131	0.153	5.069	0.022	0.020	54
Aug	0.053	0.555	0.280	1.164	7.04	0.132	0.156	5.069	0.022	0.020	59
Sep	0.054	0.555	0.281	1.164	7.24	0.132	0.160	5.069	0.023	0.020	62
Oct	0.066	0.556	0.287	1.176	8.71	0.140	0.224	5.069	0.025	0.020	84
Nov	0.059	0.556	0.287	1.166	8.79	0.138	0.185	5.068	0.027	0.020	86
Dec	0.074	0.559	0.318	1.172	15.39	0.156	0.269	5.067	**0.040**	0.021	89
Mean	***0.086***	***0.56***	***0.33***	***1.18***	***17.7***	***0.17***	***0.33***	***5.1***	***0.047***	***0.02***	***74***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table A13a. Predicted Post-closure Water Quality for Prairie Creek at Harrison Creek - Average Flows, Surface Complexation at Source and Half DLs

Assumed Source Concentrations (constant)

					End-member Concentration						
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	3	0.01	0.01	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.25	14	0.01	0.01	see below
Backfilled Mine (from pHG, 2010b)	10	20	50	5	1,000	10	50	25	25	0.3	150
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.01	0.01	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	3	0.01	0.01	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	5	0.01	0.01	244
WRP (from pHG, 2010b)	200	500	50	200	6,000	50	1000	25	50	3	1,500

Note: red values indicate source concentrations assumed equal to half the lower limit of detection

	SPN 3-11 - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Fraction Sorbed	***0.09172***	***0.9967***	***0.9938***	***0.0009768***	***0.008669***	***0.09948***	***0.01308***	***0.999***	***0.8489***		***0.001007***
Backfilled Mine (from pHG, 2010b)	9.0828	0.066	0.31	4.995116	991.331	9.0052	49.346	0.025	4	0.25	150
WRP (from pHG, 2010b)	181.656	1.65	0.31	199.80464	5947.986	45.026	986.92	0.025	8	2.5	1498

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	Mean Monthly Flows (L/s)		Predicted Flows (L/s)			
Month	**PC & HC**	**PC above Mine (SPN 3-10)**	**Harrison Creek**	**Backfilled Mine (Tr12)**	**MQV/Vein fault (Tr12)**	**WRP (pHG, 2010)**	**Combined Flow**
Jan	92	530	11	1.4	2.9	0.00	545
Feb	96	381	8	1.4	2.3	0.00	392
Mar	98	309	6	1.3	2.7	0.00	319
Apr	80	819	17	1.3	2.2	0.00	839
May	36	12,358	251	1.2	2.5	0.53	12,613
Jun	46	17,237	350	2.1	2.4	0.48	17,592
Jul	54	11,780	239	3.7	2.7	0.19	12,026
Aug	60	9,336	190	4.2	3.1	0.15	9,533
Sep	63	6,318	128	3.4	3.3	0.12	6,453
Oct	85	2,762	56	2.1	4.3	0.24	2,825
Nov	87	1,294	26	1.8	2.4	0.02	1,324
Dec	90	838	17	1.6	3.3	0.00	860
Mean	***74***	***5,330***	***108***	***2.1***	***2.9***	***0.14***	**5443**

Predicted In-Stream Concentrations (at SPN3-11)

	SPN 3-11 - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.075	0.569	0.328	1.195	15.31	0.157	0.265	2.736	0.020	0.011	93
Feb	0.084	0.569	0.332	1.199	16.97	0.166	0.312	2.735	0.023	0.011	97
Mar	0.090	0.571	0.350	1.202	20.47	0.173	0.346	2.739	0.026	0.011	100
Apr	0.063	0.567	0.308	1.190	11.07	0.145	0.204	2.732	0.016	0.010	81
May	0.057	0.565	0.291	1.191	7.01	0.132	0.170	2.729	0.011	0.010	36
Jun	0.055	0.565	0.290	1.189	6.86	0.132	0.157	2.729	0.011	0.010	46
Jul	0.054	0.565	0.291	1.187	7.08	0.133	0.155	2.729	0.011	0.010	54
Aug	0.055	0.565	0.291	1.188	7.33	0.134	0.161	2.729	0.012	0.010	60
Sep	0.057	0.565	0.293	1.189	7.66	0.135	0.169	2.729	0.012	0.010	63
Oct	0.071	0.566	0.300	1.203	9.46	0.141	0.248	2.730	0.013	0.010	85
Nov	0.064	0.566	0.302	1.192	10.03	0.144	0.210	2.730	0.015	0.010	87
Dec	0.067	0.567	0.316	1.191	12.68	0.149	0.222	2.734	0.017	0.010	91
Mean	***0.066***	***0.57***	***0.31***	***1.19***	***11.0***	***0.15***	***0.22***	***2.7***	***0.016***	***0.01***	***74***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table A13b. Predicted Post-closure Water Quality for Prairie Creek at Park Boundary - Average Flows, Surface Complexation at Source and Half DLs

Assumed Source Concentrations (constant)

	End-member Concentration										
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	3	0.01	0.01	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.25	14	0.01	0.01	see below
Backfilled Mine (from pHG, 2010b)	10	20	50	5	1,000	10	50	25	25	0.3	150
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.01	0.01	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	3	0.01	0.01	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	5	0.01	0.01	244
WRP (from pHG, 2010b)	200	500	50	200	6,000	50	1000	25	50	3	1,500

Note: red values indicate source concentrations assumed equal to half the lower limit of detection

	SPN 3-11 - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Fraction Sorbed	***0.09172***	***0.9967***	***0.9938***	***0.0009768***	***0.008669***	***0.09948***	***0.01308***	***0.999***	***0.8489***		***0.001007***
Backfilled Mine (from pHG, 2010b)	9.0828	0.066	0.31	4.995116	991.331	9.0052	49.346	0.025	4	0.25	150
WRP (from pHG, 2010b)	181.656	1.65	0.31	199.80464	5947.986	45.026	986.92	0.025	8	2.5	1498

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	Mean Monthly Flows (L/s)		Predicted Flows (L/s)			
Month	**PC & HC**	**PC at Park Boundary**	**Harrison Creek**	**Backfilled Mine (Tr12)**	**MQV/Vein fault (Tr12)**	**WRP (pHG, 2010)**	**Combined Flow**
Jan	92	602	11	1.4	2.9	0.00	617
Feb	96	433	8	1.4	2.3	0.00	444
Mar	98	351	6	1.3	2.7	0.00	361
Apr	80	930	17	1.3	2.2	0.00	950
May	36	14,040	251	1.2	2.5	0.53	14,295
Jun	46	19,584	350	2.1	2.4	0.48	19,939
Jul	54	13,384	239	3.7	2.7	0.19	13,630
Aug	60	10,607	190	4.2	3.1	0.15	10,805
Sep	63	7,178	128	3.4	3.3	0.12	7,313
Oct	85	3,138	56	2.1	4.3	0.24	3,201
Nov	87	1,470	26	1.8	2.4	0.02	1,500
Dec	90	952	17	1.6	3.3	0.00	974
Mean	***74***	***6,056***	***108***	***2.1***	***2.9***	***0.14***	**6169**

Predicted In-Stream Concentrations (at Park Boundary)

	Park Boundary - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.072	0.569	0.318	1.191	14.404	0.154	0.250	2.712	0.019	0.011	93
Feb	0.080	0.569	0.322	1.195	15.897	0.162	0.293	2.711	0.022	0.011	96
Mar	0.086	0.571	0.338	1.198	19.045	0.169	0.323	2.715	0.024	0.011	99
Apr	0.062	0.567	0.300	1.187	10.594	0.144	0.196	2.708	0.015	0.010	80
May	0.056	0.565	0.284	1.188	6.941	0.132	0.165	2.706	0.011	0.010	36
Jun	0.054	0.565	0.284	1.186	6.813	0.132	0.153	2.706	0.011	0.010	46
Jul	0.054	0.565	0.285	1.184	7.010	0.133	0.151	2.705	0.011	0.010	54
Aug	0.055	0.565	0.285	1.185	7.235	0.134	0.157	2.705	0.012	0.010	60
Sep	0.056	0.565	0.286	1.186	7.525	0.135	0.164	2.705	0.012	0.010	63
Oct	0.069	0.566	0.293	1.199	9.143	0.140	0.235	2.707	0.013	0.010	85
Nov	0.063	0.566	0.295	1.188	9.654	0.142	0.201	2.706	0.015	0.010	87
Dec	0.065	0.568	0.308	1.188	12.039	0.147	0.212	2.710	0.016	0.010	91
Mean	***0.064***	***0.57***	***0.30***	***1.19***	***10.5***	***0.14***	***0.21***	***2.7***	***0.015***	***0.01***	***74***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table A14a. Predicted Post-closure Water Quality for Prairie Creek at Harrison Creek - Minimum Flows, Surface Complexation at Source and Half DLs

Assumed Source Concentrations (constant)

		End-member Concentration									
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	3	0.01	0.01	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.25	14	0.01	0.01	see below
Backfilled Mine (from pHG, 2010b)	10	20	50	5	1,000	10	50	25	25	0.3	150
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.01	0.01	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	3	0.01	0.01	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	5	0.01	0.01	244
WRP (from pHG, 2010b)	200	500	50	200	6,000	50	1000	25	50	3	1,500

Note: red values indicate source concentrations assumed equal to half the lower limit of detection

	SPN 3-11 - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Fraction Sorbed	***0.09172***	***0.9967***	***0.9938***	***0.0009768***	***0.008669***	***0.09948***	***0.01308***	***0.999***	***0.8489***		***0.001007***
Backfilled Mine (from pHG, 2010b)	9.0828	0.066	0.31	4.995116	991.331	9.0052	49.346	0.025	4	0.25	150
WRP (from pHG, 2010b)	181.656	1.65	0.31	199.80464	5947.986	45.026	986.92	0.025	8	2.5	1498

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	Min Monthly Flows (L/s)		Predicted Flows (L/s)			
Month	**PC & HC**	**PC above Mine (SPN 3-10)**	**Harrison Creek**	**Backfilled Mine (Tr12)**	**MQV/Vein fault (Tr12)**	**WRP (pHG, 2010)**	**Combined Flow**
Jan	92	145	3	0.7	1.5	0.00	150
Feb	96	48	1	0.7	1.2	0.00	51
Mar	98	38	1	0.7	1.4	0.00	41
Apr	80	78	2	0.6	1.1	0.00	81
May	36	7,840	159	0.6	1.3	0.27	8,001
Jun	46	10,800	219	1.1	1.2	0.24	11,022
Jul	54	5,960	121	1.8	1.4	0.10	6,084
Aug	60	5,120	104	2.1	1.6	0.08	5,228
Sep	63	3,660	74	1.7	1.7	0.06	3,738
Oct	85	1,540	31	1.1	2.1	0.12	1,575
Nov	87	828	17	0.9	1.2	0.01	847
Dec	90	254	5	0.8	1.6	0.00	262
Mean	***74***	***3,026***	***61***	***1.1***	***1.4***	***0.07***	**3090**

Predicted In-Stream Concentrations (at SPN3-11)

	SPN 3-11 - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.096	0.572	0.359	1.205	22.542	0.180	0.379	2.741	0.028	0.011	94
Feb	0.184	0.581	0.455	1.245	**47.099**	0.271	0.851	2.751	**0.062**	0.013	100
Mar	0.211	0.589	0.527	1.258	**61.312**	0.301	0.993	2.770	**0.071**	0.014	104
Apr	0.126	0.574	0.388	1.218	30.388	0.211	0.540	2.743	**0.039**	0.012	83
May	0.055	0.565	0.290	1.190	6.882	0.132	0.160	2.729	0.011	0.010	36
Jun	0.053	0.565	0.290	1.187	6.774	0.131	0.150	2.729	0.011	0.010	46
Jul	0.054	0.565	0.291	1.187	7.075	0.133	0.154	2.729	0.011	0.010	54
Aug	0.055	0.565	0.291	1.187	7.253	0.134	0.158	2.729	0.012	0.010	60
Sep	0.056	0.565	0.292	1.188	7.487	0.134	0.163	2.729	0.012	0.010	63
Oct	0.069	0.566	0.299	1.201	9.145	0.140	0.235	2.730	0.013	0.010	85
Nov	0.061	0.566	0.299	1.190	9.239	0.141	0.191	2.730	0.014	0.010	87
Dec	0.079	0.569	0.334	1.197	16.708	0.161	0.286	2.737	0.021	0.011	91
Mean	***0.092***	***0.57***	***0.34***	***1.20***	***19.3***	***0.17***	***0.36***	***2.7***	***0.025***	***0.01***	***75***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table A14b. Predicted Post-closure Water Quality for Prairie Creek at Park Boundary - Minimum Flows, Surface Complexation at Source and Half DLs

Assumed Source Concentrations (constant)

		End-member Concentration									
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	3	0.01	0.01	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.25	14	0.01	0.01	see below
Backfilled Mine (from pHG, 2010b)	10	20	50	5	1,000	10	50	25	25	0.3	150
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.01	0.01	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	3	0.01	0.01	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	5	0.01	0.01	244
WRP (from pHG, 2010b)	200	500	50	200	6,000	50	1000	25	50	3	1,500

Note: red values indicate source concentrations assumed equal to half the lower limit of detection

	SPN 3-11 - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
Fraction Sorbed	***0.09172***	***0.9967***	***0.9938***	***0.0009768***	***0.008669***	***0.09948***	***0.01308***	***0.999***	***0.8489***		***0.001007***
Backfilled Mine (from pHG, 2010b)	9.0828	0.066	0.31	4.995116	991.331	9.0052	49.346	0.025	4	0.25	150
WRP (from pHG, 2010b)	181.656	1.65	0.31	199.80464	5947.986	45.026	986.92	0.025	8	2.5	1498

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	Min Monthly Flows (L/s)		Predicted Flows (L/s)			
Month	**PC & HC**	**PC at Park Boundary**	**Harrison Creek**	**Backfilled Mine (Tr12)**	**MQV/Vein fault (Tr12)**	**WRP (pHG, 2010)**	**Combined Flow**
Jan	92	165	3	0.7	1.5	0.00	170
Feb	96	55	1	0.7	1.2	0.00	57
Mar	98	43	1	0.7	1.4	0.00	46
Apr	80	89	2	0.6	1.1	0.00	92
May	36	8,908	159	0.6	1.3	0.27	9,069
Jun	46	12,271	219	1.1	1.2	0.24	12,492
Jul	54	6,772	121	1.8	1.4	0.10	6,896
Aug	60	5,817	104	2.1	1.6	0.08	5,925
Sep	63	4,158	74	1.7	1.7	0.06	4,236
Oct	85	1,750	31	1.1	2.1	0.12	1,784
Nov	87	941	17	0.9	1.2	0.01	960
Dec	90	289	5	0.8	1.6	0.00	296
Mean	***74***	***3,438***	***61***	***1.1***	***1.4***	***0.07***	**3502**

Predicted In-Stream Concentrations (at Park Boundary)

	Park Boundary - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.091	0.572	0.346	1.200	20.91	0.175	0.353	2.717	0.026	0.011	94
Feb	0.170	0.580	0.433	1.237	**43.08**	0.257	0.779	2.726	**0.057**	0.013	99
Mar	0.195	0.587	0.498	1.249	**55.96**	0.284	0.908	2.744	**0.065**	0.013	103
Apr	0.118	0.574	0.373	1.213	27.99	0.202	0.498	2.719	**0.036**	0.012	83
May	0.054	0.565	0.284	1.187	6.83	0.132	0.156	2.706	0.010	0.010	36
Jun	0.053	0.565	0.284	1.185	6.73	0.131	0.147	2.706	0.010	0.010	46
Jul	0.053	0.565	0.285	1.184	7.00	0.133	0.151	2.705	0.011	0.010	54
Aug	0.054	0.565	0.285	1.184	7.16	0.133	0.154	2.705	0.011	0.010	60
Sep	0.055	0.565	0.286	1.185	7.37	0.134	0.158	2.705	0.012	0.010	63
Oct	0.067	0.566	0.292	1.197	8.86	0.139	0.224	2.707	0.013	0.010	85
Nov	0.060	0.566	0.292	1.187	8.95	0.140	0.184	2.706	0.014	0.010	87
Dec	0.076	0.569	0.323	1.193	15.66	0.158	0.269	2.713	0.020	0.011	91
Mean	***0.087***	***0.57***	***0.33***	***1.20***	***18.0***	***0.17***	***0.33***	***2.7***	***0.024***	***0.01***	***75***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table A15a. Predicted Post-closure Water Quality for Prairie Creek at Harrison Creek - Average Flows, Reducing Conditions

Assumed Source Concentrations (constant)

		End-member Concentration									
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	5	0.02	0.02	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.50	14	0.02	0.02	see below
Backfilled Mine (from pHG, 2010b) adjusted to Eh 70 mV	0.05	0.05	0.005	0.22	1,000	0.16	0.27	50	0.02	0.02	75
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.02	0.02	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	5	0.02	0.02	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	7	0.02	0.02	244
WRP (from pHG, 2010b)	200	500	50	200	6,000	100	1000	50	50	5	1,500

Note: red values indicate source concentrations assumed equal to lower limit of detection

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	Mean Monthly Flows (L/s)		Predicted Flows (L/s)			
Month	**PC & HC**	**PC above Mine (SPN 3-10)**	**Harrison Creek**	**Backfilled Mine (Tr12)**	**MQV/Vein fault (Tr12)**	**WRP (pHG, 2010)**	**Combined Flow**
Jan	92	530	11	1.4	2.9	0.00	545
Feb	96	381	8	1.4	2.3	0.00	392
Mar	98	309	6	1.3	2.7	0.00	319
Apr	80	819	17	1.3	2.2	0.00	839
May	36	12,358	251	1.2	2.5	0.53	12,613
Jun	46	17,237	350	2.1	2.4	0.48	17,592
Jul	54	11,780	239	3.7	2.7	0.19	12,026
Aug	60	9,336	190	4.2	3.1	0.15	9,533
Sep	63	6,318	128	3.4	3.3	0.12	6,453
Oct	85	2,762	56	2.1	4.3	0.24	2,825
Nov	87	1,294	26	1.8	2.4	0.02	1,324
Dec	90	838	17	1.6	3.3	0.00	860
Mean	***74***	***5,330***	***108***	***2.1***	***2.9***	***0.14***	**5443**

Predicted In-Stream Concentrations (at SPN3-11)

	SPN 3-11 - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.051	0.569	0.327	1.182	15.33	0.134	0.141	5.306	0.020	0.020	93
Feb	0.051	0.569	0.331	1.182	17.00	0.135	0.143	5.349	0.020	0.020	96
Mar	0.053	0.571	0.349	1.182	20.50	0.137	0.149	5.379	0.020	0.020	99
Apr	0.050	0.566	0.308	1.182	11.08	0.132	0.135	5.252	0.020	0.020	80
May	0.057	0.586	0.293	1.191	7.01	0.134	0.171	5.186	0.022	0.020	36
Jun	0.054	0.578	0.291	1.188	6.87	0.132	0.156	5.186	0.021	0.020	46
Jul	0.052	0.573	0.291	1.186	7.09	0.131	0.145	5.194	0.021	0.020	54
Aug	0.052	0.573	0.292	1.186	7.34	0.131	0.145	5.200	0.021	0.020	60
Sep	0.052	0.574	0.294	1.186	7.66	0.132	0.148	5.204	0.021	0.020	63
Oct	0.066	0.608	0.304	1.200	9.47	0.139	0.217	5.219	0.024	0.020	85
Nov	0.052	0.573	0.303	1.185	10.04	0.133	0.148	5.244	0.021	0.020	87
Dec	0.050	0.567	0.316	1.183	12.69	0.133	0.138	5.268	0.020	0.020	91
Mean	***0.053***	***0.58***	***0.31***	***1.19***	***11.0***	***0.13***	***0.15***	***5.2***	***0.02***	***0.02***	***74***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table A15b. Predicted Post-closure Water Quality for Prairie Creek at Park Boundary - Average Flows, Reducing Conditions

Assumed Source Concentrations (constant)

		End-member Concentration									
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	5	0.02	0.02	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.50	14	0.02	0.02	see below
Backfilled Mine (from pHG, 2010b) adjusted to Eh 70 mV	0.05	0.05	0.005	0.22	1,000	0.16	0.27	50	0.02	0.02	75
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.02	0.02	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	5	0.02	0.02	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	7	0.02	0.02	244
WRP (from pHG, 2010b)	200	500	50	200	6,000	100	1000	50	50	5	1,500

Note: red values indicate source concentrations assumed equal to lower limit of detection

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	Mean Monthly Flows (L/s)		Predicted Flows (L/s)			
Month	**PC & HC**	**PC at Park Boundary**	**Harrison Creek**	**Backfilled Mine (Tr12)**	**MQV/Vein fault (Tr12)**	**WRP (pHG, 2010)**	**Combined Flow**
Jan	92	602	11	1.4	2.9	0.00	617
Feb	96	433	8	1.4	2.3	0.00	444
Mar	98	351	6	1.3	2.7	0.00	361
Apr	80	930	17	1.3	2.2	0.00	950
May	36	14,040	251	1.2	2.5	0.53	14,295
Jun	46	19,584	350	2.1	2.4	0.48	19,939
Jul	54	13,384	239	3.7	2.7	0.19	13,630
Aug	60	10,607	190	4.2	3.1	0.15	10,805
Sep	63	7,178	128	3.4	3.3	0.12	7,313
Oct	85	3,138	56	2.1	4.3	0.24	3,201
Nov	87	1,470	26	1.8	2.4	0.02	1,500
Dec	90	952	17	1.6	3.3	0.00	974
Mean	***74***	***6,056***	***108***	***2.1***	***2.9***	***0.14***	**6169**

Predicted In-Stream Concentrations (at Park Boundary)

	Park Boundary - In-Stream Concentrations (ug/L)										
Month	Cadmium (Cd) ug/L	Copper (Cu) ug/L	Lead (Pb) ug/L	Selenium (Se) ug/L	Zinc (Zn) ug/L	Arsenic (As) ug/L	Antimony (Sb) ug/L	Iron (Fe) ug/L	Mercury (Hg) ug/L	Silver (Ag) ug/L	SO4 mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.051	0.569	0.317	1.180	14.42	0.134	0.139	5.275	0.020	0.020	93
Feb	0.051	0.569	0.321	1.180	15.92	0.134	0.141	5.313	0.020	0.020	96
Mar	0.052	0.571	0.337	1.180	19.08	0.136	0.146	5.340	0.020	0.020	99
Apr	0.050	0.567	0.300	1.180	10.61	0.132	0.134	5.226	0.020	0.020	80
May	0.056	0.584	0.286	1.188	6.94	0.133	0.166	5.167	0.022	0.020	36
Jun	0.053	0.577	0.285	1.185	6.82	0.132	0.153	5.167	0.021	0.020	46
Jul	0.051	0.572	0.285	1.183	7.01	0.131	0.142	5.174	0.021	0.020	54
Aug	0.051	0.572	0.286	1.183	7.24	0.131	0.143	5.180	0.021	0.020	60
Sep	0.052	0.574	0.287	1.183	7.53	0.132	0.146	5.183	0.021	0.020	63
Oct	0.064	0.604	0.296	1.195	9.15	0.138	0.207	5.197	0.024	0.020	85
Nov	0.052	0.573	0.295	1.183	9.67	0.132	0.145	5.219	0.021	0.020	87
Dec	0.050	0.568	0.307	1.180	12.05	0.132	0.136	5.241	0.020	0.020	90
Mean	***0.053***	***0.58***	***0.30***	***1.18***	***10.5***	***0.13***	***0.15***	***5.2***	***0.02***	***0.02***	***74***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table A16a. Predicted Post-closure Water Quality for Prairie Creek at Harrison Creek - Minimum Flows, Reducing Conditions

Assumed Source Concentrations (constant)

		End-member Concentration									
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	5	0.02	0.02	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.50	14	0.02	0.02	see below
Backfilled Mine (from pHG, 2010b) adjusted to Eh 70 mV	0.05	0.05	0.005	0.22	1,000	0.16	0.27	50	0.02	0.02	75
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.02	0.02	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	5	0.02	0.02	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	7	0.02	0.02	244
WRP (from pHG, 2010b)	200	500	50	200	6,000	100	1000	50	50	5	1,500

Note: red values indicate source concentrations assumed equal to lower limit of detection

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	Min Monthly Flows (L/s)		Predicted Minimum Flows (L/s)			
Month	**PC & HC**	**PC above Mine (SPN 3-10)**	**Harrison Creek**	**Backfilled Mine (Tr12)**	**MQV/Vein fault (Tr12)**	**WRP (pHG, 2010)**	**Combined Flow**
Jan	92	145	3	0.7	1.5	0.00	150
Feb	96	48	1	0.7	1.2	0.00	51
Mar	98	38	1	0.7	1.4	0.00	41
Apr	80	78	2	0.6	1.1	0.00	81
May	36	7,840	159	0.6	1.3	0.27	8,001
Jun	46	10,800	219	1.1	1.2	0.24	11,022
Jul	54	5,960	121	1.8	1.4	0.10	6,084
Aug	60	5,120	104	2.1	1.6	0.08	5,228
Sep	63	3,660	74	1.7	1.7	0.06	3,738
Oct	85	1,540	31	1.1	2.1	0.12	1,575
Nov	87	828	17	0.9	1.2	0.01	847
Dec	90	254	5	0.8	1.6	0.00	262
Mean	***74***	**3,026**	**61**	**1.1**	**1.4**	**0.07**	**3090**

Predicted In-Stream Concentrations (at SPN3-11)

	SPN 3-11 - In-Stream Concentrations (ug/L)										
	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Month	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.053	0.572	0.357	1.182	22.581	0.138	0.152	5.408	0.020	0.020	93
Feb	0.060	0.580	0.451	1.179	**47.214**	0.150	0.184	5.833	0.020	0.020	99
Mar	0.065	0.589	0.522	1.182	**61.447**	0.158	0.207	5.959	0.020	0.020	103
Apr	0.055	0.574	0.386	1.181	30.453	0.142	0.162	5.553	0.020	0.020	82
May	0.055	0.581	0.292	1.189	6.885	0.133	0.162	5.184	0.022	0.020	36
Jun	0.053	0.576	0.291	1.187	6.776	0.132	0.151	5.185	0.021	0.020	46
Jul	0.052	0.572	0.291	1.186	7.079	0.131	0.145	5.194	0.021	0.020	54
Aug	0.051	0.572	0.292	1.185	7.257	0.131	0.144	5.198	0.021	0.020	60
Sep	0.052	0.573	0.293	1.186	7.492	0.131	0.146	5.201	0.021	0.020	63
Oct	0.064	0.604	0.302	1.198	9.155	0.138	0.208	5.215	0.024	0.020	85
Nov	0.052	0.571	0.300	1.185	9.249	0.132	0.144	5.230	0.021	0.020	87
Dec	0.052	0.569	0.333	1.182	16.733	0.135	0.143	5.325	0.020	0.020	91
Mean	***0.055***	***0.58***	***0.34***	***1.19***	***19.4***	***0.14***	***0.16***	***5.4***	***0.021***	***0.02***	***75***

Note: bold values exceed the in-stream criterion proposed by Hatfield

Table A16b. Predicted Post-closure Water Quality for Prairie Creek at Park Boundary - Minimum Flows, Reducing Conditions

Assumed Source Concentrations (constant)

		End-member Concentration									
Parameter	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
PC above Mine (SPN 3-10)	0.05	0.57	0.23	1.16	6.4	0.13	0.12	5	0.02	0.02	see below
Harrison Creek (HC-1) - Sep '10	0.07	0.30	3.20	2.30	9.0	0.10	0.50	14	0.02	0.02	see below
Backfilled Mine (from pHG, 2010b) adjusted to Eh 70 mV	0.05	0.05	0.005	0.22	1,000	0.16	0.27	50	0.02	0.02	75
MW09-15 - Nov '09	0.72	0.70	1.80	0.30	2,120	0.40	1.00	11	0.02	0.02	360
MW08-03 - Nov '08	0.47	2	10.4	2.3	735	1.30	3.20	5	0.02	0.02	190
MQV/Vein Fault	0.55	1.55	7.46	1.62	1,185	1.0	2.4	7	0.02	0.02	244
WRP (from pHG, 2010b)	200	500	50	200	6,000	100	1000	50	50	5	1,500

Note: red values indicate source concentrations assumed equal to lower limit of detection

Assumed Monthly Source Concentrations & Monthly Flows

	SO4 mg/L	Min Monthly Flows (L/s)		Predicted Minimum Flows (L/s)			
Month	**PC & HC**	**PC at Park Boundary**	**Harrison Creek**	**Backfilled Mine (Tr12)**	**MQV/Vein fault (Tr12)**	**WRP (pHG, 2010)**	**Combined Flow**
Jan	92	165	3	0.7	1.5	0.00	170
Feb	96	55	1	0.7	1.2	0.00	57
Mar	98	43	1	0.7	1.4	0.00	46
Apr	80	89	2	0.6	1.1	0.00	92
May	36	8,908	159	0.6	1.3	0.27	9,069
Jun	46	12,271	219	1.1	1.2	0.24	12,492
Jul	54	6,772	121	1.8	1.4	0.10	6,896
Aug	60	5,817	104	2.1	1.6	0.08	5,925
Sep	63	4,158	74	1.7	1.7	0.06	4,236
Oct	85	1,750	31	1.1	2.1	0.12	1,784
Nov	87	941	17	0.9	1.2	0.01	960
Dec	90	289	5	0.8	1.6	0.00	296
Mean	***74***	**3,438**	**61**	**1.1**	**1.4**	**0.07**	**3502**

Predicted In-Stream Concentrations (at Park Boundary)

	Park Boundary - In-Stream Concentrations (ug/L)										
Month	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Arsenic (As)	Antimony (Sb)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	SO4
	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L
SRC criteria	***0.172***	***2.53***	***1.13***	***2.16***	***22.65***	***0.56***	***0.605***	***229***	***0.034***	***0.103***	***119.3***
CCME	***0.017***	***4.0***	***7***	***1***	***30***	***5***	***20***	***300***	***0.026***	***0.1***	***100***
Hatfield	***0.38***	***4.0***	***7***	***2.16***	***35***	***5***	***20***	***300***	***0.034***	***0.103***	***200***
Jan	0.053	0.572	0.345	1.180	20.950	0.137	0.149	5.367	0.020	0.020	93
Feb	0.059	0.579	0.429	1.178	**43.187**	0.148	0.178	5.751	0.020	0.020	98
Mar	0.063	0.587	0.494	1.179	**56.081**	0.156	0.199	5.865	0.020	0.020	102
Apr	0.055	0.574	0.370	1.179	28.045	0.140	0.158	5.498	0.020	0.020	82
May	0.054	0.580	0.286	1.186	6.832	0.133	0.158	5.166	0.021	0.020	36
Jun	0.052	0.575	0.285	1.184	6.735	0.132	0.148	5.166	0.021	0.020	46
Jul	0.051	0.572	0.285	1.183	7.007	0.131	0.142	5.174	0.021	0.020	54
Aug	0.051	0.572	0.286	1.183	7.166	0.131	0.141	5.178	0.021	0.020	60
Sep	0.051	0.573	0.287	1.183	7.378	0.131	0.143	5.180	0.021	0.020	63
Oct	0.063	0.600	0.295	1.194	8.871	0.137	0.199	5.193	0.023	0.020	85
Nov	0.051	0.571	0.293	1.182	8.956	0.132	0.142	5.207	0.021	0.020	87
Dec	0.051	0.569	0.322	1.180	15.685	0.134	0.141	5.292	0.020	0.020	91
Mean	***0.055***	***0.58***	***0.33***	***1.18***	***18.1***	***0.14***	***0.16***	***5.3***	***0.021***	***0.02***	***75***

Note: bold values exceed the in-stream criterion proposed by Hatfield

APPENDIX B

PHREEQC Output (Speciation and Solubility Calculations)

```
   Input file: C:\Users\Shannon\Documents\Projects\pH007-01 CZC_Prairie Creek\pHase
Reports and Memos\Source term report\PhreeqC\Mixed waters PC.pqi
  Output file: C:\Users\Shannon\Documents\Projects\pH007-01 CZC_Prairie Creek\pHase
Reports and Memos\Source term report\PhreeqC\Mixed waters PC.pqo
Database file: C:\Program Files (x86)\USGS\Phreeqc Interactive 2.17.4799\database
\minteq.dat

------------------
Reading data base.
------------------

      SOLUTION_MASTER_SPECIES
      SOLUTION_SPECIES
      SOLUTION_SPECIES
      PHASES
      SURFACE_MASTER_SPECIES
      SURFACE_SPECIES
      END
------------------------------------
Reading input data for simulation 1.
------------------------------------

      DATABASE C:\Program Files (x86)\USGS\Phreeqc Interactive 2.17.4799\database
\minteq.dat
      EQUILIBRIUM_PHASES 1
          CO2(g)    -2 0
          O2(g)     -0.7 0
          Calcite   0 0
          Diaspore  0 0
          Ferrihydrite 0 0
          Al4(OH)10SO4 0 0
      SOLUTION 1
          temp      5
          pH        8.5
          pe        4
          redox     pe
          units     ppm
          density   1
          Alkalinity 200
          S(6)      73
          Al        7 ppb
          Sb        0.5 ppb
          As        0.3 ppb
          Ba        77 ppb
          Be        0.1 ppb
          B         50 ppb
          Cd        0.05 ppb
          Cr        1 ppb
          Cu        0.3 ppb
          Fe        5 ppb
          Pb        0.9 ppb
          Li        5 ppb
          Mn        1 ppb
          Hg        0.04 ppb
          Ni        1 ppb
          Se        1.4 ppb
          Si        1636 ppb
          Ag        0.02 ppb
          Sr        332 ppb
          Tl        0.05 ppb
          U         5.5 ppb
          V         5 ppb
          Zn        10 ppb
          Ca        69
          Mg        28
          K         0.4
          Na        2
```

```
          water    1 # kg
      SURFACE 1
-------------------------------------------
Beginning of initial solution calculations.
-------------------------------------------

Initial solution 1.

-----------------------------Solution composition------------------------------

      Elements           Molality       Moles

      Ag               1.855e-010  1.855e-010
      Al               2.595e-007  2.595e-007
      Alkalinity       3.279e-003  3.279e-003
      As               4.006e-009  4.006e-009
      B                4.627e-006  4.627e-006
      Ba               5.609e-007  5.609e-007
      Be               1.110e-008  1.110e-008
      Ca               1.722e-003  1.722e-003
      Cd               4.450e-010  4.450e-010
      Cr               1.924e-008  1.924e-008
      Cu               4.723e-009  4.723e-009
      Fe               8.956e-008  8.956e-008
      Hg               1.995e-010  1.995e-010
      K                1.023e-005  1.023e-005
      Li               7.208e-007  7.208e-007
      Mg               1.152e-003  1.152e-003
      Mn               1.821e-008  1.821e-008
      Na               8.703e-005  8.703e-005
      Ni               1.704e-008  1.704e-008
      Pb               4.345e-009  4.345e-009
      S(6)             7.602e-004  7.602e-004
      Sb               4.108e-009  4.108e-009
      Se               1.774e-008  1.774e-008
      Si               1.703e-005  1.703e-005
      Sr               3.791e-006  3.791e-006
      Tl               2.447e-010  2.447e-010
      U                2.312e-008  2.312e-008
      V                9.819e-008  9.819e-008
      Zn               1.530e-007  1.530e-007

----------------------------Description of solution----------------------------

                                       pH  =   8.500
                                       pe  =   4.000
                        Activity of water  =   1.000
                           Ionic strength  =  8.263e-003
                       Mass of water (kg)  =  1.000e+000
                    Total carbon (mol/kg)  =  3.214e-003
                       Total CO2 (mol/kg)  =  3.214e-003
                      Temperature (deg C)  =   5.000
                  Electrical balance (eq)  =  1.057e-003
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  10.71
                               Iterations  =  11
                                  Total H  = 1.110157e+002
                                  Total O  = 5.551898e+001

----------------------------Distribution of species----------------------------

                                                    Log       Log         Log
   Species                   Molality    Activity  Molality  Activity     Gamma

   OH-                     6.907e-007  6.289e-007    -6.161    -6.201    -0.041
   H+                      3.431e-009  3.162e-009    -8.465    -8.500    -0.035
   H2O                     5.551e+001  9.999e-001     1.744    -0.000     0.000
Ag                1.855e-010
```

Ag+		1.841e-010	1.679e-010	-9.735	-9.775	-0.040
AgSO4-		1.299e-012	1.185e-012	-11.886	-11.926	-0.040
AgOH		5.300e-014	5.310e-014	-13.276	-13.275	0.001
AgSeO3-		1.088e-015	9.928e-016	-14.963	-15.003	-0.040
Ag(OH)2-		1.841e-017	1.679e-017	-16.735	-16.775	-0.040
Ag2Se		2.440e-021	2.445e-021	-20.613	-20.612	0.001
Ag(SeO3)2-3		1.334e-022	5.828e-023	-21.875	-22.234	-0.360
AgOH(Se)2-4		0.000e+000	0.000e+000	-89.519	-90.158	-0.639
Al	2.595e-007					
Al(OH)3		2.222e-007	2.226e-007	-6.653	-6.652	0.001
Al(OH)4-		3.673e-008	3.352e-008	-7.435	-7.475	-0.040
Al(OH)2+		6.114e-010	5.593e-010	-9.214	-9.252	-0.039
AlOH+2		7.682e-014	5.377e-014	-13.115	-13.269	-0.155
Al+3		1.469e-016	7.042e-017	-15.833	-16.152	-0.319
AlSO4+		2.698e-017	2.463e-017	-16.569	-16.609	-0.040
Al(SO4)2-		8.544e-019	7.798e-019	-18.068	-18.108	-0.040
As(3)	2.833e-021					
H3AsO3		2.592e-021	2.597e-021	-20.586	-20.585	0.001
H2AsO3-		2.403e-022	2.192e-022	-21.619	-21.659	-0.040
HAsO3-2		3.133e-026	2.169e-026	-25.504	-25.664	-0.160
H4AsO3+		4.461e-030	4.069e-030	-29.351	-29.390	-0.040
AsO3-3		2.903e-031	1.268e-031	-30.537	-30.897	-0.360
As(5)	4.006e-009					
HAsO4-2		3.943e-009	2.729e-009	-8.404	-8.564	-0.160
H2AsO4-		5.951e-011	5.428e-011	-10.225	-10.265	-0.040
AsO4-3		2.954e-012	1.291e-012	-11.530	-11.889	-0.360
H3AsO4		2.442e-017	2.447e-017	-16.612	-16.611	0.001
B	4.627e-006					
H3BO3		4.072e-006	4.079e-006	-5.390	-5.389	0.001
H2BO3-		5.555e-007	5.045e-007	-6.255	-6.297	-0.042
Ba	5.609e-007					
Ba+2		5.609e-007	3.911e-007	-6.251	-6.408	-0.157
BaOH+		9.502e-013	8.684e-013	-12.022	-12.061	-0.039
Be	1.110e-008					
Be+2		1.110e-008	7.683e-009	-7.955	-8.114	-0.160
C(4)	3.214e-003					
HCO3-		3.078e-003	2.816e-003	-2.512	-2.550	-0.039
CO3-2		3.554e-005	2.487e-005	-4.449	-4.604	-0.155
CaCO3		2.928e-005	2.933e-005	-4.533	-4.533	0.001
MgHCO3+		2.205e-005	2.010e-005	-4.657	-4.697	-0.040
CaHCO3+		1.939e-005	1.775e-005	-4.713	-4.751	-0.038
H2CO3		1.564e-005	1.567e-005	-4.806	-4.805	0.001
MgCO3		1.320e-005	1.322e-005	-4.879	-4.879	0.001
NaHCO3		7.478e-008	7.492e-008	-7.126	-7.125	0.001
ZnCO3		6.410e-008	6.422e-008	-7.193	-7.192	0.001
Zn(CO3)2-2		4.935e-008	3.415e-008	-7.307	-7.467	-0.160
UO2(CO3)3-4		2.058e-008	4.723e-009	-7.687	-8.326	-0.639
NiCO3		1.589e-008	1.592e-008	-7.799	-7.798	0.001
NaCO3-		1.354e-008	1.239e-008	-7.868	-7.907	-0.039
PbCO3		3.897e-009	3.905e-009	-8.409	-8.408	0.001
ZnHCO3+		2.803e-009	2.557e-009	-8.552	-8.592	-0.040
UO2(CO3)2-2		2.522e-009	1.746e-009	-8.598	-8.758	-0.160
Ni(CO3)2-2		9.943e-010	6.882e-010	-9.002	-9.162	-0.160
MnHCO3+		4.112e-010	3.758e-010	-9.386	-9.425	-0.039
Pb(CO3)2-2		3.525e-010	2.440e-010	-9.453	-9.613	-0.160
CdCO3		3.461e-010	3.468e-010	-9.461	-9.460	0.001
CuCO3		2.824e-010	2.829e-010	-9.549	-9.548	0.001
NiHCO3+		2.197e-011	2.004e-011	-10.658	-10.698	-0.040
UO2CO3		1.335e-011	1.338e-011	-10.874	-10.874	0.001
Cu(CO3)2-2		1.280e-011	8.859e-012	-10.893	-11.053	-0.160
PbHCO3+		1.235e-011	1.126e-011	-10.908	-10.948	-0.040
CdHCO3+		1.205e-011	1.099e-011	-10.919	-10.959	-0.040
CuHCO3+		1.826e-012	1.666e-012	-11.738	-11.778	-0.040
Cd(CO3)3-4		6.192e-018	1.421e-018	-17.208	-17.847	-0.639
Ca	1.722e-003					
Ca+2		1.591e-003	1.123e-003	-2.798	-2.950	-0.151
CaSO4		8.280e-005	8.296e-005	-4.082	-4.081	0.001

CaCO3		2.928e-005	2.933e-005	-4.533	-4.533	0.001
CaHCO3+		1.939e-005	1.775e-005	-4.713	-4.751	-0.038
CaOH+		1.676e-008	1.535e-008	-7.776	-7.814	-0.038
Cd	4.450e-010					
CdCO3		3.461e-010	3.468e-010	-9.461	-9.460	0.001
Cd+2		8.037e-011	5.563e-011	-10.095	-10.255	-0.160
CdHCO3+		1.205e-011	1.099e-011	-10.919	-10.959	-0.040
CdSO4		6.088e-012	6.100e-012	-11.215	-11.215	0.001
CdOH+		3.272e-013	2.984e-013	-12.485	-12.525	-0.040
Cd(SO4)2-2		4.776e-014	3.306e-014	-13.321	-13.481	-0.160
Cd(OH)2		2.479e-014	2.484e-014	-13.606	-13.605	0.001
Cd(CO3)3-4		6.192e-018	1.421e-018	-17.208	-17.847	-0.639
Cd(OH)3-		9.662e-019	8.813e-019	-18.015	-18.055	-0.040
Cd(SeO3)2-2		2.861e-021	1.980e-021	-20.544	-20.703	-0.160
CdSeO4		3.179e-022	3.185e-022	-21.498	-21.497	0.001
Cd2OH+3		2.430e-022	1.062e-022	-21.614	-21.974	-0.360
Cd(OH)4-2		3.588e-024	2.484e-024	-23.445	-23.605	-0.160
Cr(2)	4.592e-028					
Cr+2		4.592e-028	3.178e-028	-27.338	-27.498	-0.160
Cr(3)	1.924e-008					
Cr(OH)3		1.817e-008	1.821e-008	-7.741	-7.740	0.001
Cr(OH)2+		8.516e-010	7.768e-010	-9.070	-9.110	-0.040
CrO2-		1.530e-010	1.395e-010	-9.815	-9.855	-0.040
Cr(OH)4-		6.028e-011	5.498e-011	-10.220	-10.260	-0.040
Cr(OH)+2		1.480e-012	1.024e-012	-11.830	-11.990	-0.160
CrOHSO4		2.004e-013	2.008e-013	-12.698	-12.697	0.001
Cr+3		8.540e-016	3.731e-016	-15.069	-15.428	-0.360
CrSO4+		1.577e-018	1.439e-018	-17.802	-17.842	-0.040
Cr2(OH)2SO4+2		5.401e-023	3.738e-023	-22.268	-22.427	-0.160
Cr2(OH)2(SO4)2		3.816e-028	3.824e-028	-27.418	-27.418	0.001
Cr(6)	1.776e-019					
CrO4-2		1.763e-019	1.218e-019	-18.754	-18.914	-0.161
HCrO4-		1.222e-021	1.115e-021	-20.913	-20.953	-0.040
NaCrO4-		5.257e-023	4.795e-023	-22.279	-22.319	-0.040
KCrO4-		7.809e-024	7.123e-024	-23.107	-23.147	-0.040
CrO3SO4-2		7.520e-031	5.205e-031	-30.124	-30.284	-0.160
H2CrO4		5.447e-031	5.457e-031	-30.264	-30.263	0.001
Cr2O7-2		1.112e-040	0.000e+000	-39.954	-40.114	-0.160
Cu(1)	1.002e-013					
Cu+		1.002e-013	9.097e-014	-12.999	-13.041	-0.042
Cu(2)	4.723e-009					
Cu(OH)2		4.415e-009	4.423e-009	-8.355	-8.354	0.001
CuCO3		2.824e-010	2.829e-010	-9.549	-9.548	0.001
Cu(CO3)2-2		1.280e-011	8.859e-012	-10.893	-11.053	-0.160
CuOH+		7.345e-012	6.696e-012	-11.134	-11.174	-0.040
Cu+2		3.113e-012	2.118e-012	-11.507	-11.674	-0.167
CuHCO3+		1.826e-012	1.666e-012	-11.738	-11.778	-0.040
CuSO4		1.613e-013	1.616e-013	-12.792	-12.791	0.001
Cu(OH)3-		9.261e-014	8.447e-014	-13.033	-13.073	-0.040
Cu(OH)4-2		7.682e-018	5.317e-018	-17.115	-17.274	-0.160
Cu2(OH)2+2		3.374e-018	2.335e-018	-17.472	-17.632	-0.160
Fe(2)	1.285e-010					
Fe+2		1.221e-010	8.592e-011	-9.913	-10.066	-0.153
FeSO4		4.467e-012	4.475e-012	-11.350	-11.349	0.001
FeOH+		1.895e-012	1.731e-012	-11.722	-11.762	-0.039
Fe(OH)2		7.205e-016	7.219e-016	-15.142	-15.142	0.001
Fe(OH)3-		7.518e-018	6.870e-018	-17.124	-17.163	-0.039
Fe(3)	8.944e-008					
Fe(OH)4-		6.510e-008	5.954e-008	-7.186	-7.225	-0.039
Fe(OH)3		1.880e-008	1.883e-008	-7.726	-7.725	0.001
Fe(OH)2+		5.542e-009	5.069e-009	-8.256	-8.295	-0.039
FeOH+2		1.965e-014	1.371e-014	-13.707	-13.863	-0.157
FeSO4+		5.822e-020	5.320e-020	-19.235	-19.274	-0.039
Fe+3		4.947e-020	2.372e-020	-19.306	-19.625	-0.319
Fe(SO4)2-		7.354e-022	6.707e-022	-21.133	-21.173	-0.040
FeHSeO3+2		1.035e-024	7.165e-025	-23.985	-24.145	-0.160
Fe2(OH)2+4		5.342e-026	1.226e-026	-25.272	-25.912	-0.639

Fe3(OH)4+5		1.175e-031	1.178e-032	-30.930	-31.929	-0.999
H(0)	1.749e-028					
H2		8.747e-029	8.764e-029	-28.058	-28.057	0.001
Hg(0)	1.995e-010					
Hg		1.995e-010	1.999e-010	-9.700	-9.699	0.001
Hg(1)	2.816e-027					
Hg2+2		1.408e-027	9.727e-028	-26.851	-27.012	-0.161
Hg(2)	2.108e-016					
Hg(OH)2		2.108e-016	2.112e-016	-15.676	-15.675	0.001
HgOH+		3.648e-022	3.327e-022	-21.438	-21.478	-0.040
Hg(OH)3-		7.250e-023	6.613e-023	-22.140	-22.180	-0.040
Hg+2		1.460e-026	1.011e-026	-25.836	-25.995	-0.160
HgSO4		2.831e-029	2.837e-029	-28.548	-28.547	0.001
K	1.023e-005					
K+		1.021e-005	9.289e-006	-4.991	-5.032	-0.041
KSO4-		2.128e-008	1.946e-008	-7.672	-7.711	-0.039
KCrO4-		7.809e-024	7.123e-024	-23.107	-23.147	-0.040
Li	7.208e-007					
Li+		7.195e-007	6.590e-007	-6.143	-6.181	-0.038
LiSO4-		1.365e-009	1.247e-009	-8.865	-8.904	-0.039
Mg	1.152e-003					
Mg+2		1.068e-003	7.575e-004	-2.972	-3.121	-0.149
MgSO4		4.918e-005	4.927e-005	-4.308	-4.307	0.001
MgHCO3+		2.205e-005	2.010e-005	-4.657	-4.697	-0.040
MgCO3		1.320e-005	1.322e-005	-4.879	-4.879	0.001
MgOH+		6.705e-008	6.148e-008	-7.174	-7.211	-0.038
Mn(2)	1.821e-008					
Mn+2		1.705e-008	1.200e-008	-7.768	-7.921	-0.153
MnSO4		7.261e-010	7.275e-010	-9.139	-9.138	0.001
MnHCO3+		4.112e-010	3.758e-010	-9.386	-9.425	-0.039
MnOH+		1.860e-011	1.699e-011	-10.731	-10.770	-0.039
Mn(OH)3-		6.579e-018	6.012e-018	-17.182	-17.221	-0.039
MnSeO4		6.779e-020	6.792e-020	-19.169	-19.168	0.001
MnSe		0.000e+000	0.000e+000	-49.795	-49.794	0.001
Mn(3)	1.775e-028					
Mn+3		1.775e-028	8.509e-029	-27.751	-28.070	-0.319
Mn(6)	0.000e+000					
MnO4-2		0.000e+000	0.000e+000	-50.111	-50.268	-0.157
Mn(7)	0.000e+000					
MnO4-		0.000e+000	0.000e+000	-57.012	-57.054	-0.041
Na	8.703e-005					
Na+		8.678e-005	7.922e-005	-4.062	-4.101	-0.040
NaSO4-		1.643e-007	1.502e-007	-6.784	-6.823	-0.039
NaHCO3		7.478e-008	7.492e-008	-7.126	-7.125	0.001
NaCO3-		1.354e-008	1.239e-008	-7.868	-7.907	-0.039
NaCrO4-		5.257e-023	4.795e-023	-22.279	-22.319	-0.040
Ni	1.704e-008					
NiCO3		1.589e-008	1.592e-008	-7.799	-7.798	0.001
Ni(CO3)2-2		9.943e-010	6.882e-010	-9.002	-9.162	-0.160
Ni+2		1.247e-010	8.634e-011	-9.904	-10.064	-0.160
NiHCO3+		2.197e-011	2.004e-011	-10.658	-10.698	-0.040
NiSO4		6.057e-012	6.068e-012	-11.218	-11.217	0.001
NiOH+		9.152e-013	8.348e-013	-12.038	-12.078	-0.040
Ni(OH)2		8.615e-013	8.632e-013	-12.065	-12.064	0.001
Ni(OH)3-		2.992e-015	2.729e-015	-14.524	-14.564	-0.040
Ni(SO4)2-2		2.455e-016	1.699e-016	-15.610	-15.770	-0.160
NiSeO4		8.053e-022	8.068e-022	-21.094	-21.093	0.001
O(0)	0.000e+000					
O2		0.000e+000	0.000e+000	-43.185	-43.184	0.001
Pb	4.345e-009					
PbCO3		3.897e-009	3.905e-009	-8.409	-8.408	0.001
Pb(CO3)2-2		3.525e-010	2.440e-010	-9.453	-9.613	-0.160
PbOH+		6.106e-011	5.569e-011	-10.214	-10.254	-0.040
Pb+2		1.305e-011	9.033e-012	-10.884	-11.044	-0.160
PbHCO3+		1.235e-011	1.126e-011	-10.908	-10.948	-0.040
Pb(OH)2		6.838e-012	6.851e-012	-11.165	-11.164	0.001
PbSO4		2.198e-012	2.202e-012	-11.658	-11.657	0.001

	Pb(OH)3-	2.727e-014	2.487e-014	-13.564	-13.604	-0.040
	Pb(SO4)2-2	7.238e-015	5.010e-015	-14.140	-14.300	-0.160
	Pb(OH)4-2	2.609e-017	1.806e-017	-16.584	-16.743	-0.160
	Pb2OH+3	2.578e-020	1.126e-020	-19.589	-19.948	-0.360
	Pb3(OH)4+2	5.630e-025	3.896e-025	-24.250	-24.409	-0.160
S(6)	7.602e-004					
	SO4-2	6.280e-004	4.335e-004	-3.202	-3.363	-0.161
	CaSO4	8.280e-005	8.296e-005	-4.082	-4.081	0.001
	MgSO4	4.918e-005	4.927e-005	-4.308	-4.307	0.001
	NaSO4-	1.643e-007	1.502e-007	-6.784	-6.823	-0.039
	KSO4-	2.128e-008	1.946e-008	-7.672	-7.711	-0.039
	LiSO4-	1.365e-009	1.247e-009	-8.865	-8.904	-0.039
	ZnSO4	1.113e-009	1.115e-009	-8.954	-8.953	0.001
	MnSO4	7.261e-010	7.275e-010	-9.139	-9.138	0.001
	HSO4-	8.534e-011	7.789e-011	-10.069	-10.109	-0.040
	Zn(SO4)2-2	6.694e-012	4.633e-012	-11.174	-11.334	-0.160
	CdSO4	6.088e-012	6.100e-012	-11.215	-11.215	0.001
	NiSO4	6.057e-012	6.068e-012	-11.218	-11.217	0.001
	FeSO4	4.467e-012	4.475e-012	-11.350	-11.349	0.001
	TlSO4-	2.618e-012	2.388e-012	-11.582	-11.622	-0.040
	PbSO4	2.198e-012	2.202e-012	-11.658	-11.657	0.001
	AgSO4-	1.299e-012	1.185e-012	-11.886	-11.926	-0.040
	CrOHSO4	2.004e-013	2.008e-013	-12.698	-12.697	0.001
	CuSO4	1.613e-013	1.616e-013	-12.792	-12.791	0.001
	Cd(SO4)2-2	4.776e-014	3.306e-014	-13.321	-13.481	-0.160
	Pb(SO4)2-2	7.238e-015	5.010e-015	-14.140	-14.300	-0.160
	Ni(SO4)2-2	2.455e-016	1.699e-016	-15.610	-15.770	-0.160
	AlSO4+	2.698e-017	2.463e-017	-16.569	-16.609	-0.040
	UO2SO4	5.206e-018	5.216e-018	-17.283	-17.283	0.001
	CrSO4+	1.577e-018	1.439e-018	-17.802	-17.842	-0.040
	Al(SO4)2-	8.544e-019	7.798e-019	-18.068	-18.108	-0.040
	VO2SO4-	1.865e-019	1.701e-019	-18.729	-18.769	-0.040
	UO2(SO4)2-2	8.619e-020	5.965e-020	-19.065	-19.224	-0.160
	FeSO4+	5.822e-020	5.320e-020	-19.235	-19.274	-0.039
	VOSO4	1.775e-021	1.778e-021	-20.751	-20.750	0.001
	Fe(SO4)2-	7.354e-022	6.707e-022	-21.133	-21.173	-0.040
	Cr2(OH)2SO4+2	5.401e-023	3.738e-023	-22.268	-22.427	-0.160
	Cr2(OH)2(SO4)2	3.816e-028	3.824e-028	-27.418	-27.418	0.001
	HgSO4	2.831e-029	2.837e-029	-28.548	-28.547	0.001
	CrO3SO4-2	7.520e-031	5.205e-031	-30.124	-30.284	-0.160
	VSO4+	8.747e-037	7.978e-037	-36.058	-36.098	-0.040
	U(SO4)2	0.000e+000	0.000e+000	-44.708	-44.707	0.001
	USO4+2	0.000e+000	0.000e+000	-45.266	-45.426	-0.160
Sb(3)	1.650e-019					
	Sb(OH)3	8.310e-020	8.325e-020	-19.080	-19.080	0.001
	HSbO2	8.187e-020	8.202e-020	-19.087	-19.086	0.001
	SbO2-	5.959e-024	5.436e-024	-23.225	-23.265	-0.040
	Sb(OH)4-	3.448e-024	3.145e-024	-23.462	-23.502	-0.040
	Sb(OH)2+	7.010e-027	6.394e-027	-26.154	-26.194	-0.040
	SbO+	1.903e-027	1.736e-027	-26.721	-26.761	-0.040
Sb(5)	4.108e-009					
	SbO3-	4.104e-009	3.743e-009	-8.387	-8.427	-0.040
	Sb(OH)6-	4.799e-012	4.377e-012	-11.319	-11.359	-0.040
	SbO2+	1.177e-026	1.074e-026	-25.929	-25.969	-0.040
Se(-2)	2.440e-021					
	Ag2Se	2.440e-021	2.445e-021	-20.613	-20.612	0.001
	HSe-	0.000e+000	0.000e+000	-43.590	-43.630	-0.040
	H2Se	0.000e+000	0.000e+000	-48.361	-48.360	0.001
	MnSe	0.000e+000	0.000e+000	-49.795	-49.794	0.001
	Se-2	0.000e+000	0.000e+000	-50.529	-50.689	-0.160
	AgOH(Se)2-4	0.000e+000	0.000e+000	-89.519	-90.158	-0.639
Se(4)	9.606e-009					
	SeO3-2	9.606e-009	6.649e-009	-8.017	-8.177	-0.160
Se(6)	8.131e-009					
	HSeO3-	8.131e-009	7.416e-009	-8.090	-8.130	-0.040
	SeO4-2	4.753e-014	3.283e-014	-13.323	-13.484	-0.161
	H2SeO3	8.517e-015	8.533e-015	-14.070	-14.069	0.001

AgSeO3-		1.088e-015	9.928e-016	-14.963	-15.003	-0.040
MnSeO4		6.779e-020	6.792e-020	-19.169	-19.168	0.001
ZnSeO4		6.750e-020	6.763e-020	-19.171	-19.170	0.001
HSeO4-		5.505e-021	5.021e-021	-20.259	-20.299	-0.040
Cd(SeO3)2-2		2.861e-021	1.980e-021	-20.544	-20.703	-0.160
NiSeO4		8.053e-022	8.068e-022	-21.094	-21.093	0.001
CdSeO4		3.179e-022	3.185e-022	-21.498	-21.497	0.001
Ag(SeO3)2-3		1.334e-022	5.828e-023	-21.875	-22.234	-0.360
FeHSeO3+2		1.035e-024	7.165e-025	-23.985	-24.145	-0.160
Zn(SeO4)2-2		1.714e-035	1.186e-035	-34.766	-34.926	-0.160
Si	1.703e-005					
H4SiO4		1.681e-005	1.684e-005	-4.775	-4.774	0.001
H3SiO4-		2.203e-007	2.008e-007	-6.657	-6.697	-0.040
H2SiO4-2		1.267e-011	8.869e-012	-10.897	-11.052	-0.155
UO2H3SiO4+		1.015e-015	9.257e-016	-14.994	-15.034	-0.040
Sr	3.791e-006					
Sr+2		3.790e-006	2.643e-006	-5.421	-5.578	-0.157
SrOH+		1.045e-011	9.553e-012	-10.981	-11.020	-0.039
Tl(1)	2.447e-010					
Tl+		2.421e-010	2.208e-010	-9.616	-9.656	-0.040
TlSO4-		2.618e-012	2.388e-012	-11.582	-11.622	-0.040
TlOH		8.651e-016	8.668e-016	-15.063	-15.062	0.001
Tl(3)	6.818e-025					
Tl(OH)3		6.688e-025	6.701e-025	-24.175	-24.174	0.001
Tl(OH)4-		1.293e-026	1.179e-026	-25.888	-25.928	-0.040
Tl(OH)2+		3.051e-031	2.783e-031	-30.516	-30.556	-0.040
TlOH+2		3.656e-038	2.531e-038	-37.437	-37.597	-0.160
Tl+3		0.000e+000	0.000e+000	-44.572	-44.931	-0.360
U(3)	0.000e+000					
U+3		0.000e+000	0.000e+000	-61.052	-61.411	-0.360
U(4)	4.338e-020					
U(OH)5-		4.338e-020	3.956e-020	-19.363	-19.403	-0.040
U(OH)4		7.360e-024	7.374e-024	-23.133	-23.132	0.001
U(OH)3+		1.208e-028	1.102e-028	-27.918	-27.958	-0.040
U(OH)2+2		4.228e-034	2.926e-034	-33.374	-33.534	-0.160
UOH+3		1.985e-040	0.000e+000	-39.702	-40.062	-0.360
U(SO4)2		0.000e+000	0.000e+000	-44.708	-44.707	0.001
USO4+2		0.000e+000	0.000e+000	-45.266	-45.426	-0.160
U+4		0.000e+000	0.000e+000	-46.690	-47.329	-0.639
U6(OH)15+9		0.000e+000	0.000e+000	-170.468	-173.705	-3.236
U(5)	4.356e-018					
UO2+		4.356e-018	3.973e-018	-17.361	-17.401	-0.040
U(6)	2.312e-008					
UO2(CO3)3-4		2.058e-008	4.723e-009	-7.687	-8.326	-0.639
UO2(CO3)2-2		2.522e-009	1.746e-009	-8.598	-8.758	-0.160
UO2CO3		1.335e-011	1.338e-011	-10.874	-10.874	0.001
UO2OH+		3.562e-014	3.249e-014	-13.448	-13.488	-0.040
UO2H3SiO4+		1.015e-015	9.257e-016	-14.994	-15.034	-0.040
UO2+2		6.309e-017	4.367e-017	-16.200	-16.360	-0.160
UO2SO4		5.206e-018	5.216e-018	-17.283	-17.283	0.001
UO2(SO4)2-2		8.619e-020	5.965e-020	-19.065	-19.224	-0.160
(UO2)2(OH)2+2		1.803e-022	1.248e-022	-21.744	-21.904	-0.160
(UO2)3(OH)5+		3.513e-024	3.204e-024	-23.454	-23.494	-0.040
V(2)	1.061e-040					
VOH+		1.061e-040	0.000e+000	-39.974	-40.014	-0.040
V+2		0.000e+000	0.000e+000	-42.714	-42.874	-0.160
V(3)	2.014e-020					
V(OH)3		2.013e-020	2.017e-020	-19.696	-19.695	0.001
V(OH)2+		1.083e-023	9.881e-024	-22.965	-23.005	-0.040
VOH+2		4.919e-029	3.405e-029	-28.308	-28.468	-0.160
V+3		1.529e-034	6.682e-035	-33.816	-34.175	-0.360
VSO4+		8.747e-037	7.978e-037	-36.058	-36.098	-0.040
V2(OH)3+3		0.000e+000	0.000e+000	-49.991	-50.350	-0.360
V2(OH)2+4		0.000e+000	0.000e+000	-54.461	-55.100	-0.639
V(4)	1.697e-017					
V(OH)3+		1.694e-017	1.545e-017	-16.771	-16.811	-0.040
VO+2		3.303e-020	2.286e-020	-19.481	-19.641	-0.160

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   VOSO4                1.775e-021  1.778e-021   -20.751   -20.750     0.001
   H2V2O4+2             2.740e-029  1.897e-029   -28.562   -28.722    -0.160
V(5)            9.819e-008
   HVO4-2               4.041e-008  2.797e-008    -7.393    -7.553    -0.160
   HV2O7-3              2.027e-008  8.856e-009    -7.693    -8.053    -0.360
   H2VO4-               1.723e-008  1.572e-008    -7.764    -7.804    -0.040
   V2O7-4               2.121e-012  4.867e-013   -11.674   -12.313    -0.639
   VO4-3                6.514e-013  2.846e-013   -12.186   -12.546    -0.360
   H3VO4                3.331e-013  3.337e-013   -12.477   -12.477     0.001
   H3V2O7-              3.290e-013  3.001e-013   -12.483   -12.523    -0.040
   V3O9-3               1.351e-016  5.901e-017   -15.869   -16.229    -0.360
   VO2+                 8.388e-018  7.651e-018   -17.076   -17.116    -0.040
   VO2SO4-              1.865e-019  1.701e-019   -18.729   -18.769    -0.040
   V4O12-4              2.420e-021  5.554e-022   -20.616   -21.255    -0.639
   V10O28-6             0.000e+000  0.000e+000   -51.255   -52.693    -1.438
   HV10O28-5            0.000e+000  0.000e+000   -55.149   -56.148    -0.999
   H2V10O28-4           0.000e+000  0.000e+000   -59.234   -59.873    -0.639
Zn              1.530e-007
   ZnCO3                6.410e-008  6.422e-008    -7.193    -7.192     0.001
   Zn(CO3)2-2           4.935e-008  3.415e-008    -7.307    -7.467    -0.160
   Zn+2                 1.839e-008  1.294e-008    -7.735    -7.888    -0.153
   Zn(OH)2              1.629e-008  1.632e-008    -7.788    -7.787     0.001
   ZnHCO3+              2.803e-009  2.557e-009    -8.552    -8.592    -0.040
   ZnSO4                1.113e-009  1.115e-009    -8.954    -8.953     0.001
   ZnOH+                9.675e-010  8.824e-010    -9.014    -9.054    -0.040
   Zn(OH)3-             1.789e-011  1.632e-011   -10.747   -10.787    -0.040
   Zn(SO4)2-2           6.694e-012  4.633e-012   -11.174   -11.334    -0.160
   Zn(OH)4-2            1.182e-015  8.179e-016   -14.927   -15.087    -0.160
   ZnSeO4               6.750e-020  6.763e-020   -19.171   -19.170     0.001
   Zn(SeO4)2-2          1.714e-035  1.186e-035   -34.766   -34.926    -0.160

------------------------------Saturation indices-------------------------------

      Phase               SI log IAP  log KT

      Ag2CO3          -12.58  -24.15  -11.57  Ag2CO3
      Ag2CrO4         -26.17  -38.46  -12.29  Ag2CrO4
      Ag2HVO4         -12.65  -11.17    1.48  Ag2HVO4
      Ag2O            -15.68   -2.55   13.13  Ag2O
      Ag2Se            -7.61  -54.68  -47.07  Ag2Se
      Ag2SeO3         -11.61  -19.18   -7.57  Ag2SeO3
      Ag2SeO4         -23.58  -33.03   -9.45  Ag2SeO4
      Ag2SO4          -17.77  -22.91   -5.14  Ag2SO4
      Ag3H2VO5        -17.62  -12.44    5.18  Ag3H2VO5
      Ag3Sb           -41.72  -97.90  -56.18  Ag3Sb
      Ag_Vanadate     -10.66   -9.89    0.77  AgVO3
      AgMetal           1.07  -13.77  -14.84  Ag
      Akerminite      -19.07   32.43   51.50  Ca2MgSi2O7
      Al(OH)3(a)       -2.46    9.35   11.81  Al(OH)3
      Al2O3            -4.28   18.70   22.98  Al2O3
      Al4(OH)10SO4     -5.67   17.03   22.70  Al4(OH)10SO4
      AlAsO4:2H2O     -12.06   -7.26    4.80  AlAsO4:2H2O
      Albite           -5.13   -0.57    4.56  NaAlSi3O8
      Albite(low)      -4.08   -0.57    3.51  NaAlSi3O8
      AlOHSO4          -7.79  -11.02   -3.23  AlOHSO4
      AlSb           -150.36  -84.73   65.62  AlSb
      AlumK           -22.36  -27.91   -5.55  KAl(SO4)2:12H2O
      Alunite          -7.66   -9.22   -1.55  KAl3(SO4)2(OH)6
      Analcime         -3.72    4.20    7.92  NaAlSi2O6:H2O
      Anglesite        -6.50  -14.41   -7.90  PbSO4
      Anhydrite        -1.87   -6.31   -4.44  CaSO4
      Annite           -7.46   19.30   26.75  KFe3AlSi3O10(OH)2
      Anorthite        -5.96   23.20   29.15  CaAl2Si2O8
      Antlerite       -12.68   -4.39    8.29  Cu3(OH)4SO4
      Aragonite         0.68   -7.55   -8.24  CaCO3
      Arsenolite      -78.79  -82.34   -3.56  As4O6
      Artinite         -4.96    6.15   11.11  MgCO3:Mg(OH)2:3H2O
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As2O5	-40.21	-33.22	6.98	As2O5
Avicennite	-32.02	-48.35	-16.32	Tl2O3
Azurite	-11.56	-27.23	-15.67	Cu3(OH)2(CO3)2
B_UO2(OH)2	-5.63	0.64	6.27	UO2(OH)2
Ba3(AsO4)2	7.60	-1.45	-9.05	Ba3(AsO4)2
BaCrO4	-15.32	-25.32	-10.00	BaCrO4
Barite	0.54	-9.77	-10.31	BaSO4
BaSeO3	-10.53	-6.04	4.49	BaSeO3
BaSeO4	-14.60	-19.89	-5.29	BaSeO4
Bianchite	-9.49	-11.25	-1.76	ZnSO4:6H2O
Birnessite	-8.16	9.93	18.09	MnO2
Bixbyite	-5.33	-5.14	0.19	Mn2O3
Boehmite	-0.71	9.35	10.06	AlOOH
Brochantite	-14.40	0.94	15.34	Cu4(OH)6SO4
Brucite	-4.27	13.88	18.15	Mg(OH)2
Bunsenite	-6.77	6.94	13.71	NiO
Ca-Nontronite	20.52	-0.37	-20.89	Fe2Al.33Si3.67O10(OH)2Ca0.165
Ca-Olivine	-17.20	23.33	40.53	Ca2SiO4
Ca2V2O7	-4.32	5.43	9.75	CaVO3.5
Ca3(AsO4)2:6H2O	-13.37	8.93	22.30	Ca3(AsO4)2:6H2O
Ca3(VO4)2	-8.87	12.46	21.33	Ca1.5VO4
Ca3Sb2	-298.21	-146.01	152.20	Ca3Sb2
Ca3SiO5	-42.09	37.38	79.47	Ca3SiO5
Ca_Vanadate	-4.96	-1.59	3.36	Ca0.5VO3
CaCrO4	-19.94	-21.86	-1.93	CaCrO4
Calcite	0.84	-7.55	-8.40	CaCO3
Carnotite	-5.20	-4.51	0.69	KUO2VO4
CaSeO3:2H2O	-5.64	-2.58	3.06	CaSeO3:2H2O
CaSeO4:2H2O	-13.44	-16.43	-2.99	CaSeO4:2H2O
Cd(BO2)2	-13.87	-4.03	9.84	Cd(BO2)2
Cd(Gamma)	-32.80	-18.25	14.55	Cd
Cd(OH)2(A)	-8.08	6.75	14.82	Cd(OH)2
Cd(OH)2(C)	-6.90	6.75	13.65	Cd(OH)2
Cd3(OH)2(SO4)2	-27.20	-20.49	6.71	Cd3(OH)2(SO4)2
Cd3(OH)4SO4	-22.69	-0.13	22.56	Cd3(OH)4SO4
Cd4(OH)6SO4	-21.78	6.62	28.40	Cd4(OH)6SO4
CdMetal	-32.69	-18.25	14.44	Cd
CdSb	-74.16	-74.83	-0.68	CdSb
CdSe	-26.35	-45.38	-19.03	CdSe
CdSiO3	-7.96	1.97	9.94	CdSiO3
CdSO4	-14.29	-13.62	0.68	CdSO4
CdSO4:2.67H2O	-11.97	-13.62	-1.65	CdSO4:2.67H2O
CdSO4:H2O	-12.36	-13.62	-1.26	CdSO4:H2O
Celestite	-2.50	-8.94	-6.44	SrSO4
Cerrusite	-2.26	-15.65	-13.39	PbCO3
CH4(g)	-78.29	-121.60	-43.31	CH4
Chalcanthite	-12.32	-15.04	-2.72	CuSO4:5H2O
Chalcedony	-1.01	-4.77	-3.77	SiO2
Chrysotile	-2.86	32.09	34.95	Mg3Si2O5(OH)4
Claudetite	-78.58	-82.34	-3.77	As4O6
Clausthalite	-23.48	-46.17	-22.69	PbSe
Clinoenstatite	-3.29	9.11	12.39	MgSiO3
CO2(g)	-3.42	-21.60	-18.19	CO2
Cr(OH)2	-21.77	-10.50	11.27	Cr(OH)2
Cr(OH)3(A)	0.14	-0.61	-0.75	Cr(OH)3
Cr(OH)3(C)	-2.69	-0.61	2.08	Cr(OH)3
Cr2O3	1.54	-1.22	-2.75	Cr2O3
Cristobalite	-0.90	-4.77	-3.88	SiO2
CrMetal	-69.55	-35.50	34.05	Cr
CrO3	-32.77	-35.91	-3.14	CrO3
Cu(OH)2	-4.12	5.33	9.44	Cu(OH)2
Cu(SbO3)2	-28.04	17.17	45.21	Cu(SbO3)2
Cu2Sb	-55.47	-93.29	-37.82	Cu2Sb
Cu2Se(alpha)	-22.42	-61.21	-38.79	Cu2Se
Cu2SO4	-27.74	-29.45	-1.71	Cu2SO4
Cu3(AsO4)2:6H2O	-23.35	-17.25	6.10	Cu3(AsO4)2:6H2O
Cu3Sb	-61.23	-107.70	-46.48	Cu3Sb

Cu3Se2	-40.24	-108.02	-67.78	Cu3Se2
CuCO3	-6.65	-16.28	-9.63	CuCO3
CuCrO4	-25.11	-30.59	-5.48	CuCrO4
CuMetal	-7.38	-17.04	-9.66	Cu
CuOCuSO4	-23.12	-9.71	13.40	CuO:CuSO4
CupricFerrite	9.16	17.08	7.92	CuFe2O4
Cuprite	-7.20	-9.08	-1.88	Cu2O
CuprousFerrite	10.05	1.33	-8.72	CuFeO2
CuSe	-18.77	-46.80	-28.04	CuSe
CuSe2	-38.80	-73.93	-35.14	CuSe2
CuSeO3:2H2O	-12.25	-11.30	0.95	CuSeO3:2H2O
CuSO4	-19.00	-15.04	3.97	CuSO4
Diaspore	1.18	9.35	8.17	AlOOH
Diopside	-3.20	18.38	21.59	CaMgSi2O6
Dioptase	-6.42	0.55	6.97	CuSiO3:H2O
Dolomite	1.28	-15.28	-16.56	CaMg(CO3)2
Epsomite	-4.20	-6.48	-2.29	MgSO4:7H2O
Fe2(OH)4SeO3	-6.43	-4.88	1.55	Fe2(OH)4SeO3
Fe2(SeO3)3:2H2O	-17.51	-38.14	-20.63	Fe2(SeO3)3:2H2O
Fe2(SO4)3	-56.03	-49.34	6.70	Fe2(SO4)3
Fe3(OH)8	-1.54	18.68	20.22	Fe3(OH)8
Fe_Vanadate	-3.68	-5.15	-1.47	Fe0.5VO3
FeAsO4:2H2O	-11.14	-10.74	0.40	FeAsO4:2H2O
FeCr2O4	5.31	5.71	0.41	FeCr2O4
Ferrihydrite	0.98	5.87	4.89	Fe(OH)3
Ferroselite	-53.13	-72.33	-19.19	FeSe2
FeSe	-38.02	-45.20	-7.17	FeSe
Forsterite	-7.87	22.99	30.85	Mg2SiO4
Gehlenite	-20.92	42.02	62.94	Ca2Al2SiO7
Gibbsite(C)	-0.62	9.35	9.97	Al(OH)3
Goethite	4.61	5.87	1.26	FeOOH
Goslarite	-9.12	-11.25	-2.13	ZnSO4:7H2O
Greenalite	-9.56	11.25	20.81	Fe3Si2O5(OH)4
Gummite	-10.98	0.64	11.62	UO3
Gypsum	-1.69	-6.31	-4.62	CaSO4:2H2O
Halloysite	-1.94	9.15	11.09	Al2Si2O5(OH)4
Hausmannite	-13.53	52.24	65.76	Mn3O4
Hematite	14.13	11.75	-2.38	Fe2O3
Hercynite	-5.66	25.63	31.29	FeAl2O4
Hg(CH3)2(g)	-179.08	-258.88	-79.81	Hg(CH3)2
Hg(g)	-9.36	-17.51	-8.15	Hg
Hg(OH)2	-12.18	-15.68	-3.50	Hg(OH)2
Hg2(g)	-19.32	-35.01	-15.69	Hg2
Hg2(OH)2	-15.27	-10.01	5.26	Hg2(OH)2
Hg2CO3	-17.66	-31.62	-13.96	Hg2CO3
Hg2CrO4	-37.22	-45.93	-8.70	Hg2CrO4
Hg2SeO3	-21.98	-26.64	-4.66	Hg2SeO3
Hg2SO4	-24.20	-30.38	-6.17	Hg2SO4
HgCO3	-7.43	-37.28	-29.85	HgCO3
HgMetal	-3.00	-17.51	-14.51	Hg
HgSeO3	-19.61	-32.31	-12.70	HgSeO3
HgSO4	-26.43	-36.04	-9.60	HgSO4
Huntite	-2.12	-30.73	-28.61	CaMg3(CO3)4
Hydcerrusite	-7.88	-25.34	-17.46	Pb(OH)2:2PbCO3
Hydromagnesite	-11.01	-17.02	-6.01	Mg5(CO3)4(OH)2:4H2O
Jarosite-H	-13.91	-23.10	-9.19	(H3O)Fe3(SO4)2(OH)6
Jarosite-K	-6.48	-19.63	-13.15	KFe3(SO4)2(OH)6
Jarosite-Na	-9.41	-18.70	-9.29	NaFe3(SO4)2(OH)6
K-Nontronite	14.01	-1.54	-15.55	Fe2Al.33Si3.67O10(OH)2K0.33
K2Cr2O7	-48.27	-64.89	-16.63	K2Cr2O7
K2CrO4	-28.76	-28.98	-0.22	K2CrO4
Kalsilite	-6.32	8.04	14.36	KAlSiO4
Kaolinite	1.56	9.15	7.59	Al2Si2O5(OH)4
Langite	-17.94	0.94	18.88	Cu4(OH)6SO4:H2O
Larnakite	-8.51	-8.45	0.06	PbO:PbSO4
Larnite	-18.83	23.33	42.16	Ca2SiO4
Laumontite	-3.47	13.65	17.12	CaAl2Si4O12:4H2O

Leonhardite	6.31	27.30	20.99	Ca2Al4Si8O24:7H2O
Lepidocrocite	4.50	5.87	1.37	FeOOH
Leucite	-4.32	3.27	7.59	KAlSi2O6
Li2CrO4	-36.70	-31.28	5.43	Li2CrO4
Lime	-21.19	14.05	35.24	CaO
Litharge	-7.63	5.96	13.58	PbO
Magadiite	-14.72	-29.02	-14.30	NaSi7O13(OH)3:3H2O
Maghemite	5.36	11.75	6.39	Fe2O3
Magnesite	-0.02	-7.72	-7.70	MgCO3
Magnetite	12.29	18.68	6.40	Fe3O4
Malachite	-6.60	-10.95	-4.36	Cu2(OH)2CO3
Manganite	-2.33	-2.57	-0.24	MnOOH
Massicot	-7.84	5.96	13.79	PbO
Melanterite	-10.81	-13.43	-2.62	FeSO4:7H2O
Merwinite	-27.71	46.48	74.19	Ca3MgSi2O8
Mg-Ferrite	5.35	25.63	20.28	MgFe2O4
Mg-Nontronite	20.19	-0.39	-20.59	Fe2Al.33Si3.67O10(OH)2Mg0.165
Mg2Sb3	-266.66	-191.98	74.68	Mg2Sb3
Mg2V2O7	-9.52	5.26	14.79	MgVO3.5
Mg_Vanadate	-8.18	-1.68	6.50	Mg0.5VO3
MgCr2O4	-1.52	12.66	14.18	MgCr2O4
MgCrO4	-28.54	-22.03	6.50	MgCrO4
MgSeO3:6H2O	-6.72	-2.75	3.97	MgSeO3:6H2O
Microcline	-2.77	-1.51	1.26	KAlSi3O8
Minium	-36.24	42.87	79.11	Pb3O4
Mirabilite	-9.45	-11.57	-2.11	Na2SO4:10H2O
Mn2(SO4)3	-62.58	-66.23	-3.65	Mn2(SO4)3
Mn2Sb	-149.50	-88.42	61.08	Mn2Sb
Mn3(AsO4)2:8H2O	-18.49	-5.99	12.50	Mn3(AsO4)2:8H2O
Mn_Vanadate	-7.11	-4.08	3.03	Mn0.5VO3
MnSb	-93.47	-96.65	-3.18	MnSb
MnSe	-49.11	-43.05	6.06	MnSe
MnSeO3	-8.76	-7.55	1.21	MnSeO3
MnSeO3:2H2O	-8.43	-7.55	0.88	MnSeO3:2H2O
MnSO4	-14.77	-11.28	3.48	MnSO4
Monteponite	-9.68	6.75	16.42	CdO
Monticellite	-9.72	23.16	32.88	CaMgSiO4
Montmorillonite	3.15	5.82	2.67	Mg0.485Fe.22Al1.71Si3.81O10(OH)2
Montroydite	-11.76	-15.68	-3.92	HgO
Morenosite	-10.91	-13.43	-2.51	NiSO4:7H2O
Muscovite	1.07	17.19	16.12	KAl3Si3O10(OH)2
Na-Nontronite	13.27	-1.23	-14.50	Fe2Al.33Si3.67O10(OH)2Na0.33
Na2Cr2O7	-52.86	-63.03	-10.17	Na2Cr2O7
Na2CrO4	-30.62	-27.12	3.50	Na2CrO4
Na3Sb	-180.73	-80.88	99.85	Na3Sb
Na3VO4	-34.70	4.58	39.28	Na3VO4
Na4V2O7	-19.79	0.18	19.97	Na2VO3.5
Na_Vanadate	-8.30	-4.22	4.08	NaVO3
NaSb	-89.04	-64.68	24.36	NaSb
Natron	-10.67	-12.81	-2.14	Na2CO3:10H2O
Nepheline	-7.00	8.97	15.97	NaAlSiO4
Nesquehonite	-2.41	-7.73	-5.32	MgCO3:3H2O
Ni(OH)2	-2.26	6.94	9.20	Ni(OH)2
Ni2SiO4	-7.20	9.10	16.30	Ni2SiO4
Ni3(AsO4)2:8H2O	-28.11	-12.41	15.70	Ni3(AsO4)2:8H2O
Ni4(OH)6SO4	-24.62	7.38	32.00	Ni4(OH)6SO4
NiCO3	-8.35	-14.67	-6.32	NiCO3
NiSb	-54.91	-74.64	-19.73	NiSb
NiSe	-27.46	-45.19	-17.74	NiSe
NiSeO3:2H2O	-12.90	-9.69	3.21	NiSeO3:2H2O
Nsutite	-7.57	9.93	17.50	MnO2
O2(g)	-40.17	50.00	90.17	O2
Otavite	-1.15	-14.86	-13.71	CdCO3
P-Wollstanite	-5.68	9.28	14.96	CaSiO3
Pb(BO2)2	-12.74	-4.82	7.92	Pb(BO2)2
Pb(OH)2(C)	-2.93	5.96	8.89	Pb(OH)2
Pb2O(OH)2	-14.29	11.91	26.20	Pb2O(OH)2

Pb2O3	-24.13	36.91	61.04	Pb2O3
Pb2OCO3	-9.80	-9.69	0.10	Pb2OCO3
Pb2SiO4	-13.99	7.14	21.13	Pb2SiO4
Pb2V2O7	-1.88	-2.66	-0.78	PbVO3.5
Pb3(AsO4)2	-21.16	-15.36	5.80	Pb3(AsO4)2
Pb3(VO4)2	-3.21	0.32	3.53	Pb1.5VO4
Pb3O2CO3	-16.15	-3.74	12.41	Pb3O2CO3
Pb3O2SO4	-13.99	-2.50	11.49	Pb3O2SO4
Pb4(OH)6SO4	-17.64	3.46	21.10	Pb4(OH)6SO4
Pb4O3SO4	-20.49	3.46	23.95	Pb4O3SO4
PbCrO4	-15.73	-29.96	-14.22	PbCrO4
PbMetal	-23.29	-19.04	4.25	Pb
PbO:0.3H2O	-7.02	5.96	12.98	PbO:0.33H2O
PbSeO4	-17.49	-24.53	-7.04	PbSeO4
PbSiO3	-6.63	1.18	7.81	PbSiO3
Periclase	-9.54	13.88	23.41	MgO
Phlogopite	-30.72	40.13	70.85	KMg3AlSi3O10(OH)2
Plattnerite	-22.07	30.96	53.03	PbO2
Portlandite	-10.24	14.05	24.29	Ca(OH)2
Pyrocroite	-7.20	9.08	16.28	Mn(OH)2
Pyrolusite	-7.47	9.93	17.40	MnO2
Pyrophyllite	1.20	-0.40	-1.60	Al2Si4O10(OH)2
Quartz	-0.44	-4.77	-4.33	SiO2
Retgersite	-11.33	-13.43	-2.10	NiSO4:6H2O
Rhodochrosite	-2.22	-12.53	-10.30	MnCO3
Rutherfordine	-6.51	-20.96	-14.45	UO2CO3
Sanidine(H)	-3.32	-1.51	1.81	KAlSi3O8
Sb	-43.82	-56.58	-12.76	Sb
Sb(OH)3(s)	-11.59	-19.08	-7.49	Sb(OH)3
Sb2O3	-29.44	-38.16	-8.72	Sb2O3
Sb2O4	-17.48	-13.16	4.32	Sb2O4
Sb2O5	-27.23	-39.72	-12.48	Sb2O5
Sb2Se3	-122.47	-194.55	-72.08	Sb2Se3
Sb4O6I	-58.81	-76.32	-17.51	Sb4O6
Sb4O6II	-55.89	-76.32	-20.43	Sb4O6
SbO2	-4.53	-32.36	-27.82	SbO2
Schoepite	-5.40	0.64	6.04	UO2(OH)2:H2O
Se(A)	-19.88	-27.13	-7.25	Se
Se(hex)	-19.23	-27.13	-7.90	Se
SeO2	-16.74	-16.63	0.11	SeO2
SeO3	-53.37	-30.48	22.89	SeO3
Sepiolite(a)	-5.34	13.44	18.78	Mg2Si3O7.5OH:3H2O
Sepiolite(c)	-3.91	13.44	17.35	Mg2Si3O7.5OH:3H2O
Siderite	-4.40	-14.67	-10.27	FeCO3
SiO2(a)	-1.52	-4.77	-3.25	SiO2
SiO2(am)	-1.86	-4.77	-2.92	SiO2
Smithsonite	-2.72	-12.49	-9.77	ZnCO3
Spinel	-8.45	32.57	41.03	MgAl2O4
SrCrO4	-19.78	-24.49	-4.72	SrCrO4
SrSeO3	-5.31	-5.21	0.10	SrSeO3
SrSeO4	-12.05	-19.06	-7.02	SrSeO4
Strontianite	-0.97	-10.18	-9.21	SrCO3
Talc	-2.36	22.54	24.90	Mg3Si4O10(OH)2
Tenorite	-3.10	5.33	8.42	CuO
Thenardite	-11.42	-11.57	-0.15	Na2SO4
Thermonatrite	-13.08	-12.81	0.27	Na2CO3:H2O
Tl(OH)3	-17.72	-24.17	-6.45	Tl(OH)3
Tl2CO3	-19.65	-23.92	-4.27	Tl2CO3
Tl2CrO4	-24.88	-38.23	-13.35	Tl2CrO4
Tl2O	-30.63	-2.31	28.31	Tl2O
Tl2Se	-46.68	-54.44	-7.76	Tl2Se
Tl2SeO4	-28.26	-32.80	-4.53	Tl2SeO4
Tl2SO4	-18.56	-22.67	-4.11	Tl2SO4
TlMetal	-19.26	-13.66	5.61	Tl
TlOH	-14.60	-1.16	13.45	TlOH
Tremolite	-2.33	59.31	61.64	Ca2Mg5Si8O22(OH)2
Tyuyamunite	-3.96	-0.95	3.00	Ca0.5UO2VO4

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      U3O8(C)         -17.21   10.01   27.22  U3O8
      U3Sb4          -581.06 -416.31  164.75  U3Sb4
      U4O9(C)         -30.27  -28.32    1.95  U4O9
      UO2(am)         -15.65  -13.33    2.32  UO2
      UO3(C)           -8.10    0.64    8.74  UO3
      Uraninite        -9.61  -13.33   -3.72  UO2
      Uranophane      -11.71    5.78   17.49  Ca(UO2)2(SiO3OH)2
      USb2           -218.34 -187.52   30.83  USb2
      USiO4(C)        -11.25  -18.10   -6.85  USiO4
      V(OH)3          -16.33   -8.68    7.65  V(OH)3
      V2O3            -14.61   -8.68    5.94  VO1.5
      V2O4             -7.65   -2.64    5.01  VO2
      V2O5             -8.12   -8.62   -0.50  VO2.5
      V3O5            -36.03  -32.92    3.11  V3O5
      V4O7            -44.77  -35.56    9.20  V4O7
      V6O13           -37.42 -101.70  -64.28  V6O13
      VMetal          -91.84  -46.18   45.67  V
      VO              -35.73  -21.18   14.56  VO
      VO(OH)2          -8.49   -2.64    5.85  VO(OH)2
      VOSO4(C)        -27.67  -23.00    4.66  VOSO4
      Wairakite        -8.55   13.65   22.20  CaAl2Si4O12:2H2O
      Willemite        -3.64   13.45   17.09  Zn2SiO4
      Witherite        -2.41  -11.01   -8.60  BaCO3
      Wollastonite     -4.75    9.28   14.02  CaSiO3
      Zincite          -3.18    9.11   12.29  ZnO
      Zincosite       -15.27  -11.25    4.02  ZnSO4
      Zn(BO2)2         -9.96   -1.67    8.29  Zn(BO2)2
      Zn(OH)2(A)       -3.34    9.11   12.45  Zn(OH)2
      Zn(OH)2(B)       -2.64    9.11   11.75  Zn(OH)2
      Zn(OH)2(C)       -3.09    9.11   12.20  Zn(OH)2
      Zn(OH)2(E)       -2.39    9.11   11.50  Zn(OH)2
      Zn(OH)2(G)       -2.60    9.11   11.71  Zn(OH)2
      Zn2(OH)2SO4      -9.64   -2.14    7.50  Zn2(OH)2SO4
      Zn3(AsO4)2:2.5H2O -19.54   -5.89   13.65  Zn3(AsO4)2:2.5H2O
      Zn3O(SO4)2      -35.68  -13.39   22.29  Zn3O(SO4)2
      Zn4(OH)6SO4     -12.32   16.08   28.40  Zn4(OH)6SO4
      ZnCO3:H2O        -2.23  -12.49  -10.26  ZnCO3:H2O
      ZnMetal         -43.58  -15.89   27.70  Zn
      ZnO(Active)      -2.20    9.11   11.31  ZnO
      ZnSb            -84.17  -72.47   11.71  ZnSb
      ZnSe            -31.31  -43.02  -11.70  ZnSe
      ZnSiO3            0.45    4.34    3.89  ZnSiO3
      ZnSO4:H2O       -11.24  -11.25   -0.01  ZnSO4:H2O

-----------------------------------------
Beginning of batch-reaction calculations.
-----------------------------------------

Reaction step 1.

Using solution 1.
Using surface 1.
Using pure phase assemblage 1.

-------------------------------Phase assemblage--------------------------------

                                                      Moles in assemblage
Phase                  SI log IAP  log KT      Initial       Final       Delta

Al4(OH)10SO4        -8.79   13.91   22.70   0.000e+000           0  0.000e+000
Calcite              0.00   -8.40   -8.40   0.000e+000  1.445e-004  1.445e-004
CO2(g)              -2.65  -20.83  -18.19   0.000e+000           0  0.000e+000
Diaspore             0.00    8.17    8.17   0.000e+000  2.441e-007  2.441e-007
Ferrihydrite        -0.00    4.89    4.89   0.000e+000  8.284e-008  8.284e-008
O2(g)              -37.81   52.36   90.17   0.000e+000           0  0.000e+000

------------------------------Surface composition------------------------------
```

----------------------------Solution composition----------------------------

Elements	Molality	Moles
Ag	1.855e-010	1.855e-010
Al	1.545e-008	1.545e-008
As	4.006e-009	4.006e-009
B	4.627e-006	4.627e-006
Ba	5.609e-007	5.609e-007
Be	1.110e-008	1.110e-008
C	3.069e-003	3.069e-003
Ca	1.578e-003	1.578e-003
Cd	4.450e-010	4.450e-010
Cr	1.924e-008	1.924e-008
Cu	4.723e-009	4.723e-009
Fe	6.725e-009	6.725e-009
Hg	1.995e-010	1.995e-010
K	1.023e-005	1.023e-005
Li	7.208e-007	7.208e-007
Mg	1.152e-003	1.152e-003
Mn	1.821e-008	1.821e-008
Na	8.703e-005	8.703e-005
Ni	1.704e-008	1.704e-008
Pb	4.345e-009	4.345e-009
S	7.602e-004	7.602e-004
Sb	4.108e-009	4.108e-009
Se	1.774e-008	1.774e-008
Si	1.703e-005	1.703e-005
Sr	3.791e-006	3.791e-006
Tl	2.447e-010	2.447e-010
U	2.312e-008	2.312e-008
V	9.819e-008	9.819e-008
Zn	1.530e-007	1.530e-007

----------------------------Description of solution----------------------------

pH	=	7.708	Charge balance
pe	=	5.383	Adjusted to redox equilibrium
Activity of water	=	1.000	
Ionic strength	=	7.926e-003	
Mass of water (kg)	=	1.000e+000	
Total alkalinity (eq/kg)	=	2.989e-003	
Total CO2 (mol/kg)	=	3.069e-003	
Temperature (deg C)	=	5.000	
Electrical balance (eq)	=	1.057e-003	
Percent error, 100*(Cat-|An|)/(Cat+|An|)	=	11.18	
Iterations	=	8	
Total H	=	1.110157e+002	
Total O	=	5.551855e+001	

----------------------------Distribution of species----------------------------

Species		Molality	Activity	Log Molality	Log Activity	Log Gamma
OH-		1.113e-007	1.016e-007	-6.953	-6.993	-0.040
H+		2.122e-008	1.958e-008	-7.673	-7.708	-0.035
H2O		5.551e+001	9.999e-001	1.744	-0.000	0.000
Ag	1.855e-010					
Ag+		1.842e-010	1.683e-010	-9.735	-9.774	-0.039
AgSO4-		1.315e-012	1.201e-012	-11.881	-11.920	-0.039
AgOH		8.575e-015	8.591e-015	-14.067	-14.066	0.001
AgSeO3-		3.228e-016	2.950e-016	-15.491	-15.530	-0.039
Ag(OH)2-		4.801e-019	4.386e-019	-18.319	-18.358	-0.039
Ag(SeO3)2-3		1.158e-023	5.135e-024	-22.936	-23.289	-0.353
Ag2Se		2.071e-025	2.075e-025	-24.684	-24.683	0.001

	AgHS	0.000e+000	0.000e+000	-74.688	-74.687	0.001
	AgOH(Se)2-4	0.000e+000	0.000e+000	-98.467	-99.095	-0.628
	Ag(HS)2-	0.000e+000	0.000e+000	-149.210	-149.250	-0.039
	Ag(HS)S4-2	0.000e+000	0.000e+000	-149.438	-149.561	-0.123
	Ag(S4)2-3	0.000e+000	0.000e+000	-151.051	-151.292	-0.242
	AgS4S5-3	0.000e+000	0.000e+000	-151.370	-151.603	-0.234
Al	1.545e-008					
	Al(OH)3	1.480e-008	1.483e-008	-7.830	-7.829	0.001
	Al(OH)4-	3.944e-010	3.606e-010	-9.404	-9.443	-0.039
	Al(OH)2+	2.518e-010	2.307e-010	-9.599	-9.637	-0.038
	AlOH+2	1.950e-013	1.373e-013	-12.710	-12.862	-0.152
	Al+3	2.296e-015	1.114e-015	-14.639	-14.953	-0.314
	AlSO4+	4.311e-016	3.941e-016	-15.365	-15.404	-0.039
	Al(SO4)2-	1.381e-017	1.263e-017	-16.860	-16.899	-0.039
As(3)	6.208e-021					
	H3AsO3	6.117e-021	6.128e-021	-20.213	-20.213	0.001
	H2AsO3-	9.140e-023	8.350e-023	-22.039	-22.078	-0.039
	HAsO3-2	1.915e-027	1.334e-027	-26.718	-26.875	-0.157
	H4AsO3+	6.508e-029	5.946e-029	-28.187	-28.226	-0.039
	AsO3-3	2.841e-033	1.260e-033	-32.547	-32.900	-0.353
As(5)	4.006e-009					
	HAsO4-2	3.661e-009	2.551e-009	-8.436	-8.593	-0.157
	H2AsO4-	3.439e-010	3.142e-010	-9.464	-9.503	-0.039
	AsO4-3	4.392e-013	1.948e-013	-12.357	-12.710	-0.353
	H3AsO4	8.754e-016	8.770e-016	-15.058	-15.057	0.001
B	4.627e-006					
	H3BO3	4.528e-006	4.536e-006	-5.344	-5.343	0.001
	H2BO3-	9.956e-008	9.058e-008	-7.002	-7.043	-0.041
Ba	5.609e-007					
	Ba+2	5.609e-007	3.937e-007	-6.251	-6.405	-0.154
	BaOH+	1.542e-013	1.411e-013	-12.812	-12.850	-0.038
Be	1.110e-008					
	Be+2	1.110e-008	7.735e-009	-7.955	-8.112	-0.157
C(4)	3.069e-003					
	HCO3-	2.926e-003	2.681e-003	-2.534	-2.572	-0.038
	H2CO3	9.226e-005	9.243e-005	-4.035	-4.034	0.001
	MgHCO3+	2.129e-005	1.944e-005	-4.672	-4.711	-0.039
	CaHCO3+	1.723e-005	1.580e-005	-4.764	-4.801	-0.037
	CO3-2	5.430e-006	3.825e-006	-5.265	-5.417	-0.152
	CaCO3	4.208e-006	4.216e-006	-5.376	-5.375	0.001
	MgCO3	2.062e-006	2.066e-006	-5.686	-5.685	0.001
	NaHCO3	7.134e-008	7.147e-008	-7.147	-7.146	0.001
	ZnCO3	4.480e-008	4.488e-008	-7.349	-7.348	0.001
	NiCO3	1.590e-008	1.593e-008	-7.798	-7.798	0.001
	UO2(CO3)3-4	1.255e-008	2.959e-009	-7.901	-8.529	-0.628
	ZnHCO3+	1.211e-008	1.107e-008	-7.917	-7.956	-0.039
	UO2(CO3)2-2	1.021e-008	7.113e-009	-7.991	-8.148	-0.157
	Zn(CO3)2-2	5.267e-009	3.670e-009	-8.278	-8.435	-0.157
	PbCO3	4.041e-009	4.048e-009	-8.394	-8.393	0.001
	NaCO3-	2.083e-009	1.908e-009	-8.681	-8.719	-0.038
	CuCO3	1.243e-009	1.245e-009	-8.906	-8.905	0.001
	MnHCO3+	3.938e-010	3.605e-010	-9.405	-9.443	-0.038
	UO2CO3	3.539e-010	3.546e-010	-9.451	-9.450	0.001
	CdCO3	1.571e-010	1.574e-010	-9.804	-9.803	0.001
	Ni(CO3)2-2	1.520e-010	1.059e-010	-9.818	-9.975	-0.157
	NiHCO3+	1.360e-010	1.242e-010	-9.867	-9.906	-0.039
	PbHCO3+	7.913e-011	7.230e-011	-10.102	-10.141	-0.039
	Pb(CO3)2-2	5.581e-011	3.889e-011	-10.253	-10.410	-0.157
	CuHCO3+	4.968e-011	4.539e-011	-10.304	-10.343	-0.039
	CdHCO3+	3.381e-011	3.089e-011	-10.471	-10.510	-0.039
	Cu(CO3)2-2	8.602e-012	5.994e-012	-11.065	-11.222	-0.157
	Cd(CO3)3-4	6.468e-020	1.525e-020	-19.189	-19.817	-0.628
Ca	1.578e-003					
	Ca+2	1.478e-003	1.050e-003	-2.830	-2.979	-0.149
	CaSO4	7.832e-005	7.846e-005	-4.106	-4.105	0.001
	CaHCO3+	1.723e-005	1.580e-005	-4.764	-4.801	-0.037
	CaCO3	4.208e-006	4.216e-006	-5.376	-5.375	0.001

	CaOH+	2.527e-009	2.318e-009	-8.597	-8.635	-0.037
Cd	4.450e-010					
	Cd+2	2.356e-010	1.642e-010	-9.628	-9.785	-0.157
	CdCO3	1.571e-010	1.574e-010	-9.804	-9.803	0.001
	CdHCO3+	3.381e-011	3.089e-011	-10.471	-10.510	-0.039
	CdSO4	1.818e-011	1.822e-011	-10.740	-10.739	0.001
	CdOH+	1.557e-013	1.422e-013	-12.808	-12.847	-0.039
	Cd(SO4)2-2	1.434e-013	9.989e-014	-12.844	-13.000	-0.157
	Cd(OH)2	1.908e-015	1.912e-015	-14.719	-14.719	0.001
	Cd(CO3)3-4	6.468e-020	1.525e-020	-19.189	-19.817	-0.628
	Cd(OH)3-	1.199e-020	1.095e-020	-19.921	-19.960	-0.039
	CdSeO4	4.228e-021	4.236e-021	-20.374	-20.373	0.001
	Cd(SeO3)2-2	7.376e-022	5.139e-022	-21.132	-21.289	-0.157
	Cd2OH+3	3.368e-022	1.494e-022	-21.473	-21.826	-0.353
	Cd(OH)4-2	7.153e-027	4.984e-027	-26.145	-26.302	-0.157
	CdHS+	0.000e+000	0.000e+000	-78.538	-78.577	-0.039
	Cd(HS)2	0.000e+000	0.000e+000	-151.181	-151.180	0.001
	Cd(HS)3-	0.000e+000	0.000e+000	-227.924	-227.963	-0.039
	Cd(HS)4-2	0.000e+000	0.000e+000	-304.579	-304.736	-0.157
Cr(2)	3.668e-027					
	Cr+2	3.668e-027	2.556e-027	-26.436	-26.592	-0.157
Cr(3)	1.924e-008					
	Cr(OH)3	1.486e-008	1.488e-008	-7.828	-7.827	0.001
	Cr(OH)2+	4.304e-009	3.932e-009	-8.366	-8.405	-0.039
	Cr(OH)+2	4.607e-011	3.210e-011	-10.337	-10.493	-0.157
	CrO2-	2.016e-011	1.842e-011	-10.696	-10.735	-0.039
	Cr(OH)4-	7.943e-012	7.257e-012	-11.100	-11.139	-0.039
	CrOHSO4	6.357e-012	6.368e-012	-11.197	-11.196	0.001
	Cr+3	1.633e-013	7.243e-014	-12.787	-13.140	-0.353
	CrSO4+	3.093e-016	2.825e-016	-15.510	-15.549	-0.039
	Cr2(OH)2SO4+2	5.334e-020	3.717e-020	-19.273	-19.430	-0.157
	Cr2(OH)2(SO4)2	3.839e-025	3.846e-025	-24.416	-24.415	0.001
Cr(6)	2.307e-019					
	CrO4-2	2.211e-019	1.537e-019	-18.655	-18.813	-0.158
	HCrO4-	9.536e-021	8.713e-021	-20.021	-20.060	-0.039
	NaCrO4-	6.637e-023	6.064e-023	-22.178	-22.217	-0.039
	KCrO4-	9.858e-024	9.006e-024	-23.006	-23.045	-0.039
	CrO3SO4-2	3.659e-029	2.549e-029	-28.437	-28.594	-0.157
	H2CrO4	2.637e-029	2.642e-029	-28.579	-28.578	0.001
	Cr2O7-2	6.749e-039	4.703e-039	-38.171	-38.328	-0.157
Cu(1)	1.185e-013					
	Cu+	1.185e-013	1.078e-013	-12.926	-12.967	-0.041
	Cu(S4)2-3	0.000e+000	0.000e+000	-151.849	-152.087	-0.238
	CuS4S5-3	0.000e+000	0.000e+000	-152.587	-152.817	-0.230
Cu(2)	4.723e-009					
	Cu(OH)2	3.295e-009	3.301e-009	-8.482	-8.481	0.001
	CuCO3	1.243e-009	1.245e-009	-8.906	-8.905	0.001
	Cu+2	8.843e-011	6.060e-011	-10.053	-10.218	-0.164
	CuHCO3+	4.968e-011	4.539e-011	-10.304	-10.343	-0.039
	CuOH+	3.388e-011	3.094e-011	-10.470	-10.509	-0.039
	Cu(CO3)2-2	8.602e-012	5.994e-012	-11.065	-11.222	-0.157
	CuSO4	4.672e-012	4.680e-012	-11.331	-11.330	0.001
	Cu(OH)3-	1.114e-014	1.018e-014	-13.953	-13.992	-0.039
	Cu2(OH)2+2	7.156e-017	4.986e-017	-16.145	-16.302	-0.157
	Cu(OH)4-2	1.485e-019	1.035e-019	-18.828	-18.985	-0.157
	Cu(HS)3-	0.000e+000	0.000e+000	-221.168	-221.207	-0.039
Fe(2)	1.288e-010					
	Fe+2	1.239e-010	8.772e-011	-9.907	-10.057	-0.150
	FeSO4	4.615e-012	4.624e-012	-11.336	-11.335	0.001
	FeOH+	3.119e-013	2.855e-013	-12.506	-12.544	-0.038
	Fe(OH)2	1.919e-017	1.922e-017	-16.717	-16.716	0.001
	Fe(OH)3-	3.227e-020	2.954e-020	-19.491	-19.530	-0.038
	Fe(HS)2	0.000e+000	0.000e+000	-159.033	-159.033	0.001
	Fe(HS)3-	0.000e+000	0.000e+000	-235.919	-235.958	-0.039
Fe(3)	6.596e-009					
	Fe(OH)2+	3.556e-009	3.258e-009	-8.449	-8.487	-0.038
	Fe(OH)3	1.951e-009	1.954e-009	-8.710	-8.709	0.001

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   Fe(OH)4-             1.089e-009  9.979e-010    -8.963    -9.001    -0.038
   FeOH+2               7.772e-014  5.455e-014   -13.109   -13.263    -0.154
   FeSO4+               1.450e-018  1.327e-018   -17.839   -17.877    -0.038
   Fe+3                 1.205e-018  5.845e-019   -17.919   -18.233    -0.314
   Fe(SO4)2-            1.853e-020  1.693e-020   -19.732   -19.771    -0.039
   FeHSeO3+2            4.654e-023  3.243e-023   -22.332   -22.489    -0.157
   Fe2(OH)2+4           8.238e-025  1.942e-025   -24.084   -24.712    -0.628
   Fe3(OH)4+5           1.147e-030  1.199e-031   -29.940   -30.921    -0.981
H(0)            1.152e-029
   H2                   5.758e-030  5.768e-030   -29.240   -29.239     0.001
Hg(0)           1.995e-010
   Hg                   1.995e-010  1.998e-010    -9.700    -9.699     0.001
Hg(1)           1.629e-024
   Hg2+2                8.147e-025  5.666e-025   -24.089   -24.247    -0.158
Hg(2)           3.202e-015
   Hg(OH)2              3.202e-015  3.208e-015   -14.495   -14.494     0.001
   HgOH+                3.426e-020  3.130e-020   -19.465   -19.504    -0.039
   Hg(OH)3-             1.776e-022  1.622e-022   -21.751   -21.790    -0.039
   Hg+2                 8.452e-024  5.889e-024   -23.073   -23.230    -0.157
   HgSO4                1.669e-026  1.672e-026   -25.777   -25.777     0.001
   HgS2-2               0.000e+000  0.000e+000  -141.023  -141.179    -0.157
   Hg(HS)2              0.000e+000  0.000e+000  -144.018  -144.018     0.001
K               1.023e-005
   K+                   1.021e-005  9.306e-006    -4.991    -5.031    -0.040
   KSO4-                2.154e-008  1.973e-008    -7.667    -7.705    -0.038
   KCrO4-               9.858e-024  9.006e-024   -23.006   -23.045    -0.039
Li              7.208e-007
   Li+                  7.195e-007  6.600e-007    -6.143    -6.180    -0.037
   LiSO4-               1.381e-009  1.264e-009    -8.860    -8.898    -0.038
Mg              1.152e-003
   Mg+2                 1.078e-003  7.695e-004    -2.967    -3.114    -0.147
   MgSO4                5.055e-005  5.065e-005    -4.296    -4.295     0.001
   MgHCO3+              2.129e-005  1.944e-005    -4.672    -4.711    -0.039
   MgCO3                2.062e-006  2.066e-006    -5.686    -5.685     0.001
   MgOH+                1.098e-008  1.008e-008    -7.959    -7.996    -0.037
Mn(2)           1.821e-008
   Mn+2                 1.707e-008  1.209e-008    -7.768    -7.918    -0.150
   MnSO4                7.401e-010  7.415e-010    -9.131    -9.130     0.001
   MnHCO3+              3.938e-010  3.605e-010    -9.405    -9.443    -0.038
   MnOH+                3.020e-012  2.764e-012   -11.520   -11.558    -0.038
   MnSeO4               3.077e-019  3.082e-019   -18.512   -18.511     0.001
   Mn(OH)3-             2.786e-020  2.550e-020   -19.555   -19.593    -0.038
   MnSe                 0.000e+000  0.000e+000   -53.865   -53.864     0.001
Mn(3)           4.264e-027
   Mn+3                 4.264e-027  2.069e-027   -26.370   -26.684    -0.314
Mn(6)           0.000e+000
   MnO4-2               0.000e+000  0.000e+000   -50.915   -51.069    -0.154
Mn(7)           0.000e+000
   MnO4-                0.000e+000  0.000e+000   -56.431   -56.472    -0.040
Na              8.703e-005
   Na+                  8.679e-005  7.936e-005    -4.062    -4.100    -0.039
   NaSO4-               1.662e-007  1.523e-007    -6.779    -6.817    -0.038
   NaHCO3               7.134e-008  7.147e-008    -7.147    -7.146     0.001
   NaCO3-               2.083e-009  1.908e-009    -8.681    -8.719    -0.038
   NaCrO4-              6.637e-023  6.064e-023   -22.178   -22.217    -0.039
Ni              1.704e-008
   NiCO3                1.590e-008  1.593e-008    -7.798    -7.798     0.001
   Ni+2                 8.065e-010  5.619e-010    -9.093    -9.250    -0.157
   Ni(CO3)2-2           1.520e-010  1.059e-010    -9.818    -9.975    -0.157
   NiHCO3+              1.360e-010  1.242e-010    -9.867    -9.906    -0.039
   NiSO4                3.989e-011  3.996e-011   -10.399   -10.398     0.001
   NiOH+                9.603e-013  8.773e-013   -12.018   -12.057    -0.039
   Ni(OH)2              1.462e-013  1.465e-013   -12.835   -12.834     0.001
   Ni(SO4)2-2           1.625e-015  1.132e-015   -14.789   -14.946    -0.157
   Ni(OH)3-             8.187e-017  7.480e-017   -16.087   -16.126    -0.039
   NiSeO4               2.362e-020  2.366e-020   -19.627   -19.626     0.001
O(0)            0.000e+000
```

	O2		0.000e+000	0.000e+000	-40.822	-40.821	0.001
Pb		4.345e-009					
	PbCO3		4.041e-009	4.048e-009	-8.394	-8.393	0.001
	Pb+2		8.740e-011	6.090e-011	-10.058	-10.215	-0.157
	PbHCO3+		7.913e-011	7.230e-011	-10.102	-10.141	-0.039
	PbOH+		6.636e-011	6.063e-011	-10.178	-10.217	-0.039
	Pb(CO3)2-2		5.581e-011	3.889e-011	-10.253	-10.410	-0.157
	PbSO4		1.499e-011	1.502e-011	-10.824	-10.823	0.001
	Pb(OH)2		1.202e-012	1.204e-012	-11.920	-11.919	0.001
	Pb(SO4)2-2		4.963e-014	3.458e-014	-13.304	-13.461	-0.157
	Pb(OH)3-		7.728e-016	7.060e-016	-15.112	-15.151	-0.039
	Pb2OH+3		1.864e-019	8.266e-020	-18.730	-19.083	-0.353
	Pb(OH)4-2		1.188e-019	8.278e-020	-18.925	-19.082	-0.157
	Pb3(OH)4+2		1.165e-025	8.119e-026	-24.934	-25.091	-0.157
	Pb(HS)2		0.000e+000	0.000e+000	-152.872	-152.871	0.001
	Pb(HS)3-		0.000e+000	0.000e+000	-230.495	-230.534	-0.039
S(-2)		0.000e+000					
	AgHS		0.000e+000	0.000e+000	-74.688	-74.687	0.001
	CdHS+		0.000e+000	0.000e+000	-78.538	-78.577	-0.039
	HS-		0.000e+000	0.000e+000	-78.923	-78.963	-0.040
	H2S		0.000e+000	0.000e+000	-79.416	-79.416	0.001
	S6-2		0.000e+000	0.000e+000	-80.979	-81.136	-0.157
	S5-2		0.000e+000	0.000e+000	-81.183	-81.340	-0.157
	S4-2		0.000e+000	0.000e+000	-81.438	-81.595	-0.157
	S-2		0.000e+000	0.000e+000	-84.657	-84.810	-0.154
	S3-2		0.000e+000	0.000e+000	-84.928	-85.085	-0.157
	S2-2		0.000e+000	0.000e+000	-86.227	-86.384	-0.157
	TlHS		0.000e+000	0.000e+000	-86.801	-86.800	0.001
	Tl2HS+		0.000e+000	0.000e+000	-90.536	-90.575	-0.039
	HgS2-2		0.000e+000	0.000e+000	-141.023	-141.179	-0.157
	Hg(HS)2		0.000e+000	0.000e+000	-144.018	-144.018	0.001
	Ag(HS)2-		0.000e+000	0.000e+000	-149.210	-149.250	-0.039
	Ag(HS)S4-2		0.000e+000	0.000e+000	-149.438	-149.561	-0.123
	Zn(HS)2		0.000e+000	0.000e+000	-150.217	-150.216	0.001
	Ag(S4)2-3		0.000e+000	0.000e+000	-151.051	-151.292	-0.242
	Cd(HS)2		0.000e+000	0.000e+000	-151.181	-151.180	0.001
	AgS4S5-3		0.000e+000	0.000e+000	-151.370	-151.603	-0.234
	Cu(S4)2-3		0.000e+000	0.000e+000	-151.849	-152.087	-0.238
	CuS4S5-3		0.000e+000	0.000e+000	-152.587	-152.817	-0.230
	Pb(HS)2		0.000e+000	0.000e+000	-152.872	-152.871	0.001
	Fe(HS)2		0.000e+000	0.000e+000	-159.033	-159.033	0.001
	Tl2(OH)2(HS)2-2		0.000e+000	0.000e+000	-172.731	-172.888	-0.157
	Cu(HS)3-		0.000e+000	0.000e+000	-221.168	-221.207	-0.039
	Cd(HS)3-		0.000e+000	0.000e+000	-227.924	-227.963	-0.039
	Zn(HS)3-		0.000e+000	0.000e+000	-227.980	-228.019	-0.039
	Pb(HS)3-		0.000e+000	0.000e+000	-230.495	-230.534	-0.039
	Fe(HS)3-		0.000e+000	0.000e+000	-235.919	-235.958	-0.039
	Tl2OH(HS)3-2		0.000e+000	0.000e+000	-247.330	-247.486	-0.157
	Cd(HS)4-2		0.000e+000	0.000e+000	-304.579	-304.736	-0.157
	Sb2S4-2		0.000e+000	0.000e+000	-316.758	-316.915	-0.157
S(6)		7.602e-004					
	SO4-2		6.311e-004	4.386e-004	-3.200	-3.358	-0.158
	CaSO4		7.832e-005	7.846e-005	-4.106	-4.105	0.001
	MgSO4		5.055e-005	5.065e-005	-4.296	-4.295	0.001
	NaSO4-		1.662e-007	1.523e-007	-6.779	-6.817	-0.038
	KSO4-		2.154e-008	1.973e-008	-7.667	-7.705	-0.038
	ZnSO4		5.118e-009	5.127e-009	-8.291	-8.290	0.001
	LiSO4-		1.381e-009	1.264e-009	-8.860	-8.898	-0.038
	MnSO4		7.401e-010	7.415e-010	-9.131	-9.130	0.001
	HSO4-		5.338e-010	4.881e-010	-9.273	-9.312	-0.039
	NiSO4		3.989e-011	3.996e-011	-10.399	-10.398	0.001
	Zn(SO4)2-2		3.094e-011	2.156e-011	-10.509	-10.666	-0.157
	CdSO4		1.818e-011	1.822e-011	-10.740	-10.739	0.001
	PbSO4		1.499e-011	1.502e-011	-10.824	-10.823	0.001
	CrOHSO4		6.357e-012	6.368e-012	-11.197	-11.196	0.001
	CuSO4		4.672e-012	4.680e-012	-11.331	-11.330	0.001
	FeSO4		4.615e-012	4.624e-012	-11.336	-11.335	0.001

TlSO4-	2.648e-012	2.420e-012	-11.577	-11.616	-0.039
AgSO4-	1.315e-012	1.201e-012	-11.881	-11.920	-0.039
Cd(SO4)2-2	1.434e-013	9.989e-014	-12.844	-13.000	-0.157
Pb(SO4)2-2	4.963e-014	3.458e-014	-13.304	-13.461	-0.157
Ni(SO4)2-2	1.625e-015	1.132e-015	-14.789	-14.946	-0.157
UO2SO4	9.080e-016	9.096e-016	-15.042	-15.041	0.001
AlSO4+	4.311e-016	3.941e-016	-15.365	-15.404	-0.039
CrSO4+	3.093e-016	2.825e-016	-15.510	-15.549	-0.039
VO2SO4-	1.788e-017	1.634e-017	-16.748	-16.787	-0.039
UO2(SO4)2-2	1.511e-017	1.053e-017	-16.821	-16.978	-0.157
Al(SO4)2-	1.381e-017	1.263e-017	-16.860	-16.899	-0.039
FeSO4+	1.450e-018	1.327e-018	-17.839	-17.877	-0.038
VOSO4	2.709e-019	2.714e-019	-18.567	-18.566	0.001
Cr2(OH)2SO4+2	5.334e-020	3.717e-020	-19.273	-19.430	-0.157
Fe(SO4)2-	1.853e-020	1.693e-020	-19.732	-19.771	-0.039
Cr2(OH)2(SO4)2	3.839e-025	3.846e-025	-24.416	-24.415	0.001
HgSO4	1.669e-026	1.672e-026	-25.777	-25.777	0.001
CrO3SO4-2	3.659e-029	2.549e-029	-28.437	-28.594	-0.157
VSO4+	2.117e-034	1.934e-034	-33.674	-33.713	-0.039
U(SO4)2	0.000e+000	0.000e+000	-42.059	-42.058	0.001
USO4+2	0.000e+000	0.000e+000	-42.626	-42.783	-0.157
Sb(3)	6.736e-020				
Sb(OH)3	3.393e-020	3.399e-020	-19.469	-19.469	0.001
HSbO2	3.343e-020	3.349e-020	-19.476	-19.475	0.001
SbO2-	3.922e-025	3.584e-025	-24.406	-24.446	-0.039
Sb(OH)4-	2.269e-025	2.073e-025	-24.644	-24.683	-0.039
Sb(OH)2+	1.769e-026	1.617e-026	-25.752	-25.791	-0.039
SbO+	4.803e-027	4.388e-027	-26.318	-26.358	-0.039
Sb2S4-2	0.000e+000	0.000e+000	-316.758	-316.915	-0.157
Sb(5)	4.108e-009				
SbO3-	4.104e-009	3.749e-009	-8.387	-8.426	-0.039
Sb(OH)6-	4.799e-012	4.384e-012	-11.319	-11.358	-0.039
SbO2+	4.514e-025	4.124e-025	-24.345	-24.385	-0.039
Se(-2)	2.071e-025				
Ag2Se	2.071e-025	2.075e-025	-24.684	-24.683	0.001
HSe-	0.000e+000	0.000e+000	-46.872	-46.911	-0.039
H2Se	0.000e+000	0.000e+000	-50.850	-50.850	0.001
MnSe	0.000e+000	0.000e+000	-53.865	-53.864	0.001
Se-2	0.000e+000	0.000e+000	-54.605	-54.762	-0.157
AgOH(Se)2-4	0.000e+000	0.000e+000	-98.467	-99.095	-0.628
Se(4)	2.830e-009				
SeO3-2	2.830e-009	1.972e-009	-8.548	-8.705	-0.157
Se(6)	1.491e-008				
HSeO3-	1.491e-008	1.362e-008	-7.827	-7.866	-0.039
SeO4-2	2.127e-013	1.479e-013	-12.672	-12.830	-0.158
H2SeO3	9.687e-014	9.705e-014	-13.014	-13.013	0.001
AgSeO3-	3.228e-016	2.950e-016	-15.491	-15.530	-0.039
ZnSeO4	1.383e-018	1.385e-018	-17.859	-17.859	0.001
MnSeO4	3.077e-019	3.082e-019	-18.512	-18.511	0.001
HSeO4-	1.533e-019	1.401e-019	-18.814	-18.854	-0.039
NiSeO4	2.362e-020	2.366e-020	-19.627	-19.626	0.001
CdSeO4	4.228e-021	4.236e-021	-20.374	-20.373	0.001
Cd(SeO3)2-2	7.376e-022	5.139e-022	-21.132	-21.289	-0.157
FeHSeO3+2	4.654e-023	3.243e-023	-22.332	-22.489	-0.157
Ag(SeO3)2-3	1.158e-023	5.135e-024	-22.936	-23.289	-0.353
Zn(SeO4)2-2	1.571e-033	1.095e-033	-32.804	-32.961	-0.157
Si	1.703e-005				
H4SiO4	1.699e-005	1.702e-005	-4.770	-4.769	0.001
H3SiO4-	3.590e-008	3.279e-008	-7.445	-7.484	-0.039
H2SiO4-2	3.319e-013	2.338e-013	-12.479	-12.631	-0.152
UO2H3SiO4+	2.851e-014	2.604e-014	-13.545	-13.584	-0.039
Sr	3.791e-006				
Sr+2	3.791e-006	2.661e-006	-5.421	-5.575	-0.154
SrOH+	1.696e-012	1.553e-012	-11.770	-11.809	-0.038
Tl(1)	2.447e-010				
Tl+	2.421e-010	2.212e-010	-9.616	-9.655	-0.039
TlSO4-	2.648e-012	2.420e-012	-11.577	-11.616	-0.039

TlOH		1.399e-016	1.402e-016	-15.854	-15.853	0.001
TlHS		0.000e+000	0.000e+000	-86.801	-86.800	0.001
Tl2HS+		0.000e+000	0.000e+000	-90.536	-90.575	-0.039
Tl2(OH)2(HS)2-2		0.000e+000	0.000e+000	-172.731	-172.888	-0.157
Tl2OH(HS)3-2		0.000e+000	0.000e+000	-247.330	-247.486	-0.157
Tl(3)	1.649e-024					
Tl(OH)3		1.644e-024	1.647e-024	-23.784	-23.783	0.001
Tl(OH)4-		5.121e-027	4.679e-027	-26.291	-26.330	-0.039
Tl(OH)2+		4.635e-030	4.235e-030	-29.334	-29.373	-0.039
TlOH+2		3.423e-036	2.385e-036	-35.466	-35.623	-0.157
Tl+3		0.000e+000	0.000e+000	-41.812	-42.165	-0.353
U(3)	0.000e+000					
U+3		0.000e+000	0.000e+000	-59.802	-60.155	-0.353
U(4)	2.071e-021					
U(OH)5-		2.068e-021	1.890e-021	-20.684	-20.724	-0.039
U(OH)4		2.177e-024	2.181e-024	-23.662	-23.661	0.001
U(OH)3+		2.210e-028	2.019e-028	-27.656	-27.695	-0.039
U(OH)2+2		4.764e-033	3.319e-033	-32.322	-32.479	-0.157
UOH+3		1.373e-038	6.091e-039	-37.862	-38.215	-0.353
U(SO4)2		0.000e+000	0.000e+000	-42.059	-42.058	0.001
USO4+2		0.000e+000	0.000e+000	-42.626	-42.783	-0.157
U+4		0.000e+000	0.000e+000	-44.063	-44.691	-0.628
U6(OH)15+9		0.000e+000	0.000e+000	-166.574	-169.752	-3.177
U(5)	3.105e-017					
UO2+		3.105e-017	2.836e-017	-16.508	-16.547	-0.039
U(6)	2.312e-008					
UO2(CO3)3-4		1.255e-008	2.959e-009	-7.901	-8.529	-0.628
UO2(CO3)2-2		1.021e-008	7.113e-009	-7.991	-8.148	-0.157
UO2CO3		3.539e-010	3.546e-010	-9.451	-9.450	0.001
UO2OH+		9.895e-013	9.041e-013	-12.005	-12.044	-0.039
UO2H3SiO4+		2.851e-014	2.604e-014	-13.545	-13.584	-0.039
UO2+2		1.080e-014	7.526e-015	-13.967	-14.123	-0.157
UO2SO4		9.080e-016	9.096e-016	-15.042	-15.041	0.001
UO2(SO4)2-2		1.511e-017	1.053e-017	-16.821	-16.978	-0.157
(UO2)2(OH)2+2		1.387e-019	9.663e-020	-18.858	-19.015	-0.157
(UO2)3(OH)5+		1.971e-021	1.801e-021	-20.705	-20.745	-0.039
V(2)	1.698e-040					
VOH+		1.698e-040	1.551e-040	-39.770	-39.809	-0.039
V+2		0.000e+000	0.000e+000	-41.720	-41.877	-0.157
V(3)	2.039e-020					
V(OH)3		2.032e-020	2.035e-020	-19.692	-19.691	0.001
V(OH)2+		6.758e-023	6.174e-023	-22.170	-22.209	-0.039
VOH+2		1.891e-027	1.317e-027	-26.723	-26.880	-0.157
V+3		3.610e-032	1.601e-032	-31.443	-31.796	-0.353
VSO4+		2.117e-034	1.934e-034	-33.674	-33.713	-0.039
V2(OH)3+3		0.000e+000	0.000e+000	-47.614	-47.967	-0.353
V2(OH)2+4		0.000e+000	0.000e+000	-51.297	-51.925	-0.628
V(4)	4.171e-016					
V(OH)3+		4.119e-016	3.763e-016	-15.385	-15.424	-0.039
VO+2		4.948e-018	3.448e-018	-17.306	-17.462	-0.157
VOSO4		2.709e-019	2.714e-019	-18.567	-18.566	0.001
H2V2O4+2		1.615e-026	1.125e-026	-25.792	-25.949	-0.157
V(5)	9.819e-008					
H2VO4-		4.260e-008	3.892e-008	-7.371	-7.410	-0.039
HV2O7-3		1.976e-008	8.765e-009	-7.704	-8.057	-0.353
HVO4-2		1.605e-008	1.118e-008	-7.795	-7.951	-0.157
H3V2O7-		1.247e-011	1.139e-011	-10.904	-10.944	-0.039
H3VO4		5.107e-012	5.116e-012	-11.292	-11.291	0.001
V2O7-4		3.299e-013	7.778e-014	-12.482	-13.109	-0.628
VO4-3		4.142e-014	1.837e-014	-13.383	-13.736	-0.353
V3O9-3		2.018e-015	8.953e-016	-14.695	-15.048	-0.353
VO2+		7.950e-016	7.263e-016	-15.100	-15.139	-0.039
VO2SO4-		1.788e-017	1.634e-017	-16.748	-16.787	-0.039
V4O12-4		8.849e-020	2.086e-020	-19.053	-19.681	-0.628
V10O28-6		0.000e+000	0.000e+000	-44.177	-45.589	-1.412
HV10O28-5		0.000e+000	0.000e+000	-47.271	-48.251	-0.981
H2V10O28-4		0.000e+000	0.000e+000	-50.558	-51.185	-0.628

Zn	1.530e-007					
	Zn+2	8.306e-008	5.881e-008	-7.081	-7.231	-0.150
	ZnCO3	4.480e-008	4.488e-008	-7.349	-7.348	0.001
	ZnHCO3+	1.211e-008	1.107e-008	-7.917	-7.956	-0.039
	Zn(CO3)2-2	5.267e-009	3.670e-009	-8.278	-8.435	-0.157
	ZnSO4	5.118e-009	5.127e-009	-8.291	-8.290	0.001
	Zn(OH)2	1.931e-009	1.935e-009	-8.714	-8.713	0.001
	ZnOH+	7.089e-010	6.477e-010	-9.149	-9.189	-0.039
	Zn(SO4)2-2	3.094e-011	2.156e-011	-10.509	-10.666	-0.157
	Zn(OH)3-	3.419e-013	3.124e-013	-12.466	-12.505	-0.039
	Zn(OH)4-2	3.628e-018	2.528e-018	-17.440	-17.597	-0.157
	ZnSeO4	1.383e-018	1.385e-018	-17.859	-17.859	0.001
	Zn(SeO4)2-2	1.571e-033	1.095e-033	-32.804	-32.961	-0.157
	Zn(HS)2	0.000e+000	0.000e+000	-150.217	-150.216	0.001
	Zn(HS)3-	0.000e+000	0.000e+000	-227.980	-228.019	-0.039

------------------------------Saturation indices-------------------------------

Phase	SI	log IAP	log KT	
Acanthite	-51.94	-90.80	-38.86	Ag2S
Ag2CO3	-13.39	-24.97	-11.57	Ag2CO3
Ag2CrO4	-26.07	-38.36	-12.29	Ag2CrO4
Ag2HVO4	-13.04	-11.56	1.48	Ag2HVO4
Ag2O	-17.26	-4.13	13.13	Ag2O
Ag2Se	-11.68	-58.75	-47.07	Ag2Se
Ag2SeO3	-12.14	-19.71	-7.57	Ag2SeO3
Ag2SeO4	-22.93	-32.38	-9.45	Ag2SeO4
Ag2SO4	-17.76	-22.91	-5.14	Ag2SO4
Ag3H2VO5	-18.81	-13.63	5.18	Ag3H2VO5
Ag3Sb	-48.03	-104.21	-56.18	Ag3Sb
Ag_Vanadate	-10.27	-9.50	0.77	AgVO3
AgMetal	-0.32	-15.16	-14.84	Ag
Akerminite	-23.86	27.64	51.50	Ca2MgSi2O7
Al(OH)3(a)	-3.63	8.17	11.81	Al(OH)3
Al2O3	-6.64	16.34	22.98	Al2O3
Al4(OH)10SO4	-8.79	13.91	22.70	Al4(OH)10SO4
AlAsO4:2H2O	-11.69	-6.89	4.80	AlAsO4:2H2O
Albite	-7.09	-2.53	4.56	NaAlSi3O8
Albite(low)	-6.04	-2.53	3.51	NaAlSi3O8
AlOHSO4	-7.37	-10.60	-3.23	AlOHSO4
AlSb	-155.47	-89.84	65.62	AlSb
AlumK	-21.15	-26.70	-5.55	KAl(SO4)2:12H2O
Alunite	-8.81	-10.36	-1.55	KAl3(SO4)2(OH)6
Analcime	-5.68	2.24	7.92	NaAlSi2O6:H2O
Anglesite	-5.67	-13.57	-7.90	PbSO4
Anhydrite	-1.90	-6.34	-4.44	CaSO4
Anilite	-59.09	-93.26	-34.17	Cu0.25Cu1.5S
Annite	-14.13	12.62	26.75	KFe3AlSi3O10(OH)2
Anorthite	-9.91	19.24	29.15	CaAl2Si2O8
Antlerite	-11.47	-3.18	8.29	Cu3(OH)4SO4
Aragonite	-0.16	-8.40	-8.24	CaCO3
Arsenolite	-77.29	-80.85	-3.56	As4O6
Artinite	-7.34	3.77	11.11	MgCO3:Mg(OH)2:3H2O
As2O5	-37.10	-30.11	6.98	As2O5
Avicennite	-31.24	-47.57	-16.32	Tl2O3
Azurite	-10.40	-26.07	-15.67	Cu3(OH)2(CO3)2
B_UO2(OH)2	-4.97	1.29	6.27	UO2(OH)2
Ba3(AsO4)2	5.97	-3.08	-9.05	Ba3(AsO4)2
BaCrO4	-15.21	-25.22	-10.00	BaCrO4
Barite	0.54	-9.76	-10.31	BaSO4
BaSeO3	-11.06	-6.56	4.49	BaSeO3
BaSeO4	-13.94	-19.23	-5.29	BaSeO4
Bianchite	-8.83	-10.59	-1.76	ZnSO4:6H2O
Birnessite	-8.56	9.53	18.09	MnO2
Bixbyite	-7.31	-7.12	0.19	Mn2O3
BlaubleiI	-58.88	-83.04	-24.16	Cu0.9Cu0.2S

BlaubleiII	-60.48	-87.76	-27.28	Cu0.6Cu0.8S
Boehmite	-1.89	8.17	10.06	AlOOH
Brochantite	-13.32	2.02	15.34	Cu4(OH)6SO4
Brucite	-5.85	12.30	18.15	Mg(OH)2
Bunsenite	-7.54	6.17	13.71	NiO
Ca-Nontronite	17.92	-2.97	-20.89	Fe2Al.33Si3.67O10(OH)2Ca0.165
Ca-Olivine	-20.43	20.11	40.53	Ca2SiO4
Ca2V2O7	-4.75	5.01	9.75	CaVO3.5
Ca3(AsO4)2:6H2O	-15.10	7.20	22.30	Ca3(AsO4)2:6H2O
Ca3(VO4)2	-10.10	11.23	21.33	Ca1.5VO4
Ca3Sb2	-310.92	-158.72	152.20	Ca3Sb2
Ca3SiO5	-46.93	32.54	79.47	Ca3SiO5
Ca_Vanadate	-4.58	-1.21	3.36	Ca0.5VO3
CaCrO4	-19.87	-21.79	-1.93	CaCrO4
Calcite	0.00	-8.40	-8.40	CaCO3
Carnotite	-4.15	-3.46	0.69	KUO2VO4
CaSeO3:2H2O	-6.20	-3.14	3.06	CaSeO3:2H2O
CaSeO4:2H2O	-12.82	-15.81	-2.99	CaSeO4:2H2O
Cd(BO2)2	-14.90	-5.06	9.84	Cd(BO2)2
Cd(Gamma)	-35.10	-20.55	14.55	Cd
Cd(OH)2(A)	-9.19	5.63	14.82	Cd(OH)2
Cd(OH)2(C)	-8.02	5.63	13.65	Cd(OH)2
Cd3(OH)2(SO4)2	-27.36	-20.65	6.71	Cd3(OH)2(SO4)2
Cd3(OH)4SO4	-24.44	-1.88	22.56	Cd3(OH)4SO4
Cd4(OH)6SO4	-24.65	3.75	28.40	Cd4(OH)6SO4
CdMetal	-34.99	-20.55	14.44	Cd
CdSb	-78.62	-79.29	-0.68	CdSb
CdSe	-29.96	-48.99	-19.03	CdSe
CdSiO3	-9.07	0.86	9.94	CdSiO3
CdSO4	-13.82	-13.14	0.68	CdSO4
CdSO4:2.67H2O	-11.50	-13.14	-1.65	CdSO4:2.67H2O
CdSO4:H2O	-11.88	-13.14	-1.26	CdSO4:H2O
Celestite	-2.49	-8.93	-6.44	SrSO4
Cerrusite	-2.25	-15.63	-13.39	PbCO3
CH4(g)	-82.25	-125.56	-43.31	CH4
Chalcanthite	-10.86	-13.58	-2.72	CuSO4:5H2O
Chalcedony	-1.00	-4.77	-3.77	SiO2
Chalcocite	-59.97	-97.19	-37.22	Cu2S
Chalcopyrite	-125.64	-162.78	-37.14	CuFeS2
Chrysotile	-7.58	27.37	34.95	Mg3Si2O5(OH)4
Cinnabar	-52.79	-101.16	-48.37	HgS
Claudetite	-77.08	-80.85	-3.77	As4O6
Clausthalite	-26.73	-49.42	-22.69	PbSe
Clinoenstatite	-4.86	7.53	12.39	MgSiO3
CO2(g)	-2.65	-20.83	-18.19	CO2
Covellite	-57.17	-81.47	-24.30	CuS
Cr(OH)2	-22.44	-11.18	11.27	Cr(OH)2
Cr(OH)3(A)	0.05	-0.70	-0.75	Cr(OH)3
Cr(OH)3(C)	-2.77	-0.70	2.08	Cr(OH)3
Cr2O3	1.36	-1.39	-2.75	Cr2O3
Cristobalite	-0.89	-4.77	-3.88	SiO2
CrMetal	-71.41	-37.36	34.05	Cr
CrO3	-31.08	-34.23	-3.14	CrO3
Cu(OH)2	-4.25	5.20	9.44	Cu(OH)2
Cu(SbO3)2	-26.59	18.62	45.21	Cu(SbO3)2
Cu2Sb	-60.25	-98.07	-37.82	Cu2Sb
Cu2Se(alpha)	-26.35	-65.14	-38.79	Cu2Se
Cu2SO4	-27.58	-29.29	-1.71	Cu2SO4
Cu3(AsO4)2:6H2O	-20.62	-14.52	6.10	Cu3(AsO4)2:6H2O
Cu3Sb	-67.32	-113.79	-46.48	Cu3Sb
Cu3Se2	-46.78	-114.56	-67.78	Cu3Se2
CuCO3	-6.00	-15.63	-9.63	CuCO3
CuCrO4	-23.56	-29.03	-5.48	CuCrO4
CuMetal	-8.69	-18.35	-9.66	Cu
CuOCuSO4	-21.78	-8.38	13.40	CuO:CuSO4
CupricFerrite	7.06	14.98	7.92	CuFe2O4
Cuprite	-8.64	-10.52	-1.88	Cu2O

CuprousFerrite	8.35	-0.37	-8.72	CuFeO2
CuSe	-21.38	-49.42	-28.04	CuSe
CuSe2	-42.72	-77.86	-35.14	CuSe2
CuSeO3:2H2O	-11.32	-10.38	0.95	CuSeO3:2H2O
CuSO4	-17.54	-13.58	3.97	CuSO4
Diaspore	0.00	8.17	8.17	AlOOH
Diopside	-6.39	15.20	21.59	CaMgSi2O6
Dioptase	-6.54	0.43	6.97	CuSiO3:H2O
Djurleite	-59.71	-96.15	-36.44	Cu0.066Cu1.868S
Dolomite	-0.36	-16.93	-16.56	CaMg(CO3)2
Epsomite	-4.18	-6.47	-2.29	MgSO4:7H2O
Fe2(OH)4SeO3	-7.35	-5.79	1.55	Fe2(OH)4SeO3
Fe2(SeO3)3:2H2O	-16.31	-36.94	-20.63	Fe2(SeO3)3:2H2O
Fe2(SO4)3	-53.24	-46.54	6.70	Fe2(SO4)3
Fe3(OH)8	-5.08	15.14	20.22	Fe3(OH)8
Fe_Vanadate	-3.28	-4.75	-1.47	Fe0.5VO3
FeAsO4:2H2O	-10.57	-10.17	0.40	FeAsO4:2H2O
FeCr2O4	3.56	3.96	0.41	FeCr2O4
Ferrihydrite	-0.00	4.89	4.89	Fe(OH)3
Ferroselite	-58.51	-77.70	-19.19	FeSe2
FeS(ppt)	-77.40	-81.31	-3.92	FeS
FeSe	-42.09	-49.26	-7.17	FeSe
Forsterite	-11.02	19.84	30.85	Mg2SiO4
Galena	-65.32	-81.47	-16.15	PbS
Gehlenite	-26.49	36.45	62.94	Ca2Al2SiO7
Gibbsite(C)	-1.80	8.17	9.97	Al(OH)3
Goethite	3.63	4.89	1.26	FeOOH
Goslarite	-8.45	-10.59	-2.13	ZnSO4:7H2O
Greenalite	-14.27	6.54	20.81	Fe3Si2O5(OH)4
Greenockite	-64.25	-81.04	-16.79	CdS
Greigite	-286.51	-331.54	-45.03	Fe3S4
Gummite	-10.32	1.29	11.62	UO3
Gypsum	-1.71	-6.34	-4.62	CaSO4:2H2O
Halloysite	-4.28	6.80	11.09	Al2Si2O5(OH)4
Hausmannite	-17.09	48.68	65.76	Mn3O4
Hematite	12.16	9.78	-2.38	Fe2O3
Hercynite	-9.59	21.70	31.29	FeAl2O4
Hg(CH3)2(g)	-185.81	-265.61	-79.81	Hg(CH3)2
Hg(g)	-9.36	-17.51	-8.15	Hg
Hg(OH)2	-11.00	-14.49	-3.50	Hg(OH)2
Hg2(g)	-19.32	-35.01	-15.69	Hg2
Hg2(OH)2	-14.09	-8.83	5.26	Hg2(OH)2
Hg2CO3	-15.71	-29.66	-13.96	Hg2CO3
Hg2CrO4	-34.36	-43.06	-8.70	Hg2CrO4
Hg2S	-82.95	-95.50	-12.56	Hg2S
Hg2SeO3	-19.75	-24.40	-4.66	Hg2SeO3
Hg2SO4	-21.43	-27.60	-6.17	Hg2SO4
HgCO3	-5.48	-35.33	-29.85	HgCO3
HgMetal	-3.00	-17.51	-14.51	Hg
HgSeO3	-17.37	-30.07	-12.70	HgSeO3
HgSO4	-23.66	-33.27	-9.60	HgSO4
Huntite	-5.38	-33.99	-28.61	CaMg3(CO3)4
Hydcerrusite	-8.60	-26.06	-17.46	Pb(OH)2:2PbCO3
Hydromagnesite	-15.81	-21.82	-6.01	Mg5(CO3)4(OH)2:4H2O
Jarosite-H	-13.68	-22.88	-9.19	(H3O)Fe3(SO4)2(OH)6
Jarosite-K	-7.05	-20.20	-13.15	KFe3(SO4)2(OH)6
Jarosite-Na	-9.97	-19.27	-9.29	NaFe3(SO4)2(OH)6
K-Nontronite	11.41	-4.14	-15.55	Fe2Al.33Si3.67O10(OH)2K0.33
K2Cr2O7	-46.48	-63.11	-16.63	K2Cr2O7
K2CrO4	-28.66	-28.88	-0.22	K2CrO4
Kalsilite	-8.28	6.08	14.36	KAlSiO4
Kaolinite	-0.78	6.80	7.59	Al2Si2O5(OH)4
Langite	-16.86	2.02	18.88	Cu4(OH)6SO4:H2O
Larnakite	-8.43	-8.37	0.06	PbO:PbSO4
Larnite	-22.05	20.11	42.16	Ca2SiO4
Laumontite	-7.42	9.70	17.12	CaAl2Si4O12:4H2O
Leonhardite	-1.58	19.41	20.99	Ca2Al4Si8O24:7H2O

Lepidocrocite	3.52	4.89	1.37	FeOOH
Leucite	-6.28	1.31	7.59	KAlSi2O6
Li2CrO4	-36.60	-31.17	5.43	Li2CrO4
Lime	-22.80	12.44	35.24	CaO
Litharge	-8.38	5.20	13.58	PbO
Mackinawite	-76.66	-81.31	-4.65	FeS
Magadiite	-15.47	-29.77	-14.30	NaSi7O13(OH)3:3H2O
Maghemite	3.40	9.78	6.39	Fe2O3
Magnesite	-0.83	-8.53	-7.70	MgCO3
Magnetite	8.74	15.14	6.40	Fe3O4
Malachite	-6.08	-10.44	-4.36	Cu2(OH)2CO3
Manganite	-3.32	-3.56	-0.24	MnOOH
Massicot	-8.59	5.20	13.79	PbO
Melanterite	-10.79	-13.42	-2.62	FeSO4:7H2O
Merwinite	-34.11	40.08	74.19	Ca3MgSi2O8
Metacinnabar	-53.21	-101.16	-47.96	HgS
Mg-Ferrite	1.81	22.08	20.28	MgFe2O4
Mg-Nontronite	17.60	-2.99	-20.59	Fe2Al.33Si3.67O10(OH)2Mg0.165
Mg2Sb3	-278.67	-203.98	74.68	Mg2Sb3
Mg2V2O7	-9.92	4.87	14.79	MgVO3.5
Mg_Vanadate	-7.78	-1.28	6.50	Mg0.5VO3
MgCr2O4	-3.27	10.91	14.18	MgCr2O4
MgCrO4	-28.43	-21.93	6.50	MgCrO4
MgSeO3:6H2O	-7.24	-3.27	3.97	MgSeO3:6H2O
Microcline	-4.72	-3.46	1.26	KAlSi3O8
Millerite	-72.33	-80.51	-8.17	NiS
Minium	-37.32	41.78	79.11	Pb3O4
Mirabilite	-9.44	-11.56	-2.11	Na2SO4:10H2O
Mn2(SO4)3	-59.79	-63.44	-3.65	Mn2(SO4)3
Mn2Sb	-157.19	-96.11	61.08	Mn2Sb
Mn3(AsO4)2:8H2O	-20.12	-7.62	12.50	Mn3(AsO4)2:8H2O
Mn_Vanadate	-6.71	-3.68	3.03	Mn0.5VO3
MnS(Green)	-83.28	-79.17	4.11	MnS
MnSb	-98.40	-101.57	-3.18	MnSb
MnSe	-53.18	-47.12	6.06	MnSe
MnSeO3	-9.29	-8.08	1.21	MnSeO3
MnSeO3:2H2O	-8.95	-8.08	0.88	MnSeO3:2H2O
MnSO4	-14.76	-11.28	3.48	MnSO4
Monteponite	-10.79	5.63	16.42	CdO
Monticellite	-12.91	19.97	32.88	CaMgSiO4
Montmorillonite	0.18	2.85	2.67	Mg0.485Fe.22Al1.71Si3.81O10(OH)2
Montroydite	-10.57	-14.49	-3.92	HgO
Morenosite	-10.09	-12.61	-2.51	NiSO4:7H2O
Muscovite	-3.23	12.88	16.12	KAl3Si3O10(OH)2
Na-Nontronite	10.67	-3.83	-14.50	Fe2Al.33Si3.67O10(OH)2Na0.33
Na2Cr2O7	-51.07	-61.24	-10.17	Na2Cr2O7
Na2CrO4	-30.52	-27.01	3.50	Na2CrO4
Na3Sb	-187.04	-87.19	99.85	Na3Sb
Na3VO4	-35.89	3.39	39.28	Na3VO4
Na4V2O7	-20.18	-0.22	19.97	Na2VO3.5
Na_Vanadate	-7.90	-3.82	4.08	NaVO3
NaSb	-92.58	-68.22	24.36	NaSb
Natron	-11.48	-13.62	-2.14	Na2CO3:10H2O
Nepheline	-8.96	7.01	15.97	NaAlSiO4
Nesquehonite	-3.22	-8.53	-5.32	MgCO3:3H2O
Ni(OH)2	-3.03	6.17	9.20	Ni(OH)2
Ni2SiO4	-8.74	7.56	16.30	Ni2SiO4
Ni3(AsO4)2:8H2O	-27.32	-11.62	15.70	Ni3(AsO4)2:8H2O
Ni4(OH)6SO4	-26.11	5.89	32.00	Ni4(OH)6SO4
NiCO3	-8.35	-14.67	-6.32	NiCO3
NiSb	-59.02	-78.76	-19.73	NiSb
NiSe	-30.71	-48.45	-17.74	NiSe
NiSeO3:2H2O	-12.61	-9.41	3.21	NiSeO3:2H2O
Nsutite	-7.97	9.53	17.50	MnO2
O2(g)	-37.81	52.36	90.17	O2
Oripment	-235.10	-300.44	-65.34	As2S3
Otavite	-1.49	-15.20	-13.71	CdCO3

P-Wollstanite	-7.29	7.67	14.96	CaSiO3
Pb(BO2)2	-13.40	-5.49	7.92	Pb(BO2)2
Pb(OH)2(C)	-3.69	5.20	8.89	Pb(OH)2
Pb2O(OH)2	-15.80	10.40	26.20	Pb2O(OH)2
Pb2O3	-24.46	36.58	61.04	Pb2O3
Pb2OCO3	-10.54	-10.43	0.10	Pb2OCO3
Pb2SiO4	-15.50	5.63	21.13	Pb2SiO4
Pb2V2O7	-1.45	-2.23	-0.78	PbVO3.5
Pb3(AsO4)2	-20.31	-14.51	5.80	Pb3(AsO4)2
Pb3(VO4)2	-3.16	0.37	3.53	Pb1.5VO4
Pb3O2CO3	-17.64	-5.23	12.41	Pb3O2CO3
Pb3O2SO4	-14.67	-3.17	11.49	Pb3O2SO4
Pb4(OH)6SO4	-19.07	2.03	21.10	Pb4(OH)6SO4
Pb4O3SO4	-21.92	2.03	23.95	Pb4O3SO4
PbCrO4	-14.80	-29.03	-14.22	PbCrO4
PbMetal	-25.23	-20.98	4.25	Pb
PbO:0.3H2O	-7.78	5.20	12.98	PbO:0.33H2O
PbSeO4	-16.01	-23.05	-7.04	PbSeO4
PbSiO3	-7.38	0.43	7.81	PbSiO3
Periclase	-11.11	12.30	23.41	MgO
Phlogopite	-37.40	33.45	70.85	KMg3AlSi3O10(OH)2
Plattnerite	-21.65	31.38	53.03	PbO2
Portlandite	-11.86	12.44	24.29	Ca(OH)2
Pyrite	-122.73	-141.80	-19.07	FeS2
Pyrocroite	-8.78	7.50	16.28	Mn(OH)2
Pyrolusite	-7.87	9.53	17.40	MnO2
Pyrophyllite	-1.14	-2.73	-1.60	Al2Si4O10(OH)2
Quartz	-0.44	-4.77	-4.33	SiO2
Realgar	-98.62	-119.97	-21.36	AsS
Retgersite	-10.51	-12.61	-2.10	NiSO4:6H2O
Rhodochrosite	-3.03	-13.34	-10.30	MnCO3
Rutherfordine	-5.09	-19.54	-14.45	UO2CO3
Sanidine(H)	-5.27	-3.46	1.81	KAlSi3O8
Sb	-45.98	-58.74	-12.76	Sb
Sb(OH)3(s)	-11.98	-19.47	-7.49	Sb(OH)3
Sb2O3	-30.22	-38.94	-8.72	Sb2O3
Sb2O4	-17.07	-12.76	4.32	Sb2O4
Sb2O5	-25.65	-38.13	-12.48	Sb2O5
Sb2Se3	-130.72	-202.79	-72.08	Sb2Se3
Sb4O6I	-60.37	-77.87	-17.51	Sb4O6
Sb4O6II	-57.45	-77.87	-20.43	Sb4O6
SbO2	-4.33	-32.16	-27.82	SbO2
Schoepite	-4.75	1.29	6.04	UO2(OH)2:H2O
Se(A)	-21.19	-28.44	-7.25	Se
Se(hex)	-20.54	-28.44	-7.90	Se
SeO2	-15.68	-15.57	0.11	SeO2
SeO3	-51.13	-28.25	22.89	SeO3
Sepiolite(a)	-8.48	10.30	18.78	Mg2Si3O7.5OH:3H2O
Sepiolite(c)	-7.05	10.30	17.35	Mg2Si3O7.5OH:3H2O
Siderite	-5.21	-15.47	-10.27	FeCO3
SiO2(a)	-1.52	-4.77	-3.25	SiO2
SiO2(am)	-1.85	-4.77	-2.92	SiO2
Smithsonite	-2.88	-12.65	-9.77	ZnCO3
Sphalerite	-66.43	-78.49	-12.05	ZnS
Spinel	-12.38	28.64	41.03	MgAl2O4
SrCrO4	-19.67	-24.39	-4.72	SrCrO4
SrSeO3	-5.84	-5.73	0.10	SrSeO3
SrSeO4	-11.39	-18.40	-7.02	SrSeO4
Stibnite	-235.14	-298.95	-63.81	Sb2S3
Strontianite	-1.78	-10.99	-9.21	SrCO3
Sulfur	-58.60	-60.49	-1.89	S
Talc	-7.07	17.83	24.90	Mg3Si4O10(OH)2
Tenorite	-3.22	5.20	8.42	CuO
Thenardite	-11.41	-11.56	-0.15	Na2SO4
Thermonatrite	-13.89	-13.62	0.27	Na2CO3:H2O
Tl(OH)3	-17.33	-23.78	-6.45	Tl(OH)3
Tl2CO3	-20.46	-24.73	-4.27	Tl2CO3

```
      Tl2CrO4         -24.78  -38.12  -13.35  Tl2CrO4
      Tl2O            -32.21   -3.89   28.31  Tl2O
      Tl2S            -82.25  -90.57   -8.32  Tl2S
      Tl2Se           -50.76  -58.51   -7.76  Tl2Se
      Tl2SeO4         -27.61  -32.14   -4.53  Tl2SeO4
      Tl2SO4          -18.56  -22.67   -4.11  Tl2SO4
      TlMetal         -20.64  -15.04    5.61  Tl
      TlOH            -15.39   -1.95   13.45  TlOH
      Tremolite       -13.40   48.24   61.64  Ca2Mg5Si8O22(OH)2
      Tyuyamunite      -2.92    0.08    3.00  Ca0.5UO2VO4
      U3O8(C)         -16.43   10.79   27.22  U3O8
      U3Sb4          -598.38 -433.63  164.75  U3Sb4
      U4O9(C)         -31.20  -29.25    1.95  U4O9
      UO2(am)         -16.17  -13.86    2.32  UO2
      UO3(C)           -7.44    1.29    8.74  UO3
      Uraninite       -10.14  -13.86   -3.72  UO2
      Uranophane      -12.01    5.48   17.49  Ca(UO2)2(SiO3OH)2
      USb2           -225.56 -194.73   30.83  USb2
      USiO4(C)        -11.77  -18.63   -6.85  USiO4
      V(OH)3          -16.32   -8.67    7.65  V(OH)3
      V2O3            -14.61   -8.67    5.94  VO1.5
      V2O4             -7.06   -2.05    5.01  VO2
      V2O5             -6.93   -7.43   -0.50  VO2.5
      V3O5            -35.43  -32.32    3.11  V3O5
      V4O7            -43.57  -34.37    9.20  V4O7
      V6O13           -32.67  -96.95  -64.28  V6O13
      VMetal          -93.61  -47.94   45.67  V
      VO              -36.32  -21.76   14.56  VO
      VO(OH)2          -7.90   -2.05    5.85  VO(OH)2
      VOSO4(C)        -25.48  -20.82    4.66  VOSO4
      Wairakite       -12.49    9.70   22.20  CaAl2Si4O12:2H2O
      Willemite        -5.49   11.60   17.09  Zn2SiO4
      Witherite        -3.22  -11.82   -8.60  BaCO3
      Wollastonite     -6.36    7.67   14.02  CaSiO3
      Wurtzite        -68.54  -78.49   -9.95  ZnS
      Zincite          -4.11    8.19   12.29  ZnO
      Zincosite       -14.61  -10.59    4.02  ZnSO4
      Zn(BO2)2        -10.79   -2.50    8.29  Zn(BO2)2
      Zn(OH)2(A)       -4.26    8.19   12.45  Zn(OH)2
      Zn(OH)2(B)       -3.56    8.19   11.75  Zn(OH)2
      Zn(OH)2(C)       -4.01    8.19   12.20  Zn(OH)2
      Zn(OH)2(E)       -3.31    8.19   11.50  Zn(OH)2
      Zn(OH)2(G)       -3.52    8.19   11.71  Zn(OH)2
      Zn2(OH)2SO4      -9.90   -2.40    7.50  Zn2(OH)2SO4
      Zn3(AsO4)2:2.5H2O -19.21   -5.56   13.65  Zn3(AsO4)2:2.5H2O
      Zn3O(SO4)2      -35.28  -12.99   22.29  Zn3O(SO4)2
      Zn4(OH)6SO4     -14.43   13.97   28.40  Zn4(OH)6SO4
      ZnCO3:H2O        -2.39  -12.65  -10.26  ZnCO3:H2O
      ZnMetal         -45.69  -18.00   27.70  Zn
      ZnO(Active)      -3.12    8.19   11.31  ZnO
      ZnS(A)          -69.24  -78.49   -9.25  ZnS
      ZnSb            -88.44  -76.74   11.71  ZnSb
      ZnSe            -34.73  -46.43  -11.70  ZnSe
      ZnSiO3           -0.48    3.42    3.89  ZnSiO3
      ZnSO4:H2O       -10.58  -10.59   -0.01  ZnSO4:H2O

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End of simulation.
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Reading input data for simulation 2.
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End of run.
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APPENDIX C

GWB Output (Surface Complexation and Sorption)

full suite results

```
Step #     0              Xi = 0.0000
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  7.700
Eh =   0.8083 volts      pe =  14.6460
Ionic strength      =    0.008247
Activity of water   =    0.999880
Solvent mass        =    1.000000 kg
Solution mass       =    1.000383 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         383 mg/kg sol'n
Rock mass           =    0.010000 kg
HFO sorbing surface:
  Surface charge    =        9.13 uC/cm2
  Surface potential =       -10.0 mV
  Surface area      =   3.00e+007 cm2
```

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.8083	14.6460

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
H+	-- sliding pH buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Dummy	0.05618	-1.250	5.000	
Ferrihydrite	0.04679	-1.330	5.000	
(total)			10.00	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.003088	188.4	0.9120	-2.5503
Ca++	0.001604	64.28	0.6919	-2.9546
Mg++	0.001076	26.16	0.6919	-3.1280
SO4--	0.0006215	59.68	0.6919	-3.3665
H2CO3* (aq)	0.0001843	11.42	1.0019	-3.7337
O2(aq)	0.0001563	4.998	1.0019	-3.8053
Na+	9.530e-005	2.190	0.9120	-4.0609
CaSO4 (aq)	8.885e-005	12.09	1.0019	-4.0505
MgSO4 (aq)	4.916e-005	5.915	1.0019	-4.3076
CaHCO3+	2.712e-005	2.741	0.9120	-4.6067
MgHCO3+	2.414e-005	2.059	0.9120	-4.6572
H4SiO4	1.765e-005	1.696	1.0019	-4.7525
K+	1.021e-005	0.3990	0.9120	-5.0310
CO3--	5.689e-006	0.3413	0.6919	-5.4049
Sr++	3.220e-006	0.2821	0.6919	-5.6520
MgCO3 (aq)	2.054e-006	0.1731	1.0019	-5.6866
CaCO3 (aq)	1.082e-006	0.1082	1.0019	-5.9651
Ba++	5.545e-007	0.07612	0.6919	-6.4160
Al(OH)4-	2.451e-007	0.02328	0.9120	-6.6506
NaSO4-	2.188e-007	0.02604	0.9120	-6.7000
NaHCO3 (aq)	1.657e-007	0.01391	1.0019	-6.7799
SrSO4 (aq)	1.513e-007	0.02778	1.0019	-6.8193
Zn++	1.194e-007	0.007801	0.6919	-7.0830
OH-	1.096e-007	0.001864	0.9120	-7.0001
SrHCO3+	4.910e-008	0.007295	0.9120	-7.3489
H3SiO4-	3.664e-008	0.003483	0.9120	-7.4761
BaSO4 (aq)	2.221e-008	0.005183	1.0019	-7.6525

H+	2.188e-008	2.204e-005	0.9120	-7.7000
KSO4-	2.122e-008	0.002867	0.9120	-7.7132
ZnCO3 (aq)	1.868e-008	0.002341	1.0019	-7.7278
Ca2UO2(CO3)3 (aq	1.787e-008	0.009469	1.0019	-7.7471
Mn++	1.501e-008	0.0008245	0.6919	-7.9834
MoO4--	1.473e-008	0.002355	0.6919	-7.9917
Ni++	1.301e-008	0.0007636	0.6919	-8.0456
NaCO3-	1.261e-008	0.001046	0.9120	-7.9394
Mg2CO3++	1.228e-008	0.001333	0.6919	-8.0709
Al(OH)3 (aq)	1.102e-008	0.0008590	1.0019	-7.9571
MgOH+	1.050e-008	0.0004338	0.9120	-8.0187

(only species > 1e-8 molal listed)

Surface species	molality	moles	Boltzman fct.	log molality
>(w)FeOMg+	0.002771	0.002771	0.67760	-2.5573
>(w)FeOH	0.002003	0.002003	1.0000	-2.6984
>(w)FeOH2+	0.001150	0.001150	0.67760	-2.9393
>(w)FeCO3H	0.0007359	0.0007359	1.0000	-3.1332
>(w)FeOSiO(OH)2-	0.0007247	0.0007247	1.4758	-3.1398
>(w)FeOSi(OH)3	0.0006748	0.0006748	1.0000	-3.1708
>(w)FeCO3-	0.0006424	0.0006424	1.4758	-3.1922
>(w)FeOCa+	0.0002323	0.0002323	0.67760	-3.6339
>(s)FeOPb+	0.0001809	0.0001809	0.67760	-3.7426
>(w)FeOCu+	0.0001081	0.0001081	0.67760	-3.9662
>(w)FeOSiO2OH--	8.340e-005	8.340e-005	2.1780	-4.0789
>(w)FeO-	7.991e-005	7.991e-005	1.4758	-4.0974
>(w)FeOPb+	7.402e-005	7.402e-005	0.67760	-4.1306
>(s)FeOHCa++	4.933e-005	4.933e-005	0.45914	-4.3068
>(w)FeAsO4--	3.498e-005	3.498e-005	2.1780	-4.4562
>(w)FeOHAsO4---	3.124e-005	3.124e-005	3.2143	-4.5053
>(w)FeONi+	4.217e-006	4.217e-006	0.67760	-5.3749
>(w)FeOHSO4--	2.438e-006	2.438e-006	2.1780	-5.6129
>(s)FeOCu+	2.301e-006	2.301e-006	0.67760	-5.6382
>(w)FeHAsO4-	2.253e-006	2.253e-006	1.4758	-5.6472
>(w)ZnOH2+	1.358e-006	1.358e-006	0.67760	-5.8672
>(w)FeSO4-	7.017e-007	7.017e-007	1.4758	-6.1538
>(w)FeOMn+	4.867e-007	4.867e-007	0.67760	-6.3128
>(s)FeONi+	3.413e-007	3.413e-007	0.67760	-6.4669
>(s)FeOH	2.186e-007	2.186e-007	1.0000	-6.6603
>(s)ZnOH2+	1.415e-007	1.415e-007	0.67760	-6.8492
>(s)FeOH2+	1.255e-007	1.255e-007	0.67760	-6.9013
>(s)FeOHSr++	1.086e-007	1.086e-007	0.45914	-6.9643
>(w)FeOSr+	8.682e-008	8.682e-008	0.67760	-7.0614
>(s)FeCO3H	8.033e-008	8.033e-008	1.0000	-7.0951
>(s)FeOSiO(OH)2-	7.911e-008	7.911e-008	1.4758	-7.1018
>(s)FeOSi(OH)3	7.367e-008	7.367e-008	1.0000	-7.1327
>(s)FeCO3-	7.012e-008	7.012e-008	1.4758	-7.1541
>(s)FeOMn+	6.688e-008	6.688e-008	0.67760	-7.1747
>(s)FeOHBa++	5.269e-008	5.269e-008	0.45914	-7.2783
>(w)FeOCd+	4.950e-008	4.950e-008	0.67760	-7.3054
>(w)FeOHMoO4--	1.294e-008	1.294e-008	2.1780	-7.8881
>(s)FeOCd+	1.267e-008	1.267e-008	0.67760	-7.8973
>(w)FeH2AsO4	9.158e-009	9.158e-009	1.0000	-8.0382
>(s)FeOSiO2OH--	9.103e-009	9.103e-009	2.1780	-8.0408
>(s)FeO-	8.723e-009	8.723e-009	1.4758	-8.0593
>(w)FeOMo(OH)5	7.411e-009	7.411e-009	1.0000	-8.1301
>(s)FeAsO4--	3.818e-009	3.818e-009	2.1780	-8.4182
>(w)FeOBa+	3.586e-009	3.586e-009	0.67760	-8.4454
>(s)FeOHAsO4---	3.410e-009	3.410e-009	3.2143	-8.4672
>(w)HgOH2+	4.661e-010	4.661e-010	0.67760	-9.3315
>(s)FeOHSO4--	2.662e-010	2.662e-010	2.1780	-9.5748
>(s)FeHAsO4-	2.460e-010	2.460e-010	1.4758	-9.6091

>(s)FeSO4-	7.660e-011	7.660e-011	1.4758	-10.1158
>(w)FeOHSbO(OH4	5.518e-011	5.518e-011	1.4758	-10.2582
>(w)FeOHSeO4--	3.652e-011	3.652e-011	2.1780	-10.4375
>(w)FeSbO(OH)4	2.046e-011	2.046e-011	1.0000	-10.6891
>(w)FeSeO4-	9.153e-012	9.153e-012	1.4758	-11.0384
>(w)FeOBaOH	4.848e-012	4.848e-012	1.0000	-11.3144
>(s)FeOHMoO4--	1.412e-012	1.412e-012	2.1780	-11.8501
>(s)HgOH2+	1.039e-012	1.039e-012	0.67760	-11.9834
>(s)FeH2AsO4	9.997e-013	9.997e-013	1.0000	-12.0001
>(s)FeOMo(OH)5	8.090e-013	8.090e-013	1.0000	-12.0920
>(s)FeOHSbO(OH4	6.024e-015	6.024e-015	1.4758	-14.2201
>(s)FeOHSeO4--	3.986e-015	3.986e-015	2.1780	-14.3995
>(s)FeSbO(OH)4	2.233e-015	2.233e-015	1.0000	-14.6511
>(s)FeSeO4-	9.991e-016	9.991e-016	1.4758	-15.0004
>(w)FeOHSeO3--	4.821e-021	4.821e-021	2.1780	-20.3169
>(w)FeSeO3-	4.701e-021	4.701e-021	1.4758	-20.3278
>(s)FeOHSeO3--	5.262e-025	5.262e-025	2.1780	-24.2788
>(s)FeSeO3-	5.132e-025	5.132e-025	1.4758	-24.2897

(Boltzman factor = exp(zF PSI/RT), where PSI is surface potential)

Mineral saturation states

	log Q/K		log Q/K
Hematite	8.7228s/sat	Vaterite	-0.5885
Nsutite	7.8966s/sat	Magnesite	-0.8209
Birnessite	7.3096s/sat	Cuprous Ferrite	-0.8981
Pyrolusite	7.3020s/sat	Dolomite (disord	-0.9369
Cupric Ferrite	5.9565s/sat	Chalcedony	-0.9542
Bixbyite	5.1852s/sat	Al2O3	-1.0003
Manganite	4.4225s/sat	Cristobalite	-1.1503
Goethite	3.2107s/sat	Al(OH)3 (am)	-1.2435
Kaolinite	3.1055s/sat	CaCO3xH2O	-1.2936
Lepidocrocite	3.0939s/sat	PbMoO4	-1.2936
Diaspore	2.7837s/sat	Cerrusite	-1.4939
Maghemite	2.5438s/sat	Smithsonite	-1.6357
Al4(OH)10SO4	2.3528s/sat	ZnCO3	-1.6878
Gibbsite (C)	1.8921s/sat	Gypsum	-1.6986
Ferrihydrite (ag	1.7748s/sat	Strontianite	-1.7995
Imogolite	1.7183s/sat	SiO2 (am,ppt)	-1.8216
Al(OH)3 (Soil)	1.3421s/sat	SiO2 (am,gel)	-1.8660
Boehmite	0.8942s/sat	Anhydrite	-2.0518
Magnesioferrite	0.8283s/sat	ZnCO3:1H2O	-2.2279
Hausmannite	0.6080s/sat	Celestite	-2.3733
Halloysite	0.5444s/sat	Rhodochrosite	-2.4119
Barite	0.4872s/sat	Zn-Al LDH	-2.6437
Calcite	0.0347s/sat	BaHAsO4:H2O	-2.6960
Dummy	0.0000 sat	NiCO3	-2.7744
Ferrihydrite	0.0000 sat	Tenorite(c)	-2.7945
Aragonite	-0.1245	Plattnerite	-2.8418
Dolomite (ordere	-0.2999	Otavite	-2.8853
Quartz	-0.4707	MnCO3 (am)	-2.8883

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
O2 (g)	0.1239	-0.907
CO2 (g)	0.002872	-2.542
Hg (g)	4.731e-025	-24.325
Hg2 (g)	5.427e-050	-49.265
H2Se (g)	1.261e-114	-113.899
H2S (g)	7.818e-156	-155.107
CH4 (g)	5.147e-156	-155.288
Hg(CH3)2 (g)	0.0000	-300.000

full suite results

Original basis	total moles	In fluid moles	In fluid mg/kg	Sorbed moles	Sorbed mg/kg	Kd L/kg
>(s)FeOH	0.000234					
>(w)FeOH	0.00936					
Al+++	2.59e-007	2.59e-007	0.00700			
AsO4---	6.85e-005	2.16e-009	0.000300	6.85e-005	9.51	
Ba++	6.39e-007	5.82e-007	0.0800	5.63e-008	0.00773	
CO3--	0.00471	0.00333	200.	0.00138	82.7	
Ca++	0.00200	0.00172	69.0	0.000282	11.3	
Cd++	6.26e-008	4.45e-010	5.00e-005	6.22e-008	0.00699	
Cu++	0.000110	4.72e-009	0.000300	0.000110	7.01	
Fe+++	0.0468	3.84e-010	2.14e-005	-1.50e-006	-0.0837	
H+	-0.138	0.00351	3.53	-0.00104	-1.05	
H2O	55.6	55.5	1.00e+006	-0.00293	-52.8	
H4SiO4	0.00150	1.77e-005	1.70	0.00148	142.	
Hg(OH)2	6.38e-010	1.70e-010	4.00e-005	4.67e-010	0.000110	
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00392	0.00115	28.0	0.00277	67.3	
Mn+++	5.72e-007	1.82e-008	0.00100	5.54e-007	0.0304	
MoO4--	4.54e-008	2.50e-008	0.00400	2.04e-008	0.00325	
Na+	9.57e-005	9.57e-005	2.20			
Ni++	4.58e-006	1.70e-008	0.00100	4.56e-006	0.268	
O2(aq)	0.000156	0.000156	5.00	-1.38e-007	-0.00443	
Pb++	0.000255	4.34e-009	0.000900	0.000255	52.8	
SO4--	0.000763	0.000760	73.0	3.14e-006	0.302	
Sb(OH)6-	2.31e-009	2.23e-009	0.000500	7.56e-011	1.69e-005	
SeO4--	9.84e-009	9.79e-009	0.00140	4.57e-011	6.53e-006	
Sr++	3.62e-006	3.42e-006	0.300	1.95e-007	0.0171	
UO2++	1.85e-008	1.85e-008	0.00500			
Zn++	1.65e-006	1.53e-007	0.0100	1.50e-006	0.0980	
dummy	0.0562	0.000	0.000			

Sorbed	fraction	log fraction
AsO4---	1.000	-0.000
Ba++	0.08811	-1.055
CO3--	0.2926	-0.534
Ca++	0.1406	-0.852
Cd++	0.9929	-0.003
Cu++	1.000	-0.000
Fe+++	1.000	0.000
H4SiO4	0.9882	-0.005
Hg(OH)2	0.7326	-0.135
Mg++	0.7064	-0.151
Mn+++	0.9682	-0.014
MoO4--	0.4487	-0.348
Ni++	0.9963	-0.002
Pb++	1.000	-0.000
SO4--	0.004115	-2.386
Sb(OH)6-	0.03275	-1.485
SeO4--	0.004642	-2.333
Sr++	0.05399	-1.268
Zn++	0.9074	-0.042

Elemental composition	total moles	In fluid moles	In fluid mg/kg	Sorbed moles	Sorbed mg/kg
Al	2.594e-007	2.594e-007	0.006997		
As	6.849e-005	2.160e-009	0.0001617	6.849e-005	5.129
Ba	6.388e-007	5.825e-007	0.07997	5.628e-008	0.007726
C	0.004711	0.003333	40.02	0.001378	16.55

full suite results

Ca	0.002003	0.001722	68.97	0.0002816	11.28
Cd	6.262e-008	4.448e-010	4.998e-005	6.217e-008	0.006985
Cu	0.0001104	4.721e-009	0.0002999	0.0001104	7.012
Du	0.05618	0.0000	0.0000		
Fe	0.04678	3.838e-010	2.143e-005	-1.500e-006	-0.08372
H	111.2	111.0	1.119e+005	-0.0009699	-0.9772
Hg	6.377e-010	1.705e-010	3.419e-005	4.672e-010	9.368e-005
K	1.023e-005	1.023e-005	0.3998		
Mg	0.003923	0.001152	27.99	0.002771	67.35
Mn	5.718e-007	1.820e-008	0.0009996	5.536e-007	0.03040
Mo	4.536e-008	2.501e-008	0.002399	2.035e-008	0.001952
Na	9.569e-005	9.569e-005	2.199		
Ni	4.576e-006	1.703e-008	0.0009996	4.559e-006	0.2675
O	55.67	55.52	8.880e+005	0.007422	118.7
Pb	0.0002549	4.344e-009	0.0008997	0.0002549	52.80
S	0.0007631	0.0007599	24.36	3.140e-006	0.1007
Sb	2.310e-009	2.234e-009	0.0002719	7.565e-011	9.207e-006
Se	9.839e-009	9.793e-009	0.0007730	4.567e-011	3.605e-006
Si	0.001501	1.769e-005	0.4966	0.001483	41.64
Sr	3.619e-006	3.424e-006	0.2999	1.954e-007	0.01711
U	1.852e-008	1.852e-008	0.004406		
Zn	1.652e-006	1.530e-007	0.009996	1.499e-006	0.09796

♀

```
Step #     0            Xi = 0.0000
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  7.700
Eh =   0.8083 volts      pe =  14.6459
Ionic strength      =    0.008005
Activity of water   =    0.999883
Solvent mass        =    1.000000 kg
Solution mass       =    1.000373 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         373 mg/kg sol'n
Rock mass           =    0.010011 kg
HFO sorbing surface:
  Surface charge    =        9.18 uC/cm2
  Surface potential =       -10.0 mV
  Surface area      =   3.00e+007 cm2
```

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.8083	14.6459

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
H+	-- sliding pH buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.331e-007	-6.363	0.0001011	
Bixbyite	2.851e-007	-6.545	4.502e-005	
Calcite	0.0001110	-3.955	0.01111	
Diaspore	2.590e-007	-6.587	1.554e-005	
Dummy	0.05618	-1.250	5.000	
Ferrihydrite	0.04679	-1.330	5.000	
(total)			10.01	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.

HCO3-	0.003008	183.5	0.9131	-2.5611
Ca++	0.001511	60.55	0.6953	-2.9785
Mg++	0.001067	25.92	0.6953	-3.1298
SO4--	0.0006246	59.98	0.6953	-3.3622
H2CO3* (aq)	0.0001797	11.14	1.0018	-3.7446
O2(aq)	0.0001561	4.994	1.0018	-3.8058
Na+	9.530e-005	2.190	0.9131	-4.0604
CaSO4 (aq)	8.494e-005	11.56	1.0018	-4.0701
MgSO4 (aq)	4.944e-005	5.949	1.0018	-4.3051
CaHCO3+	2.501e-005	2.527	0.9131	-4.6414
MgHCO3+	2.342e-005	1.998	0.9131	-4.6699
H4SiO4	1.751e-005	1.683	1.0018	-4.7559
K+	1.021e-005	0.3990	0.9131	-5.0305
CO3--	5.522e-006	0.3313	0.6953	-5.4157
Sr++	3.215e-006	0.2816	0.6953	-5.6507
MgCO3 (aq)	1.995e-006	0.1681	1.0018	-5.6993
CaCO3 (aq)	9.986e-007	0.09991	1.0018	-5.9998
NaSO4-	2.209e-007	0.02629	0.9131	-6.6952
Ba++	1.779e-007	0.02443	0.6953	-6.9075
NaHCO3 (aq)	1.618e-007	0.01359	1.0018	-6.7902
SrSO4 (aq)	1.533e-007	0.02815	1.0018	-6.8137
Zn++	1.178e-007	0.007699	0.6953	-7.0866
OH-	1.095e-007	0.001861	0.9131	-7.0001
SrHCO3+	4.798e-008	0.007128	0.9131	-7.3584
H3SiO4-	3.631e-008	0.003452	0.9131	-7.4794
H+	2.185e-008	2.201e-005	0.9131	-7.7000
KSO4-	2.143e-008	0.002896	0.9131	-7.7084
ZnCO3 (aq)	1.806e-008	0.002264	1.0018	-7.7424
Ca2UO2(CO3)3 (aq	1.781e-008	0.009439	1.0018	-7.7486
MoO4--	1.470e-008	0.002350	0.6953	-7.9905
Ni++	1.283e-008	0.0007527	0.6953	-8.0497
NaCO3-	1.229e-008	0.001020	0.9131	-7.9497
Mg2CO3++	1.182e-008	0.001283	0.6953	-8.0854
MgOH+	1.045e-008	0.0004314	0.9131	-8.0205

(only species > 1e-8 molal listed)

Surface species	molality	moles	Boltzman fct.	log molality
>(w)FeOMg+	0.002781	0.002781	0.67760	-2.5557
>(w)FeOH	0.002019	0.002019	1.0000	-2.6950
>(w)FeOH2+	0.001159	0.001159	0.67760	-2.9359
>(w)FeOSiO(OH)2-	0.0007248	0.0007248	1.4758	-3.1398
>(w)FeCO3H	0.0007234	0.0007234	1.0000	-3.1406
>(w)FeOSi(OH)3	0.0006749	0.0006749	1.0000	-3.1708
>(w)FeCO3-	0.0006315	0.0006315	1.4758	-3.1997
>(w)FeOCa+	0.0002216	0.0002216	0.67760	-3.6544
>(s)FeOPb+	0.0001821	0.0001821	0.67760	-3.7397
>(w)FeOCu+	0.0001080	0.0001080	0.67760	-3.9664
>(w)FeOSiO2OH--	8.340e-005	8.340e-005	2.1780	-4.0788
>(w)FeO-	8.054e-005	8.054e-005	1.4758	-4.0940
>(w)FeOPb+	7.283e-005	7.283e-005	0.67760	-4.1377
>(s)FeOHCa++	4.816e-005	4.816e-005	0.45914	-4.3173
>(w)FeAsO4--	3.498e-005	3.498e-005	2.1780	-4.4562
>(w)FeOHAsO4---	3.124e-005	3.124e-005	3.2143	-4.5053
>(w)FeONi+	4.210e-006	4.210e-006	0.67760	-5.3757
>(w)FeOHSO4--	2.482e-006	2.482e-006	2.1780	-5.6052
>(s)FeOCu+	2.353e-006	2.353e-006	0.67760	-5.6284
>(w)FeHAsO4-	2.253e-006	2.253e-006	1.4758	-5.6472
>(w)ZnOH2+	1.357e-006	1.357e-006	0.67760	-5.8675
>(w)FeSO4-	7.143e-007	7.143e-007	1.4758	-6.1461
>(s)FeONi+	3.486e-007	3.486e-007	0.67760	-6.4577
>(s)FeOH	2.255e-007	2.255e-007	1.0000	-6.6469
>(s)ZnOH2+	1.447e-007	1.447e-007	0.67760	-6.8395

>(s)FeOH2+	1.294e-007	1.294e-007	0.67760	-6.8879
>(s)FeOHSr++	1.123e-007	1.123e-007	0.45914	-6.9496
>(w)FeOSr+	8.778e-008	8.778e-008	0.67760	-7.0566
>(s)FeOSiO(OH)2-	8.095e-008	8.095e-008	1.4758	-7.0918
>(s)FeCO3H	8.079e-008	8.079e-008	1.0000	-7.0926
>(s)FeOSi(OH)3	7.538e-008	7.538e-008	1.0000	-7.1228
>(s)FeCO3-	7.053e-008	7.053e-008	1.4758	-7.1516
>(w)FeOCd+	4.928e-008	4.928e-008	0.67760	-7.3074
>(s)FeOHBa++	1.752e-008	1.752e-008	0.45914	-7.7564
>(w)FeOHMoO4--	1.308e-008	1.308e-008	2.1780	-7.8835
>(s)FeOCd+	1.290e-008	1.290e-008	0.67760	-7.8893
>(s)FeOSiO2OH--	9.315e-009	9.315e-009	2.1780	-8.0308
>(w)FeH2AsO4	9.158e-009	9.158e-009	1.0000	-8.0382
>(s)FeO-	8.996e-009	8.996e-009	1.4758	-8.0460
>(w)FeOMo(OH)5	7.490e-009	7.490e-009	1.0000	-8.1255
>(s)FeAsO4--	3.906e-009	3.906e-009	2.1780	-8.4082
>(s)FeOHAsO4---	3.489e-009	3.489e-009	3.2143	-8.4573
>(w)FeOMn+	1.254e-009	1.254e-009	0.67760	-8.9019
>(w)FeOBa+	1.166e-009	1.166e-009	0.67760	-8.9335
>(w)HgOH2+	4.672e-010	4.672e-010	0.67760	-9.3305
>(s)FeOHSO4--	2.772e-010	2.772e-010	2.1780	-9.5572
>(s)FeHAsO4-	2.517e-010	2.517e-010	1.4758	-9.5992
>(s)FeOMn+	1.763e-010	1.763e-010	0.67760	-9.7538
>(s)FeSO4-	7.978e-011	7.978e-011	1.4758	-10.0981
>(w)FeOHSbO(OH4	5.567e-011	5.567e-011	1.4758	-10.2544
>(w)FeOHSeO4--	3.711e-011	3.711e-011	2.1780	-10.4305
>(w)FeSbO(OH)4	2.064e-011	2.064e-011	1.0000	-10.6853
>(w)FeSeO4-	9.301e-012	9.301e-012	1.4758	-11.0315
>(w)FeOBaOH	1.576e-012	1.576e-012	1.0000	-11.8025
>(s)FeOHMoO4--	1.460e-012	1.460e-012	2.1780	-11.8355
>(s)HgOH2+	1.065e-012	1.065e-012	0.67760	-11.9725
>(s)FeH2AsO4	1.023e-012	1.023e-012	1.0000	-11.9902
>(s)FeOMo(OH)5	8.365e-013	8.365e-013	1.0000	-12.0775
>(s)FeOHSbO(OH4	6.217e-015	6.217e-015	1.4758	-14.2064
>(s)FeOHSeO4--	4.145e-015	4.145e-015	2.1780	-14.3825
>(s)FeSbO(OH)4	2.305e-015	2.305e-015	1.0000	-14.6373
>(s)FeSeO4-	1.039e-015	1.039e-015	1.4758	-14.9834
>(w)FeOHSeO3--	4.901e-021	4.901e-021	2.1780	-20.3097
>(w)FeSeO3-	4.780e-021	4.780e-021	1.4758	-20.3206
>(s)FeOHSeO3--	5.474e-025	5.474e-025	2.1780	-24.2617
>(s)FeSeO3-	5.338e-025	5.338e-025	1.4758	-24.2726

(Boltzman factor = exp(zF PSI/RT), where PSI is surface potential)

Mineral saturation states

	log Q/K		log Q/K
Hematite	8.7228s/sat	Cuprous Ferrite	-0.9016
Cupric Ferrite	5.9528s/sat	Chalcedony	-0.9576
Nsutite	5.3038s/sat	Dolomite (disord	-0.9843
Birnessite	4.7168s/sat	Cristobalite	-1.1537
Pyrolusite	4.7093s/sat	PbMoO4	-1.3030
Goethite	3.2107s/sat	CaCO3xH2O	-1.3283
Lepidocrocite	3.0939s/sat	Al(OH)3 (Soil)	-1.4416
Maghemite	2.5438s/sat	Cerrusite	-1.5152
Manganite	1.8299s/sat	Smithsonite	-1.6502
Ferrihydrite (ag	1.7748s/sat	ZnCO3	-1.7024
Magnesioferrite	0.8265s/sat	Gypsum	-1.7182
Barite	0.0000 sat	Strontianite	-1.8090
Dummy	0.0000 sat	SiO2 (am,ppt)	-1.8249
Bixbyite	0.0000 sat	SiO2 (am,gel)	-1.8694
Diaspore	0.0000 sat	Boehmite	-1.8895
Calcite	0.0000 sat	Anhydrite	-2.0713
Ferrihydrite	0.0000 sat	ZnCO3:1H2O	-2.2424

Aragonite	-0.1592	Celestite	-2.3677
Dolomite (ordere	-0.3473	Kaolinite	-2.4686
Quartz	-0.4741	NiCO3	-2.7894
Vaterite	-0.6232	Tenorite(c)	-2.7981
Magnesite	-0.8336	Plattnerite	-2.8525
Gibbsite (C)	-0.8916	Otavite	-2.9015

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
O2 (g)	0.1238	-0.907
CO2 (g)	0.002802	-2.553
Hg (g)	4.707e-025	-24.327
Hg2 (g)	5.371e-050	-49.270
H2Se (g)	1.274e-114	-113.895
H2S (g)	7.911e-156	-155.102
CH4 (g)	5.029e-156	-155.298
Hg(CH3)2 (g)	0.0000	-300.000

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
>(s)FeOH	0.000234					
>(w)FeOH	0.00936					
Al+++	2.59e-007	4.26e-010	1.15e-005			
AsO4---	6.85e-005	2.13e-009	0.000296	6.85e-005	9.51	
Ba++	6.39e-007	1.87e-007	0.0257	1.87e-008	0.00257	
CO3--	0.00471	0.00325	195.	0.00135	81.3	
Ca++	0.00200	0.00162	65.0	0.000270	10.8	
Cd++	6.26e-008	4.37e-010	4.91e-005	6.22e-008	0.00699	
Cu++	0.000110	4.57e-009	0.000290	0.000110	7.01	
Fe+++	0.0468	3.83e-010	2.14e-005	-1.50e-006	-0.0839	
H+	-0.138	0.00342	3.44	-0.00106	-1.07	
H2O	55.6	55.5	1.00e+006	-0.00291	-52.4	
H4SiO4	0.00150	1.76e-005	1.69	0.00148	143.	
Hg(OH)2	6.38e-010	1.69e-010	3.97e-005	4.68e-010	0.000110	
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00392	0.00114	27.7	0.00278	67.6	
Mn+++	5.72e-007	4.62e-011	2.54e-006	1.43e-009	7.85e-005	
MoO4--	4.54e-008	2.48e-008	0.00396	2.06e-008	0.00329	
Na+	9.57e-005	9.57e-005	2.20			
Ni++	4.58e-006	1.67e-008	0.000982	4.56e-006	0.268	
O2(aq)	0.000156	0.000156	4.99	-3.57e-010	-1.14e-005	
Pb++	0.000255	4.15e-009	0.000859	0.000255	52.8	
SO4--	0.000763	0.000759	72.9	3.20e-006	0.307	
Sb(OH)6-	2.31e-009	2.23e-009	0.000500	7.63e-011	1.71e-005	
SeO4--	9.84e-009	9.79e-009	0.00140	4.64e-011	6.63e-006	
Sr++	3.62e-006	3.42e-006	0.299	2.00e-007	0.0175	
UO2++	1.85e-008	1.85e-008	0.00500			
Zn++	1.65e-006	1.51e-007	0.00984	1.50e-006	0.0981	
dummy	0.0562	0.000	0.000			

Sorbed	fraction	log fraction
AsO4---	1.000	-0.000
Ba++	0.09086	-1.042
CO3--	0.2945	-0.531
Ca++	0.1426	-0.846
Cd++	0.9930	-0.003
Cu++	1.000	-0.000
Fe+++	1.000	0.000
H4SiO4	0.9883	-0.005
Hg(OH)2	0.7343	-0.134

Mg++	0.7090	-0.149
Mn+++	0.9687	-0.014
MoO4--	0.4534	-0.344
Ni++	0.9963	-0.002
Pb++	1.000	-0.000
SO4--	0.004191	-2.378
Sb(OH)6-	0.03304	-1.481
SeO4--	0.004718	-2.326
Sr++	0.05529	-1.257
Zn++	0.9088	-0.042

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	4.260e-010	1.149e-005		
As	6.849e-005	2.133e-009	0.0001598	6.849e-005	5.129
Ba	6.388e-007	1.870e-007	0.02567	1.869e-008	0.002566
C	0.004711	0.003245	38.96	0.001355	16.27
Ca	0.002003	0.001622	65.00	0.0002698	10.81
Cd	6.262e-008	4.367e-010	4.907e-005	6.218e-008	0.006986
Cu	0.0001104	4.573e-009	0.0002905	0.0001104	7.012
Du	0.05618	0.0000	0.0000		
Fe	0.04678	3.834e-010	2.140e-005	-1.502e-006	-0.08385
H	111.2	111.0	1.119e+005	-0.0009493	-0.9564
Hg	6.377e-010	1.694e-010	3.398e-005	4.682e-010	9.389e-005
K	1.023e-005	1.023e-005	0.3999		
Mg	0.003923	0.001142	27.74	0.002781	67.59
Mn	5.718e-007	4.619e-011	2.536e-006	1.430e-009	7.852e-005
Mo	4.536e-008	2.479e-008	0.002378	2.057e-008	0.001972
Na	9.569e-005	9.569e-005	2.199		
Ni	4.576e-006	1.673e-008	0.0009819	4.559e-006	0.2676
O	55.67	55.52	8.880e+005	0.007376	118.0
Pb	0.0002549	4.147e-009	0.0008588	0.0002549	52.80
S	0.0007631	0.0007594	24.34	3.197e-006	0.1025
Sb	2.310e-009	2.234e-009	0.0002718	7.631e-011	9.288e-006
Se	9.839e-009	9.792e-009	0.0007729	4.641e-011	3.664e-006
Si	0.001501	1.755e-005	0.4928	0.001483	41.64
Sr	3.619e-006	3.419e-006	0.2995	2.001e-007	0.01753
U	1.852e-008	1.852e-008	0.004406		
Zn	1.652e-006	1.506e-007	0.009841	1.502e-006	0.09812

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Step #    50               Xi = 0.1000
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  7.830
Eh =   0.8011 volts      pe =  14.5159
Ionic strength      =    0.006702
Activity of water   =    0.999898
Solvent mass        =    0.999996 kg
Solution mass       =    1.000334 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         338 mg/kg sol'n
Rock mass           =    0.010049 kg
HFO sorbing surface:
  Surface charge    =        8.61 uC/cm2
  Surface potential =       -10.0 mV
  Surface area      =   3.00e+007 cm2
```

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.8011	14.5159

full suite results

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
H+	-- sliding pH buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.470e-007	-6.350	0.0001043	
Bixbyite	2.853e-007	-6.545	4.504e-005	
Calcite	0.0004924	-3.308	0.04929	
Diaspore	2.589e-007	-6.587	1.553e-005	
Dummy	0.05618	-1.250	5.000	
Ferrihydrite	0.04679	-1.330	5.000	
(total)			10.05	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002867	174.9	0.9195	-2.5790
Ca++	0.001136	45.50	0.7148	-3.0906
Mg++	0.0008046	19.56	0.7148	-3.2402
SO4--	0.0006479	62.22	0.7148	-3.3343
O2(aq)	0.0001561	4.994	1.0015	-3.8059
H2CO3* (aq)	0.0001279	7.930	1.0015	-3.8925
Na+	9.529e-005	2.190	0.9195	-4.0574
CaSO4 (aq)	6.999e-005	9.525	1.0015	-4.1543
MgSO4 (aq)	4.090e-005	4.921	1.0015	-4.3876
CaHCO3+	1.841e-005	1.861	0.9195	-4.7714
MgHCO3+	1.731e-005	1.477	0.9195	-4.7982
H4SiO4	1.373e-005	1.320	1.0015	-4.8615
K+	1.021e-005	0.3990	0.9195	-5.0276
CO3--	6.954e-006	0.4172	0.7148	-5.3036
Sr++	3.149e-006	0.2758	0.7148	-5.6477
MgCO3 (aq)	2.003e-006	0.1689	1.0015	-5.6976
CaCO3 (aq)	9.989e-007	0.09995	1.0015	-5.9998
NaSO4-	2.356e-007	0.02804	0.9195	-6.6643
SrSO4 (aq)	1.646e-007	0.03023	1.0015	-6.7828
Ba++	1.623e-007	0.02229	0.7148	-6.9354
NaHCO3 (aq)	1.564e-007	0.01313	1.0015	-6.8052
OH-	1.467e-007	0.002494	0.9195	-6.8701
Zn++	8.215e-008	0.005369	0.7148	-7.2312
SrHCO3+	4.604e-008	0.006841	0.9195	-7.3733
H3SiO4-	3.814e-008	0.003626	0.9195	-7.4551
KSO4-	2.285e-008	0.003087	0.9195	-7.6776
Ca2UO2(CO3)3 (aq	1.754e-008	0.009297	1.0015	-7.7553
ZnCO3 (aq)	1.677e-008	0.002102	1.0015	-7.7748
MoO4--	1.614e-008	0.002580	0.7148	-7.9380
H+	1.609e-008	1.621e-005	0.9195	-7.8300
NaCO3-	1.591e-008	0.001320	0.9195	-7.8347
MgOH+	1.085e-008	0.0004483	0.9195	-8.0009

(only species > 1e-8 molal listed)

Surface species	molality	moles	Boltzman fct.	log molality
>(w)FeOMg+	0.003058	0.003058	0.67760	-2.5146
>(w)FeOH	0.002121	0.002121	1.0000	-2.6734
>(w)FeOH2+	0.0009030	0.0009030	0.67760	-3.0443
>(w)FeOSiO(OH)2-	0.0008057	0.0008057	1.4758	-3.0939
>(w)FeCO3-	0.0006369	0.0006369	1.4758	-3.1959
>(w)FeOSi(OH)3	0.0005561	0.0005561	1.0000	-3.2548
>(w)FeCO3H	0.0005409	0.0005409	1.0000	-3.2669
>(w)FeOCa+	0.0002427	0.0002427	0.67760	-3.6149
>(s)FeOPb+	0.0001869	0.0001869	0.67760	-3.7283

>(w)FeOSiO2OH--	0.0001251	0.0001251	2.1780	-3.9029
>(w)FeO-	0.0001142	0.0001142	1.4758	-3.9424
>(w)FeOCu+	0.0001078	0.0001078	0.67760	-3.9674
>(w)FeOPb+	6.799e-005	6.799e-005	0.67760	-4.1676
>(s)FeOHCa++	4.299e-005	4.299e-005	0.45914	-4.3667
>(w)FeOHAsO4---	3.663e-005	3.663e-005	3.2143	-4.4362
>(w)FeAsO4--	3.040e-005	3.040e-005	2.1780	-4.5172
>(w)FeONi+	4.183e-006	4.183e-006	0.67760	-5.3785
>(w)FeOHSO4--	2.781e-006	2.781e-006	2.1780	-5.5557
>(s)FeOCu+	2.582e-006	2.582e-006	0.67760	-5.5881
>(w)FeHAsO4-	1.452e-006	1.452e-006	1.4758	-5.8381
>(w)ZnOH2+	1.379e-006	1.379e-006	0.67760	-5.8604
>(w)FeSO4-	5.934e-007	5.934e-007	1.4758	-6.2267
>(s)FeONi+	3.809e-007	3.809e-007	0.67760	-6.4192
>(s)FeOH	2.605e-007	2.605e-007	1.0000	-6.5841
>(s)ZnOH2+	1.617e-007	1.617e-007	0.67760	-6.7912
>(s)FeOHSr++	1.307e-007	1.307e-007	0.45914	-6.8838
>(w)FeOSr+	1.253e-007	1.253e-007	0.67760	-6.9020
>(s)FeOH2+	1.109e-007	1.109e-007	0.67760	-6.9551
>(s)FeOSiO(OH)2-	9.894e-008	9.894e-008	1.4758	-7.0046
>(s)FeCO3-	7.822e-008	7.822e-008	1.4758	-7.1067
>(s)FeOSi(OH)3	6.830e-008	6.830e-008	1.0000	-7.1656
>(s)FeCO3H	6.642e-008	6.642e-008	1.0000	-7.1777
>(w)FeOCd+	4.838e-008	4.838e-008	0.67760	-7.3153
>(s)FeOHBa++	1.899e-008	1.899e-008	0.45914	-7.7215
>(w)FeOHMoO4--	1.551e-008	1.551e-008	2.1780	-7.8094
>(s)FeOSiO2OH--	1.536e-008	1.536e-008	2.1780	-7.8136
>(s)FeO-	1.402e-008	1.402e-008	1.4758	-7.8531
>(s)FeOCd+	1.393e-008	1.393e-008	0.67760	-7.8560
>(w)FeOMo(OH)5	4.882e-009	4.882e-009	1.0000	-8.3114
>(s)FeOHAsO4---	4.498e-009	4.498e-009	3.2143	-8.3470
>(w)FeH2AsO4	4.374e-009	4.374e-009	1.0000	-8.3591
>(s)FeAsO4--	3.733e-009	3.733e-009	2.1780	-8.4279
>(w)FeOBa+	1.550e-009	1.550e-009	0.67760	-8.8098
>(w)FeOMn+	9.767e-010	9.767e-010	0.67760	-9.0102
>(w)HgOH2+	4.346e-010	4.346e-010	0.67760	-9.3619
>(s)FeOHSO4--	3.416e-010	3.416e-010	2.1780	-9.4665
>(s)FeHAsO4-	1.783e-010	1.783e-010	1.4758	-9.7489
>(s)FeOMn+	1.510e-010	1.510e-010	0.67760	-9.8210
>(s)FeSO4-	7.288e-011	7.288e-011	1.4758	-10.1374
>(w)FeOHSbO(OH4	5.894e-011	5.894e-011	1.4758	-10.2296
>(w)FeOHSeO4--	4.065e-011	4.065e-011	2.1780	-10.3909
>(w)FeSbO(OH)4	1.620e-011	1.620e-011	1.0000	-10.7905
>(w)FeSeO4-	7.554e-012	7.554e-012	1.4758	-11.1218
>(w)FeOBaOH	2.826e-012	2.826e-012	1.0000	-11.5488
>(s)FeOHMoO4--	1.905e-012	1.905e-012	2.1780	-11.7201
>(s)HgOH2+	1.090e-012	1.090e-012	0.67760	-11.9627
>(s)FeOMo(OH)5	5.996e-013	5.996e-013	1.0000	-12.2221
>(s)FeH2AsO4	5.372e-013	5.372e-013	1.0000	-12.2699
>(s)FeOHSbO(OH4	7.239e-015	7.239e-015	1.4758	-14.1403
>(s)FeOHSeO4--	4.993e-015	4.993e-015	2.1780	-14.3017
>(s)FeSbO(OH)4	1.989e-015	1.989e-015	1.0000	-14.7013
>(s)FeSeO4-	9.277e-016	9.277e-016	1.4758	-15.0326
>(w)FeOHSeO3--	5.370e-021	5.370e-021	2.1780	-20.2700
>(w)FeSeO3-	3.882e-021	3.882e-021	1.4758	-20.4109
>(s)FeOHSeO3--	6.595e-025	6.595e-025	2.1780	-24.1808
>(s)FeSeO3-	4.768e-025	4.768e-025	1.4758	-24.3217

(Boltzman factor = exp(zF PSI/RT), where PSI is surface potential)

Mineral saturation states

	log Q/K		log Q/K
Hematite	8.7228s/sat	Gibbsite (C)	-0.8916

Cupric Ferrite	6.0603s/sat	Dolomite (disord	-0.9826
Nsutite	5.3038s/sat	Chalcedony	-1.0632
Birnessite	4.7168s/sat	Cristobalite	-1.2594
Pyrolusite	4.7093s/sat	CaCO3xH2O	-1.3283
Goethite	3.2107s/sat	PbMoO4	-1.4318
Lepidocrocite	3.0939s/sat	Al(OH)3 (Soil)	-1.4416
Maghemite	2.5438s/sat	Cerrusite	-1.5845
Manganite	1.8299s/sat	Smithsonite	-1.6827
Ferrihydrite (ag	1.7748s/sat	Strontianite	-1.6939
Magnesioferrite	0.9760s/sat	ZnCO3	-1.7348
Barite	0.0000 sat	Gypsum	-1.8024
Diaspore	0.0000 sat	Boehmite	-1.8895
Ferrihydrite	0.0000 sat	SiO2 (am,ppt)	-1.9306
Bixbyite	0.0000 sat	SiO2 (am,gel)	-1.9751
Calcite	0.0000 sat	Anhydrite	-2.1556
Dummy	0.0000 sat	ZnCO3:1H2O	-2.2749
Aragonite	-0.1592	Celestite	-2.3368
Dolomite (ordere	-0.3456	Kaolinite	-2.6799
Quartz	-0.5798	Tenorite(c)	-2.6906
Vaterite	-0.6232	Plattnerite	-2.7740
Cuprous Ferrite	-0.7941	NiCO3	-2.8317
Magnesite	-0.8319	Otavite	-2.9489

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
O2 (g)	0.1237	-0.908
CO2 (g)	0.001993	-2.700
Hg (g)	5.620e-025	-24.250
Hg2 (g)	7.658e-050	-49.116
H2Se (g)	7.303e-115	-114.137
H2S (g)	4.639e-156	-155.334
CH4 (g)	3.580e-156	-155.446
Hg(CH3)2 (g)	0.0000	-300.000

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
>(s)FeOH	0.000234					
>(w)FeOH	0.00936					
Al+++	2.59e-007	5.61e-010	1.51e-005			
AsO4---	6.85e-005	1.66e-009	0.000230	6.85e-005	9.51	
Ba++	6.39e-007	1.71e-007	0.0235	2.05e-008	0.00282	
CO3--	0.00471	0.00304	182.	0.00118	70.7	
Ca++	0.00200	0.00123	49.1	0.000286	11.4	
Cd++	6.26e-008	3.01e-010	3.38e-005	6.23e-008	0.00700	
Cu++	0.000110	4.12e-009	0.000262	0.000110	7.01	
Fe+++	0.0468	2.83e-010	1.58e-005	-1.54e-006	-0.0860	
H+	-0.139	0.00316	3.18	-0.00218	-2.20	
H2O	55.6	55.5	1.00e+006	-0.00274	-49.3	
H4SiO4	0.00150	1.38e-005	1.32	0.00149	143.	
Hg(OH)2	6.38e-010	2.02e-010	4.74e-005	4.36e-010	0.000102	
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00392	0.000865	21.0	0.00306	74.3	
Mn+++	5.72e-007	2.57e-011	1.41e-006	1.13e-009	6.19e-005	
MoO4--	4.54e-008	2.50e-008	0.00399	2.04e-008	0.00326	
Na+	9.57e-005	9.57e-005	2.20			
Ni++	4.58e-006	1.17e-008	0.000687	4.56e-006	0.268	
O2(aq)	0.000156	0.000156	4.99	-2.82e-010	-9.02e-006	
Pb++	0.000255	3.39e-009	0.000703	0.000255	52.8	
SO4--	0.000763	0.000759	72.9	3.38e-006	0.324	
Sb(OH)6-	2.31e-009	2.23e-009	0.000500	7.51e-011	1.68e-005	
SeO4--	9.84e-009	9.79e-009	0.00140	4.82e-011	6.89e-006	

Sr++	3.62e-006	3.36e-006	0.295	2.56e-007	0.0224
UO2++	1.85e-008	1.85e-008	0.00500		
Zn++	1.65e-006	1.11e-007	0.00728	1.54e-006	0.101
dummy	0.0562	0.000	0.000		

Sorbed	fraction	log fraction
AsO4---	1.000	-0.000
Ba++	0.1071	-0.970
CO3--	0.2792	-0.554
Ca++	0.1891	-0.723
Cd++	0.9952	-0.002
Cu++	1.000	-0.000
Fe+++	1.000	0.000
H4SiO4	0.9908	-0.004
Hg(OH)2	0.6832	-0.165
Mg++	0.7795	-0.108
Mn+++	0.9777	-0.010
MoO4--	0.4496	-0.347
Ni++	0.9974	-0.001
Pb++	1.000	-0.000
SO4--	0.004426	-2.354
Sb(OH)6-	0.03253	-1.488
SeO4--	0.004900	-2.310
Sr++	0.07073	-1.150
Zn++	0.9326	-0.030

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	5.615e-010	1.514e-005		
As	6.849e-005	1.658e-009	0.0001242	6.849e-005	5.129
Ba	6.388e-007	1.712e-007	0.02351	2.054e-008	0.002820
C	0.004711	0.003041	36.51	0.001178	14.14
Ca	0.002003	0.001225	49.09	0.0002857	11.45
Cd	6.262e-008	3.008e-010	3.379e-005	6.231e-008	0.007002
Cu	0.0001104	4.120e-009	0.0002617	0.0001104	7.012
Du	0.05618	0.0000	0.0000		
Fe	0.04678	2.833e-010	1.582e-005	-1.541e-006	-0.08604
H	111.2	111.0	1.119e+005	-0.001705	-1.718
Hg	6.377e-010	2.020e-010	4.051e-005	4.357e-010	8.736e-005
K	1.023e-005	1.023e-005	0.3999		
Mg	0.003923	0.0008649	21.02	0.003058	74.32
Mn	5.718e-007	2.567e-011	1.410e-006	1.128e-009	6.193e-005
Mo	4.536e-008	2.497e-008	0.002394	2.040e-008	0.001956
Na	9.569e-005	9.569e-005	2.199		
Ni	4.576e-006	1.171e-008	0.0006875	4.564e-006	0.2679
O	55.67	55.52	8.880e+005	0.007034	112.5
Pb	0.0002549	3.392e-009	0.0007025	0.0002549	52.80
S	0.0007631	0.0007592	24.34	3.375e-006	0.1082
Sb	2.310e-009	2.235e-009	0.0002720	7.515e-011	9.146e-006
Se	9.839e-009	9.791e-009	0.0007728	4.821e-011	3.806e-006
Si	0.001501	1.378e-005	0.3868	0.001487	41.75
Sr	3.619e-006	3.363e-006	0.2946	2.560e-007	0.02242
U	1.852e-008	1.852e-008	0.004406		
Zn	1.652e-006	1.114e-007	0.007280	1.541e-006	0.1007

♀

Step # 100 Xi = 0.2000
Temperature = 5.0 C Pressure = 0.938 bars
pH = 7.960
Eh = 0.7939 volts pe = 14.3859
Ionic strength = 0.005713

full suite results

```
Activity of water   =    0.999909
Solvent mass        =    0.999994 kg
Solution mass       =    1.000305 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         311 mg/kg sol'n
Rock mass           =    0.010079 kg
HFO sorbing surface:
  Surface charge    =        7.92 uC/cm2
  Surface potential =       -10.0 mV
  Surface area      =   3.00e+007 cm2
```

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.7939	14.3859

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
H+	-- sliding pH buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.572e-007	-6.340	0.0001067	
Bixbyite	2.854e-007	-6.544	4.506e-005	
Calcite	0.0007843	-3.106	0.07850	
Diaspore	2.587e-007	-6.587	1.552e-005	
Dummy	0.05618	-1.250	5.000	
Ferrihydrite	0.04679	-1.330	5.000	
(total)			10.08	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002757	168.2	0.9248	-2.5934
Ca++	0.0008502	34.07	0.7316	-3.2062
SO4--	0.0006688	64.23	0.7316	-3.3104
Mg++	0.0006026	14.65	0.7316	-3.3557
O2(aq)	0.0001561	4.994	1.0013	-3.8060
Na+	9.527e-005	2.190	0.9248	-4.0550
H2CO3* (aq)	9.174e-005	5.689	1.0013	-4.0369
CaSO4 (aq)	5.668e-005	7.714	1.0013	-4.2460
MgSO4 (aq)	3.313e-005	3.987	1.0013	-4.4792
CaHCO3+	1.357e-005	1.371	0.9248	-4.9014
MgHCO3+	1.276e-005	1.089	0.9248	-4.9280
H4SiO4	1.057e-005	1.016	1.0013	-4.9752
K+	1.021e-005	0.3989	0.9248	-5.0251
CO3--	8.866e-006	0.5319	0.7316	-5.1880
Sr++	3.072e-006	0.2691	0.7316	-5.6483
MgCO3 (aq)	2.004e-006	0.1690	1.0013	-5.6975
CaCO3 (aq)	9.991e-007	0.09997	1.0013	-5.9998
NaSO4-	2.489e-007	0.02962	0.9248	-6.6380
OH-	1.967e-007	0.003344	0.9248	-6.7401
SrSO4 (aq)	1.738e-007	0.03191	1.0013	-6.7595
NaHCO3 (aq)	1.522e-007	0.01278	1.0013	-6.8171
Ba++	1.501e-007	0.02061	0.7316	-6.9593
Zn++	5.784e-008	0.003779	0.7316	-7.3735
SrHCO3+	4.422e-008	0.006570	0.9248	-7.3883
H3SiO4-	3.937e-008	0.003743	0.9248	-7.4388
KSO4-	2.414e-008	0.003262	0.9248	-7.6512
NaCO3-	2.077e-008	0.001723	0.9248	-7.7166
MoO4--	1.729e-008	0.002765	0.7316	-7.8979
Ca2UO2(CO3)3 (aq	1.713e-008	0.009082	1.0013	-7.7656

ZnCO3 (aq)	1.577e-008	0.001977	1.0013	-7.8015
H+	1.186e-008	1.195e-005	0.9248	-7.9600
MgOH+	1.116e-008	0.0004608	0.9248	-7.9864

(only species > 1e-8 molal listed)

Surface species	molality	moles	Boltzman fct.	log molality
>(w)FeOMg+	0.003272	0.003272	0.67760	-2.4851
>(w)FeOH	0.002196	0.002196	1.0000	-2.6584
>(w)FeOSiO(OH)2-	0.0008657	0.0008657	1.4758	-3.0626
>(w)FeOH2+	0.0006928	0.0006928	0.67760	-3.1594
>(w)FeCO3-	0.0006376	0.0006376	1.4758	-3.1954
>(w)FeOSi(OH)3	0.0004430	0.0004430	1.0000	-3.3536
>(w)FeCO3H	0.0004014	0.0004014	1.0000	-3.3964
>(w)FeOCa+	0.0002597	0.0002597	0.67760	-3.5856
>(s)FeOPb+	0.0001918	0.0001918	0.67760	-3.7171
>(w)FeOSiO2OH--	0.0001813	0.0001813	2.1780	-3.7417
>(w)FeO-	0.0001594	0.0001594	1.4758	-3.7975
>(w)FeOCu+	0.0001075	0.0001075	0.67760	-3.9684
>(w)FeOPb+	6.309e-005	6.309e-005	0.67760	-4.2000
>(w)FeOHAsO4---	4.183e-005	4.183e-005	3.2143	-4.3785
>(s)FeOHCa++	3.770e-005	3.770e-005	0.45914	-4.4236
>(w)FeAsO4--	2.573e-005	2.573e-005	2.1780	-4.5895
>(w)FeONi+	4.150e-006	4.150e-006	0.67760	-5.3820
>(w)FeOHSO4--	3.041e-006	3.041e-006	2.1780	-5.5169
>(s)FeOCu+	2.848e-006	2.848e-006	0.67760	-5.5455
>(w)ZnOH2+	1.387e-006	1.387e-006	0.67760	-5.8578
>(w)FeHAsO4-	9.111e-007	9.111e-007	1.4758	-6.0404
>(w)FeSO4-	4.810e-007	4.810e-007	1.4758	-6.3178
>(s)FeONi+	4.178e-007	4.178e-007	0.67760	-6.3791
>(s)FeOH	2.982e-007	2.982e-007	1.0000	-6.5255
>(s)ZnOH2+	1.799e-007	1.799e-007	0.67760	-6.7449
>(w)FeOSr+	1.747e-007	1.747e-007	0.67760	-6.7577
>(s)FeOHSr++	1.494e-007	1.494e-007	0.45914	-6.8257
>(s)FeOSiO(OH)2-	1.176e-007	1.176e-007	1.4758	-6.9297
>(s)FeOH2+	9.409e-008	9.409e-008	0.67760	-7.0265
>(s)FeCO3-	8.660e-008	8.660e-008	1.4758	-7.0625
>(s)FeOSi(OH)3	6.016e-008	6.016e-008	1.0000	-7.2207
>(s)FeCO3H	5.452e-008	5.452e-008	1.0000	-7.2635
>(w)FeOCd+	4.733e-008	4.733e-008	0.67760	-7.3248
>(s)FeOSiO2OH--	2.462e-008	2.462e-008	2.1780	-7.6087
>(s)FeO-	2.165e-008	2.165e-008	1.4758	-7.6645
>(s)FeOHBa++	2.057e-008	2.057e-008	0.45914	-7.6868
>(w)FeOHMoO4--	1.760e-008	1.760e-008	2.1780	-7.7544
>(s)FeOCd+	1.507e-008	1.507e-008	0.67760	-7.8219
>(s)FeOHAsO4---	5.681e-009	5.681e-009	3.2143	-8.2456
>(s)FeAsO4--	3.495e-009	3.495e-009	2.1780	-8.4565
>(w)FeOMo(OH)5	3.045e-009	3.045e-009	1.0000	-8.5164
>(w)FeOBa+	2.048e-009	2.048e-009	0.67760	-8.6887
>(w)FeH2AsO4	2.035e-009	2.035e-009	1.0000	-8.6914
>(w)FeOMn+	7.494e-010	7.494e-010	0.67760	-9.1253
>(s)FeOHSO4--	4.131e-010	4.131e-010	2.1780	-9.3840
>(w)HgOH2+	3.966e-010	3.966e-010	0.67760	-9.4017
>(s)FeOMn+	1.281e-010	1.281e-010	0.67760	-9.8924
>(s)FeHAsO4-	1.237e-010	1.237e-010	1.4758	-9.9075
>(s)FeSO4-	6.533e-011	6.533e-011	1.4758	-10.1849
>(w)FeOHSbO(OH4	6.139e-011	6.139e-011	1.4758	-10.2119
>(w)FeOHSeO4--	4.357e-011	4.357e-011	2.1780	-10.3608
>(w)FeSbO(OH)4	1.251e-011	1.251e-011	1.0000	-10.9028
>(w)FeSeO4-	6.002e-012	6.002e-012	1.4758	-11.2217
>(w)FeOBaOH	5.038e-012	5.038e-012	1.0000	-11.2978
>(s)FeOHMoO4--	2.391e-012	2.391e-012	2.1780	-11.6215
>(s)HgOH2+	1.100e-012	1.100e-012	0.67760	-11.9588

>(s)FeOMo(OH)5	4.136e-013	4.136e-013	1.0000	-12.3835
>(s)FeH2AsO4	2.764e-013	2.764e-013	1.0000	-12.5585
>(s)FeOHSbO(OH4	8.338e-015	8.338e-015	1.4758	-14.0790
>(s)FeOHSeO4--	5.918e-015	5.918e-015	2.1780	-14.2278
>(s)FeSbO(OH)4	1.699e-015	1.699e-015	1.0000	-14.7699
>(s)FeSeO4-	8.151e-016	8.151e-016	1.4758	-15.0888
>(w)FeOHSeO3--	5.757e-021	5.757e-021	2.1780	-20.2398
>(w)FeSeO3-	3.085e-021	3.085e-021	1.4758	-20.5108
>(s)FeOHSeO3--	7.818e-025	7.818e-025	2.1780	-24.1069
>(s)FeSeO3-	4.190e-025	4.190e-025	1.4758	-24.3778

(Boltzman factor = exp(zF PSI/RT), where PSI is surface potential)

Mineral saturation states

	log Q/K		log Q/K
Hematite	8.7228s/sat	Dolomite (disord	-0.9825
Cupric Ferrite	6.1743s/sat	Chalcedony	-1.1769
Nsutite	5.3038s/sat	CaCO3xH2O	-1.3283
Birnessite	4.7168s/sat	Cristobalite	-1.3731
Pyrolusite	4.7092s/sat	Al(OH)3 (Soil)	-1.4416
Goethite	3.2107s/sat	PbMoO4	-1.5692
Lepidocrocite	3.0938s/sat	Strontianite	-1.5789
Maghemite	2.5437s/sat	Cerrusite	-1.6463
Manganite	1.8299s/sat	Smithsonite	-1.7094
Ferrihydrite (ag	1.7748s/sat	ZnCO3	-1.7615
Magnesioferrite	1.1205s/sat	Boehmite	-1.8895
Barite	0.0000 sat	Gypsum	-1.8941
Dummy	0.0000 sat	SiO2 (am,ppt)	-2.0443
Ferrihydrite	0.0000 sat	SiO2 (am,gel)	-2.0888
Bixbyite	0.0000 sat	Anhydrite	-2.2473
Diaspore	0.0000 sat	ZnCO3:1H2O	-2.3016
Calcite	0.0000 sat	Celestite	-2.3135
Aragonite	-0.1592	Tenorite(c)	-2.5766
Dolomite (ordere	-0.3455	Plattnerite	-2.6914
Vaterite	-0.6232	NiCO3	-2.8645
Cuprous Ferrite	-0.6800	Kaolinite	-2.9073
Quartz	-0.6935	Pb(OH)2	-2.9381
Magnesite	-0.8318	Otavite	-2.9878
Gibbsite (C)	-0.8916		

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
O2 (g)	0.1237	-0.908
CO2 (g)	0.001429	-2.845
Hg (g)	6.685e-025	-24.175
Hg2 (g)	1.084e-049	-48.965
H2Se (g)	4.158e-115	-114.381
H2S (g)	2.694e-156	-155.570
CH4 (g)	2.569e-156	-155.590
Hg(CH3)2 (g)	0.0000	-300.000

Original basis	total moles	In fluid moles	In fluid mg/kg	Sorbed moles	Sorbed mg/kg	Kd L/kg
>(s)FeOH	0.000234					
>(w)FeOH	0.00936					
Al+++	2.59e-007	7.45e-010	2.01e-005			
AsO4---	6.85e-005	1.29e-009	0.000179	6.85e-005	9.51	
Ba++	6.39e-007	1.59e-007	0.0218	2.26e-008	0.00311	
CO3--	0.00471	0.00289	173.	0.00104	62.3	
Ca++	0.00200	0.000922	36.9	0.000297	11.9	
Cd++	6.26e-008	2.12e-010	2.38e-005	6.24e-008	0.00701	

Cu++	0.000110	3.82e-009	0.000242	0.000110	7.01
Fe+++	0.0468	2.10e-010	1.17e-005	-1.57e-006	-0.0875
H+	-0.141	0.00297	2.99	-0.00313	-3.15
H2O	55.6	55.5	1.00e+006	-0.00260	-46.8
H4SiO4	0.00150	1.06e-005	1.02	0.00149	143.
Hg(OH)2	6.38e-010	2.40e-010	5.63e-005	3.98e-010	9.33e-005
K+	1.02e-005	1.02e-005	0.400		
Mg++	0.00392	0.000650	15.8	0.00327	79.5
Mn+++	5.72e-007	1.45e-011	7.96e-007	8.78e-010	4.82e-005
MoO4--	4.54e-008	2.47e-008	0.00395	2.07e-008	0.00330
Na+	9.57e-005	9.57e-005	2.20		
Ni++	4.58e-006	8.42e-009	0.000494	4.57e-006	0.268
O2(aq)	0.000156	0.000156	4.99	-2.19e-010	-7.02e-006
Pb++	0.000255	2.85e-009	0.000591	0.000255	52.8
SO4--	0.000763	0.000759	72.9	3.52e-006	0.338
Sb(OH)6-	2.31e-009	2.24e-009	0.000500	7.39e-011	1.65e-005
SeO4--	9.84e-009	9.79e-009	0.00140	4.96e-011	7.09e-006
Sr++	3.62e-006	3.30e-006	0.289	3.24e-007	0.0284
UO2++	1.85e-008	1.85e-008	0.00500		
Zn++	1.65e-006	8.50e-008	0.00555	1.57e-006	0.102
dummy	0.0562	0.000	0.000		

Sorbed	fraction	log fraction
AsO4---	1.000	-0.000
Ba++	0.1246	-0.904
CO3--	0.2646	-0.577
Ca++	0.2440	-0.613
Cd++	0.9966	-0.001
Cu++	1.000	-0.000
Fe+++	1.000	0.000
H4SiO4	0.9929	-0.003
Hg(OH)2	0.6236	-0.205
Mg++	0.8342	-0.079
Mn+++	0.9838	-0.007
MoO4--	0.4552	-0.342
Ni++	0.9982	-0.001
Pb++	1.000	-0.000
SO4--	0.004620	-2.335
Sb(OH)6-	0.03200	-1.495
SeO4--	0.005039	-2.298
Sr++	0.08954	-1.048
Zn++	0.9486	-0.023

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	7.447e-010	2.009e-005		
As	6.849e-005	1.290e-009	9.659e-005	6.849e-005	5.130
Ba	6.388e-007	1.589e-007	0.02182	2.262e-008	0.003106
C	0.004711	0.002888	34.67	0.001039	12.48
Ca	0.002003	0.0009215	36.92	0.0002974	11.91
Cd	6.262e-008	2.116e-010	2.378e-005	6.240e-008	0.007012
Cu	0.0001104	3.817e-009	0.0002425	0.0001104	7.013
Du	0.05618	0.0000	0.0000		
Fe	0.04678	2.099e-010	1.172e-005	-1.568e-006	-0.08752
H	111.2	111.0	1.119e+005	-0.002364	-2.382
Hg	6.377e-010	2.400e-010	4.813e-005	3.977e-010	7.974e-005
K	1.023e-005	1.023e-005	0.3999		
Mg	0.003923	0.0006505	15.81	0.003272	79.53
Mn	5.718e-007	1.449e-011	7.959e-007	8.775e-010	4.819e-005
Mo	4.536e-008	2.471e-008	0.002370	2.065e-008	0.001981
Na	9.569e-005	9.569e-005	2.199		

Ni	4.576e-006	8.418e-009	0.0004941	4.567e-006	0.2681
O	55.67	55.52	8.880e+005	0.006767	108.2
Pb	0.0002549	2.855e-009	0.0005913	0.0002549	52.80
S	0.0007631	0.0007591	24.33	3.523e-006	0.1129
Sb	2.310e-009	2.236e-009	0.0002721	7.391e-011	8.995e-006
Se	9.839e-009	9.789e-009	0.0007727	4.958e-011	3.914e-006
Si	0.001501	1.061e-005	0.2980	0.001490	41.84
Sr	3.619e-006	3.295e-006	0.2886	3.241e-007	0.02839
U	1.852e-008	1.852e-008	0.004406		
Zn	1.652e-006	8.497e-008	0.005553	1.567e-006	0.1024

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```
Step #   150              Xi = 0.3000
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  8.090
Eh =   0.7867 volts      pe =  14.2558
Ionic strength      =    0.004974
Activity of water   =    0.999917
Solvent mass        =    0.999992 kg
Solution mass       =    1.000283 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         290 mg/kg sol'n
Rock mass           =    0.010101 kg
HFO sorbing surface:
  Surface charge    =        7.14 uC/cm2
  Surface potential =       -10.0 mV
  Surface area      =   3.00e+007 cm2
```

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.7867	14.2558

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
H+	-- sliding pH buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.643e-007	-6.333	0.0001084	
Bixbyite	2.855e-007	-6.544	4.508e-005	
Calcite	0.001008	-2.997	0.1008	
Diaspore	2.584e-007	-6.588	1.550e-005	
Dummy	0.05618	-1.250	5.000	
Ferrihydrite	0.04679	-1.330	5.000	
(total)			10.10	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002673	163.1	0.9292	-2.6048
SO4--	0.0006869	65.97	0.7456	-3.2906
Ca++	0.0006349	25.44	0.7456	-3.3248
Mg++	0.0004506	10.95	0.7456	-3.4737
O2(aq)	0.0001561	4.994	1.0011	-3.8061
Na+	9.526e-005	2.189	0.9292	-4.0530
H2CO3* (aq)	6.626e-005	4.108	1.0011	-4.1783
CaSO4 (aq)	4.516e-005	6.146	1.0011	-4.3448
MgSO4 (aq)	2.643e-005	3.181	1.0011	-4.5773
CO3--	1.143e-005	0.6857	0.7456	-5.0694
K+	1.020e-005	0.3989	0.9292	-5.0231
CaHCO3+	1.001e-005	1.012	0.9292	-5.0314

MgHCO3+	9.429e-006	0.8043	0.9292	-5.0574
H4SiO4	7.968e-006	0.7656	1.0011	-5.0981
Sr++	2.984e-006	0.2614	0.7456	-5.6526
MgCO3 (aq)	2.008e-006	0.1692	1.0011	-5.6968
CaCO3 (aq)	9.993e-007	0.09999	1.0011	-5.9998
OH-	2.641e-007	0.004490	0.9292	-6.6101
NaSO4-	2.605e-007	0.03100	0.9292	-6.6161
SrSO4 (aq)	1.801e-007	0.03307	1.0011	-6.7440
NaHCO3 (aq)	1.489e-007	0.01251	1.0011	-6.8265
Ba++	1.407e-007	0.01932	0.7456	-6.9792
SrHCO3+	4.244e-008	0.006307	0.9292	-7.4040
Zn++	4.116e-008	0.002690	0.7456	-7.5130
H3SiO4-	3.983e-008	0.003787	0.9292	-7.4317
NaCO3-	2.728e-008	0.002264	0.9292	-7.5960
KSO4-	2.526e-008	0.003414	0.9292	-7.6294
MoO4--	1.819e-008	0.002909	0.7456	-7.8676
Ca2UO2(CO3)3 (aq	1.652e-008	0.008756	1.0011	-7.7815
ZnCO3 (aq)	1.503e-008	0.001884	1.0011	-7.8224
MgOH+	1.142e-008	0.0004716	0.9292	-7.9744

(only species > 1e-8 molal listed)

Surface species	molality	moles	Boltzman fct.	log molality
>(w)FeOMg+	0.003434	0.003434	0.67760	-2.4642
>(w)FeOH	0.002241	0.002241	1.0000	-2.6495
>(w)FeOSiO(OH)2-	0.0008982	0.0008982	1.4758	-3.0466
>(w)FeCO3-	0.0006340	0.0006340	1.4758	-3.1979
>(w)FeOH2+	0.0005242	0.0005242	0.67760	-3.2805
>(w)FeOSi(OH)3	0.0003407	0.0003407	1.0000	-3.4676
>(w)FeCO3H	0.0002959	0.0002959	1.0000	-3.5289
>(w)FeOCa+	0.0002721	0.0002721	0.67760	-3.5653
>(w)FeOSiO2OH--	0.0002537	0.0002537	2.1780	-3.5957
>(w)FeO-	0.0002195	0.0002195	1.4758	-3.6585
>(s)FeOPb+	0.0001966	0.0001966	0.67760	-3.7064
>(w)FeOCu+	0.0001072	0.0001072	0.67760	-3.9696
>(w)FeOPb+	5.831e-005	5.831e-005	0.67760	-4.2342
>(w)FeOHAsO4---	4.665e-005	4.665e-005	3.2143	-4.3312
>(s)FeOHCa++	3.248e-005	3.248e-005	0.45914	-4.4884
>(w)FeAsO4--	2.127e-005	2.127e-005	2.1780	-4.6722
>(w)FeONi+	4.111e-006	4.111e-006	0.67760	-5.3861
>(w)FeOHSO4--	3.250e-006	3.250e-006	2.1780	-5.4881
>(s)FeOCu+	3.149e-006	3.149e-006	0.67760	-5.5018
>(w)ZnOH2+	1.385e-006	1.385e-006	0.67760	-5.8584
>(w)FeHAsO4-	5.583e-007	5.583e-007	1.4758	-6.2531
>(s)FeONi+	4.590e-007	4.590e-007	0.67760	-6.3382
>(w)FeSO4-	3.810e-007	3.810e-007	1.4758	-6.4191
>(s)FeOH	3.376e-007	3.376e-007	1.0000	-6.4717
>(w)FeOSr+	2.382e-007	2.382e-007	0.67760	-6.6231
>(s)ZnOH2+	1.993e-007	1.993e-007	0.67760	-6.7005
>(s)FeOHSr++	1.674e-007	1.674e-007	0.45914	-6.7762
>(s)FeOSiO(OH)2-	1.353e-007	1.353e-007	1.4758	-6.8688
>(s)FeCO3-	9.549e-008	9.549e-008	1.4758	-7.0201
>(s)FeOH2+	7.895e-008	7.895e-008	0.67760	-7.1026
>(s)FeOSi(OH)3	5.131e-008	5.131e-008	1.0000	-7.2898
>(w)FeOCd+	4.616e-008	4.616e-008	0.67760	-7.3357
>(s)FeCO3H	4.456e-008	4.456e-008	1.0000	-7.3510
>(s)FeOSiO2OH--	3.821e-008	3.821e-008	2.1780	-7.4178
>(s)FeO-	3.306e-008	3.306e-008	1.4758	-7.4807
>(s)FeOHBa++	2.224e-008	2.224e-008	0.45914	-7.6528
>(w)FeOHMoO4--	1.927e-008	1.927e-008	2.1780	-7.7151
>(s)FeOCd+	1.630e-008	1.630e-008	0.67760	-7.7878
>(s)FeOHAsO4---	7.025e-009	7.025e-009	3.2143	-8.1533
>(s)FeAsO4--	3.204e-009	3.204e-009	2.1780	-8.4943

>(w)FeOBa+	2.694e-009	2.694e-009	0.67760	-8.5697
>(w)FeOMo(OH)5	1.832e-009	1.832e-009	1.0000	-8.7371
>(w)FeH2AsO4	9.245e-010	9.245e-010	1.0000	-9.0341
>(w)FeOMn+	5.671e-010	5.671e-010	0.67760	-9.2464
>(s)FeOHSO4--	4.895e-010	4.895e-010	2.1780	-9.3103
>(w)HgOH2+	3.538e-010	3.538e-010	0.67760	-9.4512
>(s)FeOMn+	1.075e-010	1.075e-010	0.67760	-9.9685
>(s)FeHAsO4-	8.409e-011	8.409e-011	1.4758	-10.0753
>(w)FeOHSbO(OH4	6.300e-011	6.300e-011	1.4758	-10.2006
>(s)FeSO4-	5.738e-011	5.738e-011	1.4758	-10.2412
>(w)FeOHSeO4--	4.577e-011	4.577e-011	2.1780	-10.3394
>(w)FeSbO(OH)4	9.515e-012	9.515e-012	1.0000	-11.0216
>(w)FeOBaOH	8.939e-012	8.939e-012	1.0000	-11.0487
>(w)FeSeO4-	4.674e-012	4.674e-012	1.4758	-11.3303
>(s)FeOHMoO4--	2.902e-012	2.902e-012	2.1780	-11.5373
>(s)HgOH2+	1.088e-012	1.088e-012	0.67760	-11.9634
>(s)FeOMo(OH)5	2.759e-013	2.759e-013	1.0000	-12.5593
>(s)FeH2AsO4	1.392e-013	1.392e-013	1.0000	-12.8562
>(s)FeOHSbO(OH4	9.489e-015	9.489e-015	1.4758	-14.0228
>(s)FeOHSeO4--	6.894e-015	6.894e-015	2.1780	-14.1615
>(s)FeSbO(OH)4	1.433e-015	1.433e-015	1.0000	-14.8437
>(s)FeSeO4-	7.039e-016	7.039e-016	1.4758	-15.1525
>(w)FeOHSeO3--	6.048e-021	6.048e-021	2.1780	-20.2184
>(w)FeSeO3-	2.403e-021	2.403e-021	1.4758	-20.6193
>(s)FeOHSeO3--	9.109e-025	9.109e-025	2.1780	-24.0405
>(s)FeSeO3-	3.618e-025	3.618e-025	1.4758	-24.4415

(Boltzman factor = exp(zF PSI/RT), where PSI is surface potential)

Mineral saturation states

	log Q/K		log Q/K
Hematite	8.7228s/sat	Gibbsite (C)	-0.8916
Cupric Ferrite	6.2942s/sat	Dolomite (disord	-0.9818
Nsutite	5.3038s/sat	Chalcedony	-1.2999
Birnessite	4.7168s/sat	CaCO3xH2O	-1.3283
Pyrolusite	4.7092s/sat	Al(OH)3 (Soil)	-1.4416
Goethite	3.2107s/sat	Strontianite	-1.4646
Lepidocrocite	3.0938s/sat	Cristobalite	-1.4960
Maghemite	2.5437s/sat	Cerrusite	-1.7009
Manganite	1.8299s/sat	PbMoO4	-1.7119
Ferrihydrite (ag	1.7748s/sat	Smithsonite	-1.7303
Magnesioferrite	1.2626s/sat	ZnCO3	-1.7824
Barite	0.0000 sat	Boehmite	-1.8895
Bixbyite	0.0000 sat	Gypsum	-1.9928
Calcite	0.0000 sat	SiO2 (am,ppt)	-2.1672
Dummy	0.0000 sat	SiO2 (am,gel)	-2.2117
Ferrihydrite	0.0000 sat	Celestite	-2.2980
Diaspore	0.0000 sat	ZnCO3:1H2O	-2.3225
Aragonite	-0.1592	Anhydrite	-2.3460
Dolomite (ordere	-0.3448	Tenorite(c)	-2.4568
Cuprous Ferrite	-0.5602	Plattnerite	-2.6046
Vaterite	-0.6232	Pb(OH)2	-2.8512
Quartz	-0.8164	NiCO3	-2.8889
Magnesite	-0.8311		

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
O2 (g)	0.1237	-0.908
CO2 (g)	0.001032	-2.986
Hg (g)	7.883e-025	-24.103
Hg2 (g)	1.507e-049	-48.822
H2Se (g)	2.352e-115	-114.629

CH4 (g)	1.856e-156	-155.732
H2S (g)	1.550e-156	-155.810
Hg(CH3)2 (g)	0.0000	-300.000

Original basis	total moles	In fluid moles	In fluid mg/kg	Sorbed moles	Sorbed mg/kg	Kd L/kg
>(s)FeOH	0.000234					
>(w)FeOH	0.00936					
Al+++	2.59e-007	9.92e-010	2.68e-005			
AsO4---	6.85e-005	1.00e-009	0.000139	6.85e-005	9.51	
Ba++	6.39e-007	1.49e-007	0.0205	2.49e-008	0.00343	
CO3--	0.00471	0.00277	166.	0.000930	55.8	
Ca++	0.00200	0.000691	27.7	0.000305	12.2	
Cd++	6.26e-008	1.52e-010	1.71e-005	6.25e-008	0.00702	
Cu++	0.000110	3.63e-009	0.000230	0.000110	7.01	
Fe+++	0.0468	1.56e-010	8.72e-006	-1.59e-006	-0.0885	
H+	-0.141	0.00283	2.85	-0.00393	-3.96	
H2O	55.6	55.5	1.00e+006	-0.00249	-44.9	
H4SiO4	0.00150	8.01e-006	0.770	0.00149	143.	
Hg(OH)2	6.38e-010	2.83e-010	6.63e-005	3.55e-010	8.32e-005	
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00392	0.000489	11.9	0.00343	83.5	
Mn+++	5.72e-007	8.33e-012	4.57e-007	6.75e-010	3.71e-005	
MoO4--	4.54e-008	2.43e-008	0.00388	2.11e-008	0.00337	
Na+	9.57e-005	9.57e-005	2.20			
Ni++	4.58e-006	6.21e-009	0.000365	4.57e-006	0.268	
O2(aq)	0.000156	0.000156	4.99	-1.69e-010	-5.40e-006	
Pb++	0.000255	2.47e-009	0.000511	0.000255	52.8	
SO4--	0.000763	0.000759	72.9	3.63e-006	0.349	
Sb(OH)6-	2.31e-009	2.24e-009	0.000501	7.25e-011	1.62e-005	
SeO4--	9.84e-009	9.79e-009	0.00140	5.05e-011	7.21e-006	
Sr++	3.62e-006	3.21e-006	0.282	4.06e-007	0.0355	
UO2++	1.85e-008	1.85e-008	0.00500			
Zn++	1.65e-006	6.74e-008	0.00441	1.58e-006	0.104	
dummy	0.0562	0.000	0.000			

Sorbed	fraction	log fraction
AsO4---	1.000	-0.000
Ba++	0.1430	-0.845
CO3--	0.2511	-0.600
Ca++	0.3059	-0.514
Cd++	0.9976	-0.001
Cu++	1.000	-0.000
Fe+++	1.000	0.000
H4SiO4	0.9947	-0.002
Hg(OH)2	0.5565	-0.255
Mg++	0.8755	-0.058
Mn+++	0.9878	-0.005
MoO4--	0.4653	-0.332
Ni++	0.9986	-0.001
Pb++	1.000	-0.000
SO4--	0.004762	-2.322
Sb(OH)6-	0.03140	-1.503
SeO4--	0.005128	-2.290
Sr++	0.1121	-0.951
Zn++	0.9592	-0.018

Elemental composition	total moles	In fluid moles	In fluid mg/kg	Sorbed moles	Sorbed mg/kg
Al	2.594e-007	9.920e-010	2.676e-005		

full suite results

As	6.849e-005	1.003e-009	7.514e-005	6.849e-005	5.130
Ba	6.388e-007	1.495e-007	0.02053	2.495e-008	0.003425
C	0.004711	0.002774	33.31	0.0009300	11.17
Ca	0.002003	0.0006911	27.69	0.0003046	12.20
Cd	6.262e-008	1.522e-010	1.711e-005	6.246e-008	0.007019
Cu	0.0001104	3.625e-009	0.0002303	0.0001104	7.013
Du	0.05618	0.0000	0.0000		
Fe	0.04678	1.561e-010	8.717e-006	-1.585e-006	-0.08850
H	111.2	111.0	1.119e+005	-0.002941	-2.964
Hg	6.377e-010	2.828e-010	5.671e-005	3.549e-010	7.117e-005
K	1.023e-005	1.023e-005	0.3999		
Mg	0.003923	0.0004885	11.87	0.003434	83.47
Mn	5.718e-007	8.328e-012	4.574e-007	6.746e-010	3.705e-005
Mo	4.536e-008	2.426e-008	0.002327	2.110e-008	0.002024
Na	9.569e-005	9.569e-005	2.199		
Ni	4.576e-006	6.213e-009	0.0003647	4.570e-006	0.2682
O	55.67	55.52	8.880e+005	0.006556	104.9
Pb	0.0002549	2.467e-009	0.0005111	0.0002549	52.80
S	0.0007631	0.0007590	24.33	3.631e-006	0.1164
Sb	2.310e-009	2.237e-009	0.0002723	7.253e-011	8.828e-006
Se	9.839e-009	9.788e-009	0.0007727	5.045e-011	3.983e-006
Si	0.001501	8.010e-006	0.2249	0.001493	41.91
Sr	3.619e-006	3.214e-006	0.2815	4.056e-007	0.03553
U	1.852e-008	1.852e-008	0.004406		
Zn	1.652e-006	6.742e-008	0.004406	1.585e-006	0.1036

♀

```
Step #   200              Xi = 0.4000
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  8.220
Eh =   0.7796 volts      pe =  14.1258
Ionic strength      =    0.004428
Activity of water   =    0.999923
Solvent mass        =    0.999991 kg
Solution mass       =    1.000266 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         275 mg/kg sol'n
Rock mass           =    0.010118 kg
HFO sorbing surface:
  Surface charge    =        6.27 uC/cm2
  Surface potential =       -10.0 mV
  Surface area      =   3.00e+007 cm2
```

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.7796	14.1258

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
H+	-- sliding pH buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.689e-007	-6.329	0.0001094	
Bixbyite	2.856e-007	-6.544	4.509e-005	
Calcite	0.001179	-2.928	0.1180	
Diaspore	2.581e-007	-6.588	1.548e-005	
Dummy	0.05618	-1.250	5.000	
Ferrihydrite	0.04679	-1.330	5.000	
(total)			10.12	0.0000*

full suite results

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002609	159.2	0.9328	-2.6137
SO4--	0.0007021	67.42	0.7570	-3.2745
Ca++	0.0004731	18.96	0.7570	-3.4459
Mg++	0.0003381	8.218	0.7570	-3.5918
O2(aq)	0.0001561	4.994	1.0010	-3.8061
Na+	9.524e-005	2.189	0.9328	-4.0514
H2CO3* (aq)	4.813e-005	2.984	1.0010	-4.3171
CaSO4 (aq)	3.546e-005	4.826	1.0010	-4.4498
MgSO4 (aq)	2.090e-005	2.515	1.0010	-4.6794
CO3--	1.488e-005	0.8927	0.7570	-4.9483
K+	1.020e-005	0.3989	0.9328	-5.0215
CaHCO3+	7.393e-006	0.7472	0.9328	-5.1614
MgHCO3+	7.011e-006	0.5981	0.9328	-5.1845
H4SiO4	5.872e-006	0.5642	1.0010	-5.2308
Sr++	2.885e-006	0.2527	0.7570	-5.6607
MgCO3 (aq)	2.022e-006	0.1704	1.0010	-5.6939
CaCO3 (aq)	9.994e-007	0.1000	1.0010	-5.9998
OH-	3.549e-007	0.006034	0.9328	-6.4801
NaSO4-	2.702e-007	0.03216	0.9328	-6.5985
SrSO4 (aq)	1.835e-007	0.03369	1.0010	-6.7360
NaHCO3 (aq)	1.465e-007	0.01230	1.0010	-6.8338
Ba++	1.336e-007	0.01834	0.7570	-6.9952
SrHCO3+	4.066e-008	0.006042	0.9328	-7.4210
H3SiO4-	3.943e-008	0.003749	0.9328	-7.4344
NaCO3-	3.605e-008	0.002991	0.9328	-7.4733
Zn++	2.964e-008	0.001937	0.7570	-7.6491
KSO4-	2.621e-008	0.003542	0.9328	-7.6117
MoO4--	1.892e-008	0.003026	0.7570	-7.8439
Ca2UO2(CO3)3 (aq	1.559e-008	0.008265	1.0010	-7.8066
ZnCO3 (aq)	1.453e-008	0.001821	1.0010	-7.8374
MgOH+	1.169e-008	0.0004827	0.9328	-7.9625

(only species > 1e-8 molal listed)

Surface species	molality	moles	Boltzman fct.	log molality
>(w)FeOMg+	0.003555	0.003555	0.67760	-2.4492
>(w)FeOH	0.002258	0.002258	1.0000	-2.6464
>(w)FeOSiO(OH)2-	0.0008992	0.0008992	1.4758	-3.0462
>(w)FeCO3-	0.0006257	0.0006257	1.4758	-3.2036
>(w)FeOH2+	0.0003914	0.0003914	0.67760	-3.4073
>(w)FeOSiO2OH--	0.0003426	0.0003426	2.1780	-3.4652
>(w)FeO-	0.0002983	0.0002983	1.4758	-3.5254
>(w)FeOCa+	0.0002797	0.0002797	0.67760	-3.5532
>(w)FeOSi(OH)3	0.0002529	0.0002529	1.0000	-3.5971
>(w)FeCO3H	0.0002165	0.0002165	1.0000	-3.6646
>(s)FeOPb+	0.0002011	0.0002011	0.67760	-3.6965
>(w)FeOCu+	0.0001069	0.0001069	0.67760	-3.9710
>(w)FeOPb+	5.378e-005	5.378e-005	0.67760	-4.2694
>(w)FeOHAsO4---	5.093e-005	5.092e-005	3.2143	-4.2931
>(s)FeOHCa++	2.746e-005	2.746e-005	0.45914	-4.5613
>(w)FeAsO4--	1.722e-005	1.722e-005	2.1780	-4.7640
>(w)FeONi+	4.067e-006	4.067e-006	0.67760	-5.3907
>(s)FeOCu+	3.483e-006	3.483e-006	0.67760	-5.4581
>(w)FeOHSO4--	3.397e-006	3.397e-006	2.1780	-5.4689
>(w)ZnOH2+	1.376e-006	1.376e-006	0.67760	-5.8613
>(s)FeONi+	5.037e-007	5.037e-007	0.67760	-6.2978
>(s)FeOH	3.772e-007	3.772e-007	1.0000	-6.4235
>(w)FeHAsO4-	3.350e-007	3.350e-007	1.4758	-6.4750
>(w)FeOSr+	3.177e-007	3.177e-007	0.67760	-6.4980
>(w)FeSO4-	2.952e-007	2.952e-007	1.4758	-6.5299

>(s)ZnOH2+	2.196e-007	2.196e-007	0.67760	-6.6584
>(s)FeOHSr++	1.836e-007	1.836e-007	0.45914	-6.7361
>(s)FeOSiO(OH)2-	1.502e-007	1.502e-007	1.4758	-6.8233
>(s)FeCO3-	1.045e-007	1.045e-007	1.4758	-6.9807
>(s)FeOH2+	6.540e-008	6.540e-008	0.67760	-7.1844
>(s)FeOSiO2OH--	5.724e-008	5.724e-008	2.1780	-7.2423
>(s)FeO-	4.983e-008	4.983e-008	1.4758	-7.3025
>(w)FeOCd+	4.491e-008	4.491e-008	0.67760	-7.3476
>(s)FeOSi(OH)3	4.224e-008	4.224e-008	1.0000	-7.3742
>(s)FeCO3H	3.617e-008	3.616e-008	1.0000	-7.4417
>(s)FeOHBa++	2.395e-008	2.395e-008	0.45914	-7.6206
>(w)FeOHMoO4--	2.050e-008	2.050e-008	2.1780	-7.6883
>(s)FeOCd+	1.759e-008	1.759e-008	0.67760	-7.7547
>(s)FeOHAsO4---	8.508e-009	8.508e-009	3.2143	-8.0702
>(w)FeOBa+	3.527e-009	3.527e-009	0.67760	-8.4526
>(s)FeAsO4--	2.876e-009	2.876e-009	2.1780	-8.5411
>(w)FeOMo(OH)5	1.071e-009	1.071e-009	1.0000	-8.9703
>(s)FeOHSO4--	5.675e-010	5.675e-010	2.1780	-9.2460
>(w)FeOMn+	4.235e-010	4.235e-010	0.67760	-9.3732
>(w)FeH2AsO4	4.112e-010	4.112e-010	1.0000	-9.3860
>(w)HgOH2+	3.076e-010	3.076e-010	0.67760	-9.5120
>(s)FeOMn+	8.907e-011	8.907e-011	0.67760	-10.0503
>(w)FeOHSbO(OH4	6.375e-011	6.375e-011	1.4758	-10.1955
>(s)FeHAsO4-	5.596e-011	5.596e-011	1.4758	-10.2521
>(s)FeSO4-	4.932e-011	4.932e-011	1.4758	-10.3070
>(w)FeOHSeO4--	4.718e-011	4.718e-011	2.1780	-10.3262
>(w)FeOBaOH	1.579e-011	1.579e-011	1.0000	-10.8016
>(w)FeSbO(OH)4	7.137e-012	7.137e-012	1.0000	-11.1465
>(w)FeSeO4-	3.571e-012	3.571e-012	1.4758	-11.4472
>(s)FeOHMoO4--	3.424e-012	3.424e-012	2.1780	-11.4654
>(s)HgOH2+	1.049e-012	1.049e-012	0.67760	-11.9791
>(s)FeOMo(OH)5	1.789e-013	1.789e-013	1.0000	-12.7474
>(s)FeH2AsO4	6.869e-014	6.869e-014	1.0000	-13.1631
>(s)FeOHSbO(OH4	1.065e-014	1.065e-014	1.4758	-13.9726
>(s)FeOHSeO4--	7.883e-015	7.883e-015	2.1780	-14.1033
>(s)FeSbO(OH)4	1.192e-015	1.192e-015	1.0000	-14.9236
>(s)FeSeO4-	5.967e-016	5.967e-016	1.4758	-15.2243
>(w)FeOHSeO3--	6.234e-021	6.234e-021	2.1780	-20.2052
>(w)FeSeO3-	1.836e-021	1.836e-021	1.4758	-20.7361
>(s)FeOHSeO3--	1.042e-024	1.042e-024	2.1780	-23.9823
>(s)FeSeO3-	3.067e-025	3.067e-025	1.4758	-24.5132

(Boltzman factor = exp(zF PSI/RT), where PSI is surface potential)

Mineral saturation states

	log Q/K		log Q/K
Hematite	8.7228s/sat	Quartz	-0.9491
Cupric Ferrite	6.4197s/sat	Dolomite (disord	-0.9789
Nsutite	5.3037s/sat	CaCO3xH2O	-1.3283
Birnessite	4.7167s/sat	Strontianite	-1.3516
Pyrolusite	4.7092s/sat	Chalcedony	-1.4326
Goethite	3.2107s/sat	Al(OH)3 (Soil)	-1.4416
Lepidocrocite	3.0938s/sat	Cristobalite	-1.6287
Maghemite	2.5437s/sat	Smithsonite	-1.7452
Manganite	1.8299s/sat	Cerrusite	-1.7481
Ferrihydrite (ag	1.7748s/sat	ZnCO3	-1.7974
Magnesioferrite	1.4044s/sat	PbMoO4	-1.8566
Barite	0.0000 sat	Boehmite	-1.8895
Bixbyite	0.0000 sat	Gypsum	-2.0979
Diaspore	0.0000 sat	Celestite	-2.2900
Calcite	0.0000 sat	SiO2 (am,ppt)	-2.2999
Ferrihydrite	0.0000 sat	Tenorite(c)	-2.3313
Dummy	0.0000 sat	ZnCO3:1H2O	-2.3374

Aragonite	-0.1592	SiO2 (am,gel)	-2.3444
Dolomite (ordere	-0.3419	Anhydrite	-2.4511
Cuprous Ferrite	-0.4347	Plattnerite	-2.5129
Vaterite	-0.6232	Pb(OH)2	-2.7595
Magnesite	-0.8282	NiCO3	-2.9055
Gibbsite (C)	-0.8916	Ni(OH)2 (c)	-2.9834

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
O2 (g)	0.1237	-0.908
CO2 (g)	0.0007496	-3.125
Hg (g)	9.178e-025	-24.037
Hg2 (g)	2.042e-049	-48.690
H2Se (g)	1.323e-115	-114.878
CH4 (g)	1.348e-156	-155.870
H2S (g)	8.844e-157	-156.053
Hg(CH3)2 (g)	0.0000	-300.000

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
>(s)FeOH	0.000234					
>(w)FeOH	0.00936					
Al+++	2.59e-007	1.33e-009	3.58e-005			
AsO4---	6.85e-005	7.81e-010	0.000108	6.85e-005	9.51	
Ba++	6.39e-007	1.42e-007	0.0195	2.75e-008	0.00378	
CO3--	0.00471	0.00269	161.	0.000842	50.5	
Ca++	0.00200	0.000517	20.7	0.000307	12.3	
Cd++	6.26e-008	1.12e-010	1.26e-005	6.25e-008	0.00702	
Cu++	0.000110	3.52e-009	0.000224	0.000110	7.01	
Fe+++	0.0468	1.17e-010	6.51e-006	-1.60e-006	-0.0891	
H+	-0.142	0.00272	2.74	-0.00462	-4.65	
H2O	55.6	55.5	1.00e+006	-0.00241	-43.4	
H4SiO4	0.00150	5.91e-006	0.568	0.00149	144.	
Hg(OH)2	6.38e-010	3.29e-010	7.72e-005	3.09e-010	7.24e-005	
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00392	0.000368	8.95	0.00355	86.4	
Mn+++	5.72e-007	4.89e-012	2.69e-007	5.13e-010	2.81e-005	
MoO4--	4.54e-008	2.38e-008	0.00380	2.16e-008	0.00345	
Na+	9.57e-005	9.57e-005	2.20			
Ni++	4.58e-006	4.72e-009	0.000277	4.57e-006	0.268	
O2(aq)	0.000156	0.000156	4.99	-1.28e-010	-4.10e-006	
Pb++	0.000255	2.19e-009	0.000453	0.000255	52.8	
SO4--	0.000763	0.000759	72.9	3.69e-006	0.355	
Sb(OH)6-	2.31e-009	2.24e-009	0.000501	7.09e-011	1.59e-005	
SeO4--	9.84e-009	9.79e-009	0.00140	5.08e-011	7.25e-006	
Sr++	3.62e-006	3.12e-006	0.273	5.01e-007	0.0439	
UO2++	1.85e-008	1.85e-008	0.00500			
Zn++	1.65e-006	5.62e-008	0.00367	1.60e-006	0.104	
dummy	0.0562	0.000	0.000			

Sorbed	fraction	log fraction
AsO4---	1.000	-0.000
Ba++	0.1619	-0.791
CO3--	0.2385	-0.623
Ca++	0.3727	-0.429
Cd++	0.9982	-0.001
Cu++	1.000	-0.000
Fe+++	1.000	0.000
H4SiO4	0.9961	-0.002
Hg(OH)2	0.4840	-0.315

Mg++	0.9062	-0.043
Mn+++	0.9905	-0.004
MoO4--	0.4755	-0.323
Ni++	0.9990	-0.000
Pb++	1.000	-0.000
SO4--	0.004842	-2.315
Sb(OH)6-	0.03069	-1.513
SeO4--	0.005159	-2.287
Sr++	0.1385	-0.859
Zn++	0.9660	-0.015

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	1.326e-009	3.576e-005		
As	6.849e-005	7.810e-010	5.850e-005	6.849e-005	5.130
Ba	6.388e-007	1.424e-007	0.01955	2.750e-008	0.003775
C	0.004711	0.002690	32.30	0.0008423	10.11
Ca	0.002003	0.0005170	20.72	0.0003072	12.31
Cd	6.262e-008	1.121e-010	1.260e-005	6.250e-008	0.007023
Cu	0.0001104	3.524e-009	0.0002239	0.0001104	7.013
Du	0.05618	0.0000	0.0000		
Fe	0.04678	1.167e-010	6.514e-006	-1.596e-006	-0.08912
H	111.2	111.0	1.119e+005	-0.003452	-3.478
Hg	6.377e-010	3.290e-010	6.598e-005	3.086e-010	6.189e-005
K	1.023e-005	1.023e-005	0.3999		
Mg	0.003923	0.0003681	8.946	0.003555	86.40
Mn	5.718e-007	4.891e-012	2.686e-007	5.125e-010	2.815e-005
Mo	4.536e-008	2.379e-008	0.002282	2.157e-008	0.002069
Na	9.569e-005	9.569e-005	2.199		
Ni	4.576e-006	4.717e-009	0.0002769	4.571e-006	0.2683
O	55.67	55.52	8.880e+005	0.006388	102.2
Pb	0.0002549	2.188e-009	0.0004532	0.0002549	52.80
S	0.0007631	0.0007589	24.33	3.693e-006	0.1184
Sb	2.310e-009	2.239e-009	0.0002725	7.090e-011	8.629e-006
Se	9.839e-009	9.788e-009	0.0007727	5.076e-011	4.007e-006
Si	0.001501	5.912e-006	0.1660	0.001495	41.97
Sr	3.619e-006	3.118e-006	0.2731	5.013e-007	0.04391
U	1.852e-008	1.852e-008	0.004406		
Zn	1.652e-006	5.621e-008	0.003674	1.596e-006	0.1043

♀

```
Step #   250             Xi = 0.5000
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  8.350
Eh =   0.7724 volts      pe =  13.9958
Ionic strength      =    0.004028
Activity of water   =    0.999927
Solvent mass        =    0.999989 kg
Solution mass       =    1.000253 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         264 mg/kg sol'n
Rock mass           =    0.010131 kg
HFO sorbing surface:
  Surface charge    =        5.34 uC/cm2
  Surface potential =       -10.0 mV
  Surface area      =   3.00e+007 cm2
```

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.7724	13.9958

full suite results

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
H+	-- sliding pH buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.715e-007	-6.326	0.0001101	
Bixbyite	2.857e-007	-6.544	4.510e-005	
Calcite	0.001312	-2.882	0.1313	
Diaspore	2.577e-007	-6.589	1.546e-005	
Dummy	0.05618	-1.250	5.000	
Ferrihydrite	0.04679	-1.330	5.000	
(total)			10.13	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002561	156.2	0.9355	-2.6205
SO4--	0.0007145	68.61	0.7660	-3.2618
Ca++	0.0003521	14.11	0.7660	-3.5691
Mg++	0.0002555	6.209	0.7660	-3.7084
O2(aq)	0.0001561	4.994	1.0009	-3.8062
Na+	9.522e-005	2.189	0.9355	-4.0502
H2CO3* (aq)	3.513e-005	2.178	1.0009	-4.4539
CaSO4 (aq)	2.750e-005	3.742	1.0009	-4.5603
CO3--	1.953e-005	1.172	0.7660	-4.8251
MgSO4 (aq)	1.645e-005	1.980	1.0009	-4.7833
K+	1.020e-005	0.3988	0.9355	-5.0202
CaHCO3+	5.464e-006	0.5523	0.9355	-5.2914
MgHCO3+	5.262e-006	0.4489	0.9355	-5.3078
H4SiO4	4.232e-006	0.4066	1.0009	-5.3731
Sr++	2.775e-006	0.2430	0.7660	-5.6726
MgCO3 (aq)	2.053e-006	0.1731	1.0009	-5.6872
CaCO3 (aq)	9.995e-007	0.1000	1.0009	-5.9998
OH-	4.774e-007	0.008116	0.9355	-6.3501
NaSO4-	2.782e-007	0.03311	0.9355	-6.5846
SrSO4 (aq)	1.838e-007	0.03376	1.0009	-6.7351
NaHCO3 (aq)	1.446e-007	0.01214	1.0009	-6.8394
Ba++	1.282e-007	0.01760	0.7660	-7.0080
NaCO3-	4.787e-008	0.003972	0.9355	-7.3489
SrHCO3+	3.884e-008	0.005771	0.9355	-7.4397
H3SiO4-	3.822e-008	0.003634	0.9355	-7.4466
KSO4-	2.699e-008	0.003647	0.9355	-7.5977
Zn++	2.162e-008	0.001413	0.7660	-7.7810
MoO4--	1.956e-008	0.003128	0.7660	-7.8243
Ca2UO2(CO3)3 (aq	1.425e-008	0.007553	1.0009	-7.8458
ZnCO3 (aq)	1.424e-008	0.001785	1.0009	-7.8460
MgOH+	1.202e-008	0.0004964	0.9355	-7.9491
SrCO3 (aq)	1.115e-008	0.001646	1.0009	-7.9522
Zn(OH)2 (aq)	1.058e-008	0.001051	1.0009	-7.9750

(only species > 1e-8 molal listed)

Surface species	molality	moles	Boltzman fct.	log molality
>(w)FeOMg+	0.003644	0.003644	0.67760	-2.4385
>(w)FeOH	0.002244	0.002243	1.0000	-2.6491
>(w)FeOSiO(OH)2-	0.0008687	0.0008687	1.4758	-3.0611
>(w)FeCO3-	0.0006122	0.0006121	1.4758	-3.2131
>(w)FeOSiO2OH--	0.0004465	0.0004465	2.1780	-3.3502
>(w)FeO-	0.0003999	0.0003999	1.4758	-3.3981
>(w)FeOH2+	0.0002884	0.0002884	0.67760	-3.5400
>(w)FeOCa+	0.0002824	0.0002824	0.67760	-3.5492

>(s)FeOPb+	0.0002053	0.0002053	0.67760	-3.6875
>(w)FeOSi(OH)3	0.0001811	0.0001811	1.0000	-3.7421
>(w)FeCO3H	0.0001570	0.0001570	1.0000	-3.8041
>(w)FeOCu+	0.0001065	0.0001065	0.67760	-3.9725
>(w)FeOHAsO4---	5.460e-005	5.460e-005	3.2143	-4.2628
>(w)FeOPb+	4.959e-005	4.959e-005	0.67760	-4.3046
>(s)FeOHCa++	2.275e-005	2.275e-005	0.45914	-4.6431
>(w)FeAsO4--	1.368e-005	1.368e-005	2.1780	-4.8638
>(w)FeONi+	4.021e-006	4.021e-006	0.67760	-5.3957
>(s)FeOCu+	3.842e-006	3.842e-006	0.67760	-5.4154
>(w)FeOHSO4--	3.476e-006	3.476e-006	2.1780	-5.4589
>(w)ZnOH2+	1.362e-006	1.362e-006	0.67760	-5.8659
>(s)FeONi+	5.513e-007	5.513e-007	0.67760	-6.2586
>(s)FeOH	4.149e-007	4.149e-007	1.0000	-6.3820
>(w)FeOSr+	4.144e-007	4.144e-007	0.67760	-6.3826
>(s)ZnOH2+	2.405e-007	2.405e-007	0.67760	-6.6188
>(w)FeSO4-	2.239e-007	2.239e-007	1.4758	-6.6499
>(w)FeHAsO4-	1.973e-007	1.973e-007	1.4758	-6.7048
>(s)FeOHSr++	1.966e-007	1.965e-007	0.45914	-6.7065
>(s)FeOSiO(OH)2-	1.607e-007	1.607e-007	1.4758	-6.7941
>(s)FeCO3-	1.132e-007	1.132e-007	1.4758	-6.9461
>(s)FeOSiO2OH--	8.258e-008	8.258e-008	2.1780	-7.0831
>(s)FeO-	7.395e-008	7.395e-008	1.4758	-7.1310
>(s)FeOH2+	5.334e-008	5.334e-008	0.67760	-7.2730
>(w)FeOCd+	4.362e-008	4.362e-008	0.67760	-7.3603
>(s)FeOSi(OH)3	3.349e-008	3.349e-008	1.0000	-7.4751
>(s)FeCO3H	2.904e-008	2.904e-008	1.0000	-7.5370
>(s)FeOHBa++	2.559e-008	2.559e-008	0.45914	-7.5919
>(w)FeOHMoO4--	2.131e-008	2.131e-008	2.1780	-7.6715
>(s)FeOCd+	1.891e-008	1.891e-008	0.67760	-7.7233
>(s)FeOHAsO4---	1.010e-008	1.010e-008	3.2143	-7.9958
>(w)FeOBa+	4.592e-009	4.592e-009	0.67760	-8.3380
>(s)FeAsO4--	2.531e-009	2.531e-009	2.1780	-8.5967
>(s)FeOHSO4--	6.429e-010	6.429e-010	2.1780	-9.1919
>(w)FeOMo(OH)5	6.117e-010	6.117e-010	1.0000	-9.2134
>(w)FeOMn+	3.120e-010	3.120e-010	0.67760	-9.5059
>(w)HgOH2+	2.597e-010	2.597e-010	0.67760	-9.5855
>(w)FeH2AsO4	1.796e-010	1.796e-010	1.0000	-9.7458
>(s)FeOMn+	7.264e-011	7.264e-011	0.67760	-10.1388
>(w)FeOHSbO(OH4	6.360e-011	6.360e-011	1.4758	-10.1966
>(w)FeOHSeO4--	4.775e-011	4.775e-011	2.1780	-10.3211
>(s)FeSO4-	4.142e-011	4.142e-011	1.4758	-10.3828
>(s)FeHAsO4-	3.650e-011	3.650e-011	1.4758	-10.4377
>(w)FeOBaOH	2.773e-011	2.773e-011	1.0000	-10.5570
>(w)FeSbO(OH)4	5.278e-012	5.278e-012	1.0000	-11.2775
>(s)FeOHMoO4--	3.941e-012	3.941e-012	2.1780	-11.4044
>(w)FeSeO4-	2.679e-012	2.679e-012	1.4758	-11.5720
>(s)HgOH2+	9.808e-013	9.808e-013	0.67760	-12.0084
>(s)FeOMo(OH)5	1.131e-013	1.131e-013	1.0000	-12.9464
>(s)FeH2AsO4	3.321e-014	3.321e-014	1.0000	-13.4787
>(s)FeOHSbO(OH4	1.176e-014	1.176e-014	1.4758	-13.9295
>(s)FeOHSeO4--	8.831e-015	8.831e-015	2.1780	-14.0540
>(s)FeSbO(OH)4	9.762e-016	9.762e-016	1.0000	-15.0104
>(s)FeSeO4-	4.955e-016	4.955e-016	1.4758	-15.3049
>(w)FeOHSeO3--	6.309e-021	6.309e-021	2.1780	-20.2000
>(w)FeSeO3-	1.377e-021	1.377e-021	1.4758	-20.8610
>(s)FeOHSeO3--	1.167e-024	1.167e-024	2.1780	-23.9330
>(s)FeSeO3-	2.547e-025	2.547e-025	1.4758	-24.5939

(Boltzman factor = exp(zF PSI/RT), where PSI is surface potential)

Mineral saturation states

	log Q/K		log Q/K

Hematite	8.7228s/sat	Quartz	-1.0913
Cupric Ferrite	6.5509s/sat	Strontianite	-1.2402
Nsutite	5.3037s/sat	CaCO3xH2O	-1.3283
Birnessite	4.7167s/sat	Al(OH)3 (Soil)	-1.4416
Pyrolusite	4.7092s/sat	Chalcedony	-1.5748
Goethite	3.2106s/sat	Smithsonite	-1.7539
Lepidocrocite	3.0938s/sat	Cristobalite	-1.7710
Maghemite	2.5437s/sat	Cerrusite	-1.7873
Manganite	1.8299s/sat	ZnCO3	-1.8060
Ferrihydrite (ag	1.7748s/sat	Boehmite	-1.8895
Magnesioferrite	1.5478s/sat	PbMoO4	-1.9995
Barite	0.0000 sat	Tenorite(c)	-2.2000
Bixbyite	0.0000 sat	Gypsum	-2.2084
Ferrihydrite	0.0000 sat	Celestite	-2.2892
Dummy	0.0000 sat	ZnCO3:1H2O	-2.3461
Calcite	0.0000 sat	Plattnerite	-2.4154
Diaspore	0.0000 sat	SiO2 (am,ppt)	-2.4422
Aragonite	-0.1592	SiO2 (am,gel)	-2.4866
Cuprous Ferrite	-0.3034	Anhydrite	-2.5616
Dolomite (ordere	-0.3353	Pb(OH)2	-2.6620
Vaterite	-0.6232	Ni(OH)2 (c)	-2.8557
Magnesite	-0.8215	NiCO3	-2.9146
Gibbsite (C)	-0.8916	Zn(OH)2 (delta)	-2.9250
Dolomite (disord	-0.9722		

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
O2 (g)	0.1237	-0.908
CO2 (g)	0.0005471	-3.262
Hg (g)	1.052e-024	-23.978
Hg2 (g)	2.683e-049	-48.571
H2Se (g)	7.406e-116	-115.130
CH4 (g)	9.840e-157	-156.007
H2S (g)	5.005e-157	-156.301
Hg(CH3)2 (g)	0.0000	-300.000

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
>(s)FeOH	0.000234					
>(w)FeOH	0.00936					
Al+++	2.59e-007	1.78e-009	4.79e-005			
AsO4---	6.85e-005	6.10e-010	8.47e-005	6.85e-005	9.51	
Ba++	6.39e-007	1.37e-007	0.0188	3.02e-008	0.00415	
CO3--	0.00471	0.00263	158.	0.000769	46.2	
Ca++	0.00200	0.000386	15.5	0.000305	12.2	
Cd++	6.26e-008	8.48e-011	9.53e-006	6.25e-008	0.00703	
Cu++	0.000110	3.50e-009	0.000223	0.000110	7.01	
Fe+++	0.0468	8.78e-011	4.90e-006	-1.60e-006	-0.0895	
H+	-0.143	0.00264	2.66	-0.00523	-5.27	
H2O	55.6	55.5	1.00e+006	-0.00234	-42.1	
H4SiO4	0.00150	4.27e-006	0.410	0.00150	144.	
Hg(OH)2	6.38e-010	3.77e-010	8.84e-005	2.61e-010	6.11e-005	
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00392	0.000279	6.79	0.00364	88.6	
Mn+++	5.72e-007	2.95e-012	1.62e-007	3.85e-010	2.11e-005	
MoO4--	4.54e-008	2.34e-008	0.00375	2.19e-008	0.00351	
Na+	9.57e-005	9.57e-005	2.20			
Ni++	4.58e-006	3.69e-009	0.000217	4.57e-006	0.268	
O2(aq)	0.000156	0.000156	4.99	-9.62e-011	-3.08e-006	
Pb++	0.000255	1.99e-009	0.000413	0.000255	52.8	
SO4--	0.000763	0.000759	72.9	3.70e-006	0.355	

Sb(OH)6-	2.31e-009	2.24e-009	0.000501	6.89e-011	1.54e-005
SeO4--	9.84e-009	9.79e-009	0.00140	5.04e-011	7.21e-006
Sr++	3.62e-006	3.01e-006	0.264	6.11e-007	0.0535
UO2++	1.85e-008	1.85e-008	0.00500		
Zn++	1.65e-006	4.98e-008	0.00325	1.60e-006	0.105
dummy	0.0562	0.000	0.000		

Sorbed	fraction	log fraction
AsO4---	1.000	-0.000
Ba++	0.1806	-0.743
CO3--	0.2263	-0.645
Ca++	0.4414	-0.355
Cd++	0.9986	-0.001
Cu++	1.000	-0.000
Fe+++	1.000	0.000
H4SiO4	0.9972	-0.001
Hg(OH)2	0.4088	-0.388
Mg++	0.9288	-0.032
Mn+++	0.9924	-0.003
MoO4--	0.4833	-0.316
Ni++	0.9992	-0.000
Pb++	1.000	-0.000
SO4--	0.004853	-2.314
Sb(OH)6-	0.02982	-1.525
SeO4--	0.005126	-2.290
Sr++	0.1688	-0.773
Zn++	0.9699	-0.013

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	1.776e-009	4.791e-005		
As	6.849e-005	6.096e-010	4.566e-005	6.849e-005	5.130
Ba	6.388e-007	1.370e-007	0.01882	3.021e-008	0.004148
C	0.004711	0.002630	31.58	0.0007693	9.238
Ca	0.002003	0.0003861	15.47	0.0003051	12.23
Cd	6.262e-008	8.480e-011	9.529e-006	6.253e-008	0.007027
Cu	0.0001104	3.504e-009	0.0002226	0.0001104	7.013
Du	0.05618	0.0000	0.0000		
Fe	0.04678	8.780e-011	4.902e-006	-1.603e-006	-0.08948
H	111.2	111.0	1.119e+005	-0.003912	-3.942
Hg	6.377e-010	3.770e-010	7.560e-005	2.607e-010	5.228e-005
K	1.023e-005	1.023e-005	0.3999		
Mg	0.003923	0.0002793	6.788	0.003644	88.56
Mn	5.718e-007	2.951e-012	1.621e-007	3.846e-010	2.112e-005
Mo	4.536e-008	2.344e-008	0.002248	2.192e-008	0.002103
Na	9.569e-005	9.569e-005	2.199		
Ni	4.576e-006	3.693e-009	0.0002167	4.572e-006	0.2684
O	55.67	55.52	8.881e+005	0.006247	99.92
Pb	0.0002549	1.992e-009	0.0004127	0.0002549	52.80
S	0.0007631	0.0007589	24.33	3.701e-006	0.1186
Sb	2.310e-009	2.241e-009	0.0002728	6.889e-011	8.385e-006
Se	9.839e-009	9.788e-009	0.0007727	5.044e-011	3.981e-006
Si	0.001501	4.271e-006	0.1199	0.001497	42.02
Sr	3.619e-006	3.008e-006	0.2635	6.109e-007	0.05351
U	1.852e-008	1.852e-008	0.004406		
Zn	1.652e-006	4.980e-008	0.003255	1.602e-006	0.1047

♀

Step # 300 Xi = 0.6000
Temperature = 5.0 C Pressure = 0.938 bars
pH = 8.480

full suite results

```
Eh =   0.7652 volts      pe =  13.8658
Ionic strength      =    0.003740
Activity of water   =    0.999931
Solvent mass        =    0.999988 kg
Solution mass       =    1.000244 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         256 mg/kg sol'n
Rock mass           =    0.010142 kg
HFO sorbing surface:
  Surface charge    =        4.34 uC/cm2
  Surface potential =       -10.0 mV
  Surface area      =   3.00e+007 cm2
```

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.7652	13.8658

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
H+	-- sliding pH buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.726e-007	-6.325	0.0001103	
Bixbyite	2.857e-007	-6.544	4.511e-005	
Calcite	0.001417	-2.849	0.1418	
Diaspore	2.571e-007	-6.590	1.542e-005	
Dummy	0.05618	-1.250	5.000	
Ferrihydrite	0.04679	-1.330	5.000	
(total)			10.14	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002526	154.1	0.9376	-2.6256
SO4--	0.0007244	69.57	0.7729	-3.2519
Ca++	0.0002617	10.49	0.7729	-3.6940
Mg++	0.0001950	4.740	0.7729	-3.8218
O2(aq)	0.0001561	4.994	1.0009	-3.8062
Na+	9.520e-005	2.188	0.9376	-4.0493
CO3--	2.581e-005	1.548	0.7729	-4.7002
H2CO3* (aq)	2.574e-005	1.596	1.0009	-4.5890
CaSO4 (aq)	2.110e-005	2.872	1.0009	-4.6753
MgSO4 (aq)	1.297e-005	1.560	1.0009	-4.8868
K+	1.020e-005	0.3988	0.9376	-5.0193
CaHCO3+	4.042e-006	0.4085	0.9376	-5.4214
MgHCO3+	3.996e-006	0.3409	0.9376	-5.4263
H4SiO4	2.987e-006	0.2871	1.0009	-5.5243
Sr++	2.653e-006	0.2324	0.7729	-5.6881
MgCO3 (aq)	2.108e-006	0.1777	1.0009	-5.6757
CaCO3 (aq)	9.996e-007	0.1000	1.0009	-5.9998
OH-	6.425e-007	0.01092	0.9376	-6.2201
NaSO4-	2.845e-007	0.03387	0.9376	-6.5738
SrSO4 (aq)	1.815e-007	0.03333	1.0009	-6.7408
NaHCO3 (aq)	1.432e-007	0.01203	1.0009	-6.8436
Ba++	1.242e-007	0.01705	0.7729	-7.0178
NaCO3-	6.381e-008	0.005294	0.9376	-7.2231
SrHCO3+	3.696e-008	0.005492	0.9376	-7.4603
H3SiO4-	3.631e-008	0.003453	0.9376	-7.4679
KSO4-	2.761e-008	0.003731	0.9376	-7.5869
MoO4--	2.019e-008	0.003229	0.7729	-7.8067

Zn++	1.599e-008	0.001045	0.7729	-7.9080
Zn(OH)2 (aq)	1.437e-008	0.001428	1.0009	-7.8421
SrCO3 (aq)	1.435e-008	0.002118	1.0009	-7.8428
ZnCO3 (aq)	1.417e-008	0.001777	1.0009	-7.8482
MgOH+	1.246e-008	0.0005147	0.9376	-7.9325
Ca2UO2(CO3)3 (aq	1.242e-008	0.006582	1.0009	-7.9056

(only species > 1e-8 molal listed)

Surface species	molality	moles	Boltzman fct.	log molality
>(w)FeOMg+	0.003709	0.003709	0.67760	-2.4308
>(w)FeOH	0.002198	0.002198	1.0000	-2.6580
>(w)FeOSiO(OH)2-	0.0008104	0.0008104	1.4758	-3.0913
>(w)FeCO3-	0.0005927	0.0005927	1.4758	-3.2272
>(w)FeOSiO2OH--	0.0005619	0.0005619	2.1780	-3.2503
>(w)FeO-	0.0005284	0.0005284	1.4758	-3.2770
>(w)FeOCa+	0.0002799	0.0002799	0.67760	-3.5530
>(w)FeOH2+	0.0002094	0.0002094	0.67760	-3.6790
>(s)FeOPb+	0.0002091	0.0002091	0.67760	-3.6796
>(w)FeOSi(OH)3	0.0001252	0.0001252	1.0000	-3.9023
>(w)FeCO3H	0.0001127	0.0001127	1.0000	-3.9481
>(w)FeOCu+	0.0001062	0.0001062	0.67760	-3.9740
>(w)FeOHAsO4---	5.765e-005	5.765e-005	3.2143	-4.2392
>(w)FeOPb+	4.582e-005	4.582e-005	0.67760	-4.3390
>(s)FeOHCa++	1.842e-005	1.842e-005	0.45914	-4.7346
>(w)FeAsO4--	1.071e-005	1.071e-005	2.1780	-4.9702
>(s)FeOCu+	4.220e-006	4.220e-006	0.67760	-5.3746
>(w)FeONi+	3.972e-006	3.972e-006	0.67760	-5.4009
>(w)FeOHSO4--	3.484e-006	3.484e-006	2.1780	-5.4580
>(w)ZnOH2+	1.343e-006	1.343e-006	0.67760	-5.8718
>(s)FeONi+	6.004e-007	6.004e-007	0.67760	-6.2216
>(w)FeOSr+	5.284e-007	5.284e-007	0.67760	-6.2771
>(s)FeOH	4.481e-007	4.481e-007	1.0000	-6.3486
>(s)ZnOH2+	2.615e-007	2.615e-007	0.67760	-6.5825
>(s)FeOHSr++	2.048e-007	2.048e-007	0.45914	-6.6887
>(w)FeSO4-	1.664e-007	1.664e-007	1.4758	-6.7789
>(s)FeOSiO(OH)2-	1.652e-007	1.652e-007	1.4758	-6.7820
>(s)FeCO3-	1.208e-007	1.208e-007	1.4758	-6.9178
>(s)FeOSiO2OH--	1.146e-007	1.146e-007	2.1780	-6.9410
>(w)FeHAsO4-	1.145e-007	1.145e-007	1.4758	-6.9411
>(s)FeO-	1.077e-007	1.077e-007	1.4758	-6.9676
>(s)FeOH2+	4.270e-008	4.270e-008	0.67760	-7.3696
>(w)FeOCd+	4.232e-008	4.232e-008	0.67760	-7.3734
>(s)FeOHBa++	2.701e-008	2.701e-008	0.45914	-7.5684
>(s)FeOSi(OH)3	2.553e-008	2.553e-008	1.0000	-7.5929
>(s)FeCO3H	2.297e-008	2.297e-008	1.0000	-7.6388
>(w)FeOHMoO4--	2.174e-008	2.174e-008	2.1780	-7.6627
>(s)FeOCd+	2.023e-008	2.023e-008	0.67760	-7.6941
>(s)FeOHAsO4---	1.175e-008	1.175e-008	3.2143	-7.9298
>(w)FeOBa+	5.932e-009	5.932e-009	0.67760	-8.2268
>(s)FeAsO4--	2.184e-009	2.184e-009	2.1780	-8.6608
>(s)FeOHSO4--	7.103e-010	7.102e-010	2.1780	-9.1486
>(w)FeOMo(OH)5	3.430e-010	3.430e-010	1.0000	-9.4647
>(w)FeOMn+	2.266e-010	2.266e-010	0.67760	-9.6448
>(w)HgOH2+	2.124e-010	2.124e-010	0.67760	-9.6728
>(w)FeH2AsO4	7.725e-011	7.725e-011	1.0000	-10.1121
>(w)FeOHSbO(OH4	6.251e-011	6.251e-011	1.4758	-10.2040
>(s)FeOMn+	5.815e-011	5.815e-011	0.67760	-10.2354
>(w)FeOBaOH	4.832e-011	4.832e-011	1.0000	-10.3158
>(w)FeOHSeO4--	4.744e-011	4.744e-011	2.1780	-10.3239
>(s)FeSO4-	3.392e-011	3.392e-011	1.4758	-10.4695
>(s)FeHAsO4-	2.335e-011	2.335e-011	1.4758	-10.6318
>(s)FeOHMoO4--	4.432e-012	4.432e-012	2.1780	-11.3534

>(w)FeSbO(OH)4	3.846e-012	3.846e-012	1.0000	-11.4150
>(w)FeSeO4-	1.973e-012	1.973e-012	1.4758	-11.7048
>(s)HgOH2+	8.842e-013	8.842e-013	0.67760	-12.0535
>(s)FeOMo(OH)5	6.993e-014	6.993e-014	1.0000	-13.1554
>(s)FeH2AsO4	1.575e-014	1.575e-014	1.0000	-13.8028
>(s)FeOHSbO(OH4	1.274e-014	1.274e-014	1.4758	-13.8947
>(s)FeOHSeO4--	9.671e-015	9.671e-015	2.1780	-14.0145
>(s)FeSbO(OH)4	7.841e-016	7.841e-016	1.0000	-15.1056
>(s)FeSeO4-	4.023e-016	4.023e-016	1.4758	-15.3955
>(w)FeOHSeO3--	6.268e-021	6.268e-021	2.1780	-20.2028
>(w)FeSeO3-	1.014e-021	1.014e-021	1.4758	-20.9938
>(s)FeOHSeO3--	1.278e-024	1.278e-024	2.1780	-23.8935
>(s)FeSeO3-	2.068e-025	2.068e-025	1.4758	-24.6844

(Boltzman factor = exp(zF PSI/RT), where PSI is surface potential)

Mineral saturation states

	log Q/K		log Q/K
Hematite	8.7228s/sat	Strontianite	-1.1308
Cupric Ferrite	6.6883s/sat	Quartz	-1.2426
Nsutite	5.3037s/sat	CaCO3xH2O	-1.3283
Birnessite	4.7167s/sat	Al(OH)3 (Soil)	-1.4416
Pyrolusite	4.7092s/sat	Chalcedony	-1.7261
Goethite	3.2106s/sat	Smithsonite	-1.7560
Lepidocrocite	3.0938s/sat	ZnCO3	-1.8082
Maghemite	2.5437s/sat	Cerrusite	-1.8179
Manganite	1.8299s/sat	Boehmite	-1.8895
Ferrihydrite (ag	1.7748s/sat	Cristobalite	-1.9222
Magnesioferrite	1.6944s/sat	Tenorite(c)	-2.0626
Bixbyite	0.0000 sat	PbMoO4	-2.1374
Diaspore	0.0000 sat	Celestite	-2.2948
Dummy	0.0000 sat	Plattnerite	-2.3109
Barite	0.0000 sat	Gypsum	-2.3234
Calcite	0.0000 sat	ZnCO3:1H2O	-2.3482
Ferrihydrite	0.0000 sat	Pb(OH)2	-2.5574
Aragonite	-0.1592	SiO2 (am,ppt)	-2.5934
Cuprous Ferrite	-0.1660	SiO2 (am,gel)	-2.6379
Dolomite (ordere	-0.3237	Anhydrite	-2.6766
Vaterite	-0.6232	Ni(OH)2 (c)	-2.7220
Magnesite	-0.8100	Zn(OH)2 (delta)	-2.7921
Gibbsite (C)	-0.8916	Tenorite(am)	-2.9123
Dolomite (disord	-0.9607	NiCO3	-2.9160

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
O2 (g)	0.1236	-0.908
CO2 (g)	0.0004008	-3.397
Hg (g)	1.185e-024	-23.926
Hg2 (g)	3.403e-049	-48.468
H2Se (g)	4.128e-116	-115.384
CH4 (g)	7.210e-157	-156.142
H2S (g)	2.814e-157	-156.551
Hg(CH3)2 (g)	0.0000	-300.000

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
>(s)FeOH	0.000234					
>(w)FeOH	0.00936					
Al+++	2.59e-007	2.38e-009	6.43e-005			
AsO4---	6.85e-005	4.78e-010	6.64e-005	6.85e-005		9.51
Ba++	6.39e-007	1.33e-007	0.0183	3.30e-008		0.00453

CO3--	0.00471	0.00259	155.	0.000706	42.3
Ca++	0.00200	0.000288	11.5	0.000298	12.0
Cd++	6.26e-008	6.61e-011	7.43e-006	6.25e-008	0.00703
Cu++	0.000110	3.57e-009	0.000227	0.000110	7.01
Fe+++	0.0468	6.67e-011	3.73e-006	-1.61e-006	-0.0896
H+	-0.144	0.00258	2.60	-0.00578	-5.82
H2O	55.6	55.5	1.00e+006	-0.00227	-40.9
H4SiO4	0.00150	3.02e-006	0.291	0.00150	144.
Hg(OH)2	6.38e-010	4.24e-010	9.95e-005	2.13e-010	5.00e-005
K+	1.02e-005	1.02e-005	0.400		
Mg++	0.00392	0.000214	5.20	0.00371	90.1
Mn+++	5.72e-007	1.84e-012	1.01e-007	2.85e-010	1.56e-005
MoO4--	4.54e-008	2.33e-008	0.00372	2.21e-008	0.00353
Na+	9.57e-005	9.57e-005	2.20		
Ni++	4.58e-006	2.99e-009	0.000176	4.57e-006	0.268
O2(aq)	0.000156	0.000156	4.99	-7.12e-011	-2.28e-006
Pb++	0.000255	1.87e-009	0.000386	0.000255	52.8
SO4--	0.000763	0.000759	72.9	3.65e-006	0.351
Sb(OH)6-	2.31e-009	2.24e-009	0.000502	6.64e-011	1.48e-005
SeO4--	9.84e-009	9.79e-009	0.00140	4.94e-011	7.06e-006
Sr++	3.62e-006	2.89e-006	0.253	7.33e-007	0.0642
UO2++	1.85e-008	1.85e-008	0.00500		
Zn++	1.65e-006	4.73e-008	0.00309	1.60e-006	0.105
dummy	0.0562	0.000	0.000		

Sorbed	fraction	log fraction
AsO4---	1.000	-0.000
Ba++	0.1986	-0.702
CO3--	0.2142	-0.669
Ca++	0.5089	-0.293
Cd++	0.9989	-0.000
Cu++	1.000	-0.000
Fe+++	1.000	0.000
H4SiO4	0.9980	-0.001
Hg(OH)2	0.3345	-0.476
Mg++	0.9454	-0.024
Mn+++	0.9936	-0.003
MoO4--	0.4869	-0.313
Ni++	0.9993	-0.000
Pb++	1.000	-0.000
SO4--	0.004787	-2.320
Sb(OH)6-	0.02873	-1.542
SeO4--	0.005023	-2.299
Sr++	0.2026	-0.693
Zn++	0.9714	-0.013

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	2.383e-009	6.429e-005		
As	6.849e-005	4.782e-010	3.582e-005	6.849e-005	5.130
Ba	6.388e-007	1.331e-007	0.01828	3.299e-008	0.004530
C	0.004711	0.002589	31.09	0.0007055	8.472
Ca	0.002003	0.0002879	11.54	0.0002983	11.95
Cd	6.262e-008	6.611e-011	7.428e-006	6.255e-008	0.007029
Cu	0.0001104	3.568e-009	0.0002267	0.0001104	7.013
Du	0.05618	0.0000	0.0000		
Fe	0.04678	6.674e-011	3.726e-006	-1.605e-006	-0.08961
H	111.2	111.0	1.119e+005	-0.004336	-4.369
Hg	6.377e-010	4.244e-010	8.511e-005	2.133e-010	4.277e-005
K	1.023e-005	1.023e-005	0.3999		
Mg	0.003923	0.0002141	5.204	0.003709	90.15

Mn	5.718e-007	1.844e-012	1.013e-007	2.847e-010	1.564e-005
Mo	4.536e-008	2.327e-008	0.002232	2.209e-008	0.002119
Na	9.569e-005	9.569e-005	2.199		
Ni	4.576e-006	2.991e-009	0.0001755	4.573e-006	0.2684
O	55.67	55.52	8.881e+005	0.006123	97.94
Pb	0.0002549	1.866e-009	0.0003865	0.0002549	52.81
S	0.0007631	0.0007589	24.33	3.651e-006	0.1170
Sb	2.310e-009	2.243e-009	0.0002731	6.637e-011	8.079e-006
Se	9.839e-009	9.789e-009	0.0007728	4.942e-011	3.901e-006
Si	0.001501	3.024e-006	0.08492	0.001498	42.06
Sr	3.619e-006	2.886e-006	0.2528	7.332e-007	0.06423
U	1.852e-008	1.852e-008	0.004406		
Zn	1.652e-006	4.733e-008	0.003093	1.605e-006	0.1049

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Step #   350               Xi = 0.7000
Temperature =   5.0 C     Pressure =  0.938 bars
pH =  8.610
Eh =   0.7580 volts        pe =  13.7358
Ionic strength      =    0.003535
Activity of water   =    0.999933
Solvent mass        =    0.999987 kg
Solution mass       =    1.000237 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         250 mg/kg sol'n
Rock mass           =    0.010150 kg
HFO sorbing surface:
  Surface charge    =        3.29 uC/cm2
  Surface potential =       -10.0 mV
  Surface area      =   3.00e+007 cm2
```

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.7580	13.7358

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
H+	-- sliding pH buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.727e-007	-6.325	0.0001103	
Bixbyite	2.858e-007	-6.544	4.512e-005	
Calcite	0.001502	-2.823	0.1503	
Diaspore	2.562e-007	-6.591	1.537e-005	
Dummy	0.05618	-1.250	5.000	
Ferrihydrite	0.04679	-1.330	5.000	
(total)			10.15	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002500	152.5	0.9392	-2.6293
SO4--	0.0007322	70.32	0.7780	-3.2444
Ca++	0.0001944	7.790	0.7780	-3.8203
O2(aq)	0.0001561	4.994	1.0008	-3.8062
Mg++	0.0001508	3.666	0.7780	-3.9306
Na+	9.518e-005	2.188	0.9392	-4.0487
CO3--	3.428e-005	2.057	0.7780	-4.5739
H2CO3* (aq)	1.892e-005	1.173	1.0008	-4.7228
CaSO4 (aq)	1.605e-005	2.185	1.0008	-4.7940

MgSO4 (aq)	1.027e-005	1.236	1.0008	-4.9880
K+	1.020e-005	0.3988	0.9392	-5.0186
MgHCO3+	3.079e-006	0.2627	0.9392	-5.5388
CaHCO3+	2.991e-006	0.3023	0.9392	-5.5514
Sr++	2.524e-006	0.2211	0.7780	-5.7070
MgCO3 (aq)	2.195e-006	0.1850	1.0008	-5.6582
H4SiO4	2.071e-006	0.1990	1.0008	-5.6834
CaCO3 (aq)	9.996e-007	0.1000	1.0008	-5.9998
OH-	8.653e-007	0.01471	0.9392	-6.0901
NaSO4-	2.895e-007	0.03445	0.9392	-6.5657
SrSO4 (aq)	1.768e-007	0.03247	1.0008	-6.7521
NaHCO3 (aq)	1.422e-007	0.01194	1.0008	-6.8468
Ba++	1.212e-007	0.01665	0.7780	-7.0254
NaCO3-	8.531e-008	0.007079	0.9392	-7.0963
SrHCO3+	3.502e-008	0.005204	0.9392	-7.4829
H3SiO4-	3.390e-008	0.003224	0.9392	-7.4970
KSO4-	2.809e-008	0.003796	0.9392	-7.5787
MoO4--	2.088e-008	0.003338	0.7780	-7.7893
Zn(OH)2 (aq)	1.978e-008	0.001965	1.0008	-7.7034
SrCO3 (aq)	1.837e-008	0.002712	1.0008	-7.7354
ZnCO3 (aq)	1.433e-008	0.001797	1.0008	-7.8433
MgOH+	1.306e-008	0.0005396	0.9392	-7.9113
Zn++	1.201e-008	0.0007851	0.7780	-8.0293
Ca2UO2(CO3)3 (aq	1.015e-008	0.005379	1.0008	-7.9933

(only species > 1e-8 molal listed)

Surface species	molality	moles	Boltzman fct.	log molality
>(w)FeOMg+	0.003757	0.003756	0.67760	-2.4252
>(w)FeOH	0.002120	0.002120	1.0000	-2.6737
>(w)FeOSiO(OH)2-	0.0007309	0.0007309	1.4758	-3.1361
>(w)FeO-	0.0006875	0.0006875	1.4758	-3.1627
>(w)FeOSiO2OH--	0.0006837	0.0006837	2.1780	-3.1651
>(w)FeCO3-	0.0005668	0.0005668	1.4758	-3.2466
>(w)FeOCa+	0.0002723	0.0002723	0.67760	-3.5649
>(s)FeOPb+	0.0002124	0.0002124	0.67760	-3.6728
>(w)FeOH2+	0.0001497	0.0001497	0.67760	-3.8246
>(w)FeOCu+	0.0001058	0.0001058	0.67760	-3.9756
>(w)FeOSi(OH)3	8.374e-005	8.374e-005	1.0000	-4.0771
>(w)FeCO3H	7.988e-005	7.988e-005	1.0000	-4.0976
>(w)FeOHAsO4---	6.013e-005	6.013e-005	3.2143	-4.2209
>(w)FeOPb+	4.250e-005	4.250e-005	0.67760	-4.3716
>(s)FeOHCa++	1.455e-005	1.455e-005	0.45914	-4.8370
>(w)FeAsO4--	8.281e-006	8.281e-006	2.1780	-5.0819
>(s)FeOCu+	4.606e-006	4.605e-006	0.67760	-5.3367
>(w)FeONi+	3.924e-006	3.924e-006	0.67760	-5.4063
>(w)FeOHSO4--	3.419e-006	3.419e-006	2.1780	-5.4661
>(w)ZnOH2+	1.322e-006	1.322e-006	0.67760	-5.8788
>(w)FeOSr+	6.582e-007	6.582e-007	0.67760	-6.1816
>(s)FeONi+	6.495e-007	6.495e-007	0.67760	-6.1874
>(s)FeOH	4.734e-007	4.734e-007	1.0000	-6.3248
>(s)ZnOH2+	2.818e-007	2.818e-007	0.67760	-6.5500
>(s)FeOHSr++	2.071e-007	2.071e-007	0.45914	-6.6837
>(s)FeOSiO(OH)2-	1.632e-007	1.632e-007	1.4758	-6.7872
>(s)FeO-	1.535e-007	1.535e-007	1.4758	-6.8138
>(s)FeOSiO2OH--	1.527e-007	1.527e-007	2.1780	-6.8163
>(s)FeCO3-	1.266e-007	1.266e-007	1.4758	-6.8977
>(w)FeSO4-	1.211e-007	1.210e-007	1.4758	-6.9170
>(w)FeHAsO4-	6.563e-008	6.563e-008	1.4758	-7.1829
>(w)FeOCd+	4.107e-008	4.107e-008	0.67760	-7.3865
>(s)FeOH2+	3.344e-008	3.344e-008	0.67760	-7.4758
>(s)FeOHBa++	2.804e-008	2.804e-008	0.45914	-7.5521
>(w)FeOHMoO4--	2.182e-008	2.182e-008	2.1780	-7.6611

>(s)FeOCd+	2.150e-008	2.150e-008	0.67760	-7.6676
>(s)FeOSi(OH)3	1.870e-008	1.870e-008	1.0000	-7.7282
>(s)FeCO3H	1.784e-008	1.784e-008	1.0000	-7.7487
>(s)FeOHAsO4---	1.343e-008	1.343e-008	3.2143	-7.8721
>(w)FeOBa+	7.585e-009	7.585e-009	0.67760	-8.1200
>(s)FeAsO4--	1.849e-009	1.849e-009	2.1780	-8.7330
>(s)FeOHSO4--	7.634e-010	7.634e-010	2.1780	-9.1172
>(w)FeOMo(OH)5	1.892e-010	1.892e-010	1.0000	-9.7230
>(w)HgOH2+	1.679e-010	1.679e-010	0.67760	-9.7750
>(w)FeOMn+	1.620e-010	1.620e-010	0.67760	-9.7905
>(w)FeOBaOH	8.336e-011	8.335e-011	1.0000	-10.0791
>(w)FeOHSbO(OH4	6.048e-011	6.048e-011	1.4758	-10.2184
>(w)FeOHSeO4--	4.624e-011	4.624e-011	2.1780	-10.3350
>(s)FeOMn+	4.554e-011	4.554e-011	0.67760	-10.3416
>(w)FeH2AsO4	3.282e-011	3.282e-011	1.0000	-10.4838
>(s)FeSO4-	2.703e-011	2.703e-011	1.4758	-10.5682
>(s)FeHAsO4-	1.466e-011	1.465e-011	1.4758	-10.8340
>(s)FeOHMoO4--	4.873e-012	4.873e-012	2.1780	-11.3122
>(w)FeSbO(OH)4	2.758e-012	2.758e-012	1.0000	-11.5593
>(w)FeSeO4-	1.426e-012	1.426e-012	1.4758	-11.8459
>(s)HgOH2+	7.654e-013	7.654e-013	0.67760	-12.1161
>(s)FeOMo(OH)5	4.225e-014	4.225e-014	1.0000	-13.3742
>(s)FeOHSbO(OH4	1.350e-014	1.350e-014	1.4758	-13.8695
>(s)FeOHSeO4--	1.032e-014	1.032e-014	2.1780	-13.9861
>(s)FeH2AsO4	7.329e-015	7.328e-015	1.0000	-14.1350
>(s)FeSbO(OH)4	6.159e-016	6.159e-016	1.0000	-15.2105
>(s)FeSeO4-	3.184e-016	3.184e-016	1.4758	-15.4971
>(w)FeOHSeO3--	6.111e-021	6.110e-021	2.1780	-20.2139
>(w)FeSeO3-	7.331e-022	7.330e-022	1.4758	-21.1349
>(s)FeOHSeO3--	1.364e-024	1.364e-024	2.1780	-23.8651
>(s)FeSeO3-	1.637e-025	1.637e-025	1.4758	-24.7860

(Boltzman factor = exp(zF PSI/RT), where PSI is surface potential)

Mineral saturation states

	log Q/K		log Q/K
Hematite	8.7228s/sat	Strontianite	-1.0235
Cupric Ferrite	6.8324s/sat	CaCO3xH2O	-1.3283
Nsutite	5.3037s/sat	Quartz	-1.4017
Birnessite	4.7167s/sat	Al(OH)3 (Soil)	-1.4416
Pyrolusite	4.7092s/sat	Smithsonite	-1.7511
Goethite	3.2106s/sat	ZnCO3	-1.8033
Lepidocrocite	3.0938s/sat	Cerrusite	-1.8386
Maghemite	2.5437s/sat	Chalcedony	-1.8852
Magnesioferrite	1.8457s/sat	Boehmite	-1.8895
Manganite	1.8299s/sat	Tenorite(c)	-1.9185
Ferrihydrite (ag	1.7748s/sat	Cristobalite	-2.0813
Barite	0.0000 sat	Plattnerite	-2.1979
Bixbyite	0.0000 sat	PbMoO4	-2.2670
Dummy	0.0000 sat	Celestite	-2.3061
Calcite	0.0000 sat	ZnCO3:1H2O	-2.3433
Diaspore	0.0000 sat	Gypsum	-2.4421
Ferrihydrite	0.0000 sat	Pb(OH)2	-2.4444
Cuprous Ferrite	-0.0219	Ni(OH)2 (c)	-2.5817
Aragonite	-0.1592	Zn(OH)2 (delta)	-2.6534
Dolomite (ordere	-0.3063	SiO2 (am,ppt)	-2.7526
Vaterite	-0.6232	Tenorite(am)	-2.7682
Magnesite	-0.7925	Anhydrite	-2.7953
Gibbsite (C)	-0.8916	SiO2 (am,gel)	-2.7970
Dolomite (disord	-0.9432	NiCO3	-2.9095

(only minerals with log Q/K > -3 listed)

Gases fugacity log fug.

O2 (g)	0.1236	-0.908
CO2 (g)	0.0002946	-3.531
Hg (g)	1.310e-024	-23.883
Hg2 (g)	4.159e-049	-48.381
H2Se (g)	2.293e-116	-115.640
CH4 (g)	5.300e-157	-156.276
H2S (g)	1.574e-157	-156.803
Hg(CH3)2 (g)	0.0000	-300.000

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
>(s)FeOH	0.000234					
>(w)FeOH	0.00936					
Al+++	2.59e-007	3.20e-009	8.64e-005			
AsO4---	6.85e-005	3.78e-010	5.25e-005	6.85e-005	9.51	
Ba++	6.39e-007	1.30e-007	0.0179	3.57e-008	0.00490	
CO3--	0.00471	0.00256	154.	0.000647	38.8	
Ca++	0.00200	0.000214	8.59	0.000287	11.5	
Cd++	6.26e-008	5.34e-011	6.00e-006	6.26e-008	0.00703	
Cu++	0.000110	3.72e-009	0.000237	0.000110	7.01	
Fe+++	0.0468	5.15e-011	2.88e-006	-1.60e-006	-0.0895	
H+	-0.144	0.00254	2.56	-0.00630	-6.35	
H2O	55.6	55.5	1.00e+006	-0.00222	-39.9	
H4SiO4	0.00150	2.11e-006	0.202	0.00150	144.	
Hg(OH)2	6.38e-010	4.69e-010	0.000110	1.69e-010	3.96e-005	
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00392	0.000166	4.04	0.00376	91.3	
Mn+++	5.72e-007	1.21e-012	6.65e-008	2.08e-010	1.14e-005	
MoO4--	4.54e-008	2.33e-008	0.00373	2.20e-008	0.00352	
Na+	9.57e-005	9.57e-005	2.20			
Ni++	4.58e-006	2.52e-009	0.000148	4.57e-006	0.268	
O2(aq)	0.000156	0.000156	4.99	-5.19e-011	-1.66e-006	
Pb++	0.000255	1.80e-009	0.000373	0.000255	52.8	
SO4--	0.000763	0.000759	72.9	3.54e-006	0.340	
Sb(OH)6-	2.31e-009	2.25e-009	0.000503	6.33e-011	1.42e-005	
SeO4--	9.84e-009	9.79e-009	0.00140	4.77e-011	6.81e-006	
Sr++	3.62e-006	2.75e-006	0.241	8.65e-007	0.0758	
UO2++	1.85e-008	1.85e-008	0.00500			
Zn++	1.65e-006	4.86e-008	0.00317	1.60e-006	0.105	
dummy	0.0562	0.000	0.000			

Sorbed	fraction	log fraction
AsO4---	1.000	-0.000
Ba++	0.2150	-0.668
CO3--	0.2015	-0.696
Ca++	0.5722	-0.242
Cd++	0.9991	-0.000
Cu++	1.000	-0.000
Fe+++	1.000	0.000
H4SiO4	0.9986	-0.001
Hg(OH)2	0.2645	-0.578
Mg++	0.9576	-0.019
Mn+++	0.9942	-0.003
MoO4--	0.4854	-0.314
Ni++	0.9995	-0.000
Pb++	1.000	-0.000
SO4--	0.004643	-2.333
Sb(OH)6-	0.02738	-1.563
SeO4--	0.004846	-2.315
Sr++	0.2391	-0.621

Zn++	0.9706	-0.013

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	3.203e-009	8.640e-005		
As	6.849e-005	3.781e-010	2.832e-005	6.849e-005	5.130
Ba	6.388e-007	1.304e-007	0.01790	3.571e-008	0.004904
C	0.004711	0.002563	30.77	0.0006468	7.767
Ca	0.002003	0.0002145	8.595	0.0002869	11.50
Cd	6.262e-008	5.338e-011	5.998e-006	6.256e-008	0.007030
Cu	0.0001104	3.724e-009	0.0002366	0.0001104	7.013
Du	0.05618	0.0000	0.0000		
Fe	0.04678	5.152e-011	2.877e-006	-1.604e-006	-0.08954
H	111.2	111.0	1.119e+005	-0.004734	-4.771
Hg	6.377e-010	4.690e-010	9.406e-005	1.687e-010	3.382e-005
K	1.023e-005	1.023e-005	0.3999		
Mg	0.003923	0.0001664	4.044	0.003756	91.31
Mn	5.718e-007	1.210e-012	6.645e-008	2.075e-010	1.140e-005
Mo	4.536e-008	2.334e-008	0.002239	2.202e-008	0.002112
Na	9.569e-005	9.569e-005	2.199		
Ni	4.576e-006	2.516e-009	0.0001477	4.573e-006	0.2684
O	55.67	55.52	8.881e+005	0.006008	96.10
Pb	0.0002549	1.802e-009	0.0003734	0.0002549	52.81
S	0.0007631	0.0007591	24.33	3.541e-006	0.1135
Sb	2.310e-009	2.247e-009	0.0002735	6.325e-011	7.699e-006
Se	9.839e-009	9.791e-009	0.0007729	4.768e-011	3.764e-006
Si	0.001501	2.105e-006	0.05912	0.001499	42.08
Sr	3.619e-006	2.754e-006	0.2412	8.654e-007	0.07581
U	1.852e-008	1.852e-008	0.004406		
Zn	1.652e-006	4.856e-008	0.003173	1.604e-006	0.1048

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```
Step #   400               Xi = 0.8000
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  8.740
Eh =   0.7509 volts      pe =  13.6058
Ionic strength      =    0.003395
Activity of water   =    0.999935
Solvent mass        =    0.999986 kg
Solution mass       =    1.000232 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         246 mg/kg sol'n
Rock mass           =    0.010158 kg
HFO sorbing surface:
  Surface charge    =        2.19 uC/cm2
  Surface potential =       -10.0 mV
  Surface area      =   3.00e+007 cm2
```

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.7509	13.6058

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
H+	-- sliding pH buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.720e-007	-6.326	0.0001102	
Bixbyite	2.858e-007	-6.544	4.512e-005	

Calcite	0.001572	-2.803	0.1574	
Diaspore	2.551e-007	-6.593	1.530e-005	
Dummy	0.05618	-1.250	5.000	
Ferrihydrite	0.04679	-1.330	5.000	
(total)			10.16	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002481	151.3	0.9403	-2.6321
SO4--	0.0007384	70.91	0.7816	-3.2387
O2(aq)	0.0001561	4.994	1.0008	-3.8062
Ca++	0.0001444	5.785	0.7816	-3.9475
Mg++	0.0001185	2.880	0.7816	-4.0334
Na+	9.515e-005	2.187	0.9403	-4.0484
CO3--	4.574e-005	2.744	0.7816	-4.4467
H2CO3* (aq)	1.393e-005	0.8641	1.0008	-4.8556
CaSO4 (aq)	1.214e-005	1.652	1.0008	-4.9156
K+	1.020e-005	0.3988	0.9403	-5.0181
MgSO4 (aq)	8.212e-006	0.9883	1.0008	-5.0852
MgHCO3+	2.412e-006	0.2057	0.9403	-5.6444
Sr++	2.389e-006	0.2093	0.7816	-5.7288
MgCO3 (aq)	2.322e-006	0.1957	1.0008	-5.6338
CaHCO3+	2.215e-006	0.2239	0.9403	-5.6814
H4SiO4	1.415e-006	0.1360	1.0008	-5.8488
OH-	1.166e-006	0.01982	0.9403	-5.9601
CaCO3 (aq)	9.997e-007	0.1000	1.0008	-5.9998
NaSO4-	2.931e-007	0.03489	0.9403	-6.5597
SrSO4 (aq)	1.704e-007	0.03129	1.0008	-6.7683
NaHCO3 (aq)	1.414e-007	0.01188	1.0008	-6.8492
Ba++	1.191e-007	0.01636	0.7816	-7.0310
NaCO3-	1.143e-007	0.009485	0.9403	-6.9687
SrHCO3+	3.305e-008	0.004912	0.9403	-7.5075
H3SiO4-	3.122e-008	0.002968	0.9403	-7.5324
KSO4-	2.846e-008	0.003846	0.9403	-7.5725
Zn(OH)2 (aq)	2.764e-008	0.002746	1.0008	-7.5582
SrCO3 (aq)	2.342e-008	0.003457	1.0008	-7.6300
MoO4--	2.168e-008	0.003466	0.7816	-7.7710
ZnCO3 (aq)	1.475e-008	0.001849	1.0008	-7.8308
MgOH+	1.389e-008	0.0005737	0.9403	-7.8841

(only species > 1e-8 molal listed)

Surface species	molality	moles	Boltzman fct.	log molality
>(w)FeOMg+	0.003791	0.003791	0.67760	-2.4212
>(w)FeOH	0.002010	0.002010	1.0000	-2.6968
>(w)FeO-	0.0008793	0.0008793	1.4758	-3.0559
>(w)FeOSiO2OH--	0.0008060	0.0008060	2.1780	-3.0937
>(w)FeOSiO(OH)2-	0.0006388	0.0006388	1.4758	-3.1946
>(w)FeCO3-	0.0005339	0.0005339	1.4758	-3.2725
>(w)FeOCa+	0.0002598	0.0002598	0.67760	-3.5853
>(s)FeOPb+	0.0002153	0.0002153	0.67760	-3.6670
>(w)FeOCu+	0.0001054	0.0001054	0.67760	-3.9771
>(w)FeOH2+	0.0001052	0.0001052	0.67760	-3.9778
>(w)FeOHAsO4---	6.210e-005	6.209e-005	3.2143	-4.2069
>(w)FeCO3H	5.578e-005	5.578e-005	1.0000	-4.2535
>(w)FeOSi(OH)3	5.425e-005	5.425e-005	1.0000	-4.2656
>(w)FeOPb+	3.966e-005	3.966e-005	0.67760	-4.4017
>(s)FeOHCa++	1.118e-005	1.118e-005	0.45914	-4.9516
>(w)FeAsO4--	6.340e-006	6.340e-006	2.1780	-5.1979
>(s)FeOCu+	4.983e-006	4.983e-006	0.67760	-5.3025
>(w)FeONi+	3.877e-006	3.877e-006	0.67760	-5.4115
>(w)FeOHSO4--	3.284e-006	3.284e-006	2.1780	-5.4836

>(w)ZnOH2+	1.298e-006	1.298e-006	0.67760	-5.8868
>(w)FeOSr+	8.006e-007	8.006e-007	0.67760	-6.0966
>(s)FeONi+	6.968e-007	6.968e-007	0.67760	-6.1569
>(s)FeOH	4.873e-007	4.873e-007	1.0000	-6.3122
>(s)ZnOH2+	3.005e-007	3.005e-007	0.67760	-6.5221
>(s)FeO-	2.132e-007	2.132e-007	1.4758	-6.6712
>(s)FeOHSr++	2.028e-007	2.028e-007	0.45914	-6.6929
>(s)FeOSiO2OH--	1.954e-007	1.954e-007	2.1780	-6.7090
>(s)FeOSiO(OH)2-	1.549e-007	1.549e-007	1.4758	-6.8100
>(s)FeCO3-	1.295e-007	1.295e-007	1.4758	-6.8879
>(w)FeSO4-	8.619e-008	8.619e-008	1.4758	-7.0645
>(w)FeOCd+	3.989e-008	3.989e-008	0.67760	-7.3991
>(w)FeHAsO4-	3.725e-008	3.725e-008	1.4758	-7.4289
>(s)FeOHBa++	2.850e-008	2.850e-008	0.45914	-7.5452
>(s)FeOH2+	2.552e-008	2.552e-008	0.67760	-7.5931
>(s)FeOCd+	2.268e-008	2.268e-008	0.67760	-7.6444
>(w)FeOHMoO4--	2.158e-008	2.158e-008	2.1780	-7.6659
>(s)FeOHAsO4---	1.506e-008	1.506e-008	3.2143	-7.8223
>(s)FeCO3H	1.353e-008	1.353e-008	1.0000	-7.8688
>(s)FeOSi(OH)3	1.315e-008	1.315e-008	1.0000	-7.8810
>(w)FeOBa+	9.575e-009	9.575e-009	0.67760	-8.0188
>(s)FeAsO4--	1.537e-009	1.537e-009	2.1780	-8.8133
>(s)FeOHSO4--	7.963e-010	7.963e-010	2.1780	-9.0989
>(w)FeOBaOH	1.419e-010	1.419e-010	1.0000	-9.8479
>(w)HgOH2+	1.281e-010	1.281e-010	0.67760	-9.8925
>(w)FeOMn+	1.139e-010	1.139e-010	0.67760	-9.9436
>(w)FeOMo(OH)5	1.028e-010	1.028e-010	1.0000	-9.9879
>(w)FeOHSbO(OH4	5.750e-011	5.750e-011	1.4758	-10.2403
>(w)FeOHSeO4--	4.418e-011	4.418e-011	2.1780	-10.3547
>(s)FeOMn+	3.476e-011	3.475e-011	0.67760	-10.4590
>(s)FeSO4-	2.090e-011	2.090e-011	1.4758	-10.6799
>(w)FeH2AsO4	1.381e-011	1.381e-011	1.0000	-10.8599
>(s)FeHAsO4-	9.032e-012	9.032e-012	1.4758	-11.0442
>(s)FeOHMoO4--	5.233e-012	5.233e-012	2.1780	-11.2813
>(w)FeSbO(OH)4	1.944e-012	1.944e-012	1.0000	-11.7113
>(w)FeSeO4-	1.010e-012	1.010e-012	1.4758	-11.9957
>(s)HgOH2+	6.340e-013	6.340e-013	0.67760	-12.1979
>(s)FeOMo(OH)5	2.493e-014	2.493e-014	1.0000	-13.6032
>(s)FeOHSbO(OH4	1.394e-014	1.394e-014	1.4758	-13.8557
>(s)FeOHSeO4--	1.071e-014	1.071e-014	2.1780	-13.9701
>(s)FeH2AsO4	3.348e-015	3.348e-015	1.0000	-14.4752
>(s)FeSbO(OH)4	4.714e-016	4.714e-016	1.0000	-15.3266
>(s)FeSeO4-	2.449e-016	2.449e-016	1.4758	-15.6110
>(w)FeOHSeO3--	5.839e-021	5.839e-021	2.1780	-20.2337
>(w)FeSeO3-	5.192e-022	5.192e-022	1.4758	-21.2846
>(s)FeOHSeO3--	1.416e-024	1.416e-024	2.1780	-23.8490
>(s)FeSeO3-	1.259e-025	1.259e-025	1.4758	-24.9000

(Boltzman factor = exp(zF PSI/RT), where PSI is surface potential)

Mineral saturation states

	log Q/K		log Q/K
Hematite	8.7228s/sat	CaCO3xH2O	-1.3283
Cupric Ferrite	6.9840s/sat	Al(OH)3 (Soil)	-1.4416
Nsutite	5.3037s/sat	Quartz	-1.5671
Birnessite	4.7167s/sat	Smithsonite	-1.7387
Pyrolusite	4.7092s/sat	Tenorite(c)	-1.7669
Goethite	3.2106s/sat	ZnCO3	-1.7908
Lepidocrocite	3.0938s/sat	Cerrusite	-1.8483
Maghemite	2.5437s/sat	Boehmite	-1.8895
Magnesioferrite	2.0029s/sat	Chalcedony	-2.0506
Manganite	1.8299s/sat	Plattnerite	-2.0747
Ferrihydrite (ag	1.7748s/sat	Cristobalite	-2.2467

full suite results

Cuprous Ferrite	0.1297s/sat	Pb(OH)2	-2.3213
Bixbyite	0.0000 sat	Celestite	-2.3223
Diaspore	0.0000 sat	ZnCO3:1H2O	-2.3308
Calcite	0.0000 sat	PbMoO4	-2.3855
Ferrihydrite	0.0000 sat	Ni(OH)2 (c)	-2.4338
Dummy	0.0000 sat	Zn(OH)2 (delta)	-2.5082
Barite	0.0000 sat	Gypsum	-2.5637
Aragonite	-0.1592	Tenorite(am)	-2.6165
Dolomite (ordere	-0.2819	Witherite	-2.8825
Vaterite	-0.6232	NiCO3	-2.8943
Magnesite	-0.7681	Anhydrite	-2.9169
Gibbsite (C)	-0.8916	SiO2 (am,ppt)	-2.9179
Strontianite	-0.9181	SiO2 (am,gel)	-2.9624
Dolomite (disord	-0.9188		

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
O2 (g)	0.1236	-0.908
CO2 (g)	0.0002170	-3.664
Hg (g)	1.421e-024	-23.847
Hg2 (g)	4.899e-049	-48.310
H2Se (g)	1.270e-116	-115.896
CH4 (g)	3.904e-157	-156.409
H2S (g)	8.763e-158	-157.057
Hg(CH3)2 (g)	0.0000	-300.000

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
>(s)FeOH	0.000234					
>(w)FeOH	0.00936					
Al+++	2.59e-007	4.31e-009	0.000116			
AsO4---	6.85e-005	3.02e-010	4.20e-005	6.85e-005	9.51	
Ba++	6.39e-007	1.29e-007	0.0176	3.82e-008	0.00525	
CO3--	0.00471	0.00255	153.	0.000590	35.4	
Ca++	0.00200	0.000160	6.40	0.000271	10.9	
Cd++	6.26e-008	4.49e-011	5.04e-006	6.26e-008	0.00703	
Cu++	0.000110	3.99e-009	0.000254	0.000110	7.01	
Fe+++	0.0468	4.07e-011	2.27e-006	-1.60e-006	-0.0892	
H+	-0.145	0.00251	2.53	-0.00679	-6.84	
H2O	55.6	55.5	1.00e+006	-0.00216	-38.9	
H4SiO4	0.00150	1.45e-006	0.139	0.00150	144.	
Hg(OH)2	6.38e-010	5.09e-010	0.000119	1.29e-010	3.02e-005	
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00392	0.000131	3.19	0.00379	92.2	
Mn+++	5.72e-007	8.50e-013	4.67e-008	1.49e-010	8.16e-006	
MoO4--	4.54e-008	2.37e-008	0.00379	2.17e-008	0.00347	
Na+	9.57e-005	9.57e-005	2.20			
Ni++	4.58e-006	2.21e-009	0.000129	4.57e-006	0.268	
O2(aq)	0.000156	0.000156	4.99	-3.72e-011	-1.19e-006	
Pb++	0.000255	1.80e-009	0.000374	0.000255	52.8	
SO4--	0.000763	0.000759	72.9	3.37e-006	0.324	
Sb(OH)6-	2.31e-009	2.25e-009	0.000504	5.95e-011	1.33e-005	
SeO4--	9.84e-009	9.79e-009	0.00140	4.52e-011	6.46e-006	
Sr++	3.62e-006	2.62e-006	0.229	1.00e-006	0.0879	
UO2++	1.85e-008	1.85e-008	0.00500			
Zn++	1.65e-006	5.38e-008	0.00352	1.60e-006	0.104	
dummy	0.0562	0.000	0.000			

Sorbed	fraction	log fraction
AsO4---	1.000	-0.000

full suite results

Ba++	0.2292	-0.640
CO3--	0.1879	-0.726
Ca++	0.6292	-0.201
Cd++	0.9993	-0.000
Cu++	1.000	-0.000
Fe+++	1.000	0.000
H4SiO4	0.9990	-0.000
Hg(OH)2	0.2018	-0.695
Mg++	0.9665	-0.015
Mn+++	0.9943	-0.002
MoO4--	0.4781	-0.320
Ni++	0.9995	-0.000
Pb++	1.000	-0.000
SO4--	0.004420	-2.355
Sb(OH)6-	0.02574	-1.589
SeO4--	0.004594	-2.338
Sr++	0.2772	-0.557
Zn++	0.9674	-0.014

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	4.309e-009	0.0001162		
As	6.849e-005	3.023e-010	2.264e-005	6.849e-005	5.130
Ba	6.388e-007	1.285e-007	0.01765	3.822e-008	0.005247
C	0.004711	0.002549	30.61	0.0005898	7.083
Ca	0.002003	0.0001597	6.401	0.0002710	10.86
Cd	6.262e-008	4.489e-011	5.044e-006	6.257e-008	0.007031
Cu	0.0001104	3.995e-009	0.0002538	0.0001104	7.013
Du	0.05618	0.0000	0.0000		
Fe	0.04678	4.072e-011	2.273e-006	-1.598e-006	-0.08925
H	111.2	111.0	1.119e+005	-0.005114	-5.153
Hg	6.377e-010	5.090e-010	0.0001021	1.287e-010	2.581e-005
K	1.023e-005	1.023e-005	0.3999		
Mg	0.003923	0.0001314	3.195	0.003791	92.16
Mn	5.718e-007	8.504e-013	4.671e-008	1.486e-010	8.162e-006
Mo	4.536e-008	2.367e-008	0.002271	2.169e-008	0.002080
Na	9.569e-005	9.569e-005	2.199		
Ni	4.576e-006	2.206e-009	0.0001295	4.574e-006	0.2685
O	55.67	55.52	8.881e+005	0.005895	94.30
Pb	0.0002549	1.803e-009	0.0003735	0.0002549	52.81
S	0.0007631	0.0007592	24.34	3.371e-006	0.1081
Sb	2.310e-009	2.250e-009	0.0002739	5.946e-011	7.238e-006
Se	9.839e-009	9.794e-009	0.0007731	4.520e-011	3.568e-006
Si	0.001501	1.447e-006	0.04062	0.001499	42.10
Sr	3.619e-006	2.616e-006	0.2291	1.003e-006	0.08790
U	1.852e-008	1.852e-008	0.004406		
Zn	1.652e-006	5.379e-008	0.003515	1.598e-006	0.1045

♀

```
Step #   450              Xi = 0.9000
Temperature =   5.0 C     Pressure =  0.938 bars
pH =  8.870
Eh =   0.7437 volts       pe =  13.4758
Ionic strength      =    0.003307
Activity of water   =    0.999936
Solvent mass        =    0.999985 kg
Solution mass       =    1.000229 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         243 mg/kg sol'n
Rock mass           =    0.010164 kg
HFO sorbing surface:
```

full suite results

Surface charge   =   1.06 uC/cm2
Surface potential =   -10.0 mV
Surface area   =   3.00e+007 cm2

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.7437	13.4758

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
H+	-- sliding pH buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.710e-007	-6.327	0.0001099	
Bixbyite	2.858e-007	-6.544	4.512e-005	
Calcite	0.001633	-2.787	0.1634	
Diaspore	2.536e-007	-6.596	1.522e-005	
Dummy	0.05618	-1.250	5.000	
Ferrihydrite	0.04679	-1.330	5.000	
(total)			10.16	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002467	150.5	0.9410	-2.6343
SO4--	0.0007432	71.37	0.7840	-3.2346
O2(aq)	0.0001561	4.994	1.0008	-3.8062
Ca++	0.0001072	4.297	0.7840	-4.0753
Na+	9.511e-005	2.186	0.9410	-4.0482
Mg++	9.477e-005	2.303	0.7840	-4.1290
CO3--	6.121e-005	3.672	0.7840	-4.3189
H2CO3* (aq)	1.028e-005	0.6374	1.0008	-4.9877
K+	1.020e-005	0.3988	0.9410	-5.0178
CaSO4 (aq)	9.127e-006	1.242	1.0008	-5.0393
MgSO4 (aq)	6.652e-006	0.8005	1.0008	-5.1767
MgCO3 (aq)	2.501e-006	0.2108	1.0008	-5.6016
Sr++	2.253e-006	0.1974	0.7840	-5.7528
MgHCO3+	1.924e-006	0.1641	0.9410	-5.7422
CaHCO3+	1.641e-006	0.1658	0.9410	-5.8114
OH-	1.572e-006	0.02672	0.9410	-5.8301
CaCO3 (aq)	9.997e-007	0.1000	1.0008	-5.9998
H4SiO4	9.576e-007	0.09201	1.0008	-6.0185
NaSO4-	2.958e-007	0.03521	0.9410	-6.5554
SrSO4 (aq)	1.627e-007	0.02988	1.0008	-6.7882
NaCO3-	1.534e-007	0.01273	0.9410	-6.8407
NaHCO3 (aq)	1.407e-007	0.01182	1.0008	-6.8512
Ba++	1.176e-007	0.01615	0.7840	-7.0352
Zn(OH)2 (aq)	3.927e-008	0.003902	1.0008	-7.4056
SrHCO3+	3.109e-008	0.004621	0.9410	-7.5338
SrCO3 (aq)	2.974e-008	0.004390	1.0008	-7.5263
KSO4-	2.873e-008	0.003882	0.9410	-7.5681
H3SiO4-	2.847e-008	0.002707	0.9410	-7.5721
MoO4--	2.263e-008	0.003619	0.7840	-7.7510
ZnCO3 (aq)	1.546e-008	0.001938	1.0008	-7.8104
MgOH+	1.502e-008	0.0006205	0.9410	-7.8497
UO2(CO3)3----	1.221e-008	0.005493	0.3778	-8.3361

(only species > 1e-8 molal listed)

Surface species	molality	moles	Boltzman fct.	log molality
>(w)FeOMg+	0.003817	0.003817	0.67760	-2.4183

>(w)FeOH	0.001870	0.001870	1.0000	-2.7283
>(w)FeO-	0.001103	0.001103	1.4758	-2.9573
>(w)FeOSiO2OH--	0.0009230	0.0009230	2.1780	-3.0348
>(w)FeOSiO(OH)2-	0.0005423	0.0005423	1.4758	-3.2658
>(w)FeCO3-	0.0004942	0.0004942	1.4758	-3.3061
>(w)FeOCa+	0.0002429	0.0002429	0.67760	-3.6146
>(s)FeOPb+	0.0002176	0.0002176	0.67760	-3.6623
>(w)FeOCu+	0.0001051	0.0001050	0.67760	-3.9786
>(w)FeOH2+	7.257e-005	7.257e-005	0.67760	-4.1392
>(w)FeOHAsO4---	6.363e-005	6.363e-005	3.2143	-4.1963
>(w)FeCO3H	3.827e-005	3.827e-005	1.0000	-4.4171
>(w)FeOPb+	3.730e-005	3.730e-005	0.67760	-4.4283
>(w)FeOSi(OH)3	3.414e-005	3.414e-005	1.0000	-4.4667
>(s)FeOHCa++	8.326e-006	8.326e-006	0.45914	-5.0795
>(s)FeOCu+	5.338e-006	5.338e-006	0.67760	-5.2726
>(w)FeAsO4--	4.816e-006	4.816e-006	2.1780	-5.3173
>(w)FeONi+	3.833e-006	3.833e-006	0.67760	-5.4164
>(w)FeOHSO4--	3.084e-006	3.084e-006	2.1780	-5.5109
>(w)ZnOH2+	1.272e-006	1.272e-006	0.67760	-5.8956
>(w)FeOSr+	9.504e-007	9.504e-007	0.67760	-6.0221
>(s)FeONi+	7.406e-007	7.405e-007	0.67760	-6.1304
>(s)FeOH	4.872e-007	4.872e-007	1.0000	-6.3123
>(s)ZnOH2+	3.165e-007	3.165e-007	0.67760	-6.4996
>(s)FeO-	2.875e-007	2.875e-007	1.4758	-6.5413
>(s)FeOSiO2OH--	2.405e-007	2.405e-007	2.1780	-6.6188
>(s)FeOHSr++	1.918e-007	1.918e-007	0.45914	-6.7171
>(s)FeOSiO(OH)2-	1.413e-007	1.413e-007	1.4758	-6.8498
>(s)FeCO3-	1.288e-007	1.288e-007	1.4758	-6.8901
>(w)FeSO4-	6.000e-008	6.000e-008	1.4758	-7.2219
>(w)FeOCd+	3.885e-008	3.884e-008	0.67760	-7.4107
>(s)FeOHBa++	2.822e-008	2.822e-008	0.45914	-7.5494
>(s)FeOCd+	2.373e-008	2.373e-008	0.67760	-7.6247
>(w)FeOHMoO4--	2.102e-008	2.102e-008	2.1780	-7.6773
>(w)FeHAsO4-	2.098e-008	2.098e-008	1.4758	-7.6783
>(s)FeOH2+	1.891e-008	1.891e-008	0.67760	-7.7232
>(s)FeOHAsO4---	1.658e-008	1.658e-008	3.2143	-7.7803
>(w)FeOBa+	1.190e-008	1.190e-008	0.67760	-7.9244
>(s)FeCO3H	9.974e-009	9.974e-009	1.0000	-8.0011
>(s)FeOSi(OH)3	8.897e-009	8.897e-009	1.0000	-8.0508
>(s)FeAsO4--	1.255e-009	1.255e-009	2.1780	-8.9013
>(s)FeOHSO4--	8.037e-010	8.037e-010	2.1780	-9.0949
>(w)FeOBaOH	2.380e-010	2.380e-010	1.0000	-9.6234
>(w)HgOH2+	9.422e-011	9.422e-011	0.67760	-10.0259
>(w)FeOMn+	7.851e-011	7.851e-011	0.67760	-10.1051
>(w)FeOMo(OH)5	5.505e-011	5.505e-011	1.0000	-10.2592
>(w)FeOHSbO(OH4	5.363e-011	5.363e-011	1.4758	-10.2706
>(w)FeOHSeO4--	4.133e-011	4.133e-011	2.1780	-10.3838
>(s)FeOMn+	2.576e-011	2.576e-011	0.67760	-10.5891
>(s)FeSO4-	1.564e-011	1.564e-011	1.4758	-10.8059
>(w)FeH2AsO4	5.765e-012	5.765e-012	1.0000	-11.2392
>(s)FeOHMoO4--	5.479e-012	5.479e-012	2.1780	-11.2613
>(s)FeHAsO4-	5.467e-012	5.467e-012	1.4758	-11.2623
>(w)FeSbO(OH)4	1.344e-012	1.344e-012	1.0000	-11.8715
>(w)FeSeO4-	7.003e-013	7.003e-013	1.4758	-12.1547
>(s)HgOH2+	5.013e-013	5.013e-013	0.67760	-12.2999
>(s)FeOMo(OH)5	1.435e-014	1.435e-014	1.0000	-13.8433
>(s)FeOHSbO(OH4	1.398e-014	1.398e-014	1.4758	-13.8546
>(s)FeOHSeO4--	1.077e-014	1.077e-014	2.1780	-13.9678
>(s)FeH2AsO4	1.502e-015	1.502e-015	1.0000	-14.8232
>(s)FeSbO(OH)4	3.503e-016	3.503e-016	1.0000	-15.4555
>(s)FeSeO4-	1.825e-016	1.825e-016	1.4758	-15.7387
>(w)FeOHSeO3--	5.461e-021	5.461e-021	2.1780	-20.2627
>(w)FeSeO3-	3.600e-022	3.600e-022	1.4758	-21.4436

>(s)FeOHSeO3--	1.423e-024	1.423e-024	2.1780	-23.8467
>(s)FeSeO3-	9.383e-026	9.383e-026	1.4758	-25.0277

(Boltzman factor = exp(zF PSI/RT), where PSI is surface potential)

Mineral saturation states

	log Q/K		log Q/K
Hematite	8.7228s/sat	Gibbsite (C)	-0.8916
Cupric Ferrite	7.1440s/sat	CaCO3xH2O	-1.3283
Nsutite	5.3037s/sat	Al(OH)3 (Soil)	-1.4416
Birnessite	4.7167s/sat	Tenorite(c)	-1.6070
Pyrolusite	4.7092s/sat	Smithsonite	-1.7183
Goethite	3.2106s/sat	Quartz	-1.7368
Lepidocrocite	3.0938s/sat	ZnCO3	-1.7704
Maghemite	2.5437s/sat	Cerrusite	-1.8456
Magnesioferrite	2.1672s/sat	Boehmite	-1.8895
Manganite	1.8299s/sat	Plattnerite	-1.9399
Ferrihydrite (ag	1.7748s/sat	Pb(OH)2	-2.1865
Cuprous Ferrite	0.2897s/sat	Chalcedony	-2.2203
Calcite	0.0000 sat	Ni(OH)2 (c)	-2.2773
Diaspore	0.0000 sat	ZnCO3:1H2O	-2.3104
Ferrihydrite	0.0000 sat	Celestite	-2.3422
Bixbyite	0.0000 sat	Zn(OH)2 (delta)	-2.3556
Dummy	0.0000 sat	Cristobalite	-2.4164
Barite	0.0000 sat	Tenorite(am)	-2.4566
Aragonite	-0.1592	PbMoO4	-2.4906
Dolomite (ordere	-0.2497	Gypsum	-2.6874
Vaterite	-0.6232	Witherite	-2.7588
Magnesite	-0.7360	NiCO3	-2.8700
Strontianite	-0.8143	Zincite	-2.8706
Dolomite (disord	-0.8866	Pb2O3	-2.9466

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
O2 (g)	0.1236	-0.908
CO2 (g)	0.0001600	-3.796
Hg (g)	1.517e-024	-23.819
Hg2 (g)	5.577e-049	-48.254
H2Se (g)	7.017e-117	-116.154
CH4 (g)	2.880e-157	-156.541
H2S (g)	4.861e-158	-157.313
Hg(CH3)2 (g)	0.0000	-300.000

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
>(s)FeOH	0.000234					
>(w)FeOH	0.00936					
Al+++	2.59e-007	5.80e-009	0.000157			
AsO4---	6.85e-005	2.45e-010	3.41e-005	6.85e-005	9.51	
Ba++	6.39e-007	1.27e-007	0.0175	4.04e-008	0.00554	
CO3--	0.00471	0.00255	153.	0.000533	32.0	
Ca++	0.00200	0.000119	4.77	0.000251	10.1	
Cd++	6.26e-008	3.95e-011	4.44e-006	6.26e-008	0.00703	
Cu++	0.000110	4.42e-009	0.000281	0.000110	7.01	
Fe+++	0.0468	3.33e-011	1.86e-006	-1.59e-006	-0.0887	
H+	-0.145	0.00249	2.51	-0.00727	-7.33	
H2O	55.6	55.5	1.00e+006	-0.00210	-37.9	
H4SiO4	0.00150	9.86e-007	0.0948	0.00150	144.	
Hg(OH)2	6.38e-010	5.43e-010	0.000127	9.47e-011	2.22e-005	
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00392	0.000106	2.57	0.00382	92.8	

Mn+++	5.72e-007	6.58e-013	3.61e-008	1.04e-010	5.73e-006
MoO4--	4.54e-008	2.43e-008	0.00388	2.11e-008	0.00337
Na+	9.57e-005	9.57e-005	2.20		
Ni++	4.58e-006	2.02e-009	0.000119	4.57e-006	0.268
O2(aq)	0.000156	0.000156	4.99	-2.61e-011	-8.34e-007
Pb++	0.000255	1.88e-009	0.000389	0.000255	52.8
SO4--	0.000763	0.000759	72.9	3.14e-006	0.302
Sb(OH)6-	2.31e-009	2.25e-009	0.000505	5.50e-011	1.23e-005
SeO4--	9.84e-009	9.80e-009	0.00140	4.20e-011	6.01e-006
Sr++	3.62e-006	2.48e-006	0.217	1.14e-006	0.100
UO2++	1.85e-008	1.85e-008	0.00500		
Zn++	1.65e-006	6.40e-008	0.00419	1.59e-006	0.104
dummy	0.0562	0.000	0.000		

Sorbed	fraction	log fraction
AsO4---	1.000	-0.000
Ba++	0.2406	-0.619
CO3--	0.1730	-0.762
Ca++	0.6785	-0.168
Cd++	0.9994	-0.000
Cu++	1.000	-0.000
Fe+++	1.000	0.000
H4SiO4	0.9993	-0.000
Hg(OH)2	0.1485	-0.828
Mg++	0.9730	-0.012
Mn+++	0.9937	-0.003
MoO4--	0.4648	-0.333
Ni++	0.9996	-0.000
Pb++	1.000	-0.000
SO4--	0.004124	-2.385
Sb(OH)6-	0.02381	-1.623
SeO4--	0.004273	-2.369
Sr++	0.3156	-0.501
Zn++	0.9612	-0.017

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	5.802e-009	0.0001565		
As	6.849e-005	2.452e-010	1.837e-005	6.849e-005	5.130
Ba	6.388e-007	1.274e-007	0.01749	4.036e-008	0.005542
C	0.004711	0.002546	30.57	0.0005326	6.395
Ca	0.002003	0.0001190	4.769	0.0002512	10.07
Cd	6.262e-008	3.951e-011	4.440e-006	6.258e-008	0.007032
Cu	0.0001104	4.418e-009	0.0002807	0.0001104	7.013
Du	0.05618	0.0000	0.0000		
Fe	0.04678	3.333e-011	1.861e-006	-1.588e-006	-0.08868
H	111.2	111.0	1.119e+005	-0.005478	-5.520
Hg	6.377e-010	5.430e-010	0.0001089	9.472e-011	1.900e-005
K	1.023e-005	1.023e-005	0.3999		
Mg	0.003923	0.0001059	2.573	0.003817	92.78
Mn	5.718e-007	6.576e-013	3.612e-008	1.043e-010	5.727e-006
Mo	4.536e-008	2.428e-008	0.002329	2.108e-008	0.002022
Na	9.569e-005	9.569e-005	2.199		
Ni	4.576e-006	2.024e-009	0.0001188	4.574e-006	0.2685
O	55.67	55.52	8.881e+005	0.005781	92.47
Pb	0.0002549	1.876e-009	0.0003886	0.0002549	52.81
S	0.0007631	0.0007595	24.35	3.145e-006	0.1008
Sb	2.310e-009	2.255e-009	0.0002745	5.499e-011	6.694e-006
Se	9.839e-009	9.797e-009	0.0007734	4.204e-011	3.318e-006
Si	0.001501	9.862e-007	0.02769	0.001500	42.11
Sr	3.619e-006	2.477e-006	0.2170	1.142e-006	0.1001

U	1.852e-008	1.852e-008	0.004406		
Zn	1.652e-006	6.405e-008	0.004186	1.588e-006	0.1038

♀

```
Step #   500               Xi = 1.0000
Temperature =   5.0 C     Pressure =  0.938 bars
pH =  9.000
Eh =   0.7365 volts       pe =  13.3458
Ionic strength      =    0.003260
Activity of water   =    0.999937
Solvent mass        =    0.999984 kg
Solution mass       =    1.000226 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         242 mg/kg sol'n
Rock mass           =    0.010169 kg
HFO sorbing surface:
  Surface charge    =     -0.0951 uC/cm2
  Surface potential =       -10.0 mV
  Surface area      =   3.00e+007 cm2
```

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.7365	13.3458

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
H+	-- sliding pH buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.698e-007	-6.328	0.0001096	
Bixbyite	2.858e-007	-6.544	4.513e-005	
Calcite	0.001686	-2.773	0.1688	
Diaspore	2.516e-007	-6.599	1.509e-005	
Dummy	0.05618	-1.250	5.000	
Ferrihydrite	0.04679	-1.330	5.000	
(total)			10.17	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002455	149.7	0.9413	-2.6363
SO4--	0.0007469	71.73	0.7852	-3.2317
O2(aq)	0.0001561	4.994	1.0008	-3.8062
Na+	9.505e-005	2.185	0.9413	-4.0483
CO3--	8.206e-005	4.923	0.7852	-4.1909
Ca++	7.974e-005	3.195	0.7852	-4.2033
Mg++	7.737e-005	1.881	0.7852	-4.2164
K+	1.020e-005	0.3988	0.9413	-5.0176
H2CO3* (aq)	7.585e-006	0.4703	1.0008	-5.1197
CaSO4 (aq)	6.843e-006	0.9313	1.0008	-5.1645
MgSO4 (aq)	5.476e-006	0.6590	1.0008	-5.2612
MgCO3 (aq)	2.746e-006	0.2315	1.0008	-5.5610
Sr++	2.122e-006	0.1858	0.7852	-5.7783
OH-	2.119e-006	0.03603	0.9413	-5.7001
MgHCO3+	1.565e-006	0.1335	0.9413	-5.8316
CaHCO3+	1.216e-006	0.1229	0.9413	-5.9414
CaCO3 (aq)	9.997e-007	0.1000	1.0008	-5.9998
H4SiO4	6.447e-007	0.06195	1.0008	-6.1903
NaSO4-	2.976e-007	0.03542	0.9413	-6.5526
NaCO3-	2.058e-007	0.01708	0.9413	-6.7128

SrSO4 (aq)	1.545e-007	0.02837	1.0008	-6.8108
NaHCO3 (aq)	1.401e-007	0.01177	1.0008	-6.8533
Ba++	1.167e-007	0.01602	0.7852	-7.0380
Zn(OH)2 (aq)	5.681e-008	0.005645	1.0008	-7.2452
SrCO3 (aq)	3.766e-008	0.005559	1.0008	-7.4237
SrHCO3+	2.917e-008	0.004335	0.9413	-7.5612
KSO4-	2.892e-008	0.003908	0.9413	-7.5650
H3SiO4-	2.584e-008	0.002457	0.9413	-7.6139
MoO4--	2.379e-008	0.003803	0.7852	-7.7287
MgOH+	1.656e-008	0.0006842	0.9413	-7.8071
ZnCO3 (aq)	1.651e-008	0.002069	1.0008	-7.7820
UO2(CO3)3----	1.421e-008	0.006393	0.3802	-8.2675

(only species > 1e-8 molal listed)

Surface species	molality	moles	Boltzman fct.	log molality
>(w)FeOMg+	0.003836	0.003836	0.67760	-2.4161
>(w)FeOH	0.001703	0.001703	1.0000	-2.7687
>(w)FeO-	0.001356	0.001356	1.4758	-2.8678
>(w)FeOSiO2OH--	0.001030	0.001030	2.1780	-2.9871
>(w)FeOSiO(OH)2-	0.0004487	0.0004487	1.4758	-3.3481
>(w)FeCO3-	0.0004481	0.0004481	1.4758	-3.3486
>(w)FeOCa+	0.0002223	0.0002223	0.67760	-3.6531
>(s)FeOPb+	0.0002195	0.0002195	0.67760	-3.6585
>(w)FeOCu+	0.0001047	0.0001047	0.67760	-3.9799
>(w)FeOHAsO4---	6.482e-005	6.482e-005	3.2143	-4.1883
>(w)FeOH2+	4.901e-005	4.901e-005	0.67760	-4.3097
>(w)FeOPb+	3.541e-005	3.541e-005	0.67760	-4.4508
>(w)FeCO3H	2.573e-005	2.573e-005	1.0000	-4.5896
>(w)FeOSi(OH)3	2.094e-005	2.094e-005	1.0000	-4.6791
>(s)FeOHCa++	6.002e-006	6.002e-006	0.45914	-5.2217
>(s)FeOCu+	5.655e-006	5.655e-006	0.67760	-5.2476
>(w)FeONi+	3.795e-006	3.795e-006	0.67760	-5.4208
>(w)FeAsO4--	3.637e-006	3.637e-006	2.1780	-5.4392
>(w)FeOHSO4--	2.828e-006	2.828e-006	2.1780	-5.5485
>(w)ZnOH2+	1.242e-006	1.242e-006	0.67760	-5.9058
>(w)FeOSr+	1.101e-006	1.101e-006	0.67760	-5.9581
>(s)FeONi+	7.790e-007	7.790e-007	0.67760	-6.1085
>(s)FeOH	4.716e-007	4.716e-007	1.0000	-6.3264
>(s)FeO-	3.754e-007	3.754e-007	1.4758	-6.4255
>(s)ZnOH2+	3.285e-007	3.285e-007	0.67760	-6.4834
>(s)FeOSiO2OH--	2.852e-007	2.852e-007	2.1780	-6.5448
>(s)FeOHSr++	1.751e-007	1.751e-007	0.45914	-6.7567
>(s)FeOSiO(OH)2-	1.242e-007	1.242e-007	1.4758	-6.9058
>(s)FeCO3-	1.241e-007	1.241e-007	1.4758	-6.9063
>(w)FeSO4-	4.079e-008	4.079e-008	1.4758	-7.3895
>(w)FeOCd+	3.795e-008	3.795e-008	0.67760	-7.4208
>(s)FeOHBa++	2.714e-008	2.714e-008	0.45914	-7.5664
>(s)FeOCd+	2.463e-008	2.463e-008	0.67760	-7.6085
>(w)FeOHMoO4--	2.016e-008	2.016e-008	2.1780	-7.6955
>(s)FeOHAsO4---	1.795e-008	1.795e-008	3.2143	-7.7460
>(w)FeOBa+	1.453e-008	1.453e-008	0.67760	-7.8378
>(s)FeOH2+	1.357e-008	1.357e-008	0.67760	-7.8674
>(w)FeHAsO4-	1.174e-008	1.174e-008	1.4758	-7.9302
>(s)FeCO3H	7.124e-009	7.124e-009	1.0000	-8.1473
>(s)FeOSi(OH)3	5.798e-009	5.798e-009	1.0000	-8.2367
>(s)FeAsO4--	1.007e-009	1.007e-009	2.1780	-8.9969
>(s)FeOHSO4--	7.831e-010	7.831e-010	2.1780	-9.1062
>(w)FeOBaOH	3.919e-010	3.919e-010	1.0000	-9.4068
>(w)HgOH2+	6.686e-011	6.686e-011	0.67760	-10.1748
>(w)FeOMn+	5.302e-011	5.302e-011	0.67760	-10.2756
>(w)FeOHSbO(OH4	4.899e-011	4.899e-011	1.4758	-10.3099
>(w)FeOHSeO4--	3.779e-011	3.779e-011	2.1780	-10.4227

>(w)FeOMo(OH)5	2.901e-011	2.901e-011	1.0000	-10.5374
>(s)FeOMn+	1.848e-011	1.848e-011	0.67760	-10.7332
>(s)FeSO4-	1.129e-011	1.129e-011	1.4758	-10.9471
>(s)FeOHMoO4--	5.583e-012	5.583e-012	2.1780	-11.2532
>(s)FeHAsO4-	3.252e-012	3.252e-012	1.4758	-11.4879
>(w)FeH2AsO4	2.392e-012	2.392e-012	1.0000	-11.6212
>(w)FeSbO(OH)4	9.103e-013	9.102e-013	1.0000	-12.0408
>(w)FeSeO4-	4.747e-013	4.747e-013	1.4758	-12.3236
>(s)HgOH2+	3.780e-013	3.780e-013	0.67760	-12.4225
>(s)FeOHSbO(OH4	1.357e-014	1.357e-014	1.4758	-13.8676
>(s)FeOHSeO4--	1.046e-014	1.046e-014	2.1780	-13.9803
>(s)FeOMo(OH)5	8.033e-015	8.033e-015	1.0000	-14.0951
>(s)FeH2AsO4	6.624e-016	6.624e-016	1.0000	-15.1789
>(s)FeSbO(OH)4	2.520e-016	2.520e-016	1.0000	-15.5985
>(s)FeSeO4-	1.314e-016	1.314e-016	1.4758	-15.8813
>(w)FeOHSeO3--	4.994e-021	4.993e-021	2.1780	-20.3016
>(w)FeSeO3-	2.440e-022	2.440e-022	1.4758	-21.6125
>(s)FeOHSeO3--	1.383e-024	1.383e-024	2.1780	-23.8593
>(s)FeSeO3-	6.757e-026	6.757e-026	1.4758	-25.1702

(Boltzman factor = exp(zF PSI/RT), where PSI is surface potential)

Mineral saturation states

	log Q/K		log Q/K
Hematite	8.7228s/sat	CaCO3xH2O	-1.3283
Cupric Ferrite	7.3131s/sat	Tenorite(c)	-1.4378
Nsutite	5.3037s/sat	Al(OH)3 (Soil)	-1.4416
Birnessite	4.7167s/sat	Smithsonite	-1.6899
Pyrolusite	4.7092s/sat	ZnCO3	-1.7420
Goethite	3.2106s/sat	Plattnerite	-1.7920
Lepidocrocite	3.0938s/sat	Cerrusite	-1.8297
Maghemite	2.5437s/sat	Boehmite	-1.8895
Magnesioferrite	2.3398s/sat	Quartz	-1.9086
Manganite	1.8299s/sat	Pb(OH)2	-2.0386
Ferrihydrite (ag	1.7748s/sat	Ni(OH)2 (c)	-2.1111
Cuprous Ferrite	0.4588s/sat	Zn(OH)2 (delta)	-2.1952
Diaspore	0.0000 sat	ZnCO3:1H2O	-2.2821
Calcite	0.0000 sat	Tenorite(am)	-2.2874
Bixbyite	0.0000 sat	Celestite	-2.3649
Barite	0.0000 sat	Chalcedony	-2.3921
Dummy	0.0000 sat	PbMoO4	-2.5804
Ferrihydrite	0.0000 sat	Cristobalite	-2.5882
Aragonite	-0.1592	Witherite	-2.6337
Dolomite (ordere	-0.2091	Pb2O3	-2.6507
Vaterite	-0.6232	Zincite	-2.7102
Magnesite	-0.6953	Gypsum	-2.8125
Strontianite	-0.7118	NiCO3	-2.8358
Dolomite (disord	-0.8460	Zn(OH)2 (epsilon	-2.8757
Gibbsite (C)	-0.8916	Cu(OH)2	-2.9394

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
O2 (g)	0.1236	-0.908
CO2 (g)	0.0001181	-3.928
Hg (g)	1.594e-024	-23.798
Hg2 (g)	6.157e-049	-48.211
H2Se (g)	3.871e-117	-116.412
CH4 (g)	2.125e-157	-156.673
H2S (g)	2.689e-158	-157.570
Hg(CH3)2 (g)	0.0000	-300.000

In fluid Sorbed Kd

full suite results

Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
>(s)FeOH	0.000234					
>(w)FeOH	0.00936					
Al+++	2.59e-007	7.82e-009	0.000211			
AsO4---	6.85e-005	2.02e-010	2.81e-005	6.85e-005	9.51	
Ba++	6.39e-007	1.27e-007	0.0174	4.21e-008	0.00578	
CO3--	0.00471	0.00255	153.	0.000474	28.4	
Ca++	0.00200	8.88e-005	3.56	0.000228	9.15	
Cd++	6.26e-008	3.66e-011	4.11e-006	6.26e-008	0.00703	
Cu++	0.000110	5.05e-009	0.000321	0.000110	7.01	
Fe+++	0.0468	2.87e-011	1.60e-006	-1.57e-006	-0.0877	
H+	-0.146	0.00247	2.49	-0.00774	-7.80	
H2O	55.6	55.5	1.00e+006	-0.00204	-36.8	
H4SiO4	0.00150	6.71e-007	0.0644	0.00150	144.	
Hg(OH)2	6.38e-010	5.70e-010	0.000134	6.72e-011	1.58e-005	
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00392	8.72e-005	2.12	0.00384	93.2	
Mn+++	5.72e-007	5.73e-013	3.15e-008	7.15e-011	3.93e-006	
MoO4--	4.54e-008	2.52e-008	0.00402	2.02e-008	0.00323	
Na+	9.57e-005	9.57e-005	2.20			
Ni++	4.58e-006	1.95e-009	0.000114	4.57e-006	0.268	
O2(aq)	0.000156	0.000156	4.99	-1.79e-011	-5.72e-007	
Pb++	0.000255	2.04e-009	0.000422	0.000255	52.8	
SO4--	0.000763	0.000760	73.0	2.87e-006	0.276	
Sb(OH)6-	2.31e-009	2.26e-009	0.000506	4.99e-011	1.12e-005	
SeO4--	9.84e-009	9.80e-009	0.00140	3.83e-011	5.47e-006	
Sr++	3.62e-006	2.34e-006	0.205	1.28e-006	0.112	
UO2++	1.85e-008	1.85e-008	0.00500			
Zn++	1.65e-006	8.13e-008	0.00531	1.57e-006	0.103	
dummy	0.0562	0.000	0.000			

Sorbed	fraction	log fraction
AsO4---	1.000	-0.000
Ba++	0.2489	-0.604
CO3--	0.1567	-0.805
Ca++	0.7200	-0.143
Cd++	0.9994	-0.000
Cu++	1.000	-0.000
Fe+++	1.000	0.000
H4SiO4	0.9996	-0.000
Hg(OH)2	0.1054	-0.977
Mg++	0.9778	-0.010
Mn+++	0.9920	-0.003
MoO4--	0.4452	-0.351
Ni++	0.9996	-0.000
Pb++	1.000	-0.000
SO4--	0.003763	-2.424
Sb(OH)6-	0.02161	-1.665
SeO4--	0.003890	-2.410
Sr++	0.3527	-0.453
Zn++	0.9508	-0.022

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	7.817e-009	0.0002109		
As	6.849e-005	2.024e-010	1.516e-005	6.849e-005	5.130
Ba	6.388e-007	1.269e-007	0.01743	4.206e-008	0.005775
C	0.004711	0.002551	30.64	0.0004740	5.692
Ca	0.002003	8.880e-005	3.558	0.0002283	9.148
Cd	6.262e-008	3.657e-011	4.110e-006	6.258e-008	0.007032

full suite results

Cu	0.0001104	5.053e-009	0.0003210	0.0001104	7.013
Du	0.05618	0.0000	0.0000		
Fe	0.04678	2.867e-011	1.601e-006	-1.571e-006	-0.08771
H	111.2	111.0	1.119e+005	-0.005827	-5.872
Hg	6.377e-010	5.704e-010	0.0001144	6.724e-011	1.348e-005
K	1.023e-005	1.023e-005	0.3999		
Mg	0.003923	8.717e-005	2.119	0.003836	93.23
Mn	5.718e-007	5.731e-013	3.148e-008	7.150e-011	3.927e-006
Mo	4.536e-008	2.517e-008	0.002414	2.020e-008	0.001937
Na	9.569e-005	9.569e-005	2.200		
Ni	4.576e-006	1.947e-009	0.0001143	4.574e-006	0.2685
O	55.67	55.52	8.881e+005	0.005664	90.60
Pb	0.0002549	2.037e-009	0.0004221	0.0002549	52.81
S	0.0007631	0.0007597	24.35	2.870e-006	0.09199
Sb	2.310e-009	2.260e-009	0.0002751	4.991e-011	6.076e-006
Se	9.839e-009	9.801e-009	0.0007737	3.827e-011	3.021e-006
Si	0.001501	6.706e-007	0.01883	0.001500	42.12
Sr	3.619e-006	2.343e-006	0.2052	1.276e-006	0.1118
U	1.852e-008	1.852e-008	0.004406		
Zn	1.652e-006	8.128e-008	0.005312	1.571e-006	0.1027

APPENDIX D

GWB Output (Mineral Equilibration – Reducing Conditions)

React_output_Eh slide6_final

```
Step #     0              Xi = 0.0000
Temperature =   5.0 C     Pressure =  0.938 bars
pH =  7.700
Eh =   0.8083 volts       pe =  14.6460
Ionic strength      =    0.008247
Activity of water   =    0.999880
Solvent mass        =    1.000000 kg
Solution mass       =    1.000383 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         383 mg/kg sol'n
Rock mass           =    0.000000 kg
```

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.8083	14.6460

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

No minerals in system.

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.003088	188.4	0.9120	-2.5503
Ca++	0.001604	64.28	0.6919	-2.9546
Mg++	0.001076	26.16	0.6919	-3.1280
SO4--	0.0006215	59.68	0.6919	-3.3665
H2CO3* (aq)	0.0001843	11.42	1.0019	-3.7337
O2(aq)	0.0001563	4.998	1.0019	-3.8053
Na+	9.530e-005	2.190	0.9120	-4.0609
CaSO4 (aq)	8.885e-005	12.09	1.0019	-4.0505
MgSO4 (aq)	4.916e-005	5.915	1.0019	-4.3076
CaHCO3+	2.712e-005	2.741	0.9120	-4.6067
MgHCO3+	2.414e-005	2.059	0.9120	-4.6572
H4SiO4	1.765e-005	1.696	1.0019	-4.7525
K+	1.021e-005	0.3990	0.9120	-5.0310
CO3--	5.689e-006	0.3413	0.6919	-5.4049
Sr++	3.220e-006	0.2821	0.6919	-5.6520
MgCO3 (aq)	2.054e-006	0.1731	1.0019	-5.6866
CaCO3 (aq)	1.082e-006	0.1082	1.0019	-5.9651
Fe(OH)2+	8.866e-007	0.07964	0.9120	-6.0922
Ba++	5.545e-007	0.07612	0.6919	-6.4160
Al(OH)4-	2.451e-007	0.02328	0.9120	-6.6506
NaSO4-	2.188e-007	0.02603	0.9120	-6.7000
NaHCO3 (aq)	1.657e-007	0.01391	1.0019	-6.7799
SrSO4 (aq)	1.513e-007	0.02778	1.0019	-6.8193
Zn++	1.194e-007	0.007801	0.6919	-7.0830
OH-	1.096e-007	0.001864	0.9120	-7.0001
SrHCO3+	4.910e-008	0.007295	0.9120	-7.3489
H3SiO4-	3.664e-008	0.003483	0.9120	-7.4761
BaSO4 (aq)	2.221e-008	0.005183	1.0019	-7.6525
H+	2.188e-008	2.204e-005	0.9120	-7.7000
KSO4-	2.122e-008	0.002867	0.9120	-7.7132
ZnCO3 (aq)	1.868e-008	0.002341	1.0019	-7.7278
Ca2UO2(CO3)3 (aq	1.787e-008	0.009469	1.0019	-7.7471
Mn++	1.501e-008	0.0008246	0.6919	-7.9834
MoO4--	1.473e-008	0.002355	0.6919	-7.9917
Ni++	1.301e-008	0.0007636	0.6919	-8.0456
NaCO3-	1.261e-008	0.001046	0.9120	-7.9394

Mg2CO3++	1.228e-008	0.001333	0.6919	-8.0709
Al(OH)3 (aq)	1.102e-008	0.0008590	1.0019	-7.9571
MgOH+	1.050e-008	0.0004338	0.9120	-8.0187

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.4585s/sat	Vaterite	-0.5885
Cupric Ferrite	12.6922s/sat	Magnesite	-0.8209
Maghemite	9.2795s/sat	Dolomite (disord	-0.9369
Nsutite	7.8966s/sat	Chalcedony	-0.9542
Magnesioferrite	7.5640s/sat	Al2O3	-1.0003
Birnessite	7.3096s/sat	Cristobalite	-1.1503
Pyrolusite	7.3020s/sat	Al(OH)3 (am)	-1.2435
Goethite	6.5785s/sat	CaCO3xH2O	-1.2936
Lepidocrocite	6.4617s/sat	PbMoO4	-1.2936
Bixbyite	5.1852s/sat	Cerrusite	-1.4939
Ferrihydrite (ag	5.1427s/sat	Smithsonite	-1.6357
Manganite	4.4225s/sat	K-Jarosite	-1.6483
Ferrihydrite	3.3678s/sat	ZnCO3	-1.6878
Kaolinite	3.1054s/sat	Gypsum	-1.6986
Diaspore	2.7837s/sat	Strontianite	-1.7995
Cuprous Ferrite	2.4698s/sat	SiO2 (am,ppt)	-1.8216
Al4(OH)10SO4	2.3528s/sat	SiO2 (am,gel)	-1.8660
Gibbsite (C)	1.8921s/sat	Anhydrite	-2.0518
Imogolite	1.7183s/sat	ZnCO3:1H2O	-2.2279
Al(OH)3 (Soil)	1.3421s/sat	Celestite	-2.3733
Boehmite	0.8942s/sat	Rhodochrosite	-2.4119
Hausmannite	0.6080s/sat	Zn-Al LDH	-2.6437
Halloysite	0.5444s/sat	BaHAsO4:H2O	-2.6960
Barite	0.4872s/sat	NiCO3	-2.7744
Calcite	0.0347s/sat	Tenorite(c)	-2.7945
Aragonite	-0.1245	Plattnerite	-2.8418
Dolomite (ordere	-0.2999	Otavite	-2.8853
Quartz	-0.4707	MnCO3 (am)	-2.8883

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
O2 (g)	0.1239	-0.907
CO2 (g)	0.002872	-2.542
Hg (g)	4.731e-025	-24.325
Hg2 (g)	5.427e-050	-49.265
H2Se (g)	1.261e-114	-113.899
H2S (g)	7.818e-156	-155.107
CH4 (g)	5.147e-156	-155.288
Hg(CH3)2 (g)	0.0000	-300.000

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
Al+++	2.59e-007	2.59e-007	0.00700			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	5.82e-007	0.0800			
CO3--	0.00333	0.00333	200.			
Ca++	0.00172	0.00172	69.0			
Cd++	4.45e-010	4.45e-010	5.00e-005			
Cu++	4.72e-009	4.72e-009	0.000300			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	0.00351	0.00351	3.53			
H2O	55.5	55.5	1.00e+006			
H4SiO4	1.77e-005	1.77e-005	1.70			

Hg(OH)2	1.70e-010	1.70e-010	4.00e-005
K+	1.02e-005	1.02e-005	0.400
Mg++	0.00115	0.00115	28.0
Mn+++	1.82e-008	1.82e-008	0.00100
MoO4--	2.50e-008	2.50e-008	0.00400
Na+	9.57e-005	9.57e-005	2.20
Ni++	1.70e-008	1.70e-008	0.00100
O2(aq)	0.000156	0.000156	5.00
Pb++	4.34e-009	4.34e-009	0.000900
SO4--	0.000760	0.000760	73.0
Sb(OH)6-	2.23e-009	2.23e-009	0.000500
SeO4--	9.79e-009	9.79e-009	0.00140
Sr++	3.42e-006	3.42e-006	0.300
UO2++	1.85e-008	1.85e-008	0.00500
Zn++	1.53e-007	1.53e-007	0.0100

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	2.594e-007	0.006997		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	5.825e-007	0.07997		
C	0.003333	0.003333	40.02		
Ca	0.001722	0.001722	68.97		
Cd	4.448e-010	4.448e-010	4.998e-005		
Cu	4.721e-009	4.721e-009	0.0002999		
Fe	8.953e-007	8.953e-007	0.04998		
H	111.0	111.0	1.119e+005		
Hg	1.705e-010	1.705e-010	3.419e-005		
K	1.023e-005	1.023e-005	0.3998		
Mg	0.001152	0.001152	27.99		
Mn	1.820e-008	1.820e-008	0.0009996		
Mo	2.501e-008	2.501e-008	0.002399		
Na	9.569e-005	9.569e-005	2.199		
Ni	1.703e-008	1.703e-008	0.0009996		
O	55.52	55.52	8.880e+005		
Pb	4.344e-009	4.344e-009	0.0008997		
S	0.0007599	0.0007599	24.36		
Sb	2.234e-009	2.234e-009	0.0002719		
Se	9.793e-009	9.793e-009	0.0007730		
Si	1.769e-005	1.769e-005	0.4966		
Sr	3.424e-006	3.424e-006	0.2999		
U	1.852e-008	1.852e-008	0.004406		
Zn	1.530e-007	1.530e-007	0.009996		

♀

```
Step #     0              Xi = 0.0000
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  7.671
Eh =   0.8099 volts      pe =  14.6749
Ionic strength      =    0.008212
Activity of water   =    0.999880
Solvent mass        =    1.000000 kg
Solution mass       =    1.000382 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         382 mg/kg sol'n
Rock mass           =    0.000001 kg
```

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.8099	14.6749

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	3.931e-007	-6.406	9.174e-005	
Bixbyite	9.075e-009	-8.042	1.433e-006	
Calcite	1.215e-005	-4.915	0.001216	
Gibbsite (C)	2.563e-007	-6.591	1.999e-005	
(total)			0.001329	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.003066	187.0	0.9122	-2.5534
Ca++	0.001593	63.83	0.6924	-2.9573
Mg++	0.001077	26.16	0.6924	-3.1276
SO4--	0.0006215	59.68	0.6924	-3.3662
H2CO3* (aq)	0.0001956	12.13	1.0019	-3.7079
O2(aq)	0.0001563	4.998	1.0019	-3.8054
Na+	9.530e-005	2.190	0.9122	-4.0608
CaSO4 (aq)	8.836e-005	12.02	1.0019	-4.0529
MgSO4 (aq)	4.924e-005	5.925	1.0019	-4.3069
CaHCO3+	2.675e-005	2.704	0.9122	-4.6125
MgHCO3+	2.399e-005	2.046	0.9122	-4.6599
H4SiO4	1.765e-005	1.696	1.0019	-4.7524
K+	1.021e-005	0.3990	0.9122	-5.0310
CO3--	5.282e-006	0.3168	0.6924	-5.4368
Sr++	3.221e-006	0.2821	0.6924	-5.6517
MgCO3 (aq)	1.910e-006	0.1610	1.0019	-5.7182
CaCO3 (aq)	9.985e-007	0.09991	1.0019	-5.9998
Fe(OH)2+	8.872e-007	0.07970	0.9122	-6.0919
NaSO4-	2.189e-007	0.02605	0.9122	-6.6996
Ba++	1.803e-007	0.02476	0.6924	-6.9036
NaHCO3 (aq)	1.645e-007	0.01382	1.0019	-6.7829
SrSO4 (aq)	1.515e-007	0.02783	1.0019	-6.8186
Zn++	1.208e-007	0.007891	0.6924	-7.0777
OH-	1.025e-007	0.001743	0.9122	-7.0290
SrHCO3+	4.878e-008	0.007248	0.9122	-7.3517
H3SiO4-	3.428e-008	0.003259	0.9122	-7.5049
H+	2.338e-008	2.355e-005	0.9122	-7.6711
KSO4-	2.124e-008	0.002869	0.9122	-7.7128
Ca2UO2(CO3)3 (aq	1.785e-008	0.009462	1.0019	-7.7475
ZnCO3 (aq)	1.756e-008	0.002201	1.0019	-7.7546
MoO4--	1.474e-008	0.002356	0.6924	-7.9913
Ni++	1.309e-008	0.0007684	0.6924	-8.0426
NaCO3-	1.171e-008	0.0009717	0.9122	-7.9713
Mg2CO3++	1.142e-008	0.001240	0.6924	-8.1021

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.4014s/sat	Magnesite	-0.8525
Cupric Ferrite	12.6075s/sat	Chalcedony	-0.9542
Maghemite	9.2224s/sat	Boehmite	-0.9979
Magnesioferrite	7.4495s/sat	Dolomite (disord	-1.0032
Goethite	6.5500s/sat	Cristobalite	-1.1503
Lepidocrocite	6.4332s/sat	PbMoO4	-1.2666
Nsutite	5.3039s/sat	CaCO3xH2O	-1.3283
Ferrihydrite (ag	5.1141s/sat	Cerrusite	-1.4993

Birnessite	4.7169s/sat	K-Jarosite	-1.6465
Pyrolusite	4.7094s/sat	Smithsonite	-1.6624
Ferrihydrite	3.3393s/sat	Gypsum	-1.7010
Cuprous Ferrite	2.4137s/sat	ZnCO3	-1.7146
Manganite	1.8299s/sat	SiO2 (am,ppt)	-1.8215
Diaspore	0.8916s/sat	Strontianite	-1.8311
Bixbyite	0.0000 sat	SiO2 (am,gel)	-1.8660
Barite	0.0000 sat	Anhydrite	-2.0542
Calcite	0.0000 sat	Imogolite	-2.0657
Gibbsite (C)	0.0000 sat	ZnCO3:1H2O	-2.2546
Aragonite	-0.1592	Celestite	-2.3727
Dolomite (ordere	-0.3662	NiCO3	-2.8033
Quartz	-0.4707	Tenorite(c)	-2.8221
Al(OH)3 (Soil)	-0.5500	Plattnerite	-2.8730
Vaterite	-0.6232	Otavite	-2.9152
Kaolinite	-0.6785		

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
O2 (g)	0.1239	-0.907
CO2 (g)	0.003049	-2.516
Hg (g)	4.731e-025	-24.325
Hg2 (g)	5.426e-050	-49.265
H2Se (g)	1.442e-114	-113.841
H2S (g)	8.938e-156	-155.049
CH4 (g)	5.463e-156	-155.263
Hg(CH3)2 (g)	0.0000	-300.000

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
Al+++	2.59e-007	3.12e-009	8.42e-005			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.89e-007	0.0260			
CO3--	0.00333	0.00332	199.			
Ca++	0.00172	0.00171	68.5			
Cd++	4.45e-010	4.45e-010	5.00e-005			
Cu++	4.72e-009	4.72e-009	0.000300			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	0.00351	0.00351	3.53			
H2O	55.5	55.5	1.00e+006			
H4SiO4	1.77e-005	1.77e-005	1.70			
Hg(OH)2	1.70e-010	1.70e-010	4.00e-005			
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00115	0.00115	28.0			
Mn+++	1.82e-008	5.27e-011	2.89e-006			
MoO4--	2.50e-008	2.50e-008	0.00400			
Na+	9.57e-005	9.57e-005	2.20			
Ni++	1.70e-008	1.70e-008	0.00100			
O2(aq)	0.000156	0.000156	5.00			
Pb++	4.34e-009	4.34e-009	0.000900			
SO4--	0.000760	0.000760	72.9			
Sb(OH)6-	2.23e-009	2.23e-009	0.000500			
SeO4--	9.79e-009	9.79e-009	0.00140			
Sr++	3.42e-006	3.42e-006	0.300			
UO2++	1.85e-008	1.85e-008	0.00500			
Zn++	1.53e-007	1.53e-007	0.0100			

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	3.123e-009	8.422e-005		

As	2.160e-009	2.160e-009	0.0001617
Ba	5.825e-007	1.894e-007	0.02600
C	0.003333	0.003321	39.87
Ca	0.001722	0.001709	68.49
Cd	4.448e-010	4.448e-010	4.998e-005
Cu	4.721e-009	4.721e-009	0.0002999
Fe	8.953e-007	8.953e-007	0.04998
H	111.0	111.0	1.119e+005
Hg	1.705e-010	1.705e-010	3.419e-005
K	1.023e-005	1.023e-005	0.3998
Mg	0.001152	0.001152	27.99
Mn	1.820e-008	5.266e-011	2.892e-006
Mo	2.501e-008	2.501e-008	0.002399
Na	9.569e-005	9.569e-005	2.199
Ni	1.703e-008	1.703e-008	0.0009996
O	55.52	55.52	8.880e+005
Pb	4.344e-009	4.344e-009	0.0008997
S	0.0007599	0.0007595	24.34
Sb	2.234e-009	2.234e-009	0.0002719
Se	9.793e-009	9.793e-009	0.0007730
Si	1.769e-005	1.769e-005	0.4966
Sr	3.424e-006	3.424e-006	0.2999
U	1.852e-008	1.852e-008	0.004406
Zn	1.530e-007	1.530e-007	0.009996

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Step #    50               Xi = 0.1000
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  7.885
Eh =   0.6958 volts       pe =  12.6074
Ionic strength      =    0.007036
Activity of water   =    0.999901
Solvent mass        =    1.000006 kg
Solution mass       =    1.000329 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         323 mg/kg sol'n
Rock mass           =    0.000054 kg
```

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.6958	12.6074

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.497e-005	
Bixbyite	8.386e-009	-8.076	1.324e-006	
Calcite	0.0005420	-3.266	0.05425	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
(total)			0.05436	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002639	160.9	0.9178	-2.6159
Ca++	0.001096	43.93	0.7095	-3.1090
Mg++	0.001075	26.12	0.7095	-3.1178
SO4--	0.0006401	61.47	0.7095	-3.3428

H2CO3* (aq)	0.0001034	6.413	1.0016	-3.9846
Na+	9.530e-005	2.190	0.9178	-4.0582
CaSO4 (aq)	6.578e-005	8.952	1.0016	-4.1812
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2737
MgHCO3+	2.112e-005	1.801	0.9178	-4.7126
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.624e-005	1.641	0.9178	-4.8267
K+	1.021e-005	0.3990	0.9178	-5.0284
CO3--	7.309e-006	0.4385	0.7095	-5.2852
Sr++	3.213e-006	0.2815	0.7095	-5.6421
MgCO3 (aq)	2.771e-006	0.2336	1.0016	-5.5567
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998
Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920
NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.669e-007	0.002838	0.9178	-6.8148
Ba++	1.667e-007	0.02289	0.7095	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.434e-007	0.01204	1.0016	-6.8428
Zn++	1.115e-007	0.007289	0.7095	-7.1016
H3SiO4-	5.571e-008	0.005296	0.9178	-7.2913
SrHCO3+	4.292e-008	0.006377	0.9178	-7.4046
ZnCO3 (aq)	2.358e-008	0.002955	1.0016	-7.6268
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
Ca2UO2(CO3)3 (aq	1.745e-008	0.009251	1.0016	-7.7574
NaCO3-	1.661e-008	0.001378	0.9178	-7.8169
Mg2CO3++	1.653e-008	0.001795	0.7095	-7.9308
MgOH+	1.637e-008	0.0006762	0.9178	-7.8232
MoO4--	1.510e-008	0.002415	0.7095	-7.9699
H+	1.419e-008	1.430e-005	0.9178	-7.8853
Ni++	1.280e-008	0.0007515	0.7095	-8.0417
Fe(OH)3 (aq)	1.172e-008	0.001252	1.0016	-7.9305

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8296s/sat	Magnesite	-0.6910
Cupric Ferrite	13.3178s/sat	Dolomite (disord	-0.8417
Maghemite	9.6505s/sat	Chalcedony	-0.9548
Magnesioferrite	8.3158s/sat	Boehmite	-0.9979
Goethite	6.7640s/sat	Cristobalite	-1.1510
Lepidocrocite	6.6472s/sat	CaCO3xH2O	-1.3283
Ferrihydrite (ag	5.3282s/sat	PbMoO4	-1.3725
Cuprous Ferrite	4.7632s/sat	Cerrusite	-1.4748
Ferrihydrite	3.5534s/sat	Smithsonite	-1.5346
Nsutite	3.4507s/sat	ZnCO3	-1.5868
Birnessite	2.8637s/sat	K-Jarosite	-1.5976
Pyrolusite	2.8561s/sat	Strontianite	-1.6699
Manganite	1.8299s/sat	SiO2 (am,ppt)	-1.8222
Diaspore	0.8916s/sat	Gypsum	-1.8293
Bixbyite	0.0000 sat	SiO2 (am,gel)	-1.8666
Barite	0.0000 sat	Imogolite	-2.0664
Gibbsite (C)	0.0000 sat	ZnCO3:1H2O	-2.1268
Calcite	0.0000 sat	Anhydrite	-2.1825
Aragonite	-0.1592	Celestite	-2.3397
Dolomite (ordere	-0.2047	Tenorite(c)	-2.5399
Quartz	-0.4713	NiCO3	-2.6507
Al(OH)3 (Soil)	-0.5500	Otavite	-2.7630
Vaterite	-0.6232	Pb(OH)2	-2.8187
Kaolinite	-0.6799		

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.

CO2 (g)	0.001612	-2.793
O2 (g)	4.785e-009	-8.320
Hg (g)	2.417e-021	-20.617
Hg2 (g)	1.416e-042	-41.849
H2Se (g)	3.768e-100	-99.424
H2S (g)	2.358e-141	-140.628
CH4 (g)	1.936e-141	-140.713
Hg(CH3)2 (g)	1.018e-300	-299.992

Original basis	total moles	In fluid moles	In fluid mg/kg	Sorbed moles	Sorbed mg/kg	Kd L/kg
Al+++	2.59e-007	4.95e-009	0.000134			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00279	167.			
Ca++	0.00172	0.00118	47.3			
Cd++	4.45e-010	4.45e-010	5.00e-005			
Cu++	4.72e-009	4.72e-009	0.000300			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	0.00288	0.00288	2.90			
H2O	55.5	55.5	1.00e+006			
H4SiO4	1.77e-005	1.77e-005	1.70			
Hg(OH)2	1.70e-010	1.70e-010	4.00e-005			
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00115	0.00115	28.0			
Mn+++	1.82e-008	1.43e-009	7.86e-005			
MoO4--	2.50e-008	2.50e-008	0.00400			
Na+	9.57e-005	9.57e-005	2.20			
Ni++	1.70e-008	1.70e-008	0.00100			
O2(aq)	-3.52e-010	-3.52e-010	-1.13e-005			
Pb++	4.34e-009	4.34e-009	0.000900			
SO4--	0.000760	0.000760	72.9			
Sb(OH)6-	2.23e-009	2.23e-009	0.000500			
SeO4--	9.79e-009	9.79e-009	0.00140			
Sr++	3.42e-006	3.42e-006	0.300			
UO2++	1.85e-008	1.85e-008	0.00500			
Zn++	1.53e-007	1.53e-007	0.0100			

Elemental composition	total moles	In fluid moles	In fluid mg/kg	Sorbed moles	Sorbed mg/kg
Al	2.594e-007	4.951e-009	0.0001335		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002791	33.51		
Ca	0.001722	0.001180	47.26		
Cd	4.448e-010	4.448e-010	4.998e-005		
Cu	4.721e-009	4.721e-009	0.0002999		
Fe	8.953e-007	8.953e-007	0.04998		
H	111.0	111.0	1.119e+005		
Hg	1.705e-010	1.705e-010	3.419e-005		
K	1.023e-005	1.023e-005	0.3999		
Mg	0.001152	0.001152	27.99		
Mn	1.820e-008	1.431e-009	7.860e-005		
Mo	2.501e-008	2.501e-008	0.002399		
Na	9.569e-005	9.569e-005	2.199		
Ni	1.703e-008	1.703e-008	0.0009997		
O	55.52	55.52	8.880e+005		
Pb	4.344e-009	4.344e-009	0.0008997		
S	0.0007599	0.0007595	24.35		
Sb	2.234e-009	2.234e-009	0.0002719		

Se	9.793e-009	9.793e-009	0.0007730
Si	1.769e-005	1.769e-005	0.4966
Sr	3.424e-006	3.424e-006	0.2999
U	1.852e-008	1.852e-008	0.004406
Zn	1.530e-007	1.530e-007	0.009997

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Step #    77              Xi = 0.1540
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  7.885
Eh =   0.6342 volts      pe =  11.4910
Ionic strength      =    0.007036
Activity of water   =    0.999901
Solvent mass        =    1.000006 kg
Solution mass       =    1.000329 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         323 mg/kg sol'n
Rock mass           =    0.000054 kg
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Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.6342	11.4910

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.497e-005	
Calcite	0.0005420	-3.266	0.05425	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
(total)			0.05437	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002639	160.9	0.9178	-2.6159
Ca++	0.001096	43.93	0.7095	-3.1091
Mg++	0.001075	26.12	0.7095	-3.1178
SO4--	0.0006401	61.47	0.7095	-3.3428
H2CO3* (aq)	0.0001034	6.413	1.0016	-3.9847
Na+	9.530e-005	2.190	0.9178	-4.0582
CaSO4 (aq)	6.578e-005	8.952	1.0016	-4.1812
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2737
MgHCO3+	2.112e-005	1.801	0.9178	-4.7126
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.624e-005	1.641	0.9178	-4.8267
K+	1.021e-005	0.3990	0.9178	-5.0284
CO3--	7.310e-006	0.4385	0.7095	-5.2851
Sr++	3.213e-006	0.2815	0.7095	-5.6421
MgCO3 (aq)	2.771e-006	0.2336	1.0016	-5.5567
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998
Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920
NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.669e-007	0.002838	0.9178	-6.8148
Ba++	1.667e-007	0.02289	0.7095	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.434e-007	0.01204	1.0016	-6.8428
Zn++	1.115e-007	0.007289	0.7095	-7.1016
H3SiO4-	5.571e-008	0.005297	0.9178	-7.2913

SrHCO3+	4.292e-008	0.006377	0.9178	-7.4046
ZnCO3 (aq)	2.358e-008	0.002955	1.0016	-7.6268
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
Ca2UO2(CO3)3 (aq	1.745e-008	0.009251	1.0016	-7.7574
NaCO3-	1.661e-008	0.001378	0.9178	-7.8169
Mg2CO3++	1.653e-008	0.001795	0.7095	-7.9307
MgOH+	1.637e-008	0.0006762	0.9178	-7.8232
MoO4--	1.510e-008	0.002415	0.7095	-7.9699
Mn++	1.446e-008	0.0007940	0.7095	-7.9890
H+	1.419e-008	1.430e-005	0.9178	-7.8853
Ni++	1.280e-008	0.0007515	0.7095	-8.0417
Fe(OH)3 (aq)	1.172e-008	0.001252	1.0016	-7.9304

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8296s/sat	Dolomite (disord	-0.8417
Cupric Ferrite	13.3179s/sat	Chalcedony	-0.9548
Maghemite	9.6505s/sat	Boehmite	-0.9979
Magnesioferrite	8.3159s/sat	Cristobalite	-1.1510
Goethite	6.7641s/sat	CaCO3xH2O	-1.3283
Lepidocrocite	6.6472s/sat	PbMoO4	-1.3725
Cuprous Ferrite	5.8797s/sat	Cerrusite	-1.4748
Ferrihydrite (ag	5.3282s/sat	Smithsonite	-1.5346
Ferrihydrite	3.5534s/sat	ZnCO3	-1.5868
Nsutite	2.3223s/sat	K-Jarosite	-1.5976
Manganite	1.8180s/sat	Strontianite	-1.6698
Birnessite	1.7353s/sat	SiO2 (am,ppt)	-1.8222
Pyrolusite	1.7277s/sat	Gypsum	-1.8293
Diaspore	0.8916s/sat	SiO2 (am,gel)	-1.8666
Barite	0.0000 sat	Imogolite	-2.0664
Gibbsite (C)	0.0000 sat	ZnCO3:1H2O	-2.1268
Calcite	0.0000 sat	Anhydrite	-2.1825
Bixbyite	-0.0239	Rhodochrosite	-2.2978
Aragonite	-0.1592	Celestite	-2.3397
Dolomite (ordere	-0.2047	Tenorite(c)	-2.5399
Quartz	-0.4713	NiCO3	-2.6507
Al(OH)3 (Soil)	-0.5500	Otavite	-2.7630
Vaterite	-0.6232	MnCO3 (am)	-2.7741
Kaolinite	-0.6799	Pb(OH)2	-2.8187
Magnesite	-0.6910		

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.001612	-2.793
O2 (g)	1.638e-013	-12.786
Hg (g)	4.131e-019	-18.384
Hg2 (g)	4.137e-038	-37.383
H2Se (g)	3.217e-091	-90.493
H2S (g)	2.013e-132	-131.696
CH4 (g)	1.653e-132	-131.782
Hg(CH3)2 (g)	7.423e-283	-282.129

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
Al+++	2.59e-007	4.95e-009	0.000134			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00279	167.			
Ca++	0.00172	0.00118	47.3			

Cd++	4.45e-010	4.45e-010	5.00e-005
Cu++	4.72e-009	4.72e-009	0.000300
Fe+++	8.95e-007	8.95e-007	0.0500
H+	0.00288	0.00288	2.90
H2O	55.5	55.5	1.00e+006
H4SiO4	1.77e-005	1.77e-005	1.70
Hg(OH)2	1.70e-010	1.70e-010	4.00e-005
K+	1.02e-005	1.02e-005	0.400
Mg++	0.00115	0.00115	28.0
Mn+++	1.82e-008	1.82e-008	0.00100
MoO4--	2.50e-008	2.50e-008	0.00400
Na+	9.57e-005	9.57e-005	2.20
Ni++	1.70e-008	1.70e-008	0.00100
O2(aq)	-4.55e-009	-4.55e-009	-0.000146
Pb++	4.34e-009	4.34e-009	0.000900
SO4--	0.000760	0.000760	72.9
Sb(OH)6-	2.23e-009	2.23e-009	0.000500
SeO4--	9.79e-009	9.79e-009	0.00140
Sr++	3.42e-006	3.42e-006	0.300
UO2++	1.85e-008	1.85e-008	0.00500
Zn++	1.53e-007	1.53e-007	0.0100

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	4.952e-009	0.0001336		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002791	33.51		
Ca	0.001722	0.001180	47.26		
Cd	4.448e-010	4.448e-010	4.998e-005		
Cu	4.721e-009	4.721e-009	0.0002999		
Fe	8.953e-007	8.953e-007	0.04998		
H	111.0	111.0	1.119e+005		
Hg	1.705e-010	1.705e-010	3.419e-005		
K	1.023e-005	1.023e-005	0.3999		
Mg	0.001152	0.001152	27.99		
Mn	1.820e-008	1.820e-008	0.0009997		
Mo	2.501e-008	2.501e-008	0.002399		
Na	9.569e-005	9.569e-005	2.199		
Ni	1.703e-008	1.703e-008	0.0009997		
O	55.52	55.52	8.880e+005		
Pb	4.344e-009	4.344e-009	0.0008997		
S	0.0007599	0.0007595	24.35		
Sb	2.234e-009	2.234e-009	0.0002719		
Se	9.793e-009	9.793e-009	0.0007730		
Si	1.769e-005	1.769e-005	0.4966		
Sr	3.424e-006	3.424e-006	0.2999		
U	1.852e-008	1.852e-008	0.004406		
Zn	1.530e-007	1.530e-007	0.009997		

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Step #   100              Xi = 0.2000
Temperature =   5.0 C     Pressure =  0.938 bars
pH =  7.885
Eh =   0.5817 volts       pe =  10.5399
Ionic strength       =    0.007036
Activity of water    =    0.999901
Solvent mass         =    1.000006 kg
Solution mass        =    1.000329 kg
Solution density     =    1.026    g/cm3
Chlorinity           =    0.000000 molal
Dissolved solids     =         323 mg/kg sol'n
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Rock mass = 0.000054 kg

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.5817	10.5399

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.497e-005	
Calcite	0.0005420	-3.266	0.05425	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
(total)			0.05437	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002639	160.9	0.9178	-2.6159
Ca++	0.001096	43.93	0.7095	-3.1091
Mg++	0.001075	26.12	0.7095	-3.1178
SO4--	0.0006401	61.47	0.7095	-3.3428
H2CO3* (aq)	0.0001034	6.413	1.0016	-3.9847
Na+	9.530e-005	2.190	0.9178	-4.0582
CaSO4 (aq)	6.578e-005	8.952	1.0016	-4.1812
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2737
MgHCO3+	2.112e-005	1.801	0.9178	-4.7126
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.624e-005	1.641	0.9178	-4.8267
K+	1.021e-005	0.3990	0.9178	-5.0284
CO3--	7.310e-006	0.4385	0.7095	-5.2851
Sr++	3.213e-006	0.2815	0.7095	-5.6421
MgCO3 (aq)	2.771e-006	0.2336	1.0016	-5.5567
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998
Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920
NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.669e-007	0.002838	0.9178	-6.8148
Ba++	1.667e-007	0.02289	0.7095	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.434e-007	0.01204	1.0016	-6.8428
Zn++	1.115e-007	0.007289	0.7095	-7.1016
H3SiO4-	5.571e-008	0.005297	0.9178	-7.2913
SrHCO3+	4.292e-008	0.006377	0.9178	-7.4046
ZnCO3 (aq)	2.358e-008	0.002955	1.0016	-7.6268
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
Ca2UO2(CO3)3 (aq	1.745e-008	0.009251	1.0016	-7.7574
NaCO3-	1.661e-008	0.001378	0.9178	-7.8169
Mg2CO3++	1.653e-008	0.001795	0.7095	-7.9307
MgOH+	1.637e-008	0.0006762	0.9178	-7.8232
MoO4--	1.510e-008	0.002415	0.7095	-7.9699
Mn++	1.446e-008	0.0007940	0.7095	-7.9890
H+	1.419e-008	1.430e-005	0.9178	-7.8853
Ni++	1.280e-008	0.0007515	0.7095	-8.0417
Fe(OH)3 (aq)	1.172e-008	0.001252	1.0016	-7.9304

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8296s/sat	Chalcedony	-0.9548

Cupric Ferrite	13.3179s/sat	Boehmite	-0.9979
Maghemite	9.6505s/sat	Cristobalite	-1.1510
Magnesioferrite	8.3159s/sat	CaCO3xH2O	-1.3283
Cuprous Ferrite	6.8307s/sat	PbMoO4	-1.3725
Goethite	6.7641s/sat	Cerrusite	-1.4748
Lepidocrocite	6.6472s/sat	Smithsonite	-1.5346
Ferrihydrite (ag	5.3282s/sat	ZnCO3	-1.5868
Ferrihydrite	3.5534s/sat	K-Jarosite	-1.5976
Diaspore	0.8916s/sat	Strontianite	-1.6698
Manganite	0.8669s/sat	SiO2 (am,ppt)	-1.8222
Nsutite	0.4202s/sat	Gypsum	-1.8293
Barite	0.0000 sat	SiO2 (am,gel)	-1.8666
Calcite	0.0000 sat	Bixbyite	-1.9260
Gibbsite (C)	0.0000 sat	Imogolite	-2.0664
Aragonite	-0.1592	ZnCO3:1H2O	-2.1268
Birnessite	-0.1668	Anhydrite	-2.1825
Pyrolusite	-0.1744	Rhodochrosite	-2.2978
Dolomite (ordere	-0.2047	Celestite	-2.3397
Quartz	-0.4713	Tenorite(c)	-2.5399
Al(OH)3 (Soil)	-0.5500	NiCO3	-2.6507
Vaterite	-0.6232	Otavite	-2.7630
Kaolinite	-0.6799	MnCO3 (am)	-2.7741
Magnesite	-0.6910	Pb(OH)2	-2.8187
Dolomite (disord	-0.8417		

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.001612	-2.793
Hg (g)	3.297e-017	-16.482
O2 (g)	2.571e-017	-16.590
Hg2 (g)	2.636e-034	-33.579
H2Se (g)	1.306e-083	-82.884
H2S (g)	8.169e-125	-124.088
CH4 (g)	6.709e-125	-124.173
Hg(CH3)2 (g)	1.223e-267	-266.913

Original basis	total moles	In fluid moles	In fluid mg/kg	Sorbed moles	Sorbed mg/kg	Kd L/kg
Al+++	2.59e-007	4.95e-009	0.000134			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00279	167.			
Ca++	0.00172	0.00118	47.3			
Cd++	4.45e-010	4.45e-010	5.00e-005			
Cu++	4.72e-009	4.72e-009	0.000300			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	0.00288	0.00288	2.90			
H2O	55.5	55.5	1.00e+006			
H4SiO4	1.77e-005	1.77e-005	1.70			
Hg(OH)2	1.70e-010	1.70e-010	4.00e-005			
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00115	0.00115	28.0			
Mn+++	1.82e-008	1.82e-008	0.00100			
MoO4--	2.50e-008	2.50e-008	0.00400			
Na+	9.57e-005	9.57e-005	2.20			
Ni++	1.70e-008	1.70e-008	0.00100			
O2(aq)	-4.56e-009	-4.56e-009	-0.000146			
Pb++	4.34e-009	4.34e-009	0.000900			
SO4--	0.000760	0.000760	72.9			
Sb(OH)6-	2.23e-009	2.23e-009	0.000500			
SeO4--	9.79e-009	9.79e-009	0.00140			

Sr++	3.42e-006	3.42e-006	0.300
UO2++	1.85e-008	1.85e-008	0.00500
Zn++	1.53e-007	1.53e-007	0.0100

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	4.952e-009	0.0001336		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002791	33.51		
Ca	0.001722	0.001180	47.26		
Cd	4.448e-010	4.448e-010	4.998e-005		
Cu	4.721e-009	4.721e-009	0.0002999		
Fe	8.953e-007	8.953e-007	0.04998		
H	111.0	111.0	1.119e+005		
Hg	1.705e-010	1.705e-010	3.419e-005		
K	1.023e-005	1.023e-005	0.3999		
Mg	0.001152	0.001152	27.99		
Mn	1.820e-008	1.820e-008	0.0009997		
Mo	2.501e-008	2.501e-008	0.002399		
Na	9.569e-005	9.569e-005	2.199		
Ni	1.703e-008	1.703e-008	0.0009997		
O	55.52	55.52	8.880e+005		
Pb	4.344e-009	4.344e-009	0.0008997		
S	0.0007599	0.0007595	24.35		
Sb	2.234e-009	2.234e-009	0.0002719		
Se	9.793e-009	9.793e-009	0.0007730		
Si	1.769e-005	1.769e-005	0.4966		
Sr	3.424e-006	3.424e-006	0.2999		
U	1.852e-008	1.852e-008	0.004406		
Zn	1.530e-007	1.530e-007	0.009997		

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Step #   150              Xi = 0.3000
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  7.885
Eh =   0.4676 volts      pe =   8.4725
Ionic strength      =    0.007036
Activity of water   =    0.999901
Solvent mass        =    1.000006 kg
Solution mass       =    1.000329 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         323 mg/kg sol'n
Rock mass           =    0.000054 kg
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Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.4676	8.4725

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.497e-005	
Calcite	0.0005420	-3.266	0.05425	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
(total)			0.05437	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002639	160.9	0.9178	-2.6159
Ca++	0.001096	43.93	0.7095	-3.1091
Mg++	0.001075	26.12	0.7095	-3.1178
SO4--	0.0006401	61.47	0.7095	-3.3428
H2CO3* (aq)	0.0001034	6.413	1.0016	-3.9847
Na+	9.530e-005	2.190	0.9178	-4.0582
CaSO4 (aq)	6.578e-005	8.952	1.0016	-4.1812
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2737
MgHCO3+	2.112e-005	1.801	0.9178	-4.7126
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.624e-005	1.641	0.9178	-4.8267
K+	1.021e-005	0.3990	0.9178	-5.0284
CO3--	7.310e-006	0.4385	0.7095	-5.2851
Sr++	3.213e-006	0.2815	0.7095	-5.6421
MgCO3 (aq)	2.771e-006	0.2336	1.0016	-5.5567
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998
Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920
NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.669e-007	0.002838	0.9178	-6.8148
Ba++	1.667e-007	0.02289	0.7095	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.434e-007	0.01204	1.0016	-6.8428
Zn++	1.115e-007	0.007289	0.7095	-7.1016
H3SiO4-	5.571e-008	0.005297	0.9178	-7.2913
SrHCO3+	4.292e-008	0.006377	0.9178	-7.4046
ZnCO3 (aq)	2.358e-008	0.002955	1.0016	-7.6268
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
Ca2UO2(CO3)3 (aq	1.745e-008	0.009251	1.0016	-7.7574
NaCO3-	1.661e-008	0.001378	0.9178	-7.8169
Mg2CO3++	1.653e-008	0.001795	0.7095	-7.9307
MgOH+	1.637e-008	0.0006762	0.9178	-7.8232
MoO4--	1.510e-008	0.002415	0.7095	-7.9699
Mn++	1.446e-008	0.0007940	0.7095	-7.9890
H+	1.419e-008	1.430e-005	0.9178	-7.8853
Ni++	1.280e-008	0.0007515	0.7095	-8.0417
Fe(OH)3 (aq)	1.172e-008	0.001252	1.0016	-7.9304

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8296s/sat	Cristobalite	-1.1510
Cupric Ferrite	13.3179s/sat	Manganite	-1.2006
Maghemite	9.6505s/sat	CaCO3xH2O	-1.3283
Cuprous Ferrite	8.8982s/sat	PbMoO4	-1.3725
Magnesioferrite	8.3159s/sat	Cerrusite	-1.4748
Goethite	6.7641s/sat	Smithsonite	-1.5346
Lepidocrocite	6.6472s/sat	ZnCO3	-1.5868
Ferrihydrite (ag	5.3282s/sat	K-Jarosite	-1.5976
Ferrihydrite	3.5534s/sat	Strontianite	-1.6698
Diaspore	0.8916s/sat	SiO2 (am,ppt)	-1.8222
Calcite	0.0000 sat	Gypsum	-1.8293
Gibbsite (C)	0.0000 sat	SiO2 (am,gel)	-1.8666
Barite	0.0000 sat	Imogolite	-2.0664
Aragonite	-0.1592	ZnCO3:1H2O	-2.1268
Dolomite (ordere	-0.2047	Anhydrite	-2.1825
Quartz	-0.4713	Rhodochrosite	-2.2978
Al(OH)3 (Soil)	-0.5500	Celestite	-2.3397
Vaterite	-0.6232	Tenorite(c)	-2.5399
Kaolinite	-0.6799	NiCO3	-2.6507

Magnesite	-0.6910	Otavite	-2.7630
Dolomite (disord	-0.8417	MnCO3 (am)	-2.7741
Chalcedony	-0.9548	Pb(OH)2	-2.8187
Boehmite	-0.9979		

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.001612	-2.793
Hg (g)	4.498e-013	-12.347
O2 (g)	1.381e-025	-24.860
Hg2 (g)	4.905e-026	-25.309
H2Se (g)	4.450e-067	-66.352
H2S (g)	2.832e-108	-107.548
CH4 (g)	2.326e-108	-107.633
Hg(CH3)2 (g)	1.469e-234	-233.833

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
Al+++	2.59e-007	4.95e-009	0.000134			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00279	167.			
Ca++	0.00172	0.00118	47.3			
Cd++	4.45e-010	4.45e-010	5.00e-005			
Cu++	4.72e-009	4.72e-009	0.000300			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	0.00288	0.00288	2.90			
H2O	55.5	55.5	1.00e+006			
H4SiO4	1.77e-005	1.77e-005	1.70			
Hg(OH)2	1.70e-010	1.70e-010	4.00e-005			
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00115	0.00115	28.0			
Mn+++	1.82e-008	1.82e-008	0.00100			
MoO4--	2.50e-008	2.50e-008	0.00400			
Na+	9.57e-005	9.57e-005	2.20			
Ni++	1.70e-008	1.70e-008	0.00100			
O2(aq)	-5.48e-009	-5.48e-009	-0.000175			
Pb++	4.34e-009	4.34e-009	0.000900			
SO4--	0.000760	0.000760	72.9			
Sb(OH)6-	2.23e-009	2.23e-009	0.000500			
SeO4--	9.79e-009	9.79e-009	0.00140			
Sr++	3.42e-006	3.42e-006	0.300			
UO2++	1.85e-008	1.85e-008	0.00500			
Zn++	1.53e-007	1.53e-007	0.0100			

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	4.952e-009	0.0001336		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002791	33.51		
Ca	0.001722	0.001180	47.26		
Cd	4.448e-010	4.448e-010	4.998e-005		
Cu	4.721e-009	4.721e-009	0.0002999		
Fe	8.953e-007	8.953e-007	0.04998		
H	111.0	111.0	1.119e+005		
Hg	1.705e-010	1.705e-010	3.419e-005		
K	1.023e-005	1.023e-005	0.3999		
Mg	0.001152	0.001152	27.99		
Mn	1.820e-008	1.820e-008	0.0009997		

Mo	2.501e-008	2.501e-008	0.002399
Na	9.569e-005	9.569e-005	2.199
Ni	1.703e-008	1.703e-008	0.0009997
O	55.52	55.52	8.880e+005
Pb	4.344e-009	4.344e-009	0.0008997
S	0.0007599	0.0007595	24.35
Sb	2.234e-009	2.234e-009	0.0002719
Se	9.793e-009	9.793e-009	0.0007730
Si	1.769e-005	1.769e-005	0.4966
Sr	3.424e-006	3.424e-006	0.2999
U	1.852e-008	1.852e-008	0.004406
Zn	1.530e-007	1.530e-007	0.009997

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Step #   200              Xi = 0.4000
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  7.885
Eh =   0.3535 volts      pe =   6.4050
Ionic strength      =    0.007035
Activity of water   =    0.999901
Solvent mass        =    1.000006 kg
Solution mass       =    1.000329 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         323 mg/kg sol'n
Rock mass           =    0.000054 kg
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Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.3535	6.4050

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.497e-005	
Calcite	0.0005421	-3.266	0.05426	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
(total)			0.05437	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002639	160.9	0.9178	-2.6159
Ca++	0.001096	43.93	0.7095	-3.1091
Mg++	0.001075	26.12	0.7095	-3.1178
SO4--	0.0006401	61.47	0.7095	-3.3428
H2CO3* (aq)	0.0001034	6.413	1.0016	-3.9847
Na+	9.530e-005	2.190	0.9178	-4.0582
CaSO4 (aq)	6.578e-005	8.952	1.0016	-4.1812
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2737
MgHCO3+	2.112e-005	1.801	0.9178	-4.7126
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.624e-005	1.641	0.9178	-4.8268
K+	1.021e-005	0.3990	0.9178	-5.0284
CO3--	7.310e-006	0.4385	0.7095	-5.2851
Sr++	3.213e-006	0.2815	0.7095	-5.6421
MgCO3 (aq)	2.771e-006	0.2336	1.0016	-5.5567
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998
Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920

NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.669e-007	0.002838	0.9178	-6.8148
Ba++	1.667e-007	0.02289	0.7095	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.434e-007	0.01204	1.0016	-6.8428
Zn++	1.115e-007	0.007289	0.7095	-7.1016
H3SiO4-	5.571e-008	0.005297	0.9178	-7.2913
SrHCO3+	4.292e-008	0.006377	0.9178	-7.4046
ZnCO3 (aq)	2.358e-008	0.002955	1.0016	-7.6268
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
Ca2UO2(CO3)3 (aq	1.745e-008	0.009251	1.0016	-7.7574
NaCO3-	1.661e-008	0.001378	0.9178	-7.8169
Mg2CO3++	1.653e-008	0.001795	0.7095	-7.9307
MgOH+	1.637e-008	0.0006762	0.9178	-7.8232
MoO4--	1.510e-008	0.002415	0.7095	-7.9699
Mn++	1.446e-008	0.0007940	0.7095	-7.9890
H+	1.419e-008	1.430e-005	0.9178	-7.8853
Ni++	1.280e-008	0.0007515	0.7095	-8.0417
Fe(OH)3 (aq)	1.172e-008	0.001252	1.0016	-7.9304

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8296s/sat	Cristobalite	-1.1510
Cupric Ferrite	13.3179s/sat	CaCO3xH2O	-1.3283
Cuprous Ferrite	10.9657s/sat	PbMoO4	-1.3725
Maghemite	9.6505s/sat	Cerrusite	-1.4747
Magnesioferrite	8.3159s/sat	Smithsonite	-1.5346
Goethite	6.7641s/sat	Fe2(OH)4SeO3	-1.5786
Lepidocrocite	6.6473s/sat	ZnCO3	-1.5868
Ferrihydrite (ag	5.3282s/sat	K-Jarosite	-1.5976
Ferrihydrite	3.5534s/sat	Strontianite	-1.6698
Diaspore	0.8916s/sat	SiO2 (am,ppt)	-1.8222
Calcite	0.0000 sat	Gypsum	-1.8293
Gibbsite (C)	0.0000 sat	SiO2 (am,gel)	-1.8666
Barite	0.0000 sat	Imogolite	-2.0664
Aragonite	-0.1592	ZnCO3:1H2O	-2.1268
Dolomite (ordere	-0.2047	Anhydrite	-2.1825
Quartz	-0.4713	Rhodochrosite	-2.2978
Al(OH)3 (Soil)	-0.5500	Celestite	-2.3397
Vaterite	-0.6232	Hg metal (l)	-2.5161
Kaolinite	-0.6799	Tenorite(c)	-2.5399
Magnesite	-0.6910	NiCO3	-2.6507
Dolomite (disord	-0.8417	Otavite	-2.7630
Chalcedony	-0.9548	MnCO3 (am)	-2.7741
Boehmite	-0.9979	Pb(OH)2	-2.8187

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.001612	-2.793
Hg (g)	1.356e-009	-8.868
Hg2 (g)	4.459e-019	-18.351
O2 (g)	7.415e-034	-33.130
H2Se (g)	6.674e-053	-52.176
H2S (g)	9.817e-092	-91.008
CH4 (g)	8.062e-092	-91.094
Hg(CH3)2 (g)	3.900e-202	-201.409

	In fluid		Sorbed		Kd
Original basis total moles	moles	mg/kg	moles	mg/kg	L/kg

Al+++	2.59e-007	4.95e-009	0.000134
AsO4---	2.16e-009	2.16e-009	0.000300
Ba++	5.82e-007	1.76e-007	0.0241
CO3--	0.00333	0.00279	167.
Ca++	0.00172	0.00118	47.3
Cd++	4.45e-010	4.45e-010	5.00e-005
Cu++	4.72e-009	4.72e-009	0.000300
Fe+++	8.95e-007	8.95e-007	0.0500
H+	0.00288	0.00288	2.90
H2O	55.5	55.5	1.00e+006
H4SiO4	1.77e-005	1.77e-005	1.70
Hg(OH)2	1.70e-010	1.70e-010	4.00e-005
K+	1.02e-005	1.02e-005	0.400
Mg++	0.00115	0.00115	28.0
Mn+++	1.82e-008	1.82e-008	0.00100
MoO4--	2.50e-008	2.50e-008	0.00400
Na+	9.57e-005	9.57e-005	2.20
Ni++	1.70e-008	1.70e-008	0.00100
O2(aq)	-1.08e-007	-1.08e-007	-0.00345
Pb++	4.34e-009	4.34e-009	0.000900
SO4--	0.000760	0.000760	72.9
Sb(OH)6-	2.23e-009	2.23e-009	0.000500
SeO4--	9.79e-009	9.79e-009	0.00140
Sr++	3.42e-006	3.42e-006	0.300
UO2++	1.85e-008	1.85e-008	0.00500
Zn++	1.53e-007	1.53e-007	0.0100

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	4.952e-009	0.0001336		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002791	33.51		
Ca	0.001722	0.001179	47.26		
Cd	4.448e-010	4.448e-010	4.998e-005		
Cu	4.721e-009	4.721e-009	0.0002999		
Fe	8.953e-007	8.953e-007	0.04998		
H	111.0	111.0	1.119e+005		
Hg	1.705e-010	1.705e-010	3.419e-005		
K	1.023e-005	1.023e-005	0.3999		
Mg	0.001152	0.001152	27.99		
Mn	1.820e-008	1.820e-008	0.0009997		
Mo	2.501e-008	2.501e-008	0.002399		
Na	9.569e-005	9.569e-005	2.199		
Ni	1.703e-008	1.703e-008	0.0009997		
O	55.52	55.52	8.880e+005		
Pb	4.344e-009	4.344e-009	0.0008997		
S	0.0007599	0.0007595	24.35		
Sb	2.234e-009	2.234e-009	0.0002719		
Se	9.793e-009	9.793e-009	0.0007730		
Si	1.769e-005	1.769e-005	0.4966		
Sr	3.424e-006	3.424e-006	0.2999		
U	1.852e-008	1.852e-008	0.004406		
Zn	1.530e-007	1.530e-007	0.009997		

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```
Step #   250                Xi = 0.5000
Temperature =   5.0 C      Pressure =  0.938 bars
pH =  7.885
Eh =   0.2394 volts        pe =   4.3375
Ionic strength      =    0.007035
Activity of water   =    0.999901
```

React_output_Eh slide6_final

Solvent mass	=	1.000006 kg
Solution mass	=	1.000329 kg
Solution density	=	1.026 g/cm3
Chlorinity	=	0.000000 molal
Dissolved solids	=	323 mg/kg sol'n
Rock mass	=	0.000054 kg

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.2394	4.3375

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.497e-005	
Calcite	0.0005421	-3.266	0.05426	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
(total)			0.05437	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002639	160.9	0.9178	-2.6159
Ca++	0.001096	43.93	0.7095	-3.1091
Mg++	0.001075	26.12	0.7095	-3.1178
SO4--	0.0006401	61.47	0.7095	-3.3428
H2CO3* (aq)	0.0001034	6.413	1.0016	-3.9847
Na+	9.530e-005	2.190	0.9178	-4.0582
CaSO4 (aq)	6.578e-005	8.952	1.0016	-4.1812
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2737
MgHCO3+	2.112e-005	1.801	0.9178	-4.7126
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.624e-005	1.641	0.9178	-4.8268
K+	1.021e-005	0.3990	0.9178	-5.0284
CO3--	7.310e-006	0.4385	0.7095	-5.2851
Sr++	3.213e-006	0.2815	0.7095	-5.6421
MgCO3 (aq)	2.771e-006	0.2336	1.0016	-5.5567
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998
Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920
NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.669e-007	0.002838	0.9178	-6.8148
Ba++	1.667e-007	0.02289	0.7095	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.434e-007	0.01204	1.0016	-6.8428
Zn++	1.115e-007	0.007289	0.7095	-7.1016
H3SiO4-	5.571e-008	0.005297	0.9178	-7.2913
SrHCO3+	4.292e-008	0.006377	0.9178	-7.4046
ZnCO3 (aq)	2.358e-008	0.002955	1.0016	-7.6268
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
Ca2UO2(CO3)3 (aq	1.745e-008	0.009251	1.0016	-7.7574
NaCO3-	1.661e-008	0.001378	0.9178	-7.8169
Mg2CO3++	1.653e-008	0.001795	0.7095	-7.9307
MgOH+	1.637e-008	0.0006762	0.9178	-7.8232
MoO4--	1.510e-008	0.002415	0.7095	-7.9699
Mn++	1.446e-008	0.0007940	0.7095	-7.9890
H+	1.419e-008	1.430e-005	0.9178	-7.8853
Ni++	1.280e-008	0.0007515	0.7095	-8.0417
Fe(OH)3 (aq)	1.172e-008	0.001252	1.0016	-7.9304

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8296s/sat	Cristobalite	-1.1510
Cupric Ferrite	13.3176s/sat	CaCO3xH2O	-1.3283
Cuprous Ferrite	13.0329s/sat	PbMoO4	-1.3725
Maghemite	9.6505s/sat	Cerrusite	-1.4747
Magnesioferrite	8.3159s/sat	Smithsonite	-1.5346
Goethite	6.7641s/sat	Fe2(OH)4SeO3	-1.5768
Lepidocrocite	6.6473s/sat	ZnCO3	-1.5868
Ferrihydrite (ag	5.3282s/sat	K-Jarosite	-1.5976
Ferrihydrite	3.5534s/sat	Strontianite	-1.6698
Diaspore	0.8916s/sat	SiO2 (am,ppt)	-1.8222
Calcite	0.0000 sat	Gypsum	-1.8293
Gibbsite (C)	0.0000 sat	SiO2 (am,gel)	-1.8666
Barite	0.0000 sat	Imogolite	-2.0664
Aragonite	-0.1592	ZnCO3:1H2O	-2.1268
Dolomite (ordere	-0.2047	Anhydrite	-2.1825
Quartz	-0.4713	Rhodochrosite	-2.2978
Al(OH)3 (Soil)	-0.5500	Celestite	-2.3397
Vaterite	-0.6232	Hg metal (l)	-2.4077
Kaolinite	-0.6799	Tenorite(c)	-2.5401
Magnesite	-0.6910	NiCO3	-2.6507
Dolomite (disord	-0.8417	Otavite	-2.7630
Chalcedony	-0.9548	MnCO3 (am)	-2.7741
SbO2	-0.9720	Pb(OH)2	-2.8187
Boehmite	-0.9979		

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.001612	-2.793
Hg (g)	1.741e-009	-8.759
Hg2 (g)	7.346e-019	-18.134
H2Se (g)	1.703e-040	-39.769
O2 (g)	3.982e-042	-41.400
H2S (g)	3.403e-075	-74.468
CH4 (g)	2.795e-075	-74.554
Hg(CH3)2 (g)	4.410e-173	-172.356

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
Al+++	2.59e-007	4.95e-009	0.000134			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00279	167.			
Ca++	0.00172	0.00118	47.3			
Cd++	4.45e-010	4.45e-010	5.00e-005			
Cu++	4.72e-009	4.72e-009	0.000300			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	0.00283	0.00283	2.86			
H2O	55.5	55.5	1.00e+006			
H4SiO4	1.77e-005	1.77e-005	1.70			
Hg(OH)2	1.70e-010	1.70e-010	4.00e-005			
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00115	0.00115	28.0			
Mn+++	1.82e-008	1.82e-008	0.00100			
MoO4--	2.50e-008	2.50e-008	0.00400			
Na+	9.57e-005	9.57e-005	2.20			
Ni++	1.70e-008	1.70e-008	0.00100			
O2(aq)	-1.15e-005	-1.15e-005	-0.368			

Pb++	4.34e-009	4.34e-009	0.000900
SO4--	0.000760	0.000760	72.9
Sb(OH)6-	2.23e-009	2.23e-009	0.000500
SeO4--	9.79e-009	9.79e-009	0.00140
Sr++	3.42e-006	3.42e-006	0.300
UO2++	1.85e-008	1.85e-008	0.00500
Zn++	1.53e-007	1.53e-007	0.0100

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	4.952e-009	0.0001336		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002791	33.51		
Ca	0.001722	0.001179	47.26		
Cd	4.448e-010	4.448e-010	4.998e-005		
Cu	4.721e-009	4.721e-009	0.0002999		
Fe	8.953e-007	8.953e-007	0.04998		
H	111.0	111.0	1.119e+005		
Hg	1.705e-010	1.705e-010	3.419e-005		
K	1.023e-005	1.023e-005	0.3999		
Mg	0.001152	0.001152	27.99		
Mn	1.820e-008	1.820e-008	0.0009997		
Mo	2.501e-008	2.501e-008	0.002399		
Na	9.569e-005	9.569e-005	2.199		
Ni	1.703e-008	1.703e-008	0.0009997		
O	55.52	55.52	8.880e+005		
Pb	4.344e-009	4.344e-009	0.0008997		
S	0.0007599	0.0007595	24.35		
Sb	2.234e-009	2.234e-009	0.0002719		
Se	9.793e-009	9.793e-009	0.0007730		
Si	1.769e-005	1.769e-005	0.4966		
Sr	3.424e-006	3.424e-006	0.2999		
U	1.852e-008	1.852e-008	0.004406		
Zn	1.530e-007	1.530e-007	0.009997		

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Step #   261               Xi = 0.5220
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  7.885
Eh =   0.2143 volts      pe =   3.8826
Ionic strength      =    0.007035
Activity of water   =    0.999901
Solvent mass        =    1.000006 kg
Solution mass       =    1.000329 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         323 mg/kg sol'n
Rock mass           =    0.000054 kg
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Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.2143	3.8826

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.497e-005	

Calcite	0.0005421	-3.266	0.05426	
Cu2Se (alpha)	4.346e-010	-9.362	8.955e-008	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
(total)			0.05437	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002639	160.9	0.9178	-2.6159
Ca++	0.001096	43.93	0.7095	-3.1091
Mg++	0.001075	26.12	0.7095	-3.1178
SO4--	0.0006401	61.47	0.7095	-3.3428
H2CO3* (aq)	0.0001034	6.413	1.0016	-3.9847
Na+	9.530e-005	2.190	0.9178	-4.0582
CaSO4 (aq)	6.578e-005	8.952	1.0016	-4.1812
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2737
MgHCO3+	2.112e-005	1.801	0.9178	-4.7126
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.624e-005	1.641	0.9178	-4.8268
K+	1.021e-005	0.3990	0.9178	-5.0284
CO3--	7.310e-006	0.4385	0.7095	-5.2851
Sr++	3.213e-006	0.2815	0.7095	-5.6421
MgCO3 (aq)	2.771e-006	0.2336	1.0016	-5.5567
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998
Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920
NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.669e-007	0.002838	0.9178	-6.8148
Ba++	1.667e-007	0.02289	0.7095	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.434e-007	0.01204	1.0016	-6.8428
Zn++	1.115e-007	0.007289	0.7095	-7.1016
H3SiO4-	5.571e-008	0.005297	0.9178	-7.2913
SrHCO3+	4.292e-008	0.006377	0.9178	-7.4046
ZnCO3 (aq)	2.358e-008	0.002955	1.0016	-7.6268
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
Ca2UO2(CO3)3 (aq	1.745e-008	0.009251	1.0016	-7.7574
NaCO3-	1.661e-008	0.001378	0.9178	-7.8169
Mg2CO3++	1.653e-008	0.001795	0.7095	-7.9307
MgOH+	1.637e-008	0.0006762	0.9178	-7.8232
MoO4--	1.510e-008	0.002415	0.7095	-7.9699
Mn++	1.446e-008	0.0007940	0.7095	-7.9890
H+	1.419e-008	1.430e-005	0.9178	-7.8853
Ni++	1.280e-008	0.0007515	0.7095	-8.0417
Fe(OH)3 (aq)	1.172e-008	0.001252	1.0016	-7.9304

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8296s/sat	Cristobalite	-1.1510
Cuprous Ferrite	13.3989s/sat	CaCO3xH2O	-1.3283
Cupric Ferrite	13.2288s/sat	CuSe	-1.3722
Maghemite	9.6506s/sat	PbMoO4	-1.3725
Magnesioferrite	8.3159s/sat	Cerrusite	-1.4747
Goethite	6.7641s/sat	HgSe	-1.5003
Lepidocrocite	6.6473s/sat	Smithsonite	-1.5346
Ferrihydrite (ag	5.3282s/sat	ZnCO3	-1.5868
Ferrihydrite	3.5534s/sat	Fe2(OH)4SeO3	-1.5965
Diaspore	0.8916s/sat	K-Jarosite	-1.5976
Gibbsite (C)	0.0000 sat	Strontianite	-1.6698
Cu2Se (alpha)	0.0000 sat	SiO2 (am,ppt)	-1.8222
Calcite	0.0000 sat	Gypsum	-1.8293
Barite	0.0000 sat	SiO2 (am,gel)	-1.8666

Aragonite	-0.1592	Imogolite	-2.0664
Dolomite (ordere	-0.2047	ZnCO3:1H2O	-2.1268
Quartz	-0.4713	Anhydrite	-2.1825
SbO2	-0.5172	Rhodochrosite	-2.2978
Al(OH)3 (Soil)	-0.5500	Celestite	-2.3397
Vaterite	-0.6232	Hg metal (l)	-2.4077
Kaolinite	-0.6799	Tenorite(c)	-2.6290
Magnesite	-0.6910	NiCO3	-2.6507
Dolomite (disord	-0.8417	Otavite	-2.7630
Chalcedony	-0.9548	MnCO3 (am)	-2.7741
Boehmite	-0.9979	Pb(OH)2	-2.8187

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.001612	-2.793
Hg (g)	1.741e-009	-8.759
Hg2 (g)	7.346e-019	-18.134
H2Se (g)	8.720e-038	-37.059
O2 (g)	6.036e-044	-43.219
H2S (g)	1.481e-071	-70.829
CH4 (g)	1.217e-071	-70.915
Hg(CH3)2 (g)	1.029e-166	-165.988

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
Al+++	2.59e-007	4.95e-009	0.000134			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00279	167.			
Ca++	0.00172	0.00118	47.3			
Cd++	4.45e-010	4.45e-010	5.00e-005			
Cu++	4.72e-009	3.85e-009	0.000245			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	0.00275	0.00275	2.77			
H2O	55.5	55.5	1.00e+006			
H4SiO4	1.77e-005	1.77e-005	1.70			
Hg(OH)2	1.70e-010	1.70e-010	4.00e-005			
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00115	0.00115	28.0			
Mn+++	1.82e-008	1.82e-008	0.00100			
MoO4--	2.50e-008	2.50e-008	0.00400			
Na+	9.57e-005	9.57e-005	2.20			
Ni++	1.70e-008	1.70e-008	0.00100			
O2(aq)	-3.28e-005	-3.28e-005	-1.05			
Pb++	4.34e-009	4.34e-009	0.000900			
SO4--	0.000760	0.000760	72.9			
Sb(OH)6-	2.23e-009	2.23e-009	0.000500			
SeO4--	9.79e-009	9.36e-009	0.00134			
Sr++	3.42e-006	3.42e-006	0.300			
UO2++	1.85e-008	1.85e-008	0.00500			
Zn++	1.53e-007	1.53e-007	0.0100			

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	4.952e-009	0.0001336		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002791	33.51		
Ca	0.001722	0.001179	47.26		
Cd	4.448e-010	4.448e-010	4.998e-005		

Cu	4.721e-009	3.852e-009	0.0002447
Fe	8.953e-007	8.953e-007	0.04998
H	111.0	111.0	1.119e+005
Hg	1.705e-010	1.705e-010	3.419e-005
K	1.023e-005	1.023e-005	0.3999
Mg	0.001152	0.001152	27.99
Mn	1.820e-008	1.820e-008	0.0009997
Mo	2.501e-008	2.501e-008	0.002399
Na	9.569e-005	9.569e-005	2.199
Ni	1.703e-008	1.703e-008	0.0009997
O	55.52	55.52	8.880e+005
Pb	4.344e-009	4.344e-009	0.0008997
S	0.0007599	0.0007595	24.35
Sb	2.234e-009	2.234e-009	0.0002719
Se	9.793e-009	9.358e-009	0.0007387
Si	1.769e-005	1.769e-005	0.4966
Sr	3.424e-006	3.424e-006	0.2999
U	1.852e-008	1.852e-008	0.004406
Zn	1.530e-007	1.530e-007	0.009997

```
Step #   271              Xi = 0.5420
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  7.885
Eh =   0.1915 volts      pe =   3.4691
Ionic strength      =    0.007035
Activity of water   =    0.999901
Solvent mass        =    1.000006 kg
Solution mass       =    1.000329 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         323 mg/kg sol'n
Rock mass           =    0.000054 kg
```

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.1915	3.4691

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.497e-005	
Calcite	0.0005421	-3.266	0.05426	
Cu2Se (alpha)	2.313e-009	-8.636	4.765e-007	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
HgSe	2.036e-011	-10.691	5.691e-009	
(total)			0.05437	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002639	160.9	0.9178	-2.6159
Ca++	0.001096	43.93	0.7095	-3.1091
Mg++	0.001075	26.12	0.7095	-3.1178
SO4--	0.0006401	61.47	0.7095	-3.3428
H2CO3* (aq)	0.0001034	6.413	1.0016	-3.9847
Na+	9.530e-005	2.190	0.9178	-4.0582
CaSO4 (aq)	6.578e-005	8.952	1.0016	-4.1812
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2737

MgHCO3+	2.112e-005	1.801	0.9178	-4.7126
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.624e-005	1.641	0.9178	-4.8268
K+	1.021e-005	0.3990	0.9178	-5.0284
CO3--	7.310e-006	0.4385	0.7095	-5.2851
Sr++	3.213e-006	0.2815	0.7095	-5.6421
MgCO3 (aq)	2.771e-006	0.2336	1.0016	-5.5567
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998
Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920
NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.669e-007	0.002838	0.9178	-6.8148
Ba++	1.667e-007	0.02289	0.7095	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.434e-007	0.01204	1.0016	-6.8428
Zn++	1.115e-007	0.007289	0.7095	-7.1016
H3SiO4-	5.571e-008	0.005297	0.9178	-7.2913
SrHCO3+	4.292e-008	0.006377	0.9178	-7.4046
ZnCO3 (aq)	2.358e-008	0.002955	1.0016	-7.6268
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
Ca2UO2(CO3)3 (aq	1.745e-008	0.009251	1.0016	-7.7574
NaCO3-	1.661e-008	0.001378	0.9178	-7.8169
Mg2CO3++	1.653e-008	0.001795	0.7095	-7.9307
MgOH+	1.637e-008	0.0006762	0.9178	-7.8232
MoO4--	1.510e-008	0.002415	0.7095	-7.9699
Mn++	1.446e-008	0.0007940	0.7095	-7.9890
H+	1.419e-008	1.430e-005	0.9178	-7.8853
Ni++	1.280e-008	0.0007515	0.7095	-8.0417
Fe(OH)3 (aq)	1.172e-008	0.001252	1.0016	-7.9304

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8296s/sat	Chalcedony	-0.9548
Cuprous Ferrite	12.2077s/sat	Boehmite	-0.9979
Cupric Ferrite	11.6241s/sat	Cristobalite	-1.1510
Maghemite	9.6506s/sat	CaCO3xH2O	-1.3283
Magnesioferrite	8.3160s/sat	PbMoO4	-1.3725
Goethite	6.7641s/sat	Cerrusite	-1.4747
Lepidocrocite	6.6473s/sat	Smithsonite	-1.5346
Ferrihydrite (ag	5.3282s/sat	ZnCO3	-1.5868
Ferrihydrite	3.5534s/sat	K-Jarosite	-1.5976
Diaspore	0.8916s/sat	Strontianite	-1.6698
Calcite	0.0000 sat	Fe2(OH)4SeO3	-1.6950
HgSe	0.0000 sat	SiO2 (am,ppt)	-1.8222
Gibbsite (C)	0.0000 sat	Gypsum	-1.8293
Cu2Se (alpha)	0.0000 sat	SiO2 (am,gel)	-1.8666
Barite	0.0000 sat	Imogolite	-2.0664
SbO2	-0.1037	ZnCO3:1H2O	-2.1268
Aragonite	-0.1592	Anhydrite	-2.1825
Dolomite (ordere	-0.2047	Rhodochrosite	-2.2977
Quartz	-0.4713	Celestite	-2.3397
Al(OH)3 (Soil)	-0.5500	Hg metal (l)	-2.4629
CuSe	-0.5944	NiCO3	-2.6507
Vaterite	-0.6232	Otavite	-2.7630
Kaolinite	-0.6799	MnCO3 (am)	-2.7741
Magnesite	-0.6910	Pb(OH)2	-2.8187
Dolomite (disord	-0.8417		

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.001612	-2.793

Hg (g)	1.533e-009	-8.815
Hg2 (g)	5.697e-019	-18.244
H2Se (g)	2.104e-035	-34.677
O2 (g)	1.339e-045	-44.873
H2S (g)	3.010e-068	-67.521
CH4 (g)	2.472e-068	-67.607
Hg(CH3)2 (g)	5.571e-161	-160.254

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
Al+++	2.59e-007	4.95e-009	0.000134			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00279	167.			
Ca++	0.00172	0.00118	47.3			
Cd++	4.45e-010	4.45e-010	5.00e-005			
Cu++	4.72e-009	9.60e-011	6.10e-006			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	0.00254	0.00254	2.56			
H2O	55.5	55.5	1.00e+006			
H4SiO4	1.77e-005	1.77e-005	1.70			
Hg(OH)2	1.70e-010	1.50e-010	3.52e-005			
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00115	0.00115	28.0			
Mn+++	1.82e-008	1.82e-008	0.00100			
MoO4--	2.50e-008	2.50e-008	0.00400			
Na+	9.57e-005	9.57e-005	2.20			
Ni++	1.70e-008	1.70e-008	0.00100			
O2(aq)	-8.49e-005	-8.49e-005	-2.72			
Pb++	4.34e-009	4.34e-009	0.000900			
SO4--	0.000760	0.000760	72.9			
Sb(OH)6-	2.23e-009	2.23e-009	0.000500			
SeO4--	9.79e-009	7.46e-009	0.00107			
Sr++	3.42e-006	3.42e-006	0.300			
UO2++	1.85e-008	1.85e-008	0.00500			
Zn++	1.53e-007	1.53e-007	0.0100			

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	4.952e-009	0.0001336		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002791	33.51		
Ca	0.001722	0.001179	47.26		
Cd	4.448e-010	4.448e-010	4.998e-005		
Cu	4.721e-009	9.596e-011	6.096e-006		
Fe	8.953e-007	8.953e-007	0.04998		
H	111.0	111.0	1.119e+005		
Hg	1.705e-010	1.501e-010	3.011e-005		
K	1.023e-005	1.023e-005	0.3999		
Mg	0.001152	0.001152	27.99		
Mn	1.820e-008	1.820e-008	0.0009997		
Mo	2.501e-008	2.501e-008	0.002399		
Na	9.569e-005	9.569e-005	2.199		
Ni	1.703e-008	1.703e-008	0.0009997		
O	55.52	55.52	8.880e+005		
Pb	4.344e-009	4.344e-009	0.0008997		
S	0.0007599	0.0007595	24.35		
Sb	2.234e-009	2.234e-009	0.0002719		
Se	9.793e-009	7.460e-009	0.0005889		
Si	1.769e-005	1.769e-005	0.4966		

Sr	3.424e-006	3.424e-006	0.2999
U	1.852e-008	1.852e-008	0.004406
Zn	1.530e-007	1.530e-007	0.009997

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Step # 291 Xi = 0.5820
Temperature = 5.0 C Pressure = 0.938 bars
pH = 7.885
Eh = 0.1458 volts pe = 2.6421
Ionic strength = 0.007035
Activity of water = 0.999901
Solvent mass = 1.000006 kg
Solution mass = 1.000329 kg
Solution density = 1.026 g/cm3
Chlorinity = 0.000000 molal
Dissolved solids = 323 mg/kg sol'n
Rock mass = 0.000054 kg

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.1458	2.6421

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.497e-005	
Calcite	0.0005421	-3.266	0.05426	
Clausthalite	1.025e-009	-8.989	2.934e-007	
Cu2Se (alpha)	2.360e-009	-8.627	4.864e-007	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
HgSe	1.704e-010	-9.769	4.764e-008	
(total)			0.05437	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002639	160.9	0.9178	-2.6159
Ca++	0.001096	43.93	0.7095	-3.1091
Mg++	0.001075	26.12	0.7095	-3.1178
SO4--	0.0006401	61.47	0.7095	-3.3428
H2CO3* (aq)	0.0001034	6.413	1.0016	-3.9847
Na+	9.530e-005	2.190	0.9178	-4.0582
CaSO4 (aq)	6.577e-005	8.952	1.0016	-4.1812
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2737
MgHCO3+	2.112e-005	1.801	0.9178	-4.7126
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.624e-005	1.641	0.9178	-4.8268
K+	1.021e-005	0.3990	0.9178	-5.0284
CO3--	7.310e-006	0.4385	0.7095	-5.2851
Sr++	3.213e-006	0.2815	0.7095	-5.6421
MgCO3 (aq)	2.771e-006	0.2336	1.0016	-5.5567
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998
Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920
NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.669e-007	0.002838	0.9178	-6.8148
Ba++	1.667e-007	0.02289	0.7095	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.434e-007	0.01204	1.0016	-6.8428
Zn++	1.115e-007	0.007289	0.7095	-7.1016

H3SiO4-	5.571e-008	0.005297	0.9178	-7.2913
SrHCO3+	4.292e-008	0.006377	0.9178	-7.4046
ZnCO3 (aq)	2.358e-008	0.002955	1.0016	-7.6268
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
Ca2UO2(CO3)3 (aq	1.745e-008	0.009251	1.0016	-7.7574
NaCO3-	1.661e-008	0.001378	0.9178	-7.8169
Mg2CO3++	1.653e-008	0.001795	0.7095	-7.9307
MgOH+	1.637e-008	0.0006763	0.9178	-7.8232
MoO4--	1.510e-008	0.002415	0.7095	-7.9699
Mn++	1.446e-008	0.0007940	0.7095	-7.9890
H+	1.419e-008	1.430e-005	0.9178	-7.8853
Ni++	1.280e-008	0.0007515	0.7095	-8.0417
Fe(OH)3 (aq)	1.172e-008	0.001252	1.0016	-7.9304

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8296s/sat	Dolomite (disord	-0.8417
Cuprous Ferrite	9.7656s/sat	Chalcedony	-0.9548
Maghemite	9.6506s/sat	Boehmite	-0.9979
Cupric Ferrite	8.3550s/sat	Cristobalite	-1.1510
Magnesioferrite	8.3160s/sat	CaCO3xH2O	-1.3283
Goethite	6.7641s/sat	PbMoO4	-1.4894
Lepidocrocite	6.6473s/sat	Smithsonite	-1.5346
Ferrihydrite (ag	5.3282s/sat	ZnCO3	-1.5868
Ferrihydrite	3.5534s/sat	Cerrusite	-1.5917
CuSe	1.0207s/sat	K-Jarosite	-1.5976
Diaspore	0.8916s/sat	Strontianite	-1.6698
SbO2	0.7233s/sat	Fe2(OH)4SeO3	-1.7727
Barite	0.0000 sat	SiO2 (am,ppt)	-1.8222
HgSe	0.0000 sat	Gypsum	-1.8293
Calcite	0.0000 sat	SiO2 (am,gel)	-1.8666
Cu2Se (alpha)	0.0000 sat	Imogolite	-2.0664
Gibbsite (C)	0.0000 sat	ZnCO3:1H2O	-2.1268
Clausthalite	0.0000 sat	Anhydrite	-2.1825
Aragonite	-0.1592	Rhodochrosite	-2.2977
Dolomite (ordere	-0.2047	Celestite	-2.3397
Quartz	-0.4713	NiCO3	-2.6507
Al(OH)3 (Soil)	-0.5500	Otavite	-2.7630
Vaterite	-0.6232	MnCO3 (am)	-2.7741
Kaolinite	-0.6799	Pb(OH)2	-2.9356
Magnesite	-0.6910		

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.001612	-2.793
Hg (g)	9.022e-013	-12.045
Hg2 (g)	1.974e-025	-24.705
H2Se (g)	1.611e-030	-29.793
O2 (g)	6.589e-049	-48.181
H2S (g)	1.243e-061	-60.905
CH4 (g)	1.021e-061	-60.991
Hg(CH3)2 (g)	1.241e-152	-151.906

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
Al+++	2.59e-007	4.95e-009	0.000134			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00279	167.			

Ca++	0.00172	0.00118	47.3
Cd++	4.45e-010	4.45e-010	5.00e-005
Cu++	4.72e-009	5.29e-014	3.36e-009
Fe+++	8.95e-007	8.95e-007	0.0500
H+	0.000600	0.000601	0.606
H2O	55.5	55.5	1.00e+006
H4SiO4	1.77e-005	1.77e-005	1.70
Hg(OH)2	1.70e-010	8.84e-014	2.07e-008
K+	1.02e-005	1.02e-005	0.400
Mg++	0.00115	0.00115	28.0
Mn+++	1.82e-008	1.82e-008	0.00100
MoO4--	2.50e-008	2.50e-008	0.00400
Na+	9.57e-005	9.57e-005	2.20
Ni++	1.70e-008	1.70e-008	0.00100
O2(aq)	-0.000570	-0.000570	-18.2
Pb++	4.34e-009	3.32e-009	0.000687
SO4--	0.000760	0.000760	72.9
Sb(OH)6-	2.23e-009	2.23e-009	0.000500
SeO4--	9.79e-009	6.24e-009	0.000891
Sr++	3.42e-006	3.42e-006	0.300
UO2++	1.85e-008	1.85e-008	0.00500
Zn++	1.53e-007	1.53e-007	0.0100

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	4.952e-009	0.0001336		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002791	33.51		
Ca	0.001722	0.001179	47.26		
Cd	4.448e-010	4.448e-010	4.998e-005		
Cu	4.721e-009	5.294e-014	3.363e-009		
Fe	8.953e-007	8.953e-007	0.04998		
H	111.0	111.0	1.119e+005		
Hg	1.705e-010	8.837e-014	1.772e-008		
K	1.023e-005	1.023e-005	0.3999		
Mg	0.001152	0.001152	27.99		
Mn	1.820e-008	1.820e-008	0.0009997		
Mo	2.501e-008	2.501e-008	0.002399		
Na	9.569e-005	9.569e-005	2.199		
Ni	1.703e-008	1.703e-008	0.0009997		
O	55.52	55.52	8.880e+005		
Pb	4.344e-009	3.318e-009	0.0006873		
S	0.0007599	0.0007595	24.35		
Sb	2.234e-009	2.234e-009	0.0002719		
Se	9.793e-009	6.237e-009	0.0004923		
Si	1.769e-005	1.769e-005	0.4966		
Sr	3.424e-006	3.424e-006	0.2999		
U	1.852e-008	1.852e-008	0.004406		
Zn	1.530e-007	1.530e-007	0.009997		

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Step #   300               Xi = 0.6000
Temperature =   5.0 C     Pressure =  0.938 bars
pH =  7.885
Eh =   0.1253 volts        pe =   2.2700
Ionic strength       =    0.007035
Activity of water    =    0.999901
Solvent mass         =    1.000006 kg
Solution mass        =    1.000329 kg
Solution density     =    1.026    g/cm3
Chlorinity           =    0.000000 molal
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Dissolved solids = 323 mg/kg sol'n
Rock mass = 0.000054 kg

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.1253	2.2700

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.497e-005	
Calcite	0.0005421	-3.266	0.05426	
Clausthalite	4.303e-009	-8.366	1.231e-006	
Cu2Se (alpha)	2.360e-009	-8.627	4.864e-007	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
HgSe	1.705e-010	-9.768	4.766e-008	
(total)			0.05438	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002639	160.9	0.9178	-2.6159
Ca++	0.001096	43.93	0.7095	-3.1091
Mg++	0.001075	26.12	0.7095	-3.1178
SO4--	0.0006401	61.47	0.7095	-3.3428
H2CO3* (aq)	0.0001034	6.412	1.0016	-3.9847
Na+	9.530e-005	2.190	0.9178	-4.0582
CaSO4 (aq)	6.577e-005	8.952	1.0016	-4.1812
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2737
MgHCO3+	2.112e-005	1.801	0.9178	-4.7126
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.624e-005	1.641	0.9178	-4.8268
K+	1.021e-005	0.3990	0.9178	-5.0284
CO3--	7.310e-006	0.4385	0.7095	-5.2851
Sr++	3.213e-006	0.2815	0.7095	-5.6421
MgCO3 (aq)	2.771e-006	0.2336	1.0016	-5.5567
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998
Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920
NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.669e-007	0.002838	0.9178	-6.8148
Ba++	1.667e-007	0.02289	0.7095	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.434e-007	0.01204	1.0016	-6.8428
Zn++	1.115e-007	0.007289	0.7095	-7.1016
H3SiO4-	5.571e-008	0.005297	0.9178	-7.2913
SrHCO3+	4.292e-008	0.006377	0.9178	-7.4046
ZnCO3 (aq)	2.358e-008	0.002956	1.0016	-7.6267
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
Ca2UO2(CO3)3 (aq	1.745e-008	0.009251	1.0016	-7.7574
NaCO3-	1.661e-008	0.001378	0.9178	-7.8169
Mg2CO3++	1.653e-008	0.001795	0.7095	-7.9307
MgOH+	1.637e-008	0.0006763	0.9178	-7.8232
MoO4--	1.510e-008	0.002415	0.7095	-7.9699
Mn++	1.446e-008	0.0007940	0.7095	-7.9890
H+	1.419e-008	1.429e-005	0.9178	-7.8854
Ni++	1.280e-008	0.0007515	0.7095	-8.0417
Fe(OH)3 (aq)	1.172e-008	0.001252	1.0016	-7.9304

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8297s/sat	Kaolinite	-0.6799
Maghemite	9.6506s/sat	Magnesite	-0.6910
Cuprous Ferrite	8.8111s/sat	Dolomite (disord	-0.8417
Magnesioferrite	8.3160s/sat	Chalcedony	-0.9548
Cupric Ferrite	7.0283s/sat	Boehmite	-0.9979
Goethite	6.7641s/sat	Cristobalite	-1.1510
Lepidocrocite	6.6473s/sat	CaCO3xH2O	-1.3283
Ferrihydrite (ag	5.3282s/sat	Smithsonite	-1.5346
Ferrihydrite	3.5534s/sat	ZnCO3	-1.5867
CuSe	1.6030s/sat	K-Jarosite	-1.5976
SbO2	1.0954s/sat	Strontianite	-1.6698
Diaspore	0.8916s/sat	SiO2 (am,ppt)	-1.8222
Barite	0.0000 sat	Gypsum	-1.8293
Cu2Se (alpha)	0.0000 sat	SiO2 (am,gel)	-1.8666
HgSe	0.0000 sat	Imogolite	-2.0664
Calcite	0.0000 sat	Fe2(OH)4SeO3	-2.0965
Clausthalite	0.0000 sat	ZnCO3:1H2O	-2.1268
Gibbsite (C)	0.0000 sat	Anhydrite	-2.1825
Aragonite	-0.1592	Rhodochrosite	-2.2977
Dolomite (ordere	-0.2047	Celestite	-2.3397
Quartz	-0.4713	NiCO3	-2.6507
Al(OH)3 (Soil)	-0.5500	Otavite	-2.7630
Vaterite	-0.6232	MnCO3 (am)	-2.7741

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.001612	-2.793
Hg (g)	6.174e-014	-13.209
Hg2 (g)	9.241e-028	-27.034
H2Se (g)	1.307e-028	-27.884
O2 (g)	2.139e-050	-49.670
H2S (g)	1.179e-058	-57.928
CH4 (g)	9.686e-059	-58.014
Hg(CH3)2 (g)	1.377e-148	-147.861

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
Al+++	2.59e-007	4.95e-009	0.000134			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00279	167.			
Ca++	0.00172	0.00118	47.3			
Cd++	4.45e-010	4.45e-010	5.00e-005			
Cu++	4.72e-009	2.59e-015	1.65e-010			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	-0.00249	-0.00249	-2.51			
H2O	55.5	55.5	1.00e+006			
H4SiO4	1.77e-005	1.77e-005	1.70			
Hg(OH)2	1.70e-010	6.05e-015	1.42e-009			
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00115	0.00115	28.0			
Mn+++	1.82e-008	1.82e-008	0.00100			
MoO4--	2.50e-008	2.50e-008	0.00400			
Na+	9.57e-005	9.57e-005	2.20			
Ni++	1.70e-008	1.70e-008	0.00100			
O2(aq)	-0.00134	-0.00134	-43.0			
Pb++	4.34e-009	4.09e-011	8.47e-006			
SO4--	0.000760	0.000760	72.9			

Sb(OH)6-	2.23e-009	2.23e-009	0.000500
SeO4--	9.79e-009	2.96e-009	0.000423
Sr++	3.42e-006	3.42e-006	0.300
UO2++	1.85e-008	1.85e-008	0.00500
Zn++	1.53e-007	1.53e-007	0.0100

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	4.952e-009	0.0001336		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002791	33.51		
Ca	0.001722	0.001179	47.26		
Cd	4.448e-010	4.448e-010	4.998e-005		
Cu	4.721e-009	2.592e-015	1.647e-010		
Fe	8.953e-007	8.953e-007	0.04998		
H	111.0	111.0	1.119e+005		
Hg	1.705e-010	6.047e-015	1.213e-009		
K	1.023e-005	1.023e-005	0.3999		
Mg	0.001152	0.001152	27.99		
Mn	1.820e-008	1.820e-008	0.0009997		
Mo	2.501e-008	2.501e-008	0.002399		
Na	9.569e-005	9.569e-005	2.199		
Ni	1.703e-008	1.703e-008	0.0009997		
O	55.52	55.52	8.880e+005		
Pb	4.344e-009	4.091e-011	8.474e-006		
S	0.0007599	0.0007595	24.35		
Sb	2.234e-009	2.234e-009	0.0002719		
Se	9.793e-009	2.959e-009	0.0002336		
Si	1.769e-005	1.769e-005	0.4966		
Sr	3.424e-006	3.424e-006	0.2999		
U	1.852e-008	1.852e-008	0.004406		
Zn	1.530e-007	1.530e-007	0.009997		

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Step #   327              Xi = 0.6540
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  7.885
Eh =   0.0637 volts      pe =   1.1535
Ionic strength      =    0.007035
Activity of water   =    0.999901
Solvent mass        =    1.000006 kg
Solution mass       =    1.000329 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         323 mg/kg sol'n
Rock mass           =    0.000054 kg
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Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.0637	1.1535

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.497e-005	
Calcite	0.0005421	-3.266	0.05426	
Clausthalite	4.344e-009	-8.362	1.243e-006	

Cu2Se (alpha)	2.360e-009	-8.627	4.864e-007	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
HgSe	1.705e-010	-9.768	4.766e-008	
Se metal (hex,bl	1.827e-010	-9.738	1.443e-008	
(total)			0.05438	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002639	160.9	0.9178	-2.6159
Ca++	0.001096	43.93	0.7095	-3.1091
Mg++	0.001075	26.12	0.7095	-3.1178
SO4--	0.0006401	61.47	0.7095	-3.3428
H2CO3* (aq)	0.0001034	6.412	1.0016	-3.9847
Na+	9.530e-005	2.190	0.9178	-4.0582
CaSO4 (aq)	6.577e-005	8.952	1.0016	-4.1812
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2737
MgHCO3+	2.112e-005	1.801	0.9178	-4.7126
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.624e-005	1.641	0.9178	-4.8268
K+	1.021e-005	0.3990	0.9178	-5.0284
CO3--	7.310e-006	0.4385	0.7095	-5.2851
Sr++	3.213e-006	0.2815	0.7095	-5.6421
MgCO3 (aq)	2.771e-006	0.2336	1.0016	-5.5567
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998
Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920
NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.669e-007	0.002838	0.9178	-6.8148
Ba++	1.667e-007	0.02289	0.7095	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.434e-007	0.01204	1.0016	-6.8428
Zn++	1.115e-007	0.007289	0.7095	-7.1016
H3SiO4-	5.571e-008	0.005297	0.9178	-7.2913
SrHCO3+	4.292e-008	0.006377	0.9178	-7.4046
ZnCO3 (aq)	2.358e-008	0.002956	1.0016	-7.6267
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
Ca2UO2(CO3)3 (aq	1.745e-008	0.009251	1.0016	-7.7574
NaCO3-	1.661e-008	0.001378	0.9178	-7.8169
Mg2CO3++	1.653e-008	0.001795	0.7095	-7.9307
MgOH+	1.637e-008	0.0006763	0.9178	-7.8232
MoO4--	1.510e-008	0.002415	0.7095	-7.9699
Mn++	1.446e-008	0.0007940	0.7095	-7.9890
H+	1.419e-008	1.429e-005	0.9178	-7.8854
Ni++	1.280e-008	0.0007515	0.7095	-8.0417
Fe(OH)3 (aq)	1.172e-008	0.001252	1.0016	-7.9304

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8297s/sat	Se metal (am)	-0.6618
Maghemite	9.6506s/sat	Kaolinite	-0.6799
Magnesioferrite	8.3160s/sat	Magnesite	-0.6910
Goethite	6.7641s/sat	Dolomite (disord	-0.8417
Lepidocrocite	6.6473s/sat	Chalcedony	-0.9548
Cuprous Ferrite	5.4788s/sat	Boehmite	-0.9979
Ferrihydrite (ag	5.3282s/sat	Cristobalite	-1.1510
CuSe	3.8189s/sat	CaCO3xH2O	-1.3283
Ferrihydrite	3.5534s/sat	Smithsonite	-1.5346
Cupric Ferrite	2.5796s/sat	ZnCO3	-1.5867
SbO2	2.2031s/sat	K-Jarosite	-1.5976
CdSe	1.3679s/sat	Strontianite	-1.6698
Diaspore	0.8916s/sat	SiO2 (am,ppt)	-1.8222

Calcite	0.0000 sat	Gypsum	-1.8293
Cu2Se (alpha)	0.0000 sat	SiO2 (am,gel)	-1.8666
Gibbsite (C)	0.0000 sat	Imogolite	-2.0664
Se metal (hex,bl	0.0000 sat	ZnCO3:1H2O	-2.1268
Clausthalite	0.0000 sat	Fe2(OH)4SeO3	-2.1307
Barite	0.0000 sat	Anhydrite	-2.1825
HgSe	0.0000 sat	Rhodochrosite	-2.2977
Aragonite	-0.1592	Celestite	-2.3397
Dolomite (ordere	-0.2047	ZnSe	-2.5960
Quartz	-0.4713	NiCO3	-2.6507
Al(OH)3 (Soil)	-0.5500	Otavite	-2.7630
NiSe	-0.5574	MnCO3 (am)	-2.7741
Vaterite	-0.6232		

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.001612	-2.793
Hg (g)	2.285e-018	-17.641
H2Se (g)	6.037e-022	-21.219
Hg2 (g)	1.266e-036	-35.898
H2S (g)	1.008e-049	-48.997
CH4 (g)	8.274e-050	-49.082
O2 (g)	7.319e-055	-54.136
Hg(CH3)2 (g)	2.175e-137	-136.663

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
Al+++	2.59e-007	4.95e-009	0.000134			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00279	167.			
Ca++	0.00172	0.00118	47.3			
Cd++	4.45e-010	4.45e-010	5.00e-005			
Cu++	4.72e-009	1.65e-019	1.05e-014			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	-0.0673	-0.0673	-67.9			
H2O	55.5	55.5	1.00e+006			
H4SiO4	1.77e-005	1.77e-005	1.70			
Hg(OH)2	1.70e-010	2.24e-019	5.25e-014			
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00115	0.00115	28.0			
Mn+++	1.82e-008	1.82e-008	0.00100			
MoO4--	2.50e-008	2.50e-008	0.00400			
Na+	9.57e-005	9.57e-005	2.20			
Ni++	1.70e-008	1.70e-008	0.00100			
O2(aq)	-0.0176	-0.0176	-562.			
Pb++	4.34e-009	8.86e-018	1.83e-012			
SO4--	0.000760	0.000760	72.9			
Sb(OH)6-	2.23e-009	2.23e-009	0.000500			
SeO4--	9.79e-009	2.74e-009	0.000391			
Sr++	3.42e-006	3.42e-006	0.300			
UO2++	1.85e-008	1.85e-008	0.00500			
Zn++	1.53e-007	1.53e-007	0.0100			

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	4.952e-009	0.0001336		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002791	33.51		

Ca	0.001722	0.001179	47.26
Cd	4.448e-010	4.448e-010	4.998e-005
Cu	4.721e-009	1.649e-019	1.047e-014
Fe	8.953e-007	8.953e-007	0.04998
H	111.0	111.0	1.119e+005
Hg	1.705e-010	2.238e-019	4.488e-014
K	1.023e-005	1.023e-005	0.3999
Mg	0.001152	0.001152	27.99
Mn	1.820e-008	1.820e-008	0.0009997
Mo	2.501e-008	2.501e-008	0.002399
Na	9.569e-005	9.569e-005	2.199
Ni	1.703e-008	1.703e-008	0.0009997
O	55.52	55.52	8.880e+005
Pb	4.344e-009	8.858e-018	1.835e-012
S	0.0007599	0.0007595	24.35
Sb	2.234e-009	2.234e-009	0.0002719
Se	9.793e-009	2.736e-009	0.0002159
Si	1.769e-005	1.769e-005	0.4966
Sr	3.424e-006	3.424e-006	0.2999
U	1.852e-008	1.852e-008	0.004406
Zn	1.530e-007	1.530e-007	0.009997

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Step #   334              Xi = 0.6680
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  7.885
Eh =   0.0477 volts      pe =   0.8641
Ionic strength      =    0.007035
Activity of water   =    0.999901
Solvent mass        =    1.000006 kg
Solution mass       =    1.000329 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         323 mg/kg sol'n
Rock mass           =    0.000054 kg
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Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.0477	0.8641

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.497e-005	
Calcite	0.0005421	-3.266	0.05426	
Clausthalite	4.344e-009	-8.362	1.243e-006	
Cu2Se (alpha)	2.360e-009	-8.627	4.864e-007	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
HgSe	1.705e-010	-9.768	4.766e-008	
NiSe	8.218e-010	-9.085	1.131e-007	
Se metal (hex,bl	1.906e-009	-8.720	1.505e-007	
(total)			0.05438	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002639	160.9	0.9178	-2.6159
Ca++	0.001096	43.93	0.7095	-3.1091
Mg++	0.001075	26.12	0.7095	-3.1178

SO4--	0.0006401	61.47	0.7095	-3.3428
H2CO3* (aq)	0.0001034	6.412	1.0016	-3.9847
Na+	9.530e-005	2.190	0.9178	-4.0582
CaSO4 (aq)	6.577e-005	8.952	1.0016	-4.1812
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2737
MgHCO3+	2.112e-005	1.801	0.9178	-4.7126
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.624e-005	1.641	0.9178	-4.8268
K+	1.021e-005	0.3990	0.9178	-5.0284
CO3--	7.310e-006	0.4385	0.7095	-5.2851
Sr++	3.213e-006	0.2815	0.7095	-5.6421
MgCO3 (aq)	2.771e-006	0.2336	1.0016	-5.5567
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998
Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920
NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.669e-007	0.002838	0.9178	-6.8147
Ba++	1.667e-007	0.02289	0.7095	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.434e-007	0.01204	1.0016	-6.8428
Zn++	1.115e-007	0.007289	0.7095	-7.1016
H3SiO4-	5.571e-008	0.005297	0.9178	-7.2913
SrHCO3+	4.292e-008	0.006377	0.9178	-7.4046
ZnCO3 (aq)	2.358e-008	0.002956	1.0016	-7.6267
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
Ca2UO2(CO3)3 (aq	1.745e-008	0.009251	1.0016	-7.7574
NaCO3-	1.661e-008	0.001378	0.9178	-7.8169
Mg2CO3++	1.653e-008	0.001795	0.7095	-7.9307
MgOH+	1.637e-008	0.0006763	0.9178	-7.8231
MoO4--	1.510e-008	0.002415	0.7095	-7.9699
Mn++	1.446e-008	0.0007940	0.7095	-7.9890
H+	1.419e-008	1.429e-005	0.9178	-7.8854
Ni++	1.219e-008	0.0007153	0.7095	-8.0631
Fe(OH)3 (aq)	1.172e-008	0.001252	1.0016	-7.9304

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8297s/sat	Vaterite	-0.6232
Maghemite	9.6506s/sat	Se metal (am)	-0.6618
Magnesioferrite	8.3160s/sat	Kaolinite	-0.6799
Goethite	6.7641s/sat	Magnesite	-0.6910
Lepidocrocite	6.6473s/sat	Dolomite (disord	-0.8416
Ferrihydrite (ag	5.3282s/sat	Chalcedony	-0.9548
Cuprous Ferrite	5.1894s/sat	Boehmite	-0.9979
CuSe	3.8189s/sat	Cristobalite	-1.1510
Ferrihydrite	3.5534s/sat	CaCO3xH2O	-1.3283
SbO2	2.4690s/sat	Smithsonite	-1.5346
Cupric Ferrite	2.0008s/sat	ZnCO3	-1.5867
CdSe	1.9468s/sat	K-Jarosite	-1.5976
Diaspore	0.8916s/sat	Strontianite	-1.6698
Clausthalite	0.0000 sat	SiO2 (am,ppt)	-1.8222
HgSe	0.0000 sat	Gypsum	-1.8293
Calcite	0.0000 sat	SiO2 (am,gel)	-1.8666
Barite	0.0000 sat	ZnSe	-2.0171
Se metal (hex,bl	0.0000 sat	Imogolite	-2.0664
Gibbsite (C)	0.0000 sat	ZnCO3:1H2O	-2.1268
Cu2Se (alpha)	0.0000 sat	Anhydrite	-2.1825
NiSe	0.0000 sat	Rhodochrosite	-2.2977
Aragonite	-0.1592	Celestite	-2.3397
Dolomite (ordere	-0.2047	NiCO3	-2.6721
Quartz	-0.4713	Otavite	-2.7630
Al(OH)3 (Soil)	-0.5500	MnCO3 (am)	-2.7741

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.001612	-2.793
Hg (g)	2.285e-018	-17.641
H2Se (g)	2.289e-021	-20.640
Hg2 (g)	1.266e-036	-35.898
H2S (g)	2.083e-047	-46.681
CH4 (g)	1.711e-047	-46.767
O2 (g)	5.090e-056	-55.293
Hg(CH3)2 (g)	2.453e-133	-132.610

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
Al+++	2.59e-007	4.95e-009	0.000134			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00279	167.			
Ca++	0.00172	0.00118	47.3			
Cd++	4.45e-010	4.45e-010	5.00e-005			
Cu++	4.72e-009	6.31e-020	4.01e-015			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	-0.134	-0.134	-135.			
H2O	55.6	55.6	1.00e+006			
H4SiO4	1.77e-005	1.77e-005	1.70			
Hg(OH)2	1.70e-010	2.24e-019	5.25e-014			
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00115	0.00115	28.0			
Mn+++	1.82e-008	1.82e-008	0.00100			
MoO4--	2.50e-008	2.50e-008	0.00400			
Na+	9.57e-005	9.57e-005	2.20			
Ni++	1.70e-008	1.62e-008	0.000951			
O2(aq)	-0.0342	-0.0342	-1.09e+003			
Pb++	4.34e-009	2.34e-018	4.84e-013			
SO4--	0.000760	0.000760	72.9			
Sb(OH)6-	2.23e-009	2.23e-009	0.000500			
SeO4--	9.79e-009	1.90e-010	2.72e-005			
Sr++	3.42e-006	3.42e-006	0.300			
UO2++	1.85e-008	1.85e-008	0.00500			
Zn++	1.53e-007	1.53e-007	0.0100			

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	4.952e-009	0.0001336		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002791	33.51		
Ca	0.001722	0.001179	47.26		
Cd	4.448e-010	4.448e-010	4.998e-005		
Cu	4.721e-009	6.311e-020	4.009e-015		
Fe	8.953e-007	8.953e-007	0.04998		
H	111.0	111.0	1.119e+005		
Hg	1.705e-010	2.238e-019	4.488e-014		
K	1.023e-005	1.023e-005	0.3999		
Mg	0.001152	0.001152	27.99		
Mn	1.820e-008	1.820e-008	0.0009997		
Mo	2.501e-008	2.501e-008	0.002399		
Na	9.569e-005	9.569e-005	2.199		
Ni	1.703e-008	1.621e-008	0.0009514		
O	55.52	55.52	8.880e+005		

Pb	4.344e-009	2.336e-018	4.838e-013
S	0.0007599	0.0007595	24.35
Sb	2.234e-009	2.234e-009	0.0002719
Se	9.793e-009	1.902e-010	1.502e-005
Si	1.769e-005	1.769e-005	0.4966
Sr	3.424e-006	3.424e-006	0.2999
U	1.852e-008	1.852e-008	0.004406
Zn	1.530e-007	1.530e-007	0.009997

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Step #   335              Xi = 0.6700
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  7.885
Eh =   0.0454 volts      pe =   0.8227
Ionic strength      =    0.007035
Activity of water   =    0.999901
Solvent mass        =    1.000006 kg
Solution mass       =    1.000329 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         323 mg/kg sol'n
Rock mass           =    0.000054 kg
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Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.0454	0.8227

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.497e-005	
Calcite	0.0005421	-3.266	0.05426	
Clausthalite	4.344e-009	-8.362	1.243e-006	
Cu2Se (alpha)	2.360e-009	-8.627	4.864e-007	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
HgSe	1.705e-010	-9.768	4.766e-008	
NiSe	2.796e-009	-8.553	3.849e-007	
(total)			0.05438	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002639	160.9	0.9178	-2.6159
Ca++	0.001096	43.93	0.7095	-3.1091
Mg++	0.001075	26.12	0.7095	-3.1178
SO4--	0.0006401	61.47	0.7095	-3.3428
H2CO3* (aq)	0.0001034	6.412	1.0016	-3.9847
Na+	9.530e-005	2.190	0.9178	-4.0582
CaSO4 (aq)	6.577e-005	8.952	1.0016	-4.1812
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2737
MgHCO3+	2.112e-005	1.801	0.9178	-4.7126
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.624e-005	1.641	0.9178	-4.8268
K+	1.021e-005	0.3990	0.9178	-5.0284
CO3--	7.310e-006	0.4385	0.7095	-5.2851
Sr++	3.213e-006	0.2815	0.7095	-5.6421
MgCO3 (aq)	2.771e-006	0.2336	1.0016	-5.5566
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998
Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920

NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.669e-007	0.002838	0.9178	-6.8147
Ba++	1.667e-007	0.02289	0.7095	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.434e-007	0.01204	1.0016	-6.8428
Zn++	1.115e-007	0.007289	0.7095	-7.1016
H3SiO4-	5.571e-008	0.005297	0.9178	-7.2913
SrHCO3+	4.292e-008	0.006377	0.9178	-7.4046
ZnCO3 (aq)	2.358e-008	0.002956	1.0016	-7.6267
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
Ca2UO2(CO3)3 (aq	1.745e-008	0.009251	1.0016	-7.7574
NaCO3-	1.661e-008	0.001378	0.9178	-7.8169
Mg2CO3++	1.653e-008	0.001795	0.7095	-7.9307
MgOH+	1.637e-008	0.0006763	0.9178	-7.8231
MoO4--	1.510e-008	0.002415	0.7095	-7.9699
Mn++	1.446e-008	0.0007940	0.7095	-7.9890
H+	1.419e-008	1.429e-005	0.9178	-7.8854
Fe(OH)3 (aq)	1.172e-008	0.001252	1.0016	-7.9304
Ni++	1.070e-008	0.0006282	0.7095	-8.1195

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8297s/sat	Vaterite	-0.6232
Maghemite	9.6506s/sat	Kaolinite	-0.6799
Magnesioferrite	8.3160s/sat	Se metal (am)	-0.6881
Goethite	6.7641s/sat	Magnesite	-0.6910
Lepidocrocite	6.6473s/sat	Dolomite (disord	-0.8416
Ferrihydrite (ag	5.3282s/sat	Chalcedony	-0.9548
Cuprous Ferrite	5.1612s/sat	Boehmite	-0.9979
CuSe	3.8057s/sat	Cristobalite	-1.1510
Ferrihydrite	3.5534s/sat	CaCO3xH2O	-1.3283
SbO2	2.5038s/sat	Smithsonite	-1.5346
CdSe	2.0032s/sat	ZnCO3	-1.5867
Cupric Ferrite	1.9312s/sat	K-Jarosite	-1.5976
Diaspore	0.8916s/sat	Strontianite	-1.6698
Clausthalite	0.0000 sat	SiO2 (am,ppt)	-1.8222
HgSe	0.0000 sat	Gypsum	-1.8293
Calcite	0.0000 sat	SiO2 (am,gel)	-1.8666
Barite	0.0000 sat	ZnSe	-1.9607
Gibbsite (C)	0.0000 sat	Imogolite	-2.0664
Cu2Se (alpha)	0.0000 sat	ZnCO3:1H2O	-2.1268
NiSe	0.0000 sat	Anhydrite	-2.1825
Se metal (hex,bl	-0.0263	Rhodochrosite	-2.2977
Aragonite	-0.1592	Celestite	-2.3397
Dolomite (ordere	-0.2047	NiCO3	-2.7285
Quartz	-0.4713	Otavite	-2.7630
Al(OH)3 (Soil)	-0.5500	MnCO3 (am)	-2.7741

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.001612	-2.793
Hg (g)	2.428e-018	-17.615
H2Se (g)	2.607e-021	-20.584
Hg2 (g)	1.429e-036	-35.845
H2S (g)	4.463e-047	-46.350
CH4 (g)	3.665e-047	-46.436
O2 (g)	3.478e-056	-55.459
Hg(CH3)2 (g)	9.882e-133	-132.005

	In fluid	Sorbed	Kd

Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
Al+++	2.59e-007	4.95e-009	0.000134			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00279	167.			
Ca++	0.00172	0.00118	47.3			
Cd++	4.45e-010	4.45e-010	5.00e-005			
Cu++	4.72e-009	5.72e-020	3.63e-015			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	-0.148	-0.148	-149.			
H2O	55.6	55.6	1.00e+006			
H4SiO4	1.77e-005	1.77e-005	1.70			
Hg(OH)2	1.70e-010	2.38e-019	5.58e-014			
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00115	0.00115	28.0			
Mn+++	1.82e-008	1.82e-008	0.00100			
MoO4--	2.50e-008	2.50e-008	0.00400			
Na+	9.57e-005	9.57e-005	2.20			
Ni++	1.70e-008	1.42e-008	0.000836			
O2(aq)	-0.0376	-0.0376	-1.20e+003			
Pb++	4.34e-009	2.05e-018	4.25e-013			
SO4--	0.000760	0.000760	72.9			
Sb(OH)6-	2.23e-009	2.23e-009	0.000500			
SeO4--	9.79e-009	1.22e-010	1.75e-005			
Sr++	3.42e-006	3.42e-006	0.300			
UO2++	1.85e-008	1.85e-008	0.00500			
Zn++	1.53e-007	1.53e-007	0.0100			

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	4.952e-009	0.0001336		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002791	33.51		
Ca	0.001722	0.001179	47.26		
Cd	4.448e-010	4.448e-010	4.998e-005		
Cu	4.721e-009	5.721e-020	3.634e-015		
Fe	8.953e-007	8.953e-007	0.04998		
H	111.0	111.0	1.119e+005		
Hg	1.705e-010	2.378e-019	4.768e-014		
K	1.023e-005	1.023e-005	0.3999		
Mg	0.001152	0.001152	27.99		
Mn	1.820e-008	1.820e-008	0.0009997		
Mo	2.501e-008	2.501e-008	0.002399		
Na	9.569e-005	9.569e-005	2.199		
Ni	1.703e-008	1.424e-008	0.0008356		
O	55.52	55.52	8.880e+005		
Pb	4.344e-009	2.051e-018	4.249e-013		
S	0.0007599	0.0007595	24.35		
Sb	2.234e-009	2.234e-009	0.0002719		
Se	9.793e-009	1.223e-010	9.657e-006		
Si	1.769e-005	1.769e-005	0.4966		
Sr	3.424e-006	3.424e-006	0.2999		
U	1.852e-008	1.852e-008	0.004406		
Zn	1.530e-007	1.530e-007	0.009997		

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Step #   350   Xi = 0.7000
Temperature =   5.0 C   Pressure = 0.938 bars
pH = 7.885
Eh =   0.0112 volts   pe =   0.2025

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Ionic strength      =    0.007035
Activity of water   =    0.999901
Solvent mass        =    1.000006 kg
Solution mass       =    1.000329 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         323 mg/kg sol'n
Rock mass           =    0.000054 kg
```

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	0.0112	0.2025

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.497e-005	
Calcite	0.0005421	-3.266	0.05426	
Clausthalite	4.344e-009	-8.362	1.243e-006	
Cu2Se (alpha)	2.360e-009	-8.627	4.864e-007	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
HgSe	1.705e-010	-9.768	4.766e-008	
NiSe	2.918e-009	-8.535	4.018e-007	
(total)			0.05438	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002639	160.9	0.9178	-2.6159
Ca++	0.001096	43.93	0.7095	-3.1091
Mg++	0.001075	26.12	0.7095	-3.1178
SO4--	0.0006401	61.47	0.7095	-3.3428
H2CO3* (aq)	0.0001034	6.412	1.0016	-3.9847
Na+	9.530e-005	2.190	0.9178	-4.0582
CaSO4 (aq)	6.577e-005	8.952	1.0016	-4.1812
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2737
MgHCO3+	2.112e-005	1.801	0.9178	-4.7126
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.624e-005	1.641	0.9178	-4.8268
K+	1.021e-005	0.3990	0.9178	-5.0284
CO3--	7.310e-006	0.4385	0.7095	-5.2851
Sr++	3.213e-006	0.2815	0.7095	-5.6421
MgCO3 (aq)	2.771e-006	0.2336	1.0016	-5.5566
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998
Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920
NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.669e-007	0.002838	0.9178	-6.8147
Ba++	1.667e-007	0.02289	0.7095	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.434e-007	0.01204	1.0016	-6.8428
Zn++	1.115e-007	0.007289	0.7095	-7.1016
H3SiO4-	5.571e-008	0.005297	0.9178	-7.2913
SrHCO3+	4.292e-008	0.006377	0.9178	-7.4046
ZnCO3 (aq)	2.358e-008	0.002956	1.0016	-7.6267
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
Ca2UO2(CO3)3 (aq	1.745e-008	0.009251	1.0016	-7.7574
NaCO3-	1.661e-008	0.001378	0.9178	-7.8169
Mg2CO3++	1.653e-008	0.001795	0.7095	-7.9307
MgOH+	1.637e-008	0.0006763	0.9178	-7.8231

MoO4--	1.510e-008	0.002415	0.7095	-7.9699
Mn++	1.446e-008	0.0007940	0.7095	-7.9890
H+	1.419e-008	1.429e-005	0.9178	-7.8854
Fe(OH)3 (aq)	1.172e-008	0.001252	1.0016	-7.9304
Ni++	1.061e-008	0.0006228	0.7095	-8.1233

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8297s/sat	Magnesite	-0.6910
Maghemite	9.6506s/sat	Dolomite (disord	-0.8416
Magnesioferrite	8.3160s/sat	Chalcedony	-0.9548
Goethite	6.7641s/sat	Boehmite	-0.9979
Lepidocrocite	6.6473s/sat	Cristobalite	-1.1510
Ferrihydrite (ag	5.3282s/sat	Se metal (hex,bl	-1.2631
Cuprous Ferrite	5.1593s/sat	CaCO3xH2O	-1.3283
Ferrihydrite	3.5534s/sat	Smithsonite	-1.5346
CuSe	3.1873s/sat	ZnCO3	-1.5867
SbO2	2.7436s/sat	K-Jarosite	-1.5976
CdSe	2.0070s/sat	Strontianite	-1.6698
Cupric Ferrite	1.3091s/sat	SiO2 (am,ppt)	-1.8222
Diaspore	0.8916s/sat	Gypsum	-1.8293
NiSe	0.0000 sat	SiO2 (am,gel)	-1.8666
Barite	0.0000 sat	Uraninite	-1.9191
Calcite	0.0000 sat	Se metal (am)	-1.9248
HgSe	0.0000 sat	ZnSe	-1.9570
Gibbsite (C)	0.0000 sat	Imogolite	-2.0664
Clausthalite	0.0000 sat	ZnCO3:1H2O	-2.1268
Cu2Se (alpha)	0.0000 sat	Anhydrite	-2.1825
Aragonite	-0.1592	Rhodochrosite	-2.2977
Dolomite (ordere	-0.2047	Celestite	-2.3397
Quartz	-0.4713	NiCO3	-2.7323
Al(OH)3 (Soil)	-0.5500	Otavite	-2.7630
Vaterite	-0.6232	MnCO3 (am)	-2.7741
Kaolinite	-0.6799		

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.001612	-2.793
Hg (g)	4.187e-017	-16.378
H2Se (g)	2.629e-021	-20.580
Hg2 (g)	4.251e-034	-33.371
H2S (g)	4.088e-042	-41.388
CH4 (g)	3.358e-042	-41.474
O2 (g)	1.149e-058	-57.940
Hg(CH3)2 (g)	8.223e-123	-122.085

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
Al+++	2.59e-007	4.95e-009	0.000134			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00279	167.			
Ca++	0.00172	0.00118	47.3			
Cd++	4.45e-010	4.45e-010	5.00e-005			
Cu++	4.72e-009	4.23e-020	2.69e-015			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	-0.624	-0.624	-629.			
H2O	55.8	55.8	1.01e+006			
H4SiO4	1.77e-005	1.77e-005	1.70			

Hg(OH)2	1.70e-010	4.10e-018	9.62e-013
K+	1.02e-005	1.02e-005	0.400
Mg++	0.00115	0.00115	28.0
Mn+++	1.82e-008	1.82e-008	0.00100
MoO4--	2.50e-008	2.50e-008	0.00400
Na+	9.57e-005	9.57e-005	2.20
Ni++	1.70e-008	1.41e-008	0.000828
O2(aq)	-0.157	-0.157	-5.02e+003
Pb++	4.34e-009	2.03e-018	4.21e-013
SO4--	0.000760	0.000760	72.9
Sb(OH)6-	2.23e-009	2.23e-009	0.000500
SeO4--	9.79e-009	2.34e-014	3.35e-009
Sr++	3.42e-006	3.42e-006	0.300
UO2++	1.85e-008	1.85e-008	0.00500
Zn++	1.53e-007	1.53e-007	0.0100

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	4.952e-009	0.0001336		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002791	33.51		
Ca	0.001722	0.001179	47.26		
Cd	4.448e-010	4.448e-010	4.998e-005		
Cu	4.721e-009	4.230e-020	2.687e-015		
Fe	8.953e-007	8.953e-007	0.04998		
H	111.0	111.0	1.119e+005		
Hg	1.705e-010	4.102e-018	8.225e-013		
K	1.023e-005	1.023e-005	0.3999		
Mg	0.001152	0.001152	27.99		
Mn	1.820e-008	1.820e-008	0.0009997		
Mo	2.501e-008	2.501e-008	0.002399		
Na	9.569e-005	9.569e-005	2.199		
Ni	1.703e-008	1.411e-008	0.0008284		
O	55.52	55.52	8.880e+005		
Pb	4.344e-009	2.034e-018	4.212e-013		
S	0.0007599	0.0007595	24.35		
Sb	2.234e-009	2.234e-009	0.0002719		
Se	9.793e-009	2.344e-014	1.850e-009		
Si	1.769e-005	1.769e-005	0.4966		
Sr	3.424e-006	3.424e-006	0.2999		
U	1.852e-008	1.852e-008	0.004406		
Zn	1.530e-007	1.530e-007	0.009997		

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Step #   374               Xi = 0.7480
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  7.885
Eh =  -0.0436 volts      pe =  -0.7899
Ionic strength      =    0.007035
Activity of water   =    0.999901
Solvent mass        =    1.000006 kg
Solution mass       =    1.000329 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         323 mg/kg sol'n
Rock mass           =    0.000054 kg
```

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	-0.0436	-0.7899

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.497e-005	
Calcite	0.0005421	-3.266	0.05426	
Clausthalite	4.344e-009	-8.362	1.243e-006	
Cu2Se (alpha)	2.360e-009	-8.627	4.864e-007	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
HgSe	1.705e-010	-9.768	4.766e-008	
NiSe	2.918e-009	-8.535	4.018e-007	
Uraninite	2.598e-009	-8.585	7.015e-007	
(total)			0.05438	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002639	160.9	0.9178	-2.6159
Ca++	0.001096	43.93	0.7095	-3.1091
Mg++	0.001075	26.12	0.7095	-3.1178
SO4--	0.0006401	61.47	0.7095	-3.3428
H2CO3* (aq)	0.0001034	6.412	1.0016	-3.9847
Na+	9.530e-005	2.190	0.9178	-4.0582
CaSO4 (aq)	6.577e-005	8.952	1.0016	-4.1812
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2736
MgHCO3+	2.112e-005	1.801	0.9178	-4.7126
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.624e-005	1.641	0.9178	-4.8268
K+	1.021e-005	0.3990	0.9178	-5.0284
CO3--	7.310e-006	0.4385	0.7095	-5.2851
Sr++	3.213e-006	0.2815	0.7095	-5.6421
MgCO3 (aq)	2.771e-006	0.2336	1.0016	-5.5566
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998
Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920
NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.669e-007	0.002838	0.9178	-6.8147
Ba++	1.667e-007	0.02289	0.7095	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.434e-007	0.01204	1.0016	-6.8428
Zn++	1.115e-007	0.007289	0.7095	-7.1016
H3SiO4-	5.572e-008	0.005297	0.9178	-7.2913
SrHCO3+	4.292e-008	0.006377	0.9178	-7.4046
ZnCO3 (aq)	2.358e-008	0.002956	1.0016	-7.6267
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
NaCO3-	1.661e-008	0.001378	0.9178	-7.8169
Mg2CO3++	1.653e-008	0.001795	0.7095	-7.9307
MgOH+	1.637e-008	0.0006763	0.9178	-7.8231
MoO4--	1.510e-008	0.002415	0.7095	-7.9699
Ca2UO2(CO3)3 (aq	1.500e-008	0.007953	1.0016	-7.8231
Mn++	1.446e-008	0.0007940	0.7095	-7.9890
H+	1.419e-008	1.429e-005	0.9178	-7.8854
Fe(OH)3 (aq)	1.172e-008	0.001252	1.0016	-7.9304
Ni++	1.061e-008	0.0006228	0.7095	-8.1233

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8297s/sat	Vaterite	-0.6232
Maghemite	9.6506s/sat	Kaolinite	-0.6799

Magnesioferrite	8.3161s/sat	Magnesite	-0.6910
Goethite	6.7641s/sat	Dolomite (disord	-0.8416
Lepidocrocite	6.6473s/sat	Chalcedony	-0.9548
Ferrihydrite (ag	5.3282s/sat	Boehmite	-0.9979
Cuprous Ferrite	5.1593s/sat	Cristobalite	-1.1510
Ferrihydrite	3.5534s/sat	CaCO3xH2O	-1.3283
CuSe	2.1949s/sat	Smithsonite	-1.5346
CdSe	2.0070s/sat	ZnCO3	-1.5867
SbO2	1.9566s/sat	K-Jarosite	-1.5976
Diaspore	0.8916s/sat	Strontianite	-1.6698
Cupric Ferrite	0.3167s/sat	SiO2 (am,ppt)	-1.8222
NiSe	0.0000 sat	Gypsum	-1.8293
Gibbsite (C)	0.0000 sat	SiO2 (am,gel)	-1.8666
HgSe	0.0000 sat	ZnSe	-1.9570
Calcite	0.0000 sat	Imogolite	-2.0664
Uraninite	0.0000 sat	ZnCO3:1H2O	-2.1268
Clausthalite	0.0000 sat	Anhydrite	-2.1825
Cu2Se (alpha)	0.0000 sat	Rhodochrosite	-2.2977
Barite	0.0000 sat	Celestite	-2.3397
Aragonite	-0.1592	NiCO3	-2.7323
Dolomite (ordere	-0.2047	Otavite	-2.7630
Quartz	-0.4713	MnCO3 (am)	-2.7741
Al(OH)3 (Soil)	-0.5500	U4O9	-2.9207

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.001612	-2.793
Hg (g)	4.043e-015	-14.393
H2Se (g)	2.629e-021	-20.580
Hg2 (g)	3.964e-030	-29.402
H2S (g)	3.554e-034	-33.449
CH4 (g)	2.919e-034	-33.535
O2 (g)	1.232e-062	-61.909
Hg(CH3)2 (g)	6.213e-107	-106.207

Original basis	total moles	In fluid moles	In fluid mg/kg	Sorbed moles	Sorbed mg/kg	Kd L/kg
Al+++	2.59e-007	4.95e-009	0.000134			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00279	167.			
Ca++	0.00172	0.00118	47.3			
Cd++	4.45e-010	4.45e-010	5.00e-005			
Cu++	4.72e-009	3.81e-020	2.42e-015			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	-6.16	-6.16	-6.21e+003			
H2O	58.6	58.6	1.06e+006			
H4SiO4	1.77e-005	1.77e-005	1.70			
Hg(OH)2	1.70e-010	3.96e-016	9.29e-011			
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00115	0.00115	28.0			
Mn+++	1.82e-008	1.82e-008	0.00100			
MoO4--	2.50e-008	2.50e-008	0.00400			
Na+	9.57e-005	9.57e-005	2.20			
Ni++	1.70e-008	1.41e-008	0.000828			
O2(aq)	-1.54	-1.54	-4.93e+004			
Pb++	4.34e-009	2.03e-018	4.21e-013			
SO4--	0.000760	0.000760	72.9			
Sb(OH)6-	2.23e-009	2.23e-009	0.000500			
SeO4--	9.79e-009	3.79e-018	5.41e-013			
Sr++	3.42e-006	3.42e-006	0.300			

UO2++	1.85e-008	1.59e-008	0.00430
Zn++	1.53e-007	1.53e-007	0.0100

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	4.952e-009	0.0001336		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002791	33.51		
Ca	0.001722	0.001179	47.26		
Cd	4.448e-010	4.448e-010	4.998e-005		
Cu	4.721e-009	3.814e-020	2.423e-015		
Fe	8.953e-007	8.953e-007	0.04998		
H	111.0	111.0	1.119e+005		
Hg	1.705e-010	3.961e-016	7.942e-011		
K	1.023e-005	1.023e-005	0.3999		
Mg	0.001152	0.001152	27.99		
Mn	1.820e-008	1.820e-008	0.0009997		
Mo	2.501e-008	2.501e-008	0.002399		
Na	9.569e-005	9.569e-005	2.199		
Ni	1.703e-008	1.411e-008	0.0008284		
O	55.52	55.52	8.880e+005		
Pb	4.344e-009	2.034e-018	4.212e-013		
S	0.0007599	0.0007595	24.35		
Sb	2.234e-009	2.234e-009	0.0002719		
Se	9.793e-009	3.786e-018	2.989e-013		
Si	1.769e-005	1.769e-005	0.4966		
Sr	3.424e-006	3.424e-006	0.2999		
U	1.852e-008	1.592e-008	0.003788		
Zn	1.530e-007	1.530e-007	0.009997		

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Step #   400              Xi = 0.8000
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  7.885
Eh =  -0.1029 volts      pe =  -1.8650
Ionic strength      =    0.007035
Activity of water   =    0.999901
Solvent mass        =    1.000006 kg
Solution mass       =    1.000329 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         323 mg/kg sol'n
Rock mass           =    0.000054 kg
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Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	-0.1029	-1.8650

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.498e-005	
Calcite	0.0005422	-3.266	0.05427	
Clausthalite	4.344e-009	-8.362	1.243e-006	
Cu2Se (alpha)	2.360e-009	-8.627	4.864e-007	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
HgSe	1.704e-010	-9.768	4.765e-008	

NiSe	2.918e-009	-8.535	4.018e-007	
Uraninite	1.840e-008	-7.735	4.970e-006	
(total)			0.05439	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002639	160.9	0.9178	-2.6159
Ca++	0.001096	43.93	0.7095	-3.1091
Mg++	0.001075	26.12	0.7095	-3.1178
SO4--	0.0006401	61.47	0.7095	-3.3428
H2CO3* (aq)	0.0001034	6.412	1.0016	-3.9847
Na+	9.530e-005	2.190	0.9178	-4.0582
CaSO4 (aq)	6.577e-005	8.951	1.0016	-4.1813
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2736
MgHCO3+	2.112e-005	1.801	0.9178	-4.7126
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.624e-005	1.641	0.9178	-4.8268
K+	1.021e-005	0.3990	0.9178	-5.0284
CO3--	7.310e-006	0.4385	0.7095	-5.2851
Sr++	3.213e-006	0.2815	0.7095	-5.6421
MgCO3 (aq)	2.771e-006	0.2336	1.0016	-5.5566
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998
Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920
NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.669e-007	0.002838	0.9178	-6.8147
Ba++	1.667e-007	0.02289	0.7095	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.434e-007	0.01204	1.0016	-6.8428
Zn++	1.115e-007	0.007289	0.7095	-7.1016
H3SiO4-	5.572e-008	0.005297	0.9178	-7.2913
SrHCO3+	4.292e-008	0.006377	0.9178	-7.4046
ZnCO3 (aq)	2.358e-008	0.002956	1.0016	-7.6267
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
NaCO3-	1.661e-008	0.001378	0.9178	-7.8169
Mg2CO3++	1.653e-008	0.001795	0.7095	-7.9307
MgOH+	1.637e-008	0.0006763	0.9178	-7.8231
MoO4--	1.510e-008	0.002415	0.7095	-7.9699
Mn++	1.446e-008	0.0007940	0.7095	-7.9890
H+	1.419e-008	1.429e-005	0.9178	-7.8854
Fe(OH)3 (aq)	1.172e-008	0.001252	1.0016	-7.9304
Ni++	1.061e-008	0.0006228	0.7095	-8.1233

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8297s/sat	Kaolinite	-0.6799
Maghemite	9.6506s/sat	Magnesite	-0.6910
Magnesioferrite	8.3161s/sat	Cupric Ferrite	-0.7584
Goethite	6.7641s/sat	Dolomite (disord	-0.8416
Lepidocrocite	6.6473s/sat	Chalcedony	-0.9548
Ferrihydrite (ag	5.3282s/sat	Boehmite	-0.9979
Cuprous Ferrite	5.1593s/sat	Cristobalite	-1.1510
Ferrihydrite	3.5534s/sat	CaCO3xH2O	-1.3283
CdSe	2.0070s/sat	Smithsonite	-1.5346
CuSe	1.1199s/sat	ZnCO3	-1.5867
Diaspore	0.8916s/sat	K-Jarosite	-1.5976
SbO2	0.8842s/sat	Strontianite	-1.6698
NiSe	0.0000 sat	SiO2 (am,ppt)	-1.8222
Gibbsite (C)	0.0000 sat	Gypsum	-1.8293
Cu2Se (alpha)	0.0000 sat	SiO2 (am,gel)	-1.8666
Barite	0.0000 sat	ZnSe	-1.9570

Calcite	0.0000	sat	Imogolite	-2.0664
Uraninite	0.0000	sat	ZnCO3:1H2O	-2.1268
Clausthalite	0.0000	sat	Anhydrite	-2.1825
HgSe	0.0000	sat	Rhodochrosite	-2.2977
Aragonite	-0.1592		Celestite	-2.3397
Dolomite (ordere	-0.2047		NiCO3	-2.7323
Quartz	-0.4713		Otavite	-2.7630
Al(OH)3 (Soil)	-0.5500		MnCO3 (am)	-2.7741
Vaterite	-0.6232			

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.001612	-2.793
Hg (g)	5.714e-013	-12.243
H2Se (g)	2.629e-021	-20.580
H2S (g)	1.417e-025	-24.849
CH4 (g)	1.164e-025	-24.934
Hg2 (g)	7.916e-026	-25.102
O2 (g)	6.171e-067	-66.210
Hg(CH3)2 (g)	9.881e-090	-89.005

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
Al+++	2.59e-007	4.95e-009	0.000134			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00279	167.			
Ca++	0.00172	0.00118	47.3			
Cd++	4.45e-010	4.45e-010	5.00e-005			
Cu++	4.72e-009	3.77e-020	2.40e-015			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	-73.3	-73.3	-7.38e+004			
H2O	92.2	92.2	1.66e+006			
H4SiO4	1.77e-005	1.77e-005	1.70			
Hg(OH)2	1.70e-010	5.60e-014	1.31e-008			
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00115	0.00115	28.0			
Mn+++	1.82e-008	1.82e-008	0.00100			
MoO4--	2.50e-008	2.50e-008	0.00400			
Na+	9.57e-005	9.57e-005	2.20			
Ni++	1.70e-008	1.41e-008	0.000828			
O2(aq)	-18.3	-18.3	-5.86e+005			
Pb++	4.34e-009	2.03e-018	4.21e-013			
SO4--	0.000760	0.000760	72.9			
Sb(OH)6-	2.23e-009	2.23e-009	0.000500			
SeO4--	9.79e-009	3.76e-018	5.37e-013			
Sr++	3.42e-006	3.42e-006	0.300			
UO2++	1.85e-008	1.13e-010	3.04e-005			
Zn++	1.53e-007	1.53e-007	0.0100			

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	4.952e-009	0.0001336		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002791	33.51		
Ca	0.001722	0.001179	47.25		
Cd	4.448e-010	4.448e-010	4.998e-005		
Cu	4.721e-009	3.771e-020	2.396e-015		
Fe	8.953e-007	8.953e-007	0.04998		

H	111.0	111.0	1.119e+005
Hg	1.705e-010	5.597e-014	1.122e-008
K	1.023e-005	1.023e-005	0.3999
Mg	0.001152	0.001152	27.99
Mn	1.820e-008	1.820e-008	0.0009997
Mo	2.501e-008	2.501e-008	0.002399
Na	9.569e-005	9.569e-005	2.199
Ni	1.703e-008	1.411e-008	0.0008284
O	55.52	55.52	8.880e+005
Pb	4.344e-009	2.034e-018	4.212e-013
S	0.0007599	0.0007595	24.35
Sb	2.234e-009	2.234e-009	0.0002719
Se	9.793e-009	3.760e-018	2.968e-013
Si	1.769e-005	1.769e-005	0.4966
Sr	3.424e-006	3.424e-006	0.2999
U	1.852e-008	1.127e-010	2.681e-005
Zn	1.530e-007	1.530e-007	0.009997

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Step #   436              Xi = 0.8720
Temperature =   5.0 C     Pressure =  0.938 bars
pH =  7.886
Eh =  -0.1851 volts       pe =  -3.3536
Ionic strength      =    0.007034
Activity of water   =    0.999901
Solvent mass        =    1.000006 kg
Solution mass       =    1.000329 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         323 mg/kg sol'n
Rock mass           =    0.000054 kg
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Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	-0.1851	-3.3536

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.498e-005	
Calcite	0.0005425	-3.266	0.05430	
Clausthalite	4.344e-009	-8.362	1.243e-006	
Cu2Se (alpha)	2.360e-009	-8.627	4.864e-007	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
HgSe	1.176e-010	-9.930	3.287e-008	
MoS2	1.619e-008	-7.791	2.592e-006	
NiSe	2.971e-009	-8.527	4.090e-007	
Uraninite	1.852e-008	-7.732	5.000e-006	
(total)			0.05442	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002638	160.9	0.9178	-2.6159
Ca++	0.001096	43.92	0.7095	-3.1092
Mg++	0.001075	26.12	0.7095	-3.1178
SO4--	0.0006401	61.47	0.7095	-3.3428
H2CO3* (aq)	0.0001034	6.409	1.0016	-3.9849
Na+	9.530e-005	2.190	0.9178	-4.0582

CaSO4 (aq)	6.575e-005	8.949	1.0016	-4.1814
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2736
MgHCO3+	2.112e-005	1.801	0.9178	-4.7126
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.623e-005	1.640	0.9178	-4.8270
K+	1.021e-005	0.3990	0.9178	-5.0284
CO3--	7.312e-006	0.4386	0.7095	-5.2850
Sr++	3.213e-006	0.2815	0.7095	-5.6421
MgCO3 (aq)	2.772e-006	0.2337	1.0016	-5.5565
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998
Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920
NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.670e-007	0.002839	0.9178	-6.8146
Ba++	1.667e-007	0.02289	0.7095	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.434e-007	0.01204	1.0016	-6.8428
Zn++	1.115e-007	0.007288	0.7095	-7.1017
H3SiO4-	5.574e-008	0.005299	0.9178	-7.2911
SrHCO3+	4.291e-008	0.006377	0.9178	-7.4046
ZnCO3 (aq)	2.359e-008	0.002956	1.0016	-7.6266
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
NaCO3-	1.661e-008	0.001379	0.9178	-7.8168
Mg2CO3++	1.654e-008	0.001796	0.7095	-7.9306
MgOH+	1.638e-008	0.0006766	0.9178	-7.8230
Mn++	1.446e-008	0.0007939	0.7095	-7.9890
H+	1.418e-008	1.429e-005	0.9178	-7.8855
Fe(OH)3 (aq)	1.172e-008	0.001252	1.0016	-7.9302
Ni++	1.057e-008	0.0006204	0.7095	-8.1249

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8300s/sat	Kaolinite	-0.6799
Maghemite	9.6509s/sat	Magnesite	-0.6908
Magnesioferrite	8.3167s/sat	Dolomite (disord	-0.8415
Goethite	6.7643s/sat	Chalcedony	-0.9548
Lepidocrocite	6.6474s/sat	Boehmite	-0.9979
Ferrihydrite (ag	5.3284s/sat	Spharelite	-1.0841
Cuprous Ferrite	5.1588s/sat	Cristobalite	-1.1510
Ferrihydrite	3.5536s/sat	CaCO3xH2O	-1.3283
CdSe	2.0086s/sat	Smithsonite	-1.5345
Diaspore	0.8916s/sat	ZnCO3	-1.5866
HgSe	0.0000 sat	K-Jarosite	-1.5976
Clausthalite	0.0000 sat	Strontianite	-1.6697
MoS2	0.0000 sat	SiO2 (am,ppt)	-1.8222
Calcite	0.0000 sat	Gypsum	-1.8295
NiSe	0.0000 sat	SiO2 (am,gel)	-1.8666
Gibbsite (C)	0.0000 sat	ZnSe	-1.9554
Uraninite	0.0000 sat	Imogolite	-2.0664
Cu2Se (alpha)	0.0000 sat	ZnCO3:1H2O	-2.1267
Barite	0.0000 sat	Anhydrite	-2.1826
Greenockite	-0.0410	Cupric Ferrite	-2.2471
Aragonite	-0.1592	NiS (beta)	-2.2853
Dolomite (ordere	-0.2046	Rhodochrosite	-2.2976
CuSe	-0.3679	Celestite	-2.3397
Quartz	-0.4713	NiCO3	-2.7338
Al(OH)3 (Soil)	-0.5500	Otavite	-2.7629
NiS (gamma)	-0.5853	MnCO3 (am)	-2.7740
SbO2	-0.6042	Cinnabar	-2.8225
Vaterite	-0.6232	Hg metal (l)	-2.9159

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.001611	-2.793
Hg (g)	5.401e-010	-9.268
H2S (g)	1.144e-013	-12.941
CH4 (g)	9.401e-014	-13.027
Hg2 (g)	7.073e-020	-19.150
H2Se (g)	2.637e-021	-20.579
Hg(CH3)2 (g)	6.427e-066	-65.192
O2 (g)	6.865e-073	-72.163

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
Al+++	2.59e-007	4.95e-009	0.000134			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00279	167.			
Ca++	0.00172	0.00118	47.2			
Cd++	4.45e-010	4.45e-010	5.00e-005			
Cu++	4.72e-009	3.76e-020	2.39e-015			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	-2.26e+003	-2.26e+003	-2.27e+006			
H2O	1.18e+003	1.18e+003	2.13e+007			
H4SiO4	1.77e-005	1.77e-005	1.70			
Hg(OH)2	1.70e-010	5.29e-011	1.24e-005			
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00115	0.00115	28.0			
Mn+++	1.82e-008	1.82e-008	0.00100			
MoO4--	2.50e-008	8.82e-009	0.00141			
Na+	9.57e-005	9.57e-005	2.20			
Ni++	1.70e-008	1.41e-008	0.000825			
O2(aq)	-564.	-564.	-1.81e+007			
Pb++	4.34e-009	2.03e-018	4.20e-013			
SO4--	0.000760	0.000759	72.9			
Sb(OH)6-	2.23e-009	2.23e-009	0.000500			
SeO4--	9.79e-009	3.77e-018	5.39e-013			
Sr++	3.42e-006	3.42e-006	0.300			
UO2++	1.85e-008	1.39e-013	3.76e-008			
Zn++	1.53e-007	1.53e-007	0.0100			

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	4.954e-009	0.0001336		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002790	33.50		
Ca	0.001722	0.001179	47.24		
Cd	4.448e-010	4.448e-010	4.998e-005		
Cu	4.721e-009	3.760e-020	2.389e-015		
Fe	8.953e-007	8.953e-007	0.04998		
H	111.0	111.0	1.119e+005		
Hg	1.705e-010	5.291e-011	1.061e-005		
K	1.023e-005	1.023e-005	0.3999		
Mg	0.001152	0.001152	27.99		
Mn	1.820e-008	1.820e-008	0.0009997		
Mo	2.501e-008	8.817e-009	0.0008456		
Na	9.569e-005	9.569e-005	2.199		
Ni	1.703e-008	1.406e-008	0.0008253		
O	55.52	55.52	8.880e+005		
Pb	4.344e-009	2.027e-018	4.198e-013		
S	0.0007599	0.0007595	24.34		

Sb	2.234e-009	2.234e-009	0.0002719
Se	9.793e-009	3.773e-018	2.978e-013
Si	1.769e-005	1.769e-005	0.4966
Sr	3.424e-006	3.424e-006	0.2999
U	1.852e-008	1.392e-013	3.313e-008
Zn	1.530e-007	1.530e-007	0.009997

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Step #   437              Xi = 0.8740
Temperature =   5.0 C     Pressure =  0.938 bars
pH =  7.886
Eh =  -0.1874 volts       pe =  -3.3950
Ionic strength      =    0.007034
Activity of water   =    0.999901
Solvent mass        =    1.000006 kg
Solution mass       =    1.000329 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         323 mg/kg sol'n
Rock mass           =    0.000054 kg
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Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	-0.1874	-3.3950

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.498e-005	
Calcite	0.0005427	-3.265	0.05432	
Clausthalite	4.344e-009	-8.362	1.243e-006	
Cu2Se (alpha)	2.360e-009	-8.627	4.864e-007	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
Greenockite	2.163e-010	-9.665	3.125e-008	
HgSe	1.065e-010	-9.972	2.979e-008	
MoS2	2.341e-008	-7.631	3.748e-006	
NiSe	2.982e-009	-8.525	4.106e-007	
Uraninite	1.852e-008	-7.732	5.000e-006	
(total)			0.05444	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002638	160.9	0.9178	-2.6160
Ca++	0.001096	43.91	0.7095	-3.1093
Mg++	0.001075	26.12	0.7095	-3.1178
SO4--	0.0006401	61.47	0.7095	-3.3428
H2CO3* (aq)	0.0001033	6.408	1.0016	-3.9850
Na+	9.530e-005	2.190	0.9178	-4.0582
CaSO4 (aq)	6.575e-005	8.948	1.0016	-4.1814
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2736
MgHCO3+	2.112e-005	1.801	0.9178	-4.7127
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.623e-005	1.640	0.9178	-4.8270
K+	1.021e-005	0.3990	0.9178	-5.0284
CO3--	7.313e-006	0.4387	0.7095	-5.2849
Sr++	3.213e-006	0.2815	0.7095	-5.6421
MgCO3 (aq)	2.772e-006	0.2337	1.0016	-5.5565
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998

Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920
NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.670e-007	0.002840	0.9178	-6.8145
Ba++	1.667e-007	0.02289	0.7095	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.434e-007	0.01204	1.0016	-6.8428
Zn++	1.115e-007	0.007288	0.7095	-7.1017
H3SiO4-	5.575e-008	0.005300	0.9178	-7.2910
SrHCO3+	4.291e-008	0.006376	0.9178	-7.4047
ZnCO3 (aq)	2.359e-008	0.002956	1.0016	-7.6266
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
NaCO3-	1.662e-008	0.001379	0.9178	-7.8167
Mg2CO3++	1.654e-008	0.001796	0.7095	-7.9305
MgOH+	1.638e-008	0.0006767	0.9178	-7.8229
Mn++	1.446e-008	0.0007939	0.7095	-7.9890
H+	1.418e-008	1.429e-005	0.9178	-7.8856
Fe(OH)3 (aq)	1.173e-008	0.001253	1.0016	-7.9302
Ni++	1.056e-008	0.0006199	0.7095	-8.1253

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8301s/sat	Kaolinite	-0.6799
Maghemite	9.6511s/sat	Magnesite	-0.6908
Magnesioferrite	8.3170s/sat	Spharelite	-0.7539
Goethite	6.7643s/sat	Dolomite (disord	-0.8415
Lepidocrocite	6.6475s/sat	Chalcedony	-0.9548
Ferrihydrite (ag	5.3285s/sat	Boehmite	-0.9979
Cuprous Ferrite	5.1588s/sat	Cristobalite	-1.1510
Ferrihydrite	3.5537s/sat	CaCO3xH2O	-1.3283
CdSe	1.7197s/sat	Smithsonite	-1.5345
Diaspore	0.8916s/sat	ZnCO3	-1.5866
Barite	0.0000 sat	K-Jarosite	-1.5976
MoS2	0.0000 sat	Strontianite	-1.6696
Clausthalite	0.0000 sat	SiO2 (am,ppt)	-1.8222
HgSe	0.0000 sat	Gypsum	-1.8295
Gibbsite (C)	0.0000 sat	SiO2 (am,gel)	-1.8666
Cu2Se (alpha)	0.0000 sat	ZnSe	-1.9550
NiSe	0.0000 sat	NiS (beta)	-1.9554
Greenockite	0.0000 sat	Imogolite	-2.0664
Uraninite	0.0000 sat	ZnCO3:1H2O	-2.1267
Calcite	0.0000 sat	Anhydrite	-2.1827
Aragonite	-0.1592	Cupric Ferrite	-2.2884
Dolomite (ordere	-0.2045	Rhodochrosite	-2.2976
NiS (gamma)	-0.2554	Celestite	-2.3397
CuSe	-0.4091	Cinnabar	-2.4926
Quartz	-0.4713	NiCO3	-2.7341
Al(OH)3 (Soil)	-0.5500	MnCO3 (am)	-2.7739
Vaterite	-0.6232	Hg metal (l)	-2.8336
SbO2	-0.6455	Metacinnabar	-2.8896

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.001611	-2.793
Hg (g)	6.529e-010	-9.185
H2S (g)	2.447e-013	-12.611
CH4 (g)	2.010e-013	-12.697
Hg2 (g)	1.034e-019	-18.986
H2Se (g)	2.638e-021	-20.579
Hg(CH3)2 (g)	2.938e-065	-64.532
O2 (g)	4.694e-073	-72.328

Original basis	total moles	In fluid moles	In fluid mg/kg	Sorbed moles	Sorbed mg/kg	Kd L/kg
Al+++	2.59e-007	4.95e-009	0.000134			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00279	167.			
Ca++	0.00172	0.00118	47.2			
Cd++	4.45e-010	2.29e-010	2.57e-005			
Cu++	4.72e-009	3.76e-020	2.39e-015			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	-2.48e+003	-2.48e+003	-2.50e+006			
H2O	1.30e+003	1.30e+003	2.34e+007			
H4SiO4	1.77e-005	1.77e-005	1.70			
Hg(OH)2	1.70e-010	6.40e-011	1.50e-005			
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00115	0.00115	28.0			
Mn+++	1.82e-008	1.82e-008	0.00100			
MoO4--	2.50e-008	1.59e-009	0.000255			
Na+	9.57e-005	9.57e-005	2.20			
Ni++	1.70e-008	1.41e-008	0.000825			
O2(aq)	-621.	-621.	-1.99e+007			
Pb++	4.34e-009	2.03e-018	4.19e-013			
SO4--	0.000760	0.000759	72.9			
Sb(OH)6-	2.23e-009	2.23e-009	0.000500			
SeO4--	9.79e-009	3.78e-018	5.40e-013			
Sr++	3.42e-006	3.42e-006	0.300			
UO2++	1.85e-008	1.19e-013	3.20e-008			
Zn++	1.53e-007	1.53e-007	0.0100			

Elemental composition	total moles	In fluid moles	In fluid mg/kg	Sorbed moles	Sorbed mg/kg
Al	2.594e-007	4.955e-009	0.0001336		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002790	33.50		
Ca	0.001722	0.001179	47.23		
Cd	4.448e-010	2.286e-010	2.568e-005		
Cu	4.721e-009	3.759e-020	2.388e-015		
Fe	8.953e-007	8.953e-007	0.04998		
H	111.0	111.0	1.119e+005		
Hg	1.705e-010	6.395e-011	1.282e-005		
K	1.023e-005	1.023e-005	0.3999		
Mg	0.001152	0.001152	27.99		
Mn	1.820e-008	1.820e-008	0.0009997		
Mo	2.501e-008	1.595e-009	0.0001530		
Na	9.569e-005	9.569e-005	2.199		
Ni	1.703e-008	1.405e-008	0.0008246		
O	55.52	55.52	8.880e+005		
Pb	4.344e-009	2.025e-018	4.195e-013		
S	0.0007599	0.0007595	24.34		
Sb	2.234e-009	2.234e-009	0.0002719		
Se	9.793e-009	3.775e-018	2.980e-013		
Si	1.769e-005	1.769e-005	0.4966		
Sr	3.424e-006	3.424e-006	0.2999		
U	1.852e-008	1.186e-013	2.823e-008		
Zn	1.530e-007	1.530e-007	0.009997		

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Step # 438 Xi = 0.8760
Temperature = 5.0 C Pressure = 0.938 bars

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pH =  7.886
Eh =  -0.1896 volts      pe =  -3.4363
Ionic strength      =    0.007034
Activity of water   =    0.999901
Solvent mass        =    1.000006 kg
Solution mass       =    1.000329 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         323 mg/kg sol'n
Rock mass           =    0.000054 kg
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Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	-0.1896	-3.4363

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.498e-005	
Calcite	0.0005427	-3.265	0.05432	
Clausthalite	4.344e-009	-8.362	1.243e-006	
Cu2Se (alpha)	2.360e-009	-8.627	4.864e-007	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
Greenockite	3.381e-010	-9.471	4.884e-008	
HgSe	1.054e-010	-9.977	2.947e-008	
MoS2	2.472e-008	-7.607	3.957e-006	
NiS (gamma)	2.234e-009	-8.651	2.028e-007	
NiSe	2.983e-009	-8.525	4.107e-007	
Uraninite	1.852e-008	-7.732	5.000e-006	
(total)			0.05445	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002638	160.9	0.9178	-2.6160
Ca++	0.001096	43.91	0.7095	-3.1093
Mg++	0.001075	26.12	0.7095	-3.1178
SO4--	0.0006401	61.47	0.7095	-3.3428
H2CO3* (aq)	0.0001033	6.407	1.0016	-3.9850
Na+	9.530e-005	2.190	0.9178	-4.0581
CaSO4 (aq)	6.574e-005	8.948	1.0016	-4.1814
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2736
MgHCO3+	2.112e-005	1.801	0.9178	-4.7127
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.623e-005	1.640	0.9178	-4.8270
K+	1.021e-005	0.3990	0.9178	-5.0284
CO3--	7.313e-006	0.4387	0.7095	-5.2849
Sr++	3.213e-006	0.2815	0.7095	-5.6421
MgCO3 (aq)	2.772e-006	0.2337	1.0016	-5.5564
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998
Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920
NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.670e-007	0.002840	0.9178	-6.8145
Ba++	1.667e-007	0.02289	0.7095	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.434e-007	0.01204	1.0016	-6.8428
Zn++	1.115e-007	0.007288	0.7095	-7.1017
H3SiO4-	5.575e-008	0.005300	0.9178	-7.2910
SrHCO3+	4.291e-008	0.006376	0.9178	-7.4047

ZnCO3 (aq)	2.359e-008	0.002957	1.0016	-7.6266
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
NaCO3-	1.662e-008	0.001379	0.9178	-7.8167
Mg2CO3++	1.654e-008	0.001796	0.7095	-7.9305
MgOH+	1.638e-008	0.0006767	0.9178	-7.8229
Mn++	1.446e-008	0.0007939	0.7095	-7.9890
H+	1.418e-008	1.429e-005	0.9178	-7.8856
Fe(OH)3 (aq)	1.173e-008	0.001253	1.0016	-7.9301

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8302s/sat	SbO2	-0.6868
Maghemite	9.6511s/sat	Magnesite	-0.6908
Magnesioferrite	8.3171s/sat	Dolomite (disord	-0.8414
Goethite	6.7643s/sat	Chalcedony	-0.9548
Lepidocrocite	6.6475s/sat	Boehmite	-0.9979
Ferrihydrite (ag	5.3285s/sat	Cristobalite	-1.1510
Cuprous Ferrite	5.1212s/sat	CaCO3xH2O	-1.3283
Ferrihydrite	3.5537s/sat	Smithsonite	-1.5344
CdSe	1.4643s/sat	ZnCO3	-1.5866
Diaspore	0.8916s/sat	K-Jarosite	-1.5976
Gibbsite (C)	0.0000 sat	Strontianite	-1.6696
Barite	0.0000 sat	NiS (beta)	-1.7000
Greenockite	0.0000 sat	SiO2 (am,ppt)	-1.8222
MoS2	0.0000 sat	Gypsum	-1.8295
NiS (gamma)	0.0000 sat	SiO2 (am,gel)	-1.8666
NiSe	0.0000 sat	ZnSe	-1.8798
Calcite	0.0000 sat	Imogolite	-2.0664
Uraninite	0.0000 sat	ZnCO3:1H2O	-2.1266
Cu2Se (alpha)	0.0000 sat	Anhydrite	-2.1827
HgSe	0.0000 sat	Cinnabar	-2.2372
Clausthalite	0.0000 sat	Rhodochrosite	-2.2976
Aragonite	-0.1592	Celestite	-2.3397
Dolomite (ordere	-0.2045	Cupric Ferrite	-2.3673
CuSe	-0.4128	Metacinnabar	-2.6342
Spharelite	-0.4233	Wurtzite	-2.7344
Quartz	-0.4713	MnCO3 (am)	-2.7739
Al(OH)3 (Soil)	-0.5500	NiCO3	-2.8093
Vaterite	-0.6232	Hg metal (l)	-2.8261
Kaolinite	-0.6799		

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.001610	-2.793
Hg (g)	6.642e-010	-9.178
H2S (g)	5.239e-013	-12.281
CH4 (g)	4.304e-013	-12.366
Hg2 (g)	1.070e-019	-18.971
H2Se (g)	3.137e-021	-20.503
Hg(CH3)2 (g)	1.133e-064	-63.946
O2 (g)	3.208e-073	-72.494

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
Al+++	2.59e-007	4.95e-009	0.000134			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00279	167.			
Ca++	0.00172	0.00118	47.2			

Cd++	4.45e-010	1.07e-010	1.20e-005
Cu++	4.72e-009	3.45e-020	2.19e-015
Fe+++	8.95e-007	8.95e-007	0.0500
H+	-2.73e+003	-2.73e+003	-2.75e+006
H2O	1.42e+003	1.42e+003	2.56e+007
H4SiO4	1.77e-005	1.77e-005	1.70
Hg(OH)2	1.70e-010	6.51e-011	1.53e-005
K+	1.02e-005	1.02e-005	0.400
Mg++	0.00115	0.00115	28.0
Mn+++	1.82e-008	1.82e-008	0.00100
MoO4--	2.50e-008	2.88e-010	4.60e-005
Na+	9.57e-005	9.57e-005	2.20
Ni++	1.70e-008	1.18e-008	0.000693
O2(aq)	-683.	-683.	-2.18e+007
Pb++	4.34e-009	1.70e-018	3.53e-013
SO4--	0.000760	0.000759	72.9
Sb(OH)6-	2.23e-009	2.23e-009	0.000500
SeO4--	9.79e-009	4.49e-018	6.42e-013
Sr++	3.42e-006	3.42e-006	0.300
UO2++	1.85e-008	1.02e-013	2.74e-008
Zn++	1.53e-007	1.53e-007	0.0100

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	4.955e-009	0.0001336		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002790	33.50		
Ca	0.001722	0.001179	47.23		
Cd	4.448e-010	1.067e-010	1.199e-005		
Cu	4.721e-009	3.447e-020	2.190e-015		
Fe	8.953e-007	8.953e-007	0.04998		
H	111.0	111.0	1.119e+005		
Hg	1.705e-010	6.506e-011	1.305e-005		
K	1.023e-005	1.023e-005	0.3999		
Mg	0.001152	0.001152	27.99		
Mn	1.820e-008	1.820e-008	0.0009997		
Mo	2.501e-008	2.877e-010	2.759e-005		
Na	9.569e-005	9.569e-005	2.199		
Ni	1.703e-008	1.182e-008	0.0006935		
O	55.52	55.52	8.880e+005		
Pb	4.344e-009	1.703e-018	3.528e-013		
S	0.0007599	0.0007595	24.34		
Sb	2.234e-009	2.234e-009	0.0002719		
Se	9.793e-009	4.489e-018	3.543e-013		
Si	1.769e-005	1.769e-005	0.4966		
Sr	3.424e-006	3.424e-006	0.2999		
U	1.852e-008	1.016e-013	2.418e-008		
Zn	1.530e-007	1.530e-007	0.009997		

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Step #   440              Xi = 0.8800
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  7.886
Eh =  -0.1942 volts      pe =  -3.5190
Ionic strength      =    0.007033
Activity of water   =    0.999901
Solvent mass        =    1.000006 kg
Solution mass       =    1.000329 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         323 mg/kg sol'n
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Rock mass = 0.000055 kg

Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	-0.1942	-3.5190

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.498e-005	
Calcite	0.0005432	-3.265	0.05437	
Clausthalite	4.344e-009	-8.362	1.243e-006	
Cu2Se (alpha)	2.360e-009	-8.627	4.864e-007	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
Greenockite	4.215e-010	-9.375	6.089e-008	
HgSe	1.496e-010	-9.825	4.183e-008	
MoS2	2.500e-008	-7.602	4.002e-006	
NiS (gamma)	1.151e-008	-7.939	1.044e-006	
NiSe	2.939e-009	-8.532	4.046e-007	
Spharelite	6.419e-008	-7.193	6.254e-006	
Uraninite	1.852e-008	-7.732	5.000e-006	
(total)			0.05451	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002638	160.9	0.9178	-2.6160
Ca++	0.001095	43.89	0.7096	-3.1095
Mg++	0.001075	26.12	0.7096	-3.1178
SO4--	0.0006401	61.47	0.7096	-3.3428
H2CO3* (aq)	0.0001033	6.403	1.0016	-3.9854
Na+	9.530e-005	2.190	0.9178	-4.0581
CaSO4 (aq)	6.571e-005	8.944	1.0016	-4.1816
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2736
MgHCO3+	2.111e-005	1.801	0.9178	-4.7127
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.622e-005	1.639	0.9178	-4.8273
K+	1.021e-005	0.3990	0.9178	-5.0283
CO3--	7.316e-006	0.4389	0.7096	-5.2847
Sr++	3.213e-006	0.2815	0.7096	-5.6421
MgCO3 (aq)	2.774e-006	0.2338	1.0016	-5.5562
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998
Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920
NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.671e-007	0.002841	0.9178	-6.8142
Ba++	1.667e-007	0.02289	0.7096	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.433e-007	0.01204	1.0016	-6.8429
Zn++	6.472e-008	0.004229	0.7096	-7.3380
H3SiO4-	5.578e-008	0.005303	0.9178	-7.2908
SrHCO3+	4.291e-008	0.006376	0.9178	-7.4047
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
NaCO3-	1.662e-008	0.001379	0.9178	-7.8165
Mg2CO3++	1.655e-008	0.001797	0.7096	-7.9303
MgOH+	1.639e-008	0.0006771	0.9178	-7.8226
Mn++	1.445e-008	0.0007939	0.7096	-7.9890
H+	1.417e-008	1.428e-005	0.9178	-7.8859
ZnCO3 (aq)	1.370e-008	0.001717	1.0016	-7.8627
Fe(OH)3 (aq)	1.173e-008	0.001253	1.0016	-7.9299

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8307s/sat	Kaolinite	-0.6799
Maghemite	9.6516s/sat	Magnesite	-0.6906
Magnesioferrite	8.3181s/sat	SbO2	-0.7692
Goethite	6.7646s/sat	Dolomite (disord	-0.8412
Lepidocrocite	6.6478s/sat	Chalcedony	-0.9548
Ferrihydrite (ag	5.3287s/sat	Boehmite	-0.9979
Cuprous Ferrite	4.7919s/sat	Cristobalite	-1.1510
Ferrihydrite	3.5539s/sat	CaCO3xH2O	-1.3283
CdSe	1.4643s/sat	ZnSe	-1.4566
Diaspore	0.8916s/sat	K-Jarosite	-1.5976
Barite	0.0000 sat	Strontianite	-1.6694
Calcite	0.0000 sat	NiS (beta)	-1.7000
NiS (gamma)	0.0000 sat	Smithsonite	-1.7706
HgSe	0.0000 sat	SiO2 (am,ppt)	-1.8222
Clausthalite	0.0000 sat	ZnCO3	-1.8227
Gibbsite (C)	0.0000 sat	Gypsum	-1.8297
Cu2Se (alpha)	0.0000 sat	SiO2 (am,gel)	-1.8666
NiSe	0.0000 sat	Imogolite	-2.0664
MoS2	0.0000 sat	Anhydrite	-2.1829
Spharelite	0.0000 sat	Cinnabar	-2.2372
Greenockite	0.0000 sat	Rhodochrosite	-2.2974
Uraninite	0.0000 sat	Wurtzite	-2.3112
Aragonite	-0.1592	Celestite	-2.3397
CuSe	-0.1657	ZnCO3:1H2O	-2.3628
Dolomite (ordere	-0.2043	Metacinnabar	-2.6342
Quartz	-0.4713	MnCO3 (am)	-2.7737
Al(OH)3 (Soil)	-0.5500	Cupric Ferrite	-2.7787
Vaterite	-0.6232		

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.001609	-2.793
Hg (g)	2.129e-010	-9.672
H2S (g)	2.390e-012	-11.622
CH4 (g)	1.964e-012	-11.707
H2Se (g)	1.431e-020	-19.844
Hg2 (g)	1.099e-020	-19.959
Hg(CH3)2 (g)	5.171e-064	-63.286
O2 (g)	1.501e-073	-72.824

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
Al+++	2.59e-007	4.96e-009	0.000134			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00279	167.			
Ca++	0.00172	0.00118	47.2			
Cd++	4.45e-010	2.34e-011	2.63e-006			
Cu++	4.72e-009	1.61e-020	1.02e-015			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	-3.30e+003	-3.30e+003	-3.33e+006			
H2O	1.71e+003	1.71e+003	3.07e+007			
H4SiO4	1.77e-005	1.77e-005	1.70			
Hg(OH)2	1.70e-010	2.09e-011	4.89e-006			
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00115	0.00115	28.0			

Mn+++	1.82e-008	1.82e-008	0.00100
MoO4--	2.50e-008	9.47e-012	1.51e-006
Na+	9.57e-005	9.57e-005	2.20
Ni++	1.70e-008	2.59e-009	0.000152
O2(aq)	-826.	-826.	-2.64e+007
Pb++	4.34e-009	3.73e-019	7.73e-014
SO4--	0.000760	0.000759	72.9
Sb(OH)6-	2.23e-009	2.23e-009	0.000500
SeO4--	9.79e-009	2.05e-017	2.93e-012
Sr++	3.42e-006	3.42e-006	0.300
UO2++	1.85e-008	7.59e-014	2.05e-008
Zn++	1.53e-007	8.88e-008	0.00580

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	4.957e-009	0.0001337		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002790	33.49		
Ca	0.001722	0.001178	47.21		
Cd	4.448e-010	2.338e-011	2.627e-006		
Cu	4.721e-009	1.613e-020	1.025e-015		
Fe	8.953e-007	8.953e-007	0.04998		
H	111.0	111.0	1.119e+005		
Hg	1.705e-010	2.085e-011	4.181e-006		
K	1.023e-005	1.023e-005	0.3999		
Mg	0.001152	0.001152	27.99		
Mn	1.820e-008	1.820e-008	0.0009997		
Mo	2.501e-008	9.471e-012	9.083e-007		
Na	9.569e-005	9.569e-005	2.199		
Ni	1.703e-008	2.588e-009	0.0001519		
O	55.52	55.52	8.880e+005		
Pb	4.344e-009	3.731e-019	7.728e-014		
S	0.0007599	0.0007594	24.34		
Sb	2.234e-009	2.234e-009	0.0002719		
Se	9.793e-009	2.049e-017	1.617e-012		
Si	1.769e-005	1.769e-005	0.4966		
Sr	3.424e-006	3.424e-006	0.2999		
U	1.852e-008	7.593e-014	1.807e-008		
Zn	1.530e-007	8.879e-008	0.005802		

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Step #   450                Xi = 0.9000
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  7.886
Eh =  -0.2170 volts      pe =  -3.9325
Ionic strength      =    0.007031
Activity of water   =    0.999901
Solvent mass        =    1.000006 kg
Solution mass       =    1.000329 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         323 mg/kg sol'n
Rock mass           =    0.000055 kg
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Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	-0.2170	-3.9325

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted

e- -- sliding pe buffer --

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.069e-007	-6.390	9.498e-005	
Calcite	0.0005439	-3.264	0.05444	
Clausthalite	4.344e-009	-8.362	1.243e-006	
Cu2Se (alpha)	2.360e-009	-8.627	4.864e-007	
Gibbsite (C)	2.545e-007	-6.594	1.985e-005	
Greenockite	4.448e-010	-9.352	6.426e-008	
HgSe	1.704e-010	-9.768	4.764e-008	
MoS2	2.501e-008	-7.602	4.003e-006	
NiS (gamma)	1.411e-008	-7.850	1.281e-006	
NiSe	2.918e-009	-8.535	4.018e-007	
Spharelite	1.529e-007	-6.816	1.490e-005	
Uraninite	1.852e-008	-7.732	5.000e-006	
(total)			0.05458	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002637	160.9	0.9178	-2.6161
Ca++	0.001095	43.86	0.7096	-3.1097
Mg++	0.001075	26.12	0.7096	-3.1178
SO4--	0.0006400	61.46	0.7096	-3.3428
H2CO3* (aq)	0.0001032	6.397	1.0016	-3.9858
Na+	9.530e-005	2.190	0.9178	-4.0581
CaSO4 (aq)	6.568e-005	8.938	1.0016	-4.1819
MgSO4 (aq)	5.317e-005	6.398	1.0016	-4.2736
MgHCO3+	2.111e-005	1.801	0.9178	-4.7128
H4SiO4	1.763e-005	1.694	1.0016	-4.7531
CaHCO3+	1.620e-005	1.638	0.9178	-4.8276
K+	1.021e-005	0.3990	0.9178	-5.0283
CO3--	7.320e-006	0.4391	0.7096	-5.2845
Sr++	3.213e-006	0.2815	0.7096	-5.6421
MgCO3 (aq)	2.775e-006	0.2339	1.0016	-5.5560
CaCO3 (aq)	9.988e-007	0.09994	1.0016	-5.9998
Fe(OH)2+	8.815e-007	0.07919	0.9178	-6.0920
NaSO4-	2.311e-007	0.02750	0.9178	-6.6735
OH-	1.672e-007	0.002843	0.9178	-6.8139
Ba++	1.667e-007	0.02289	0.7096	-6.9270
SrSO4 (aq)	1.636e-007	0.03003	1.0016	-6.7856
NaHCO3 (aq)	1.433e-007	0.01204	1.0016	-6.8430
H3SiO4-	5.582e-008	0.005307	0.9178	-7.2905
SrHCO3+	4.290e-008	0.006374	0.9178	-7.4048
KSO4-	2.241e-008	0.003028	0.9178	-7.6868
NaCO3-	1.663e-008	0.001380	0.9178	-7.8163
Mg2CO3++	1.656e-008	0.001798	0.7096	-7.9300
MgOH+	1.641e-008	0.0006776	0.9178	-7.8223
Mn++	1.445e-008	0.0007936	0.7096	-7.9891
H+	1.416e-008	1.427e-005	0.9178	-7.8862
Fe(OH)3 (aq)	1.174e-008	0.001254	1.0016	-7.9296

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	15.8313s/sat	Al(OH)3 (Soil)	-0.5500
Maghemite	9.6523s/sat	Vaterite	-0.6232
Magnesioferrite	8.3194s/sat	Kaolinite	-0.6799
Goethite	6.7649s/sat	Magnesite	-0.6903
Lepidocrocite	6.6481s/sat	Dolomite (disord	-0.8410
Ferrihydrite (ag	5.3291s/sat	Chalcedony	-0.9548

Ferrihydrite	3.5543s/sat	Boehmite	-0.9979
Cuprous Ferrite	3.1399s/sat	Cristobalite	-1.1510
CdSe	1.4643s/sat	SbO2	-1.1824
CuSe	1.0734s/sat	CaCO3xH2O	-1.3283
Diaspore	0.8916s/sat	ZnSe	-1.4566
Gibbsite (C)	0.0000 sat	K-Jarosite	-1.5977
Barite	0.0000 sat	Strontianite	-1.6692
Calcite	0.0000 sat	NiS (beta)	-1.7000
Spharelite	0.0000 sat	SiO2 (am,ppt)	-1.8222
NiSe	0.0000 sat	Gypsum	-1.8300
Clausthalite	0.0000 sat	SiO2 (am,gel)	-1.8666
Uraninite	0.0000 sat	Imogolite	-2.0664
NiS (gamma)	0.0000 sat	Anhydrite	-2.1832
MoS2	0.0000 sat	Cinnabar	-2.2372
Cu2Se (alpha)	0.0000 sat	Rhodochrosite	-2.2973
HgSe	0.0000 sat	Wurtzite	-2.3112
Greenockite	0.0000 sat	Celestite	-2.3397
Aragonite	-0.1592	Metacinnabar	-2.6342
Dolomite (ordere	-0.2040	MnCO3 (am)	-2.7737
Quartz	-0.4713		

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.001608	-2.794
H2S (g)	4.820e-009	-8.317
CH4 (g)	3.964e-009	-8.402
Hg (g)	7.076e-013	-12.150
H2Se (g)	2.886e-017	-16.540
Hg2 (g)	1.214e-025	-24.916
Hg(CH3)2 (g)	1.044e-060	-59.981
O2 (g)	3.340e-075	-74.476

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
Al+++	2.59e-007	4.96e-009	0.000134			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00279	167.			
Ca++	0.00172	0.00118	47.2			
Cd++	4.45e-010	1.46e-014	1.64e-009			
Cu++	4.72e-009	3.59e-022	2.28e-017			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	-8.56e+003	-8.56e+003	-8.63e+006			
H2O	4.34e+003	4.34e+003	7.81e+007			
H4SiO4	1.77e-005	1.77e-005	1.70			
Hg(OH)2	1.70e-010	6.93e-014	1.63e-008			
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00115	0.00115	28.0			
Mn+++	1.82e-008	1.82e-008	0.00100			
MoO4--	2.50e-008	3.48e-019	5.56e-014			
Na+	9.57e-005	9.57e-005	2.20			
Ni++	1.70e-008	1.28e-012	7.52e-008			
O2(aq)	-2.14e+003	-2.14e+003	-6.85e+007			
Pb++	4.34e-009	1.85e-022	3.83e-017			
SO4--	0.000760	0.000759	72.9			
Sb(OH)6-	2.23e-009	2.23e-009	0.000500			
SeO4--	9.79e-009	4.14e-014	5.91e-009			
Sr++	3.42e-006	3.42e-006	0.300			
UO2++	1.85e-008	2.87e-014	7.75e-009			
Zn++	1.53e-007	4.42e-011	2.89e-006			

Elemental composition	total moles	In fluid moles	In fluid mg/kg	Sorbed moles	Sorbed mg/kg
Al	2.594e-007	4.961e-009	0.0001338		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.756e-007	0.02411		
C	0.003333	0.002789	33.49		
Ca	0.001722	0.001178	47.18		
Cd	4.448e-010	1.456e-014	1.637e-009		
Cu	4.721e-009	3.589e-022	2.280e-017		
Fe	8.953e-007	8.953e-007	0.04998		
H	111.0	111.0	1.119e+005		
Hg	1.705e-010	6.931e-014	1.390e-008		
K	1.023e-005	1.023e-005	0.3999		
Mg	0.001152	0.001152	27.99		
Mn	1.820e-008	1.820e-008	0.0009997		
Mo	2.501e-008	3.477e-019	3.335e-014		
Na	9.569e-005	9.569e-005	2.199		
Ni	1.703e-008	1.282e-012	7.523e-008		
O	55.52	55.52	8.880e+005		
Pb	4.344e-009	1.850e-022	3.832e-017		
S	0.0007599	0.0007593	24.34		
Sb	2.234e-009	2.234e-009	0.0002719		
Se	9.793e-009	4.135e-014	3.264e-009		
Si	1.769e-005	1.769e-005	0.4966		
Sr	3.424e-006	3.424e-006	0.2999		
U	1.852e-008	2.872e-014	6.834e-009		
Zn	1.530e-007	4.419e-011	2.888e-006		

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Step #   470             Xi = 0.9400
Temperature =   5.0 C    Pressure =  0.938 bars
pH =  8.160
Eh =  -0.2627 volts      pe =  -4.7595
Ionic strength      =    0.005891
Activity of water   =    0.999916
Solvent mass        =    1.000010 kg
Solution mass       =    1.000281 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         271 mg/kg sol'n
Rock mass           =    0.000102 kg
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Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	-0.2627	-4.7595

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.068e-007	-6.391	9.495e-005	
Calcite	0.0009768	-3.010	0.09776	
Clausthalite	4.344e-009	-8.362	1.243e-006	
Cu2Se (alpha)	2.360e-009	-8.627	4.864e-007	
Dolomite (ordere	2.471e-005	-4.607	0.004557	
Gibbsite (C)	2.503e-007	-6.601	1.953e-005	
Greenockite	4.435e-010	-9.353	6.407e-008	
HgSe	1.705e-010	-9.768	4.766e-008	
MoS2	2.501e-008	-7.602	4.003e-006	

NiS (gamma)	1.468e-008	-7.833	1.332e-006	
NiSe	2.356e-009	-8.628	3.244e-007	
Spharelite	1.530e-007	-6.815	1.490e-005	
Uraninite	1.852e-008	-7.732	5.000e-006	
(total)			0.1025	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.002217	135.2	0.9238	-2.6887
Mg++	0.001053	25.58	0.7284	-3.1154
Ca++	0.0006703	26.86	0.7284	-3.3113
SO4--	0.0006068	58.27	0.7284	-3.3546
Na+	9.532e-005	2.191	0.9238	-4.0552
HS-	5.368e-005	1.775	0.9238	-4.3046
MgSO4 (aq)	5.204e-005	6.263	1.0014	-4.2831
H2CO3* (aq)	4.644e-005	2.879	1.0014	-4.3325
CaSO4 (aq)	4.019e-005	5.469	1.0014	-4.3953
MgHCO3+	1.784e-005	1.522	0.9238	-4.7830
H4SiO4	1.758e-005	1.689	1.0014	-4.7544
CO3--	1.134e-005	0.6806	0.7284	-5.0828
K+	1.021e-005	0.3990	0.9238	-5.0255
CaHCO3+	8.562e-006	0.8653	0.9238	-5.1018
H2S (aq)	6.163e-006	0.2100	1.0014	-5.2096
MgCO3 (aq)	4.441e-006	0.3743	1.0014	-5.3520
Sr++	3.216e-006	0.2817	0.7284	-5.6303
CaCO3 (aq)	9.991e-007	0.09997	1.0014	-5.9998
Fe(OH)2+	8.666e-007	0.07785	0.9238	-6.0966
OH-	3.124e-007	0.005312	0.9238	-6.5397
NaSO4-	2.249e-007	0.02677	0.9238	-6.6824
Ba++	1.669e-007	0.02292	0.7284	-6.9152
SrSO4 (aq)	1.636e-007	0.03004	1.0014	-6.7856
NaHCO3 (aq)	1.221e-007	0.01026	1.0014	-6.9126
H3SiO4-	1.040e-007	0.009885	0.9238	-7.0175
SrHCO3+	3.705e-008	0.005506	0.9238	-7.4656
MgOH+	3.081e-008	0.001273	0.9238	-7.5457
NaCO3-	2.647e-008	0.002196	0.9238	-7.6117
Mg2CO3++	2.594e-008	0.002817	0.7284	-7.7236
Fe(OH)3 (aq)	2.185e-008	0.002335	1.0014	-7.6599
KSO4-	2.181e-008	0.002947	0.9238	-7.6958
MnHS+	1.451e-008	0.001277	0.9238	-7.8727

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	16.3706s/sat	Quartz	-0.4726
Maghemite	10.1916s/sat	Magnesite	-0.4863
Magnesioferrite	9.4095s/sat	Al(OH)3 (Soil)	-0.5500
Goethite	7.0346s/sat	Vaterite	-0.6232
Lepidocrocite	6.9178s/sat	Dolomite (disord	-0.6370
Ferrihydrite (ag	5.5987s/sat	Kaolinite	-0.6825
Ferrihydrite	3.8239s/sat	Chalcedony	-0.9561
CuSe	2.4516s/sat	Boehmite	-0.9979
Cuprous Ferrite	1.4786s/sat	Cristobalite	-1.1523
CdSe	1.4643s/sat	CaCO3xH2O	-1.3283
Diaspore	0.8916s/sat	Strontianite	-1.4557
Calcite	0.0000 sat	ZnSe	-1.4566
NiSe	0.0000 sat	K-Jarosite	-1.6321
Barite	0.0000 sat	NiS (beta)	-1.7000
Uraninite	0.0000 sat	SiO2 (am,ppt)	-1.8235
Spharelite	0.0000 sat	SiO2 (am,gel)	-1.8679
NiS (gamma)	0.0000 sat	Gypsum	-2.0434

Greenockite	0.0000 sat	Imogolite	-2.0677
Cu2Se (alpha)	0.0000 sat	Cinnabar	-2.2372
MoS2	0.0000 sat	Wurtzite	-2.3112
Dolomite (ordere	0.0000 sat	Celestite	-2.3397
Clausthalite	0.0000 sat	Anhydrite	-2.3966
Gibbsite (C)	0.0000 sat	Metacinnabar	-2.6342
HgSe	0.0000 sat	Se metal (hex,bl	-2.7344
Aragonite	-0.1592	Rhodochrosite	-2.8146

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CO2 (g)	0.0007235	-3.141
CH4 (g)	4.716e-005	-4.326
H2S (g)	3.508e-005	-4.455
H2Se (g)	2.100e-013	-12.678
Hg (g)	1.240e-015	-14.907
Hg2 (g)	3.727e-031	-30.429
Hg(CH3)2 (g)	2.031e-056	-55.692
O2 (g)	2.054e-077	-76.687

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
Al+++	2.59e-007	9.11e-009	0.000246			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.76e-007	0.0241			
CO3--	0.00333	0.00231	138.			
Ca++	0.00172	0.000720	28.9			
Cd++	4.45e-010	1.36e-012	1.53e-007			
Cu++	4.72e-009	2.22e-024	1.41e-019			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	-5.75e+004	-5.75e+004	-5.79e+007			
H2O	2.88e+004	2.88e+004	5.19e+008			
H4SiO4	1.77e-005	1.77e-005	1.70			
Hg(OH)2	1.70e-010	1.39e-016	3.26e-011			
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00115	0.00113	27.4			
Mn+++	1.82e-008	1.82e-008	0.00100			
MoO4--	2.50e-008	1.73e-027	2.76e-022			
Na+	9.57e-005	9.57e-005	2.20			
Ni++	1.70e-008	4.92e-016	2.89e-011			
O2(aq)	-1.44e+004	-1.44e+004	-4.60e+008			
Pb++	4.34e-009	1.50e-021	3.11e-016			
SO4--	0.000760	0.000759	72.9			
Sb(OH)6-	2.23e-009	2.23e-009	0.000500			
SeO4--	9.79e-009	5.62e-010	8.03e-005			
Sr++	3.42e-006	3.42e-006	0.300			
UO2++	1.85e-008	2.08e-014	5.61e-009			
Zn++	1.53e-007	2.37e-013	1.55e-008			

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	9.112e-009	0.0002458		
As	2.160e-009	2.160e-009	0.0001617		
Ba	5.825e-007	1.757e-007	0.02412		
C	0.003333	0.002307	27.70		
Ca	0.001722	0.0007201	28.85		
Cd	4.448e-010	1.360e-012	1.528e-007		
Cu	4.721e-009	2.223e-024	1.412e-019		
Fe	8.953e-007	8.953e-007	0.04999		
H	111.0	111.0	1.119e+005		

Hg	1.705e-010	1.390e-016	2.788e-011
K	1.023e-005	1.023e-005	0.3999
Mg	0.001152	0.001127	27.39
Mn	1.820e-008	1.820e-008	0.0009997
Mo	2.501e-008	1.727e-027	1.656e-022
Na	9.569e-005	9.569e-005	2.199
Ni	1.703e-008	4.916e-016	2.885e-011
O	55.52	55.52	8.880e+005
Pb	4.344e-009	1.502e-021	3.111e-016
S	0.0007599	0.0007593	24.34
Sb	2.234e-009	2.234e-009	0.0002719
Se	9.793e-009	5.622e-010	4.438e-005
Si	1.769e-005	1.769e-005	0.4966
Sr	3.424e-006	3.424e-006	0.2999
U	1.852e-008	2.077e-014	4.942e-009
Zn	1.530e-007	2.372e-013	1.550e-008

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Step #   500              Xi = 1.0000
Temperature =   5.0 C     Pressure =  0.938 bars
pH =  9.189
Eh =  -0.3311 volts       pe =  -6.0000
Ionic strength      =    0.002452
Activity of water   =    0.999964
Solvent mass        =    1.000022 kg
Solution mass       =    1.000151 kg
Solution density    =    1.026    g/cm3
Chlorinity          =    0.000000 molal
Dissolved solids    =         129 mg/kg sol'n
Rock mass           =    0.000232 kg
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Nernst redox couples	Eh (volts)	pe
e- + .25*O2(aq) + H+ = .5*H2O	-0.3311	-6.0000

Reactants	moles remaining	moles reacted	grams reacted	cm3 reacted
e-	-- sliding pe buffer --			

Minerals in system	moles	log moles	grams	volume (cm3)
Barite	4.121e-007	-6.385	9.617e-005	
Calcite	0.0006618	-3.179	0.06624	
Clausthalite	4.344e-009	-8.362	1.243e-006	
Cu2Se (alpha)	2.360e-009	-8.627	4.864e-007	
Dolomite (ordere	0.0009000	-3.046	0.1660	
Gibbsite (C)	1.661e-007	-6.780	1.296e-005	
Greenockite	4.443e-010	-9.352	6.418e-008	
HgSe	1.705e-010	-9.768	4.766e-008	
MoS2	2.501e-008	-7.602	4.003e-006	
NiS (gamma)	1.648e-008	-7.783	1.496e-006	
NiSe	5.505e-010	-9.259	7.579e-008	
Spharelite	1.530e-007	-6.815	1.490e-005	
Uraninite	1.852e-008	-7.732	5.000e-006	
(total)			0.2323	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
HCO3-	0.0008200	50.03	0.9484	-3.1092
SO4--	0.0005090	48.89	0.8092	-3.3852
Mg++	0.0002336	5.679	0.8092	-3.7235

HS-	0.0002261	7.477	0.9484	-3.6687
Ca++	0.0001488	5.962	0.8092	-3.9194
Na+	9.533e-005	2.191	0.9484	-4.0438
CO3--	4.142e-005	2.485	0.8092	-4.4748
H4SiO4	1.666e-005	1.601	1.0006	-4.7781
MgSO4 (aq)	1.197e-005	1.440	1.0006	-4.9218
K+	1.021e-005	0.3991	0.9484	-5.0140
CaSO4 (aq)	9.241e-006	1.258	1.0006	-5.0341
MgCO3 (aq)	4.444e-006	0.3747	1.0006	-5.3520
OH-	3.250e-006	0.05527	0.9484	-5.5111
Sr++	3.209e-006	0.2811	0.8092	-5.5856
H2S (aq)	2.497e-006	0.08509	1.0006	-5.6023
H2CO3* (aq)	1.652e-006	0.1025	1.0006	-5.7816
MgHCO3+	1.627e-006	0.1388	0.9484	-5.8116
H3SiO4-	1.024e-006	0.09739	0.9484	-6.0126
CaCO3 (aq)	9.999e-007	0.1001	1.0006	-5.9998
CaHCO3+	7.808e-007	0.07893	0.9484	-6.1304
Fe(OH)2+	4.119e-007	0.03701	0.9484	-6.4082
Fe(OH)4-	3.694e-007	0.04576	0.9484	-6.4554
NaSO4-	2.096e-007	0.02495	0.9484	-6.7016
SrSO4 (aq)	1.691e-007	0.03106	1.0006	-6.7716
Ba++	1.612e-007	0.02214	0.8092	-6.8845
Fe(OH)3 (aq)	1.140e-007	0.01218	1.0006	-6.9429
NaCO3-	1.074e-007	0.008909	0.9484	-6.9922
Al(OH)4-	9.319e-008	0.008853	0.9484	-7.0536
MgOH+	7.904e-008	0.003265	0.9484	-7.1251
NaHCO3 (aq)	4.765e-008	0.004003	1.0006	-7.3217
SrCO3 (aq)	3.054e-008	0.004508	1.0006	-7.5149
KSO4-	2.033e-008	0.002747	0.9484	-7.7149
MnHS+	1.661e-008	0.001462	0.9484	-7.8026
SrHCO3+	1.519e-008	0.002258	0.9484	-7.8414

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
Hematite	17.8045s/sat	Magnesite	-0.4863
Magnesioferrite	12.2925s/sat	Quartz	-0.4964
Maghemite	11.6254s/sat	Al(OH)3 (Soil)	-0.5500
Goethite	7.7515s/sat	Vaterite	-0.6232
Lepidocrocite	7.6347s/sat	Dolomite (disord	-0.6370
Ferrihydrite (ag	6.3157s/sat	Kaolinite	-0.7300
Ferrihydrite	4.5409s/sat	Strontianite	-0.8030
Cuprous Ferrite	2.3919s/sat	Chalcedony	-0.9799
CuSe	2.0434s/sat	Boehmite	-0.9979
CdSe	1.4643s/sat	Cristobalite	-1.1760
Diaspore	0.8916s/sat	CaCO3xH2O	-1.3283
NiS (gamma)	0.0000 sat	ZnSe	-1.4566
Dolomite (ordere	0.0000 sat	NiS (beta)	-1.7000
HgSe	0.0000 sat	SiO2 (am,ppt)	-1.8472
Greenockite	0.0000 sat	SiO2 (am,gel)	-1.8917
Uraninite	0.0000 sat	Imogolite	-2.0915
MoS2	0.0000 sat	Sepiolite	-2.2223
Gibbsite (C)	0.0000 sat	Cinnabar	-2.2372
Barite	0.0000 sat	Wurtzite	-2.3112
Spharelite	0.0000 sat	Celestite	-2.3256
Calcite	0.0000 sat	K-Jarosite	-2.6168
Clausthalite	0.0000 sat	Metacinnabar	-2.6342
NiSe	0.0000 sat	Gypsum	-2.6821
Cu2Se (alpha)	0.0000 sat	Witherite	-2.7641
Aragonite	-0.1592	Rhodochrosite	-2.7724
Chrysotile	-0.2617		

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
CH4 (g)	8.311e-005	-4.080
CO2 (g)	2.572e-005	-4.590
H2S (g)	1.420e-005	-4.848
H2Se (g)	8.503e-014	-13.070
Hg (g)	8.125e-015	-14.090
Hg2 (g)	1.601e-029	-28.796
Hg(CH3)2 (g)	1.558e-055	-54.808
O2 (g)	2.918e-078	-77.535

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
Al+++	2.59e-007	9.33e-008	0.00252			
AsO4---	2.16e-009	2.16e-009	0.000300			
Ba++	5.82e-007	1.70e-007	0.0234			
CO3--	0.00333	0.000871	52.3			
Ca++	0.00172	0.000160	6.40			
Cd++	4.45e-010	5.57e-013	6.26e-008			
Cu++	4.72e-009	3.19e-025	2.02e-020			
Fe+++	8.95e-007	8.95e-007	0.0500			
H+	-1.00e+006	-1.00e+006	-1.01e+009			
H2O	5.00e+005	5.00e+005	9.01e+009			
H4SiO4	1.77e-005	1.77e-005	1.70			
Hg(OH)2	1.70e-010	1.04e-015	2.44e-010			
K+	1.02e-005	1.02e-005	0.400			
Mg++	0.00115	0.000252	6.12			
Mn+++	1.82e-008	1.82e-008	0.00100			
MoO4--	2.50e-008	2.95e-025	4.72e-020			
Na+	9.57e-005	9.57e-005	2.20			
Ni++	1.70e-008	4.18e-017	2.46e-012			
O2(aq)	-2.50e+005	-2.50e+005	-8.00e+009			
Pb++	4.34e-009	6.11e-022	1.27e-016			
SO4--	0.000760	0.000759	72.9			
Sb(OH)6-	2.23e-009	2.23e-009	0.000500			
SeO4--	9.79e-009	2.37e-009	0.000338			
Sr++	3.42e-006	3.42e-006	0.300			
UO2++	1.85e-008	2.05e-014	5.53e-009			
Zn++	1.53e-007	2.36e-013	1.54e-008			

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Al	2.594e-007	9.334e-008	0.002518		
As	2.160e-009	2.160e-009	0.0001618		
Ba	5.825e-007	1.704e-007	0.02340		
C	0.003333	0.0008711	10.46		
Ca	0.001722	0.0001598	6.404		
Cd	4.448e-010	5.568e-013	6.258e-008		
Cu	4.721e-009	3.186e-025	2.024e-020		
Fe	8.953e-007	8.953e-007	0.04999		
H	111.0	111.0	1.119e+005		
Hg	1.705e-010	1.040e-015	2.087e-010		
K	1.023e-005	1.023e-005	0.3999		
Mg	0.001152	0.0002517	6.119		
Mn	1.820e-008	1.820e-008	0.0009998		
Mo	2.501e-008	2.954e-025	2.834e-020		
Na	9.569e-005	9.569e-005	2.200		
Ni	1.703e-008	4.185e-017	2.456e-012		
O	55.52	55.51	8.881e+005		
Pb	4.344e-009	6.107e-022	1.265e-016		

	React_output_Eh	slide6_final	
S	0.0007599	0.0007593	24.34
Sb	2.234e-009	2.234e-009	0.0002720
Se	9.793e-009	2.368e-009	0.0001869
Si	1.769e-005	1.769e-005	0.4967
Sr	3.424e-006	3.424e-006	0.3000
U	1.852e-008	2.049e-014	4.875e-009
Zn	1.530e-007	2.361e-013	1.543e-008

APPENDIX B

Results of Additional Groundwater Flow Modelling, Prairie Creek Mine, NWT

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February 18, 2011
RGC Project No: 148002/2

Canadian Zinc Corporation

Suite 1710 – 650 West Georgia Street
Vancouver, B.C.
V6B 4N9

Attention: Dave Harpley

RE: REV 0 - Results of Additional Groundwater Flow Modeling, Prairie Creek Mine, NWT

Dave,

This letter report summarizes the results of additional groundwater flow modeling completed for the Prairie Creek Mine site in support of a DAR application by Canadian Zinc Corporation (CZN) to the Mackenzie Valley Review Board.

This letter report should be read in conjunction with the Site Hydrogeology Report for the Prairie Creek Mine site (RGC, 2010a)[1] which describes the conceptual and numerical groundwater flow model and an earlier letter report (RGC, 2010b)[2] which describes preliminary transient calibration results.

1 Background and Scope of Work

A groundwater model was developed for the Prairie Creek Mine site to assess groundwater flow at the mine site for past, current and future conditions. During the initial phase of this study groundwater flow was simulated assuming steady-state conditions. These steady-state modeling runs provided initial estimates of (mean annual)

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[1] Robertson GeoConsultants Inc. (2010a) "Site Hydrogeology Report" RGC Report 148002/1 prepared for Canadian Zinc Corporation, February 2010.

[2] Robertson GeoConsultants Inc. (2010b) "REV 0 - ADDENDUM to Site Hydrogeology Report - Results of Transient Groundwater Modeling, Prairie Creek Mine, NWT" RGC Letter Report prepared for Canadian Zinc Corporation, March 17, 2010.

groundwater flow at the site for pre-mining, pre-decline development, current mine development, end-of-mining and post-closure (RGC, 2010a).

The scope of the initial groundwater flow modeling for the DAR submission was subsequently extended to include transient modeling of groundwater flow (RGC, 2010b). A first transient calibration of the flow model was completed in March 2010 using the seasonal variations of outflow from the 870 tunnel as primary calibration targets. Once calibrated, this transient flow model was used to provide estimates of seasonal dewatering rates during active mining and seasonal groundwater flow after closure of the mine (RGC, 2010b).

In the second round of information requests, INAC raised several questions related to the modeling assumptions & predictions and requested upper and lower bounds on predicted mine inflows. Additional modeling runs have since been completed to address some of these questions and are summarized in the following sections.

2 Sensitivity Analysis using Transient Model

2.1 Scope of Sensitivity Analysis

Four additional transient model runs were completed for current conditions to determine the sensitivity of simulated mine outflow from 870 Portal to a range of hydraulic parameters. Table 1 shows the hydraulic parameters used in these four sensitivity runs. The hydraulic parameters determined during initial model calibration (in March 2010) are also shown for ease of reference (model run “NM10tr”). The hydraulic parameters which were changed with respect to the calibrated model are highlighted in the table.

Specific yield was assumed to be constant at 1.0 % for the fault and 0.1 % for bedrock. A value of 43.2 1/d was used as transfer rate for the fault and 2.59x10-2 1/d for bedrock. Recharge was applied on two zones with a time varying cyclical function. Yearly recharge over the mine foot print was 200 mm/year, and 100 mm/year for the remaining areas. The transient model was run for five consecutive years to allow equilibration with the transient recharge conditions (see RGC, 2010b for more details).

2.2 Results

Figure 1 shows the simulated seasonal inflow to the current mine workings for the four sensitivity runs. The simulated flows for the initial calibration run (NM10Tr) and the observed seasonal outflow from the 870 Portal are also shown for comparison. Table 2 summarizes the simulated minimum (winter) and maximum (summer) fluxes to the current mine workings for the different sensitivity runs.

Figure 2 shows the simulated groundwater discharge to the Harrison Creek alluvial aquifer via the MQV fault zone. Table 3 summarizes minimum (winter) and maximum (summer) flows from the MQV into Harrison Creek. Note that earlier load calculations (using zinc loading) had suggested a groundwater discharge from the MQV into Harrison Creek of about 1.7 L/s (RGC, 2010c)[3].

The following conclusions can be drawn from these additional sensitivity runs:

- All of the sensitivity runs over-predicted the observed minimum (winter) inflows to the mine workings (by 1.5-2.5 L/s);
- All of the sensitivity runs matched the observed maximum (summer) inflows to the mine workings reasonably well considering the uncertainty in simulated summer flows (note: oscillation in summer flows suggested some numerical instability);
- The calibration run (NMtr10) and sensitivity run 1 (high K fault) best reproduced the rapid decline in the observed inflow to the mine workings after spring/summer runoff period suggesting that groundwater inflow is dominated by direct recharge to the fault zone;
- Groundwater discharge from the MQV into the Harrison Creek alluvial aquifer is almost directly proportional to the assumed K in the MQV (and Vein Fault) but less sensitive to the assumed bedrock K; the MQV discharge predicted for the two low-K fault scenarios (w/ $K=1*10^{-5}$ m/s) is considered more realistic (see section 3 below).

In summary, the additional sensitivity runs demonstrate that there is some remaining uncertainty in the actual hydraulic parameters of the Vein Fault and the bedrock because the main target for transient calibration (mine inflow to current mine workings, i.e. 870 Portal outflow) is not very sensitive to the hydraulic parameters (within the range of K and S varied).

Groundwater discharge from the MQV into Harrison Creek is better suited for calibration of the fault K. However, groundwater discharge via the MQV cannot be measured directly and has to be estimated using loading calculations which carry some uncertainty (see Section 3 below).

[3] Robertson GeoConsultants Inc. (2010c) “REV 1 – Load balance calculations for Mine Water and Surface Water, Prairie Creek Mine, NWT”, Letter Report prepared for Canadian Zinc Corporation, March 17, 2010.

It is concluded that the hydraulic parameters obtained during initial calibration (NM10Tr) should be retained as best estimates. However, the range of hydraulic parameters assumed in the four sensitivity runs is plausible and should be used for estimating “high flow scenarios” for active mining.

3 Additional Sensitivity Analysis for Active Mining

According to our conceptual model of the site hydrogeology, the highly-permeable Vein Fault extends into the Harrison Creek valley but does not intersect the Prairie Creek valley. Consequently, the more permeable “fault zone” unit introduced into the numerical model does not intersect the southern model boundary representing the Prairie Creek Alluvial Aquifer, PCAA (RGC, 2010a).

On the request of INAC, additional sensitivity runs were completed using the steady state model to assess the sensitivity of mine inflow during active mining (see section 4.4.1 in RGC, 2010a for details) on the southern extent of the permeable Vein Fault.

For the purpose of this sensitivity analysis, the permeable “fault zone” was extended to the southern model boundary representing the PCAA (see right panel in Figure 3). Two different scenarios were run with this extended fault zone:

- HCAA supplying recharge to bedrock aquifer (spring/summer runoff conditions)
- HCAA not supplying recharge to bedrock aquifer (winter baseflow conditions)

Note that aerial recharge (from precipitation) was also “turned off” for the winter scenario. This winter scenario is considered a worst-case scenario with respect to seepage from PCAA towards the mine workings. In other words, this scenario would produce the highest likely seepage from the PCAA to the mine workings. These sensitivity runs were completed for both the “low flow” scenario (Run “AM13” w/ fault K =1x10-5 m/s) and the “high flow” scenario (Run “AM21” w/ K=1x10-4 m/s).

Table 4 compares the simulated total inflow to the mine workings and the simulated contribution (or “seepage”) from the Prairie Creek Alluvial Aquifer for the four sensitivity scenarios. The original estimates of these flows (assuming no extension of the Vein fault to PCAA) are also shown for ease of comparison.

During spring runoff/summer conditions when flow in HCAA is providing adequate recharge to the bedrock aquifer, the vast majority of inflow to the mine workings is still provided from the HCAA. Assuming the Vein Fault extends into Prairie Creek valley the additional seepage from PCAA contributing to mine inflow is predicted to range from 1.7 to 13.3 L/s, i.e. representing only about 5-6% of the total mine inflow.

During winter conditions, when Harrison Creek is frozen and recharge from the HCAA is assumed to be negligible, seepage from the PCAA would represent the main source of recharge to the active mine workings (assuming, of course, that the Vein Fault intersects the PCAA). Under those conditions, seepage from the PCAA could range from 9-90 L/s, depending on the effective permeability of the Vein Fault potentially connecting the mine workings to the PCAA (see AM13a runs in Table 4).

4 Updated Estimates Of Seasonal Mine Inflow (Active Mining)

In our response to the first round of Information Requests (submitted September 6, 2010 to CZN) we provided initial estimates of seasonal inflow to the active mine workings (see Table 6 of the September 6 letter report). These initial estimates did not take into account the effects of limited recharge from HCAA during winter baseflow, nor did they take into account the potential for recharge from PCAA via a permeable fault zone.

Our sensitivity runs described in Section 2 of this letter report illustrate that the seasonal mine inflow rates are strongly dependent on the effective permeability of any fault structure connecting HCAA and/or PCAA with the existing and future mine workings.

As described in Section 2, the current outflow from the 870 Portal is not a good predictor of the effective permeability of the Vein fault. Instead, current zinc loading to HCAA provides a better estimate of the effective permeability of the Vein Fault (at least between the mine workings and HCAA).

Earlier mixing calculations using estimated sulphate and zinc loading in Harrison Creek (at HC-3) had suggested a seepage flow from the Vein Fault (with elevated SO_4 and zinc) of about 1.7 L/s for November 2009 (see Table 2-1a in RGC, 2010c). However, additional sampling performed at HC-3 in September 2010 showed much lower zinc concentrations (7 ug/L instead of 230 ug/L) suggesting no impact from Vein Fault flow with elevated zinc concentrations. No stream flow estimates were available to assess the influence of discharge on the observed (large) variation in surface water quality in Harrison Creek. Nevertheless, these variations highlight the uncertainty in estimating Vein Fault flow based on water quality in Harrison Creek.

An alternative method of estimating groundwater discharge from the Vein fault to HCAA is to estimate the zinc load in HCAA (upstream of the mill area where other sources of zinc may contribute to zinc loading). Zinc concentrations observed at MW09-14, screened in HCAA upstream of the mill, range from 58 to 105 ug/L with an average of 84 ug/L. Assuming these zinc concentrations are representative of the HCAA and further assuming a zinc concentration in the mineralized Vein fault of 2,120 ug/L (as observed at

MW09), the contribution of mineralized groundwater from the MQV to the HCAA is estimated to range from 2 to 4.5% of total flow in the HCAA. Using our estimates of groundwater in the HCAA (ranging from 5.0 to 16.5 L/s, see Table 4-4 in RGC, 2010a) the discharge of mineralized groundwater from the MQV to HCAA is estimated to range from 0.1 to 0.75 L/s. These zinc loading calculations are more consistent with the "low flow" scenario (i.e. Vein Fault K = $1*10^{-5}$ m/s) than the "high flow" scenario (Vein Fault K = $1*10^{-4}$ m/s).

Based on all available information to date, we conclude that the calibrated transient flow model (with a Vein fault K = $5*10^{-5}$ m/s) provides a reasonably conservative estimate of seasonal groundwater inflow to the active mine workings. The Vein fault K values assumed for the earlier steady-state simulations (i.e. Vein Fault K = $1*10^{-5}$ m/s for "low flow" and Vein fault K = $1*10^{-4}$ m/s for "high flow") provide reasonable upper and lower bounds for these mine inflow estimates.

Table 5 shows our updated best estimate of seasonal inflow to future mine workings. This best estimate uses the monthly inflows to the mine workings simulated with the calibrated transient model (with a fault K=$5*10^{-5}$ m/s) for the spring/summer high flow period when Harrison Creek provides adequate recharge to HCAA. During the winter months, the predicted inflows are reduced to take into account the freeze-up of Harrison Creek and the limited supply of recharge from HCAA.

5 Closure

We trust that the information provided in this memo meets your requirements.

Please contact the undersigned if you have any questions regarding the content of this report or require further information.

Best Regards,

ROBERTSON GEOCONSULTANTS INC.

ORIGINAL SIGNED

Dr. Christoph Wels, M.Sc., P.Geo.
Principal and Senior Hydrogeologist

6 References

Robertson GeoConsultants Inc. (2010), Site Hydrogeology Report, Prairie Creek Mine, Northwest Territories, February 2010.

Robertson GeoConsultants Inc. (2010b) “REV 0 - ADDENDUM to Site Hydrogeology Report - Results of Transient Groundwater Modeling, Prairie Creek Mine, NWT” RGC Letter Report prepared for Canadian Zinc Corporation, March 17, 2010.

Robertson GeoConsultants Inc. (2010c) “REV 1 – Load balance calculations for Mine Water and Surface Water, Prairie Creek Mine, NWT”, Letter Report prepared for Canadian Zinc Corporation, March 17, 2010.

Figures

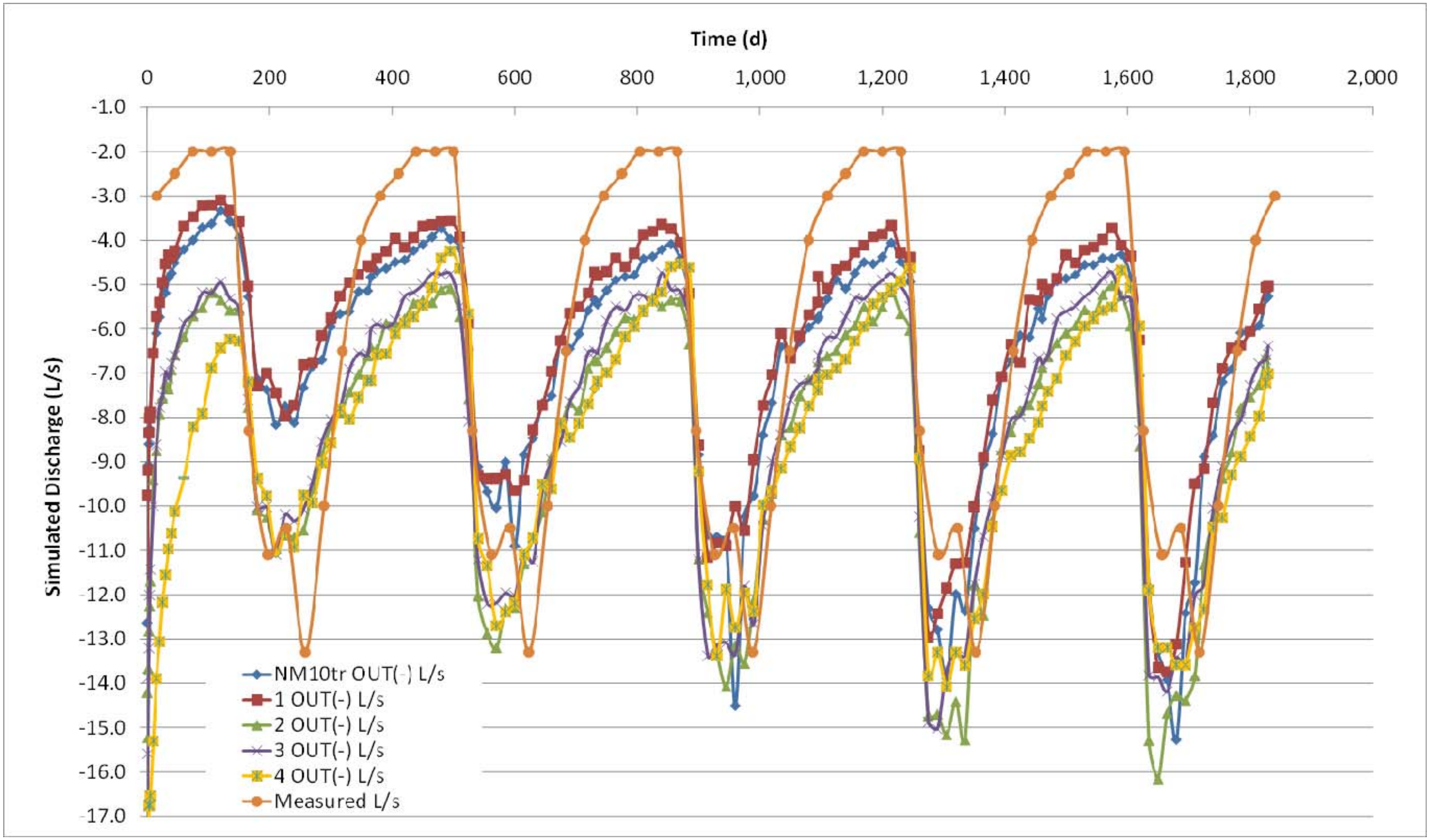

Figure 1. Simulated discharge to current mine workings (870 Portal).

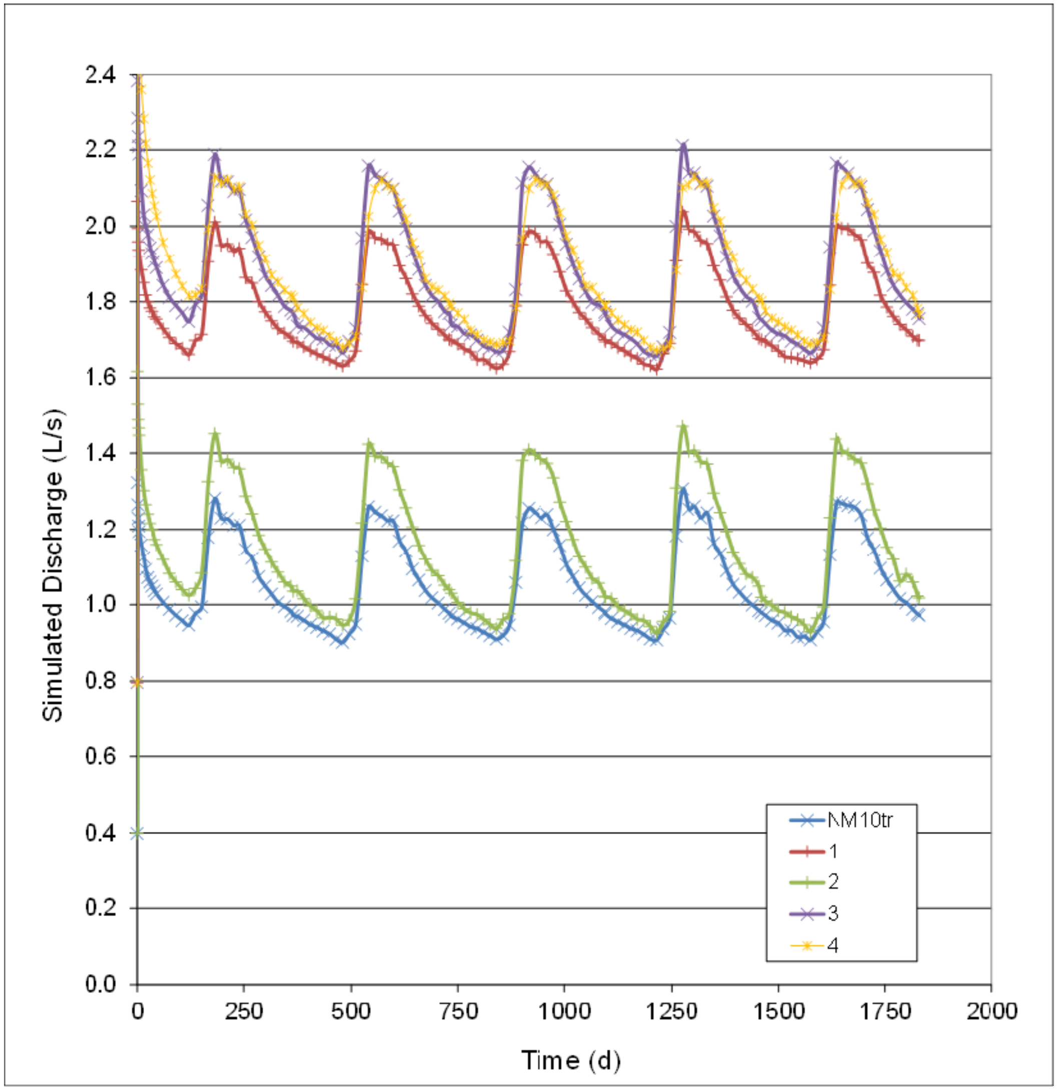

Figure 2. Simulated discharge to Harrison Creek via fault.

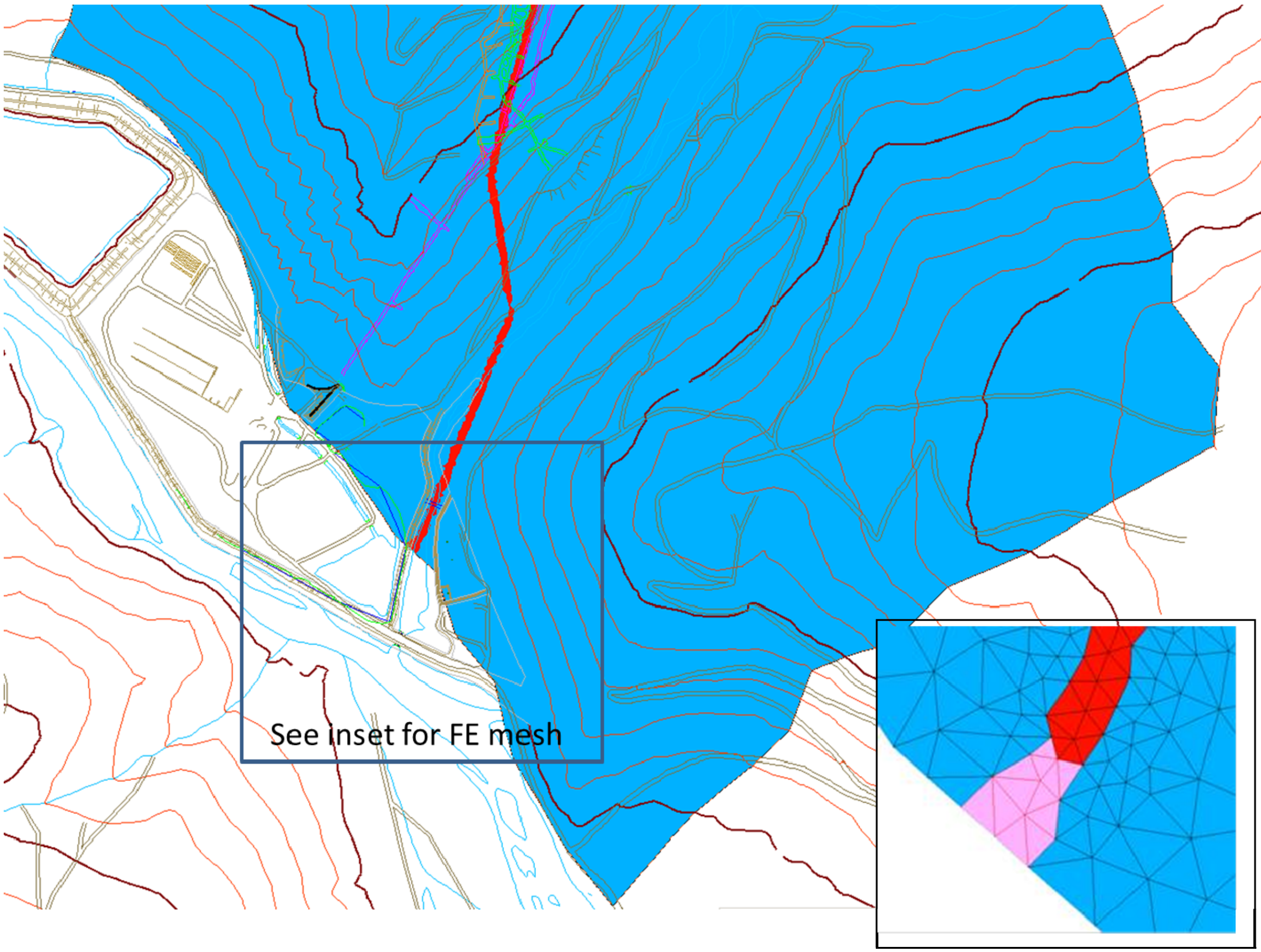

Figure 3. Extension of permeable Vein Fault unit to PCAA in FE mesh (red zone represents original extent and purple zone represents extension).

Tables

Table 1. Hydraulic Parameters for Sensitivity Analysis

No.	**Run**	Fault		Bedrock	
		K (m/s)	**Ss (1/m)**	**K (m/s)**	**Ss (1/m)**
0	NM10tr	5.0E-05	1.0E-06	3.0E-08	1.0E-07
1	CC1tr	**1.0E-04**	1.0E-06	3.0E-08	1.0E-07
2	CC2tr	5.0E-05	1.0E-06	**5.0E-08**	1.0E-07
3	CC3tr	**1.0E-04**	1.0E-06	**5.0E-08**	1.0E-07
4	CC4tr	**1.0E-04**	**1.0E-05**	**5.0E-08**	**1.0E-06**

Table 2. Total Flow to the Mine in L/s

No.	**Qmin**	**Qmax**	**Difference**
0	4.4	13.9	9.5
1	3.9	13.0	9.1
2	5.2	15.3	10.1
3	4.9	14.2	9.3
4	4.7	13.6	8.9
TARGET	**2.5**	**13.3**	**10.8**

Table 3. Total Flow to Harrison Creek via Fault in L/s

No.	Q out min	Q out max	Differenc e
0	0.9	1.4	0.5
1	1.7	2.0	0.3
2	0.9	1.4	0.5
3	1.7	2.2	0.5
4	1.7	2.1	0.4
TARGET	**1.0**	**2.0**	**1.0**

Table 4. Results of Sensitivity Analysis on Southern Extent of Permeable Vein Fault.

	Low Flow Scenario (Fault K=1E-5 m/s)			**High Flow Scenario (Fault K=1E-4 m/s)**		
Description	Low Flow Estimate (RGC, 2010a)	AM13 w/ Vein Fault extended to PCAA	AM13a w/o recharge from HCAA	Low Flow Estimate (RGC, 2010a)	AM13 w/ Vein Fault extended to PCAA	AM13a w/o recharge from HCAA
Run	AM13	AM13a		AM13	AM13a	
Mine Inflow (L/s)	28.8	28.9	18.3	205.1	206.2	105.4
Seepage from PCAA (L/s)	0.0	1.7	9.1	0.0	13.3	88.8

Table 5. Updated estimates of seasonal mine inflow during active mining. Also shown are estimated upper and lower bounds and their estimated likelihood of occurrence.

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.	Estimated Probability of Occurrence (%)
Low Estimate (K Fault =1E-5 m/s)	15	15	15	15	21	32	47	38	31	29	25	20	25.2	10%
Best Estimate (Nm15Tr w/ K Fault = 5E-5 m/s)	15	15	15	15	41.3	61.7	90.3	74.3	60.5	55.3	25	20	40.7	70%
High Estimate (K Fault =1E-4 m/s)	15	15	15	15	83	123	181	149	121	111	25	20	72.7	15%
High Estimate with Vein Fault-PCAA Connection	100	100	100	150	207	207	207	207	207	207	150	100	162	5%

(Yellow shading:) flow reduced to account for limited recharge of HCAA during winter freeze-up

APPENDIX C

Groundwater Quality Data

Exhibit 1a - Groundwater quality data, Prairie Creek mine, NWT

ID	DESCRIPTION/LOCATION	DATE	pH	EC	pH	EC	Alkalinity	Hardness	Ca	Mg	Na	K	HCO3	SO4	Cl	Al_f	Ag_f	As_f	Cd_f	Co_f	Cu_f	Fe_f	Hg_f	Mn_f	Ni_f	Pb_F	Sb_F	Se_F	Zn_F
				µS/cm		µS/cm	mg/L CaCO3	mg/L CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
MS-1	Mill weir	28-Sep-08	7.8	769	8.4	750	230	453	98	51	1	1	270	190	1	7	0.02	0.8	1.4	0.5	3.4	5	0.02	1	1	12.5	2.7	2.2	414
MS-1	Mill weir	30-Jul-09	-	-	8.3	727	220	411	91	45	1	1	260	170	1	3	0.02	0.7	1.1	0.5	2.6	5	0.02	1	1	9	2.8	1.9	317
MS-1	Mill weir	8-Jun-10	-	-	8.5	671	210	415	90	46	1	1	250	190	1	65	0.02	0.7	1.1	0.5	3.2	169	0.02	3	1	27.5	1.3	1.4	249
MS-1	Mill weir	9-Sep-10	-	-	8.0	712	210	412	86	48	1	1	250	170	0.5	4.0	0.02	0.7	1.3	0.5	3.8	5	0.02	1	1.0	10.3	3.1	2.1	405
MS-2	Mill pipe	28-Sep-08	7.8	754	8.3	760	230	446	96	50	1	1	280	200	1	14	0.02	1	1.4	0.5	4.0	10	0.02	1	1	15	3.7	2.1	316
MS-2	Mill pipe	7-Jul-09	-	-	8.2	670	-	376	80	43	1	1	-	-	-	10	0.02	0.4	0.9	0.5	2.1	10	0.02	1	1	10.4	1.2	1.6	213
MS-2	Mill pipe	8-Jun-10	-	-	8.5	647	210	388	84	44	2	1	240	170	1	7	0.02	0.6	1.1	0.5	3.2	11	0.02	1	1	9.8	2.4	1.3	333
MS-2	Mill pipe	9-Sep-10	-	-	8.1	718	210	402	85	46	2	0.8	250	170	0.5	15.0	0.02	0.6	1.0	0.5	2.8	5	0.02	1	2.0	9.1	2.1	2.0	284
MS-3	Camp ditch	30-Jul-09	-	-	8.4	1140	300	704	147	82	9	1	340	370	2	3	0.02	0.5	0.1	0.5	0.7	6	0.02	17	13	2.2	61.1	5.3	307
MS-3	Camp ditch	8-Jun-10	-	-	8.3	642	220	404	93	42	4	1	270	140	1	774	0.02	5.4	2.7	0.5	19.4	1120	0.02	18	5	207	12.6	1.5	667
MS-3	Camp ditch	9-Sep-10	-	-	7.9	717	280	395	85	45	3	1	330	130	0.5	10.0	0.02	0.7	0.5	0.5	4.1	28	0.02	6	2.0	16.3	3.8	2.2	137
MS-4	Mill culvert	7-Jul-09	-	-	8.2	670	-	386	83	44	1	1	-	-	-	26	0.02	1.0	1.4	0.5	5.4	262	0.02	4	1	24.2	2.5	1.5	275
PW-1	Pumping well	1-Oct-08	7.4	813	8.2	810	310	502	108	56	4	1	370	150	1	6	0.02	2.3	0.1	0.5	0.8	29	0.02	6	2	0.2	0.5	3.0	20
PW-1	Pumping well	30-Jul-09	-	-	8.1	875	300	501	112	54	5	1	370	170	1	3	0.02	2.2	0.0	0.5	0.2	137	0.02	23	2	0.3	0.5	1.9	21
PW-1	Pumping well	8-Jul-10	7.3	754	8.0	959	310	563	119	65	6	1	380	220	1	10	0.02	1.7	0.1	0.5	5.2	82	0.02	12	4	2.2	0.5	1.4	59
PW-1	Pumping well (3-1)	23-Oct-10	-	650	8.2	792	280	442	92	52	3	1	340	140	1	11	0.02	2	0.1	0.5	8.7	48	0.02	10	2	1	0.5	3.4	43
PW-1	Pumping well (3-1)	9-Jun-10	-	-	8.2	854	-	503	109	56	5	1	-	-	-	3.0	0.02	2.8	0.1	0.5	0.8	157	-	15	3.0	1.5	0.5	1.3	23
MW08-01	Prairie Creek Alluvium below H. Cr.	29-Sep-08	7.4	870	8.2	860	240	495	114	51	1	1	290	250	1	7	0.02	0.1	0.7	0.5	2.3	11	0.02	8	4	0.4	2	1.3	942
MW08-01	Prairie Creek Alluvium below H. Cr.	30-Jul-09	7.7	870	-	-	220	491	108	54	2	1	270	240	1	3	0.02	0.2	0.7	0.5	3.0	30	0.02	5	4	0.7	2.4	1.1	930
MW08-01	Prairie Creek Alluvium below H. Cr.	6-Jul-10	7.1	452	8.0	811	230	453	93	54	1	1	280	220	1	4	0.02	0.5	0.6	0.5	1.6	5	0.02	1	3	8.8	2.3	2.5	956
MW08-01	Prairie Creek Alluvium below H. Cr.	23-Oct-10	-	513	8.1	867	220	508	108	58	1	1	270	210	1	3	0.02	0.2	0.9	0.5	1.1	9	0.02	1	8	0.6	2.2	1.2	1140
MW08-02	Bedrock below Prairie Creek (below H. Cr.)	29-Sep-08	7.3	917	8.1	910	320	542	123	57	2	1	390	210	1	7	0.02	4.2	0.2	0.5	0.4	167	0.02	8	3	5.2	0.5	0.1	310
MW08-02	Bedrock below Prairie Creek (below H. Cr.)	30-Jul-09	7.4	990	-	-	320	550	119	62	2	1	380	190	2	3	0.02	4.4	0.0	0.5	1.4	222	0.02	9	3	0.6	0.5	0.1	281
MW08-02	Bedrock below Prairie Creek (below H. Cr.)	6-Jul-10	6.9	558	7.9	932	320	535	118	58	2	1	390	220	1	6	0.02	4.2	0.0	0.5	0.6	211	0.02	8	4	1.4	0.5	0.1	120
MW08-02	Bedrock below Prairie Creek (below H. Cr.)	23-Oct-10	-	544	8.3	913	300	543	114	63	2	1	370	220	1	3	0.02	4	0.01	0.5	0.2	151	0.02	8	5	0.3	0.5	0.1	340
MW08-03	Bedrock in Harrison Creek valley (Vein Fault)	29-Sep-08	8.7	671	8.3	730	220	427	90	49	1	1	260	190	1	7	0.02	1.3	0.5	0.5	2.0	5	0.02	1	3	10.4	3.2	2.3	735
MW08-03	Bedrock in Harrison Creek valley (Vein Fault)	30-Jul-09	7.8	780	-	-	210	426	87	51	2	1	260	160	1	3	0.02	1.1	0.4	0.5	1.2	5	0.02	2	3	8.1	3.4	2.4	714
MW08-03	Bedrock in Harrison Creek valley (Vein Fault)	7-Jul-10	7.2	484	8.1	754	220	422	95	45	1	1	260	200	2	5	0.02	0.1	0.7	0.5	4.0	15	0.02	2	4	0.3	3.2	1.0	740
MW08-03	Bedrock in Harrison Creek valley (Vein Fault)	23-Oct-10	-	439	8.2	742	210	413	82	51	1	1	260	170	1	3	0.02	0.8	0.7	0.5	1.7	5	0.02	1	5	7.9	3	2.4	879
MW08-05	MQV/Vein Fault near workings (3DU3)	13-Oct-08	7.1	1012	8.0	1100	360	694	168	67	1	3	440	280	2	1	0.02	5.8	0.3	1.5	0.2	5	0.02	14	16	1.1	12.1	0.1	322
MW08-06	Bedrock in Upper Harrison Creek valley	29-Sep-08	7.5	883	8.3	900	320	555	114	66	1	1	380	200	1	8	0.02	0.1	0.2	0.5	1.1	9	0.02	6	3	0.2	0.5	5.7	24
MW08-06	Bedrock in Upper Harrison Creek valley	31-Jul-09	7.8	900	-	-	290	498	105	58	1	1	360	170	1	3	0.02	0.1	0.2	0.5	0.7	5	0.02	1	2	0.2	0.5	5.0	25
MW08-06	Bedrock in Upper Harrison Creek valley	6-Jul-10	7.1	440	8.3	736	260	460	92	56	1	1	320	160	1	6	0.02	0.1	0.4	0.5	1.9	7	0.02	1	4	0.6	0.5	3.3	34
MW08-06	Bedrock in Upper Harrison Creek valley	23-Oct-10	-	-	8.3	928	300	557	105	72	1	1	370	180	1	3	0.02	0.2	0.2	0.5	2.5	5	0.02	1	6	1	0.5	7.5	43
MW08-07	Colluvium in Lower WRD Valley	29-Sep-08	7.9	820	8.3	810	280	491	104	56	1	1	330	180	3	10	0.02	0.2	0.1	0.5	0.8	10	0.02	6	5	0.7	0.5	3.8	25
MW08-07	Colluvium in Lower WRD Valley	30-Jul-09	7.8	820	-	-	250	451	91	54	1	1	310	160	1	10	0.02	0.2	0.2	0.5	2.0	34	0.02	1	2	4.0	0.5	3.0	39
MW08-07	Colluvium in Lower WRD Valley	6-Jul-10	7.2	340	8.1	622	230	337	73	38	1	1	280	120	1	6	0.02	0.1	0.1	0.5	1.9	5	0.02	1	3	1.0	0.5	2.2	32
MW08-07	Colluvium in Lower WRD Valley	23-Oct-10	-	-	8.2	835	270	508	103	61	1	1	330	170	1	14	0.02	0.2	0.2	0.5	1.7	5	0.02	6	6	1.2	0.5	5.1	43
MW08-09	Bedrock in Middle WRD Valley	11-Oct-08	7.2	746	8.1	800	260	475	106	51	1	1	320	190	1	4	0.02	1.5	0.7	0.5	4.1	5	0.02	9	7	8.9	2.5	4.2	290
MW08-09	Bedrock in Middle WRD Valley	30-Jul-09	-	-	-	-	280	459	103	49	1	1	320	160	1	7	0.02	0.6	0.8	0.5	4.1	8	0.02	13	7	24.6	3.0	4.8	308
MW08-09	Bedrock in Middle WRD Valley	6-Jul-10	7.6	542	8.2	665	280	376	88	38	1	1	330	110	1	5	0.02	0.9	0.2	0.5	1.9	5	0.02	12	10	4.5	2.8	0.7	234
MW08-10	Bedrock above mine workings (PC95-109)	30-Jul-09	-	-	-	-	230	301	60	37	1	1	280	74	2	9	0.02	0.4	0.2	0.5	3.1	5	0.02	3	3	0.4	0.5	2.1	35
MW08-10	Bedrock above mine workings (PC95-109)	7-Jul-10	7.5	264	8.1	426	200	245	46	32	1	1	250	39	1	8	0.02	0.1	0.2	0.5	5.5	8	0.02	1	2	1.9	0.5	1.3	32
MW09-11	Prairie Creek Alluvium (at Ore Stockpile)	15-Nov-09	6.7	794	7.8	867	280	429	108	39	5	2	340	180	1	3.0	0.02	0.4	0.2	1.0	0.6	8	0.02	151	3.0	0.5	3.8	1.8	139
MW09-11	Prairie Creek Alluvium (at Ore Stockpile)	8-Jul-10	7.1	814	7.9	1410	340	608	164	48	18	3	420	510	2	5	0.02	0.3	0.3	2.6	1.4	5	0.02	640	7	2.2	0.9	0.1	200
MW09-11	Prairie Creek Alluvium (at Ore Stockpile)	23-Oct-10	-	762	8.0	1270	310	720	187	62	21	4	380	370	1	4	0.02	0.8	0.3	1.8	0.9	5	0.02	560	12	2.1	0.9	0.2	376
MW09-12	Harrison Creek Alluvium (at mill site)	15-Nov-09	7.1	601	8.0	809	230	447	95	51	1	1	280	190	1	9.0	0.02	0.2	0.4	0.5	1.0	6	0.02	1	2.0	1.6	1.5	2.1	144
MW09-12	Harrison Creek Alluvium (at mill site)	6-Jul-10	8.2	375	8.2	594	190	346	73	40	1	1	220	150	1	9	0.02	0.2	0.1	0.5	3.1	6	0.02	6	2	0.7	0.8	1.8	32
MW09-12	Harrison Creek Alluvium (at mill site)	23-Oct-10	-	-	8.2	820	220	570	129	61	1	1	270	250	1	5	0.02	0.3	0.2	0.5	1.8	6	0.02	1	5	0.9	0.7	2.7	80
MW09-13	Bedrock below Harrison Creek (at mill site)	15-Nov-09	6.8	779	7.8	1080	230	607	145	59	1	1	280	280	1	3.0	0.02	0.4	0.8	1.1	0.9	38	0.0	31	12.0	1.6	1.2	0.2	2140
MW09-13	Bedrock below Harrison Creek (at mill site)	6-Jul-10	7.1	669	8.2	1060	210	671	163	64	1	1	250	430	1	4	0.02	0.6	0.6	1.4	0.5	119	0.02	34	28	3.3	3.6	0.1	2570
MW09-13	Bedrock below Harrison Creek (at mill site)	23-Oct-10	-	-	8.2	1040	220	606	149	57	1	1	270	320	1	4	0.02	0.2	0.9	1	0.2	5	0.02	24	15	5.9	2.4	0.2	2380
MW09-14	Harrison Creek Alluvium (at Guardhouse)	15-Nov-09	7.3	597	8.1	802	230	450	96	51	1	1	280	190	1	3.0	0.02	0.4	0.4	0.5	1.2	7	0.02	1	1.0	8.8	0.8	2.5	105
MW09-14	Harrison Creek Alluvium (at Guardhouse)	6-Jul-10	7.7	365	8.4	587	200	325	68	38	1	1	230	130	1	6	0.02	0.2	0.2	0.5	2.8	5	0.02	1	3	7.6	0.7	1.4	58
MW09-14	Harrison Creek Alluvium (at Guardhouse)	23-Oct-10	-	461	8.3	789	220	489	98	59	1	1	260	210	1	79	0.02	0.5	0.3	0.5	1.7	5	0.02	5	3	10.6	0.7	2.6	90
MW09-15	Bedrock in Harrison Creek valley (MQV)	17-Nov-09	7.2	622	7.8	1100	250	602	143	59	1	1	300	360	1	9.0	0.02	0.4	0.7	1.1	0.7	11	0.02	33	13.0	1.8	1.0	0.3	2120
MSW-1	Mill site well	8-Jul-10	7.2	595	7.9	950	310	513	109	59	4	2	380	220	2	6	0.02	2.6	0.0	0.5	0.2	2580	0.02	32	3	0.7	0.5	0.8	5
MSW-1	Mill site well	23-Oct-10	-	445	8.0	725	320	60	14	6	9	11	390	2	13	8	0.02	1.2	0.01	0.5	0.5	21	0.02	44	4	0.2	0.5	0.1	5
MSW-2	Mill site well	7-Jul-10	6.6	743	7.6	1240	370	744	181	71	2	1	450	370	1	4	0.02	0.7	0.1	0.7	0.5	27	0.02	14	20	0.3	1.1	0.3	733
MSW-2	Mill site well	23-Oct-10	-	313	8.1	537	85	570	8	7	93	1	100	1	110	3	0.02	0.1	0.0	0.5	0.2	5	0.02	2	1	0.2	0.5	0.1	5
MSW-3	Mill site well	23-Oct-10	-	412	8.2	721	110	62	7	11	137	1	130	1	140	13	0.02	0.1	0.02	0.5	0.2	5	0.02	67	3	0.2	0.5	0.1	7
STP1	Prairie Creek Alluvium at Holding Pond	29-Sep-08	7.7	982	8.0	1000	381	623	154	58	5	3	460	240	1	11	0.02	1.6	0.0	2.5	0.2	14	0.02	305	16	0.4	2.2	0.3	10
STP1	Prairie Creek Alluvium at Holding Pond	31-Jul-09	-	-	-	-	340	915	225	86	11	6	410	500	5	4	0.02	2.8	0.0	1.4	0.9	5	0.02	188	15	1.0	8.1	0.7	5
STP2	Prairie Creek Alluvium at Holding Pond	29-Sep-08	7.5	608	8.2	600	210	356	86	34	3	1	250	110	1	7	0.02	2.2	0.1	0.5	0.4	6	0.02	3	3	1.1	0.7	1.3	17
STP2	Prairie Creek Alluvium at Holding Pond	31-Jul-09	9.3	120	-	-	55	541	12	6	1	1	67	2	1	7	0.02	0.3	0.0	0.5	0.4	21	0.02	12	1	0.6	0.5	0.1	5
STP2	Prairie Creek Alluvium at Holding Pond	7-Jul-10	7.3	359	8.4	615	220	351	83	35	3	1	260	130	2	7	0.02	2.9	0.0	0.5	0.5	6	0.02	2	3	0.9	0.7	1.1	20
STP2	Prairie Creek Alluvium at Holding Pond	23-Oct-10	-	58	7.9	112	52	57	11	7	1	1	63	1	1	3	0.02	0.2	0.0	0.5	0.2	5	0.02	16	1	0.2	0.5	0.1	5

0.01 **Concentration less than indicated detection limit**

\- **Data not available**

Note: Alkalinity (total) and hardness are expressed in mg/L as CaCO3

Exhibit 1b - Mine water & surface water quality data, Prairie Creek mine, NWT

ID	DESCRIPTION/LOCATION	DATE	pH	EC	pH	EC	Alkalinity	Hardness	Ca	Mg	Na	K	HCO3	SO4	Cl	Al_f	Ag_f	As_f	Cd_f	Co_f	Cu_f	Fe_f	Hg_f	Mn_f	Ni_f	Pb_F	Sb_F	Se_F	Zn_F
				µS/cm		µS/cm	mg/L CaCO3	mg/L CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Mine1	Flooded decline near spillpoint to 870-level adit	29-Sep-08	6.9	1721	8.0	1700	530	1081	250	111	2	4	640	480	2	7	0.02	15.4	0.0	2.3	0.2	4520	0.02	43	40	0.2	4.5	0.1	302
Mine1	Flooded decline near spillpoint to 870-level adit	31-Jul-09	-	-	-	-	540	1080	255	108	2	4	650	540	2	3	0.02	9.8	0.0	1.4	0.5	11900	0.02	70	15	0.5	0.5	0.1	5
Mine1	Flooded decline near spillpoint to 870-level adit	13-Nov-09	6.5	1282	7.9	1680	520	1030	238	105	2	4	640	500	2	3.0	0.06	8.6	0.0	1.5	0.2	10800	0.02	64	11.0	0.2	0.5	0.1	5
Mine1	Flooded decline near spillpoint to 870-level adit	28-Jan-10	-	-	7.7	1670	520	1090	258	108	2	4	640	560	3	10.0	0.10	8.0	0.1	1.2	1.0	11500	0.20	74	14.0	0.3	0.8	0.8	10
Mine1	Flooded decline near spillpoint to 870-level adit	9-Sep-10	-	-	7.3	1690	510	1080	247	113	2	4	620	540	2	3.0	0.02	6.8	0.01	1.3	0.8	13500	0.02	79	10.0	0.2	0.5	0.1	5
XC-2	Water flowing from cross-cut no. 2 from 870-level adit	13-Nov-09	7.2	653	8.0	863	230	483	102	55	1	1	280	210	1	3.0	0.02	14.9	4.4	0.5	14.7	16	0.02	1	6.0	22.8	30.0	3.2	1180
XC-2	Water flowing from cross-cut no. 2 from 870-level adit	9-Sep-10	-	-	7.8	958	230	551	109	68	1	1	280	290	1	3.0	0.04	14.2	5.2	0.5	18.0	42	0.02	1	7.0	23.8	25.4	3.4	1700
XC-04	Water flowing from cross-cut no. 4 from 870-level adit	13-Nov-09	6.9	760	7.7	984	290	498	117	50	1	1	360	230	1	3.0	0.04	5.6	29.9	0.6	39.2	78	0.02	23	18.0	32.4	105.0	8.3	11800
XC-04	Water flowing from cross-cut no. 4 from 870-level adit	28-Jan-10	-	-	7.8	1010	290	550	131	54	1	1	350	260	1	10.0	0.10	3.7	44.7	0.9	36.0	20	0.20	32	25.0	30.8	84.4	8.9	15800
XC-04	Water flowing from cross-cut no. 4 from 870-level adit	9-Sep-10	-	-	7.6	1040	270	591	134	62	1	1	340	290	0.5	6.0	0.02	5.8	22.3	0.8	53.6	32	0.02	28	21.0	33.4	67.3	6.2	12000
Mine2	Outflow from 870-level portal	29-Sep-08	8.1	1196	8.1	1200	290	712	156	78	2	2	360	420	1	56	0.02	4	49.7	0.7	52.0	28	0.02	19	15	11.6	64.3	6.7	8780
Mine2	Outflow from 870-level portal	30-Jul-09	-	-	8.1	1200	-	735	162	81	1	1	-	410	1	3	0.02	3	42.0	0.6	37.5	5	0.02	15	14	5.3	75.8	6.2	8340
Mine2	Outflow from 870-level portal	13-Nov-09	7.6	843	8.1	1130	300	646	146	68	1	1	370	350	1	3.0	0.03	2.6	31.5	0.6	27.7	17	0.02	16	13.0	4.2	68.2	7.4	7880
Mine2	Outflow from 870-level portal	28-Jan-10	-	-	8.1	1210	320	739	177	72	1	1	390	280	1	10.0	0.10	1.4	30.7	0.7	34.0	20	0.20	19	16.0	8.3	64.9	8.9	6770
Mine2	Outflow from 870-level portal (3-7)	8-Jun-10	-	-	8.6	644	240	641	145	68	1	1	300	350	1	5	0.02	3.5	25.3	0.5	37.4	199	0.02	15	15	31.4	60	6.0	6780
Mine2	Outflow from 870-level portal (3-7)	8-Jun-10	-	-	8.3	1020	-	641	145	68	1	1	-	-	-	5.0	0.02	3.5	25.3	0.5	37.4	199	0.08	15	15.0	31.4	64.7	6.0	6780
Mine2	Outflow from 870-level portal (3-7)	9-Sep-10	-	-	7.9	1160	280	731	158	82	1	1	340	370	0.5	3.0	0.02	7.2	59.5	0.5	80.2	516	0.02	16	13.0	31.6	59.5	6.4	11500
Mine3	Outflow from 870-level portal after treatment	29-Sep-08	8.2	1206	8.3	1200	300	727	158	81	11	1	360	400	1	5	0.02	0.2	0.0	0.5	0.2	5	0.02	21	15	0.2	61	6.0	31
Mine3	Outflow from 870-level portal after treatment (3-4)	30-Jul-09	-	-	8.4	1200	300	756	165	83	9	1	350	380	2	3	0.02	0.3	0.0	0.5	0.2	6	0.02	18	14	0.2	70.1	5.8	275
Mine3	Outflow from 870-level portal after treatment (3-4)	9-Sep-10	-	-	8.1	1170	240	681	146	77	10	1.2	300	430	1	3.0	0.02	0.7	2.9	0.6	3.6	641	0.02	22	13.0	2.0	56.4	5.4	624
Mine 5	Mine water sample from 930-level adit	28-Jan-10	-	-	8.2	824	270	458	98	52	1	1	340	180	1	10.0	0.10	19.0	5.3	0.5	55.0	20	0.20	1	12.0	27.3	115.0	2.4	1770
HC-1*	Harrison Creek upstream of mill (at 3-9)	30-Jul-09	-	-	8.4	711	-	421	89	48	1	1	-	-	-	5	0.02	0.1	0.0	0.5	0.4	8	0.02	1	1	1.5	0.5	2.1	7
HC-1	Harrison Creek upstream of mill (at 3-9)	8-Jun-10	-	-	8.6	601	190	16	5	1	1	0.2	220	150	1	19.0	0.02	0.1	0.03	0.5	2.0	22	0.02	4	1.0	0.2	0.5	0.1	5
HC-1	Harrison Creek upstream of mill (at 3-9)	9-Sep-10	-	-	8.3	712	210	413	84	49	1	1	240	170	0.5	6.0	0.02	0.1	0.1	0.5	0.4	7	0.02	1	1.0	0.7	0.5	2.1	7
HC-2	Harrison Cr. upstream of mill	29-Sep-08	8.5	788	8.5	790	240	482	103	55	1	1	270	210	2	7	0.02	0.1	0.1	0.5	0.3	5	0.02	1	1	3.2	0.5	2.3	9
HC-2	Harrison Creek upstream of mill	8-Jun-10	-	-	8.5	607	200	370	78	42	1	1	220	150	1	11	0.02	0.1	0.1	0.5	0.7	18	0.02	1	1	2.4	0.5	1.3	8
HC-2	Harrison Creek upstream of mill	9-Sep-10	-	-	8.3	710	210	408	84	48	1	0.8	240	170	0.5	25.0	0.02	0.1	0.1	0.5	0.8	43	0.02	1	2.0	2.3	0.5	2.2	8
HC-3	Harrison Creek near mill	30-Jul-09	-	-	8.3	721	220	399	88	52	1	1	260	160	1	4	0.02	0.4	0.9	0.5	1.3	5	0.02	1	1	10.7	1.4	2.0	230
HC-3	Harrison Creek near mill	8-Jun-10	-	-	8.5	609	190	672	194	45	1	1	220	150	1	249	0.02	0.4	0.4	0.5	1.6	649	0.02	42	2	22.8	0.5	1.3	24
HC-3	Harrison Creek near mill	9-Sep-10	-	-	8.3	710	200	408	83	49	1	0.7	240	170	0.5	7.0	0.02	0.1	0.07	0.5	0.3	6	0.02	1	1.0	1.1	0.5	2.2	7
CPO	Catchment Pond outflow (at 3-5)	8-Jun-10	-	-	8.5	656	210	366	78	42	2	1	240	160	1	15	0.02	0.6	1.0	0.5	2.9	28	0.02	2	2	12.6	3.9	1.3	492
CPO	Catchment Pond outflow (at 3-5)	9-Sep-10	-	-	8.1	798	220	454	94	53	3	1	270	190	0.5	5.0	0.02	0.4	0.8	0.5	1.9	86	0.02	4	3.0	4.6	11.5	2.6	301
HC-4	Harrison Cr. before entering Prairie Cr.	29-Sep-08	8.2	900	8.4	900	260	536	117	59	5	1	300	260	1	7	0.02	0.3	0.0	0.5	0.2	5	0.02	7	6	0.7	21.4	3.2	314
HC-4	Harrison Creek before entering Prairie Creek	30-Jul-09	-	-	8.2	740	-	474	104	52	3	1	-	190	1	3	0.02	0.5	0.2	0.5	0.5	5	0.02	4	4	3.9	14.9	2.5	335
HC-4	Harrison Cr. before entering Prairie Cr. (3-6)	8-Jun-10	-	-	8.6	644	200	343	73	39	1	1	230	170	1	6	0.02	0.6	1.1	0.5	2.4	19	0.02	2	2	11.8	3.6	1.3	508
HC-4	Harrison Cr. before entering Prairie Cr. (3-6)	9-Sep-10	-	-	8.1	793	230	479	100	56	4	1	260	190	0.5	3.0	0.02	0.5	0.7	0.5	1.9	74	0.02	4	2.0	3.9	11.0	2.8	301
PCU	Prairie Creek upstream of mill (SNP 3-10)	30-Jul-09	-	-	8.4	422	-	230	58	21	2	0	-	61	1	4	0.03	0.2	0.0	0.5	0.3	5	0.02	1	1	0.2	0.5	1.0	5
PCU	Prairie Creek upstream of mill (SNP 3-10)	28-Jan-10	-	-	8.2	528	200	280	68	27	2	0	240	98	1	1.0	0.005	0.1	0.0	0.0	0.3	2	0.01	0	0.5	0.03	0.16	1.7	4
PCU	Prairie Creek upstream of mill (SNP 3-10)	8-Jun-10	-	-	8.5	352	150	204	50	19	1	0	180	46	1	67	0.02	0.2	0.1	0.5	0.5	97	0.02	2	1	0.4	0.5	0.9	5
PCU	Prairie Creek upstream of mill (SNP 3-10)	8-Sep-10	-	-	8.3	437	170	233	55	23	1	0	200	66	1	16	0.02	0.1	0.0	0.5	5	19	0.03	1	2	0.2	0.5	1.5	5
PC-1	Prairie Cr. upstream of mill (near STP 2)	29-Sep-08	8.5	493	8.4	500	200	282	68	27	2	0	230	70	1	7	0.02	0.3	0.0	0.5	0.3	5	0.02	1	1	0.7	0.5	1.4	9
PC-1	Prairie Cr. Upstream of mill	28-Jan-10	-	-	8.3	554	220	320	78	31	2	0	270	100	1	1.4	0.005	0.5	0.0	0.0	0.2	3	0.01	0	1.5	0.04	0.22	1.9	10
PC-1	Prairie Creek upstream of mill (near STP-2)	8-Jun-10	-	-	8.3	357	150	209	52	19	1	0	180	46	1	143	0.02	0.2	0.1	0.5	0.5	171	0.02	3	1	0.3	0.5	0.9	5
PC-1	Prairie Creek upstream of mill (near STP-2)	9-Sep-10	-	-	8.3	471	180	266	62	27	2	0	210	80	0.5	16.0	0.02	0.1	0.03	0.5	0.4	19	0.02	1	1.0	0.2	0.5	1.2	9
PC-2	Prairie Cr. downstream of mill	29-Sep-08	8.4	534	8.4	530	200	320	77	31	3	0	240	84	1	7	0.02	0.3	0.0	0.5	0.2	5	0.02	1	1	0.2	1.4	1.4	27
PC-2	Prairie Cr. downstream of mill	30-Jul-09	-	-	8.5	442	170	253	59	25	2	0	200	65	1	6	0.02	0.3	0.0	0.5	0.5	5	0.02	1	1	0.2	0.5	1.1	11
PC-2	Prairie Cr. downstream of mill	28-Jan-10	-	-	8.2	596	220	308	73	30	2	0	270	110	1	1.0	0.005	0.5	0.0	0.0	0.2	3	0.01	0	1.5	0.1	0.29	1.8	25
PC-3	Prairie Creek downstream of Site	29-Sep-08	8.5	506	8.4	510	200	298	72	29	2	0	230	70	1	7	0.02	0.2	0.0	0.5	2.4	5	0.02	1	1	0.4	0.5	1.3	10
PC-3	Prairie Cr. below Cadillac Mine (mine side of creek)	28-Jan-10	-	-	8.2	587	220	300	71	30	2	0	270	110	1	1.0	0.005	0.5	0.0	0.0	0.2	2	0.01	0	1.4	0.1	0.26	1.4	17
PC-3	Prairie Cr. below Cadillac Mine (far side of creek)	28-Jan-10	-	-	8.2	589	220	315	75	31	2	0	270	100	1	1.2	0.005	0.5	0.0	0.0	0.2	3	0.01	0	1.4	0.1	0.26	1.4	17
PC-3	Prairie Cr. downstream of mill	8-Jun-10	-	-	8.3	321	140	209	53	19	1	1	160	39	1	513	0.02	0.5	0.1	0.5	1.0	714	0.02	14	2	1.1	0.5	0.7	17
PC-3	Prairie Cr. downstream of mill	9-Sep-10	-	-	8.3	482	180	259	60	26	1	0.4	210	83	0.5	20.0	0.02	0.2	0.1	0.5	0.5	24	0.02	1	2.0	0.2	0.5	1.2	14
PCD	Prairie Creek downstream of Site (SNP 3-11)	30-Jul-09	-	-	8.5	437	-	233	58	21	2	0	-	63	1	6	0.02	0.2	0.0	0.5	0.5	5	0.02	1	1	0.2	0.5	1.0	7
PCD	Prairie Creek downstream of Site (SNP 3-11)	28-Jan-10	-	-	8.2	597	220	320	76	32	2	0	270	98	1	1.0	0.005	0.4	0.0	0.0	0.4	3	0.01	0	1.6	0.5	0.28	1.8	21
PCD	Prairie Creek downstream of Site (SNP 3-11)	8-Jun-10	-	-	8.5	319	140	221	59	18	1	1	160	39	1	931	0.02	0.6	0.1	0.5	1.4	1040	0.02	14	3	1.7	0.5	0.8	20
PCD	Prairie Creek downstream of Site (SNP 3-11)	8-Sep-10	-	-	8.3	476	180	257	60	26	1	0	210	78	1	24	0.02	0.2	0.0	0.5	0.4	31	0.02	1	2	0.2	0.5	1.2	11
Spring	Sample of water from Galena Spring	28-Jan-10	-	-	8.2	1140	350	689	141	82	3	1	430	360	1	1.5	0.005	0.3	0.1	0.0	0.6	6	0.01	6	3.1	0.2	0.74	2.8	23
SNP 3-8	Reagent Catchment Basin (SNP 3-8)	9-Jun-10	-	-	8.1	268	-	17	5	1	1	0.2	-	-	-	11.0	0.02	0.1	0.1	0.5	0.6	22	-	4	1.0	0.2	0.5	0.1	5

0.01 **Concentration less than indicated detection limit**

\- **Data not available**

Note: Alkalinity (total) and hardness are expressed in mg/L as CaCO3

APPENDIX D

Groundwater Level Data

Well ID	TOC	Well Depth	Well Dip	Stickup	28-Sep-08		22-Jun-09		16-Sep-09		15-Nov-09		8-Jun-10		6-Jul-10		17 to 21 Oct-2010	
	m amsl	m	degrees	m	m btoc	m amsl	m btoc	m amsl	m btoc	m amsl	m btoc	m amsl	m btoc	m amsl	m btoc	m amsl	m btoc	m amsl
STP1	881.21	10.03	90	1.23	8.58	872.63	8.38	872.83					8.00	873.21				
STP2	873.40	16.17	90	1.60	2.44	870.96	2.06	871.34					3.03	870.38	2.08	871.32	2.41	870.99
STP3	880.89	10.18	90	1.20	9.38	871.51	9.30	871.59					9.47	871.42				
STP4	880.91	10.79	90	1.21	10.19	870.72	10.16	870.75					plugged					
STP5	880.85	10.20	90	1.20	10.17	870.68	10.23	870.62					dry	<869.45				
STP6	880.54	11.37	90	1.25	dry	<870.42	dry	<870.42					dry	<870.42				
STP7	880.58	9.68	90	1.20	dry	<868.78	9.95	870.63					dry	<868.78				
STP8	880.71	11.93	90	1.23	11.92	868.79	N/A	N/A					11.92	868.79				
MSW-01	869.46	15.97	90	0.21	1.97	867.49	2.26	867.20	1.95	867.51	2.00	867.46	frozen		1.84	867.62	1.81	867.65
MSW-02	868.43	17.67	90	0.94	2.47	865.96	1.79	866.64	Buried	N/A			frozen		1.59	866.84	2.11	866.32
MSW-03	869.91	17.82	90	1.00	2.48	867.43	1.90	868.01	2.44	867.47	2.77	867.14	2.89	867.02	dry	<851.09	2.22	867.69
PW-02	869.79	19.17	90	0.58	1.86	867.93	2.65	867.14	0.86	868.93	2.10	867.69	frozen					
MW08-01	866.22	5.86	90	0.44	1.14	865.08	1.10	865.12	1.115	865.10	dry	< 860.42	1.10	865.12	1.12	865.10	1.27	864.95
MW08-02	869.74	50.60	80	0.14	2.14	867.63	1.56	868.20	1.74	868.02	2.49	867.29	1.95	867.82	1.62	868.14	2.17	867.60
MW08-03	887.33	78.50	85	0.12	6.70	880.66	6.34	881.02	6.03	881.33	6.60	880.76	9.32	878.05	1.57	885.77	6.53	880.83
MW08-04-50m	977.96	50	90	0.00		945.34		943.52		-			n/a					
MW08-04-100m	977.96	100	90	0.00		894.07		895.23		895.23			n/a					
MW08-04-150m	977.96	150	90	0.00		877.99		877.14		877.14			n/a					
MW08-05	933.36	182	76	0.00	40.05	894.50	34.18	900.20					-		frozen		35.00	899.40
MW08-06	955.14	33.3	90	0.18	14.94	940.20	12.69	942.45	12.01	943.13			13.49	941.65	11.95	943.19	12.83	942.31
MW08-07	917.47	7.9	90	0.19	4.25	913.22	3.99	913.48	5.745	911.72			3.63	913.84	4.01	913.46	4.29	913.17
MW08-08	946.55	81.8	79	2.30	62.30	885.39	65.35	882.40										
MW08-09	948.02	84.80	75	0.14	51.99	897.80	52.17	897.62					51.33	898.43	59.68	890.37		
MW08-10	1196	280	50	0.00	-	-	30.15	1173					-		26.27	1176		
MW09-11	868.45	5.2	90	0.18							1.19	867.27	frozen		1.28	867.17	1.01	867.44
MW09-12	869.01	7.4	90	0.16							2.55	866.46	1.50	867.51	1.47	867.54	2.17	866.84
MW09-13	869.55	25.2	90	0.18							2.84	866.71	1.70	867.85	1.44	868.11	2.00	867.56
MW09-14	880	12.7	90	0.15							9.16		5.84		5.65		6.56	
MW09-15	885	23.9	90	0.18							6.52		plugged					

Notes:

880 estimate only (not surveyed)

APPENDIX O

Water Quality Monitoring and AEMP Approach

Hatfield Consultants

MEMO

Date:	February 28, 2011	HCP Ref No.: CZN1682
From:	John Wilcockson / Martin Davies	
To:	David Harpley, CZN	
Subject:	Proposed Aquatic Monitoring Framework for CZN's Prairie Creek Mine. DRAFT	

This memo outlines a proposed approach to operational monitoring of effluent and water quality, and potential effects to the aquatic environment resulting from effluent discharged from the Prairie Creek Mine.

1.0 OVERVIEW

In a previous memo, *Assessment of Potential Aquatic Effects, Prairie Creek* (Hatfield 2010), background information was provided and three primary questions were identified. Answers to these questions are needed prior to the issuance of a discharge permit. The questions are:

1. **Potential toxicity of whole effluent** – Will final effluent cause toxicity to aquatic organisms in Prairie Creek?

2. **Appropriate Water Quality Objectives** – What are appropriate site-specific water quality objectives (SSWQO) for Prairie Creek downstream of an initial dilution zone?

3. **Operational aquatic monitoring -** What aquatic monitoring activities should the mine undertake once it becomes operational? What are appropriate frequencies of measurement, triggers and management/monitoring actions?

A companion memo to this memo, *Prairie Creek Mine – assessment of potential aquatic effects* (Hatfield 2011) addresses the first two questions. This memo addresses the last question. The monitoring plan proposed builds upon previous studies in the Prairie Creek watershed by Spencer *et al.* (2008) and Bowman *et al.* (2009), as well as discussions of site-specific water quality objectives by Harwood and Dubé (2010), and a conceptual outline of an aquatic effects monitoring plan (AEMP) by Dubé (2010). It also ensures consistency with federal Metal Mining Effluent Regulations (MMER) requirements, which must be followed by the Prairie Creek Mine during operations.

Once the mine is operational, the mine will need to routinely monitor effluent and the receiving environment to assess the potential for aquatic effects. Specific measurement end-points will be established with a set testing schedule; each measurement end-point will have an accompanying action trigger. For some triggers, the action will be to confirm the measurement and take additional measurements. For other triggers, the mine will need to mitigate potential effects and determine the magnitude and spatial extent of the potential effect.

Aquatic monitoring programs will include the following elements:

1. Routine monitoring of effluent quantity and quality (including both chemistry and toxicity);

2. Routine water quality and quantity monitoring in Prairie Creek (referred to by Dubé [2010] as a Surveillance Network Program [SNP]);

3. Biological monitoring in the Prairie Creek watershed, following Environmental Effects Monitoring guidelines (referred to by Dubé [2010] as the AEMP); and

4. Monitoring as required by any authorizations or compensation agreements associated with Section 35(2) of the *Fisheries Act* (administered by Fisheries and Oceans Canada).

The first three of these programs is discussed below, with regard to general scope, frequency, and objectives. Targets and triggers associated with each component, flowing from various regulatory requirements, also are discussed.

Regarding monitoring associated with the fourth program, if this is necessary, it has been our experience at other mine sites that coordinated consideration and implementation of studies increases the efficiency and value of all programs.

Generally, the regulatory drivers for aquatic monitoring programs at the Prairie Creek mine will include:

- An expected Effluent Discharge Permit (Water Licence), issued and administered by the Mackenzie Valley Land and Water Board (MVLWB) with enforcement by INAC; and

- The Metal Mining Effluent Regulations (MMER), associated with Section 36(3) of the federal *Fisheries Act* (administered by Environment Canada) and including requirements for effluent quality monitoring and Environmental Effects Monitoring (EEM).

2.0 SURVEILLANCE NETWORK PROGRAM (SNP)

2.1 OVERVIEW

Effluent chemistry, toxicology and flow will be regularly assessed as part of the operational monitoring program. These measurement end-points are required under the MMER, and will also be associated with Effluent Quality Criteria (EQC) and volume discharge limits stipulated in an Effluent Discharge Permit (EDP). The MMER also specifies the minimum measurement frequencies and actions that must be taken if measurements exceed pre-defined triggers (for effluent toxicity and chemistry). These measurement end-points along with analytical chemistry measurements of Prairie Creek (upstream and downstream), will be core components of the routine SNP.

Each SNP component is discussed individually below.

2.2 ROUTINE EFFLUENT MONITORING

Effluent quantity and quality monitoring will be stipulated in the mill's Effluent Discharge Permit, which ideally should be consistent with federal MMER.

Table 1 Proposed effluent monitoring program.

Applicable Regulatory Device (Regulator)	Regulatory requirement	Proposed monitoring	Proposed/required frequency (routine)
Effluent Discharge Permit (MVLWB)	Effluent flow may need to fall within a prescribed maximum.	Discharge rate	Continuous
	Effluent quality must meet Effluent Quality Criteria (EQC) for all stipulated analytes.	*In situ* effluent quality: temperature, conductivity, pH.	Continuous
		Chemistry: Measurement of major ions, nutrients, and total and dissolved metals (CCME low-level detection limits, full scan).	Weekly
Metal Mining Effluent Regulations (EC)	Reporting of effluent quality and quantity	*Consistent with Effluent Discharge Permit data presented above.*	*Consistent with above*
	Effluent must not be acutely toxic to fish.	Acute toxicity testing: LC50 tests using rainbow trout and the water flea, *Daphnia magna.*	Monthly
	Required monitoring of sub-lethal toxicity	Sub-lethal toxicity testing: Larval salmonid *Ceriodaphnia* reproduction Algal reproduction Duckweed growth	Twice annually

2.2.1 Effluent Flow

Discharge rate of final, treated effluent to Prairie Creek will be monitored continuously, using an automated flow monitoring device. Total discharge volume may be required to fall within a total allowable discharge stipulated in the Effluent Discharge Permit.

2.2.2 Effluent Chemistry

Monitoring of effluent chemistry is a measurement end-point required under the federal MMER. Routine effluent chemistry monitoring will be conducted weekly, or if there are any significant changes to the mill or water treatment process. If any of the regulated contaminants exceeded the effluent quality criterion (EQC), this would trigger a management action, as described in Section 4.0.

In addition, *in situ* measurements of the effluent stream--including pH, temperature and conductivity--would be collected continuously (along with flow), using installed monitoring devices. Continuous measurement of these variables will allow identification of any upsets in effluent quality that could indicate other changes in effluent composition or quality. As an operational dataset describing effluent pH and conductivity is generated through normal operations, it may be possible to define normal ranges of operational effluent quality. These normal ranges could be used in future to identify deviations from normal effluent quality, using standard control-charting approaches.

2.2.3 Acute Toxicity Testing

Following MMER requirements, final effluent will be collected for acute toxicity testing once per month using rainbow trout and the waterflea *Daphnia magna*. Acute toxicity testing would include a 48-hr *Daphnia magna* mortality test, and a 96-hr rainbow trout mortality test, following Environment Canada protocols as stipulated in the MMER.

Should final effluent show acute toxicity to either trout or *Daphnia*, triggers would be activated as described in Section 4.0. Conversely, if effluent is shown consistently to be non-toxic to these test species, testing frequency will be reduced, in accordance with MMER requirements and also as described in Section 4.0.

2.2.4 Sub-lethal Toxicity Testing

Final effluent will be collected for sub-lethal toxicity testing twice annually (summer and winter), as a part of MMER Environmental Effects Monitoring (EEM) requirements. Tests will include survival and development of larval salmonids (*Oncorhynchus mykiss*), survival and reproduction of the cladoceran *Ceriodaphnia dubia*, growth and reproduction of the green alga *Pseudokirchneriella subcapitata*, and growth of duckweed (*Lemna minor*). These tests will be done on a dilution series of final effluent. As discussed below, sub-lethal toxicity testing is also proposed as a tool to help determine the magnitude and significance of potential effects should there be an effluent-quality trigger excursion.

2.3 ROUTINE PRAIRIE CREEK MONITORING

Monitoring requirements for water quality and quantity monitoring in Prairie Creek will presumably be attached to the mine's Effluent Discharge Permit. The federal MMER also requires monitoring of receiving water quality; the proposed program would harmonize MMER requirements within broader EDP requirements. The table below summarizes proposed receiving environment monitoring.

Table 2 Proposed aquatic surveillance network program.

Applicable Regulatory Device (Regulator)	Waterbody/location	Proposed monitoring	Proposed/required frequency (routine)
Effluent Discharge Permit (MVLWB)	Prairie Creek upstream of mine discharge	Discharge rate	Continuous (hydrometric station)
		Chemistry: Measurement of major ions, nutrients (low-level DL), and total and dissolved metals (CCME low-level DL, full scan).	Weekly for first year, monthly for subsequent years
	Harrison Creek upstream of confluence with Prairie Creek	Discharge rate	Weekly (weir/flume)
		Measurement of *in situ* water quality (pH, conductivity, turbidity) and chemistry: major ions, nutrients (low-level DL), and total and dissolved metals (CCME low-level DL, full scan).	Monthly (when creek flowing)
	Prairie Creek, 100 m downstream of mine discharge (IDZ)	Measurement of *in situ* water quality (pH, conductivity, turbidity) and chemistry: major ions, nutrients (low-level DL), and total and dissolved metals (CCME low-level DL, full scan).	Weekly
MMER (EC)	Prairie Creek, 100 m downstream of mine discharge (IDZ)	Chemistry as for Effluent Discharge Permit, above.	4x per year *(harmonized with EDP monitoring above)*

2.3.1 Creek Flows

Flow measurements will be conducted in Prairie Creek and Harrison Creek (when flowing) to assess possible physical impacts to fish and fish food species. Hydrology data may also provide an indication of natural physical processes that may confound mine monitoring programs throughout the year, and be potentially useful for mine-site water management planning or modelling activities.

Prairie Creek flow will be continuously monitored upstream of the mine discharge using an automated monitoring device such as a pressure transducer with attached data-logger. A temperature probe will be included with this device, to collect continuous water-temperature data as well.

Flow in Harrison Creek, which is ephemeral and enters Prairie Creek immediately downstream of the mine discharge, would be monitored weekly—when accessible and visibly flowing—using an installed weir, flume or other manually-read device installed in the creek channel.

2.3.2 Creek Chemistry Monitoring

The purpose of creek water quality monitoring is to confirm the absence of SSWQO excursions. Prairie Creek chemistry will be monitored weekly at the downstream edge of the IDZ (100 m downstream of the discharge, along the creek's left [mine-side] bank), for a full suite of chemistry variables, consistent with (but not limited to) MMER requirements.

In addition, paired, weekly samples will be collected from Prairie Creek upstream of the mine discharge, to capture seasonal changes in natural creek chemistry and potentially further refine site-specific water quality objectives defined using upstream water quality. After one year, the upstream natural variability of Prairie Creek water quality will be well described and clarified, and the frequency of monitoring can be reduced from weekly to monthly.

Measured SSWQO excursion(s) for any of the analytes of concern (AOC) downstream of the effluent discharge (IDZ) will constitute a trigger for further action, as described in Section 4.0.

3.0 AQUATIC EFFECTS MONITORING PROGRAM (AEMP/EEM)

The purpose of effects-based biological monitoring in the receiving environment is to verify that effluent quality and quantity restrictions are adequate to prevent significant effects of the mine's discharge on the aquatic ecosystem of Prairie Creek. As such, this biological monitoring serves as an operational confirmation of the validity of Effluent Quality Criteria defined for the mine's discharge, and of Site-Specific Water Quality Objectives defined for Prairie Creek.

Guiding principles for an Aquatic Effects Monitoring (AEMP) program for the Prairie Creek mine were outlined by Dubé (2010), and considerable initial biological-monitoring work was done in the vicinity of the Prairie Creek mine by Spencer *et al.* (2008) and Bowman *et al.* (2009). These previous studies, and MMER Environmental Effects Monitoring (EEM) requirements, will form the basis of on-going biological monitoring in Prairie Creek. The MMER outlines, in detail, requirements for EEM programs in the receiving environments of Canadian metal mines, and will become a requirement at the Prairie Creek Mine if it becomes operational.

The AEMP will follow federal EEM guidance. EEM programs are required under the MMER and include the following measurement end-points: sub-lethal toxicity testing (of effluent); and biological monitoring investigations of fish health and benthic invertebrate community structure (fish habitat). EEM programs are conducted less frequently than the routine SNP and are primarily designed to monitor the efficacy of the mine's environmental management programs (including the SNP).

Sub-lethal toxicity testing of effluent under the MMER is required twice a year. Testing is conducted utilizing three test species encompassing aquatic plants, invertebrate animals and larval fish, and end-points such as growth, development and reproduction. Sub-lethal toxicity testing done as part of the EEM program is conducted using a dilution series of mine effluent. No triggers have been established for sub-lethal toxicity testing conducted as part of EEM studies.

Biological monitoring components of the EEM program will consist of environmental studies conducted in the receiving environment, normally every two or three years (as per MMER). Biological monitoring studies include assessments of fish health, metals concentrations in fish tissue, and benthic community (invertebrate) assessments. Consistent with EEM guidance, sediment quality monitoring is not proposed, given the dominant substrates in Prairie Creek are erosional, rather than depositional. Based on preliminary studies by Spencer *et al.* and Bowman *et al.*, biological monitoring in Prairie Creek also should include periphyton, given the possibility of downstream enrichment.

Triggers and responses for biological monitoring are defined in the federal Environmental Effects Monitoring (EEM) guidance, and are discussed further in Section 4.4. Under EEM guidance, there are no triggers that, if exceeded, will require immediate response. Rather, triggers influence the frequency of EEM studies and the types of assessments conducted. EEM study designs are detailed, mine-specific, approved by multiple stakeholders upon review of a cycle-specific design document, and, therefore, are outside the scope of this memo. However, an EEM program for the Prairie Creek mine is anticipated to include the following elements:

- An autumn benthic invertebrate survey, with sampling in upstream and downstream erosional areas, following Environment Canada's CABIN (kick-net-based) protocols but with numbers of stations augmented to allow calculation and comparison of target statistical end-points requested in federal EEM guidance;

- An autumn[1] fish-health survey, in upstream and downstream areas (matching benthos sampling reaches), focusing on resident slimy sculpin, which in its first operational year would include lethal sampling in both upstream and downstream areas, but in subsequent years would, if possible, include non-lethal sampling only to minimize sampling impacts on local fish populations;

- Supporting water quality in fish/benthos sampling areas, with concurrent effluent-quality sampling;

- Autumn periphyton sampling in benthos reaches (periphyton is not a core requirement of EEM, but is appropriate for this project to address possible downstream enrichment in Prairie Creek);

- A fish-tissue survey, using tissues of sculpin sacrificed for the first cycle of the fish-health survey (future fish-health surveys would focus on non-lethal sampling if possible, and with tissue-residue-monitoring efforts shifting to benthic invertebrate tissues if required [see below]); and

- Bulk samples of benthic invertebrates collected for community assessment from each sampling area in the first cycle of EEM also would be retained and analyzed for tissue metals, to provide baseline data for use in future (analysis of metals in these small tissue samples will be made possible by utilizing sample micro-digestion methods recently introduced at some commercial laboratories).

A detailed EEM design document will be prepared for the mine for its First Cycle of EEM studies, and submitted to Environment Canada in a separate document. It is expected that sampling locations and designs of previous EEM-style studies undertaken by Spencer *et al.* (2008) and Bowman *et al.* (2009) will be used in operational-phase EEM studies to the extent possible, so that a full Before-After-Control-Impact (BACI) design can be implemented.

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[1] Although slimy sculpin are spring spawners, sampling is recommended for autumn to synchronize with benthic invertebrate programs, for logistical reasons (concerns regarding missing pre-spawning conditions in spring), and because EEM-type assessments of enrichment effects in fish, which are deemed to be the most likely effects of mine discharge on Prairie Creek, have been shown to be most effective outside of the spawning season (Barrett 2010).

Given the relatively small size of Prairie Creek and the potential for destructive sampling of fish to negatively affect local fish populations, a guiding objective of EEM programs in Prairie Creek will be to minimize lethal sampling of fish whenever possible.

We recommend that EEM sampling be undertaken in each of the first two years of mine operation to refine methodologies to provide a clearer, more immediate understanding of any effects of mine discharges on Prairie Creek biota, and better describe understand natural, inter-annual variability and its effects on EEM end-points. These two years of data would be reported together in the mine's First Cycle EEM report to Environment Canada, submitted three years after commencement of the mine's first EEM cycle during operations.

4.0 ACTION TRIGGERS AND RESPONSES

As outlined above, the following events will be considered triggers for additional monitoring and/or corrective action:

1. Measured concentration(s) of permitted water quality variables in effluent exceed relevant Effluent Quality Criterion in the Effluent Discharge Permit;

2. Effluent is acutely toxic to rainbow trout or *Daphnia magna*;

3. Concentration(s) of one or more AOC in Prairie Creek downstream of mine discharge (measured at downstream edge of IDZ) exceed relevant SSWQO; **or**

4. Biological monitoring indicates an effect on fish, fish habitat, or fish tissue that exceeds significance criteria defined by the federal EEM program.

Details of these triggers, and proposed responses to them, are described below. Generally, these responses include the following elements:

- Confirm the trigger condition;

- Quantify effects of the trigger event in the receiving environment;

- Take corrective action.

4.1 TRIGGER #1: EFFLUENT CHEMISTRY EXCEEDS QUALITY CRITERIA

Effluent quality will be monitored routinely (see Table 1) for a range of chemical end-points, including (but not limited to) deleterious substances listed in the MMER.

We anticipate that the mine will have a list of Effluent Quality Criteria, related to both monthly average values and concentrations in instantaneous grab samples (i.e., two sets of EQC), which will indicate the maximum permissible concentrations of certain metals or other substances in effluent.

In the event that routine effluent monitoring indicates that effluent quality exceeds permitted limits for grab samples, two additional effluent samples (a primary sample and a duplicate) will be collected immediately, submitted to the same analytical laboratory, and analyzed to confirm the excursion. If the excursion is not confirmed, no further action will be taken.

However, if excursion of an Effluent Quality Criterion is confirmed by additional analyses, the following actions will be taken:

- Mine staff will alert regulators regarding the effluent-quality excursion;

- The frequency of effluent chemistry sampling and analysis will be increased to every three days, until two consecutive tests show effluent quality complies with all discharge criteria;

- Concurrently, a water sample will be collected from Prairie Creek downstream of the mine discharge (at the downstream edge of the Initial Dilution Zone), and analyzed for all water quality variables examined in effluent (above);

- Frequency of water-quality sampling in Prairie Creek downstream of the mine discharge will continue at the same frequency as effluent chemistry sampling; and

- Mine staff will attempt to determine the cause of effluent-quality problems, and to identify and take corrective actions to make effluent quality compliant with permit conditions.

If effluent quality testing over three consecutive sampling periods (i.e., 9 days total) indicates on-going permit excursions, and corrective actions have been taken that should have rectified the problem (reduced process water discharge, for example), the following additional actions will be taken:

- Acute toxicity testing will be undertaken immediately using rainbow trout and *Daphnia magna*; and

- Concurrently, sub-lethal toxicity testing of effluent on *Ceriodaphnia dubia* survival and reproduction will be undertaken.

Results of toxicity testing will be considered along with downstream water quality data and knowledge of seasonal effluent mixing patterns in Prairie Creek, to assess the likelihood of biological effects in Prairie Creek, using a deductive, weight-of-evidence approach.

If sub-lethal toxicity testing using effluent shows an effect at an environmentally relevant concentration, a sample of downstream creek water should be collected and assessed for sub-lethal toxicity. An effect level of 20% on two or more species will be considered ecologically relevant.

If acute toxicity of effluent is observed, action triggers outlined in Section 4.2 will be followed.

In the event of excursion of monthly-average EQC, or on-going EQC excursions in grab samples, mine staff will continue to attempt to identify causes of excursions and corrective actions, and will contact regulators to determine appropriate next steps.

4.2 Trigger #2: Effluent exhibits acute toxicity

Following MMER requirements, the mine will routinely monitor acute toxicity to rainbow trout and *Daphnia magna*, on a schedule that is initially monthly? during mine operations.

4.2.1 Acute Toxicity to Rainbow Trout

If acute toxicity to trout is observed, and this doesn't correlate with excursions from the 'grab' sample limits in the EQC, the mine's response will follow and expand upon MMER (Section 15) requirements, as follows:

- An additional effluent sample will be collected immediately and sent for toxicity testing using trout, to confirm the toxicity observed in the initial test;

- Concurrently, a full characterization of effluent chemistry will be conducted, including all routinely monitored effluent-quality variables;

- Concurrently, a water sample will be collected from Prairie Creek downstream of the mine discharge (at the downstream edge of the Initial Dilution Zone), and analyzed for all water quality variables examined in effluent (above); and

- The frequency of toxicity testing to trout will increase to twice monthly (per MMER), until three consecutive tests at this schedule have demonstrated no toxicity to trout.

If acute toxicity to trout persists over more than one testing period, the mine will examine possible corrective actions to identify and eliminate causes of the toxicity, in discussion with regulators.

If acute toxicity to trout is observed, and this correlates with excursions from the 'grab' sample limits in the EQC, the mine's response will be to stop process water treatment or recycle the water, until the excursions can be corrected.

4.2.2 Acute Toxicity to *Daphnia magna*

Following MMER requirements, acute toxicity of effluent to *Daphnia magna* will also be assessed at the same time and frequency as tests with trout, including when frequency is changed because of observed toxicity to trout (described above), or consistent lack of toxicity (see below).

The MMER does not require any mine response to observed toxicity of effluent to *Daphnia magna*. However, at the Prairie Creek mine, an observation of acute toxicity to *Daphnia magna* will be responded to as follows:

- An additional effluent sample will be collected and sent for toxicity testing using *Daphnia*, to confirm the toxicity observed in the initial test;
- Concurrently, a full characterization of effluent chemistry will be conducted, including all routinely monitored effluent-quality variables; and
- Concurrently, a water sample will be collected from Prairie Creek downstream of the mine discharge (at the downstream edge of the Initial Dilution Zone), and analyzed for all water quality variables examined in effluent (above).

4.2.3 Consistent Lack of Acute Toxicity

Consistent with Section 16 of the MMER, if no acute toxicity to trout is observed over 12 consecutive (months), then the frequency of acute toxicity testing will be reduced to once in each calendar quarter.

4.3 Trigger #3: Prairie Creek water quality exceeds SSWQO

As described elsewhere, site-specific water quality objectives (SSWQO) used to assess water quality in Prairie Creek will be defined either using the CCME reference-condition approach (RCA, based on the mean +2SD of upstream values), or using published CCME guidelines. These objectives will be targets to assess the potential for impacts of water quality in Prairie Creek. EQC are then selected based on the predicted discharges upon which impacts have been assessed.

Two levels of objective excursions, with different action triggers, have been identified below.

4.3.1 Minor Objective Excursion

Minor excursions of objectives are defined as:

- Downstream concentrations for a given water quality variable that exceed a reference-condition-defined SSWQO but are less than 1.5 times the *maximum* concentration historically observed upstream of the Prairie Creek mine; or

- Downstream concentrations for a given water quality variable that exceed a CCME-guideline-defined SSWQO by less than five times (five times has been selected as a benchmark to fall within the typical ten-times margin of safety in defined CCME guidelines).

Such minor excursions of downstream SSWQO will trigger collection of paired upstream and downstream water quality samples in the next scheduled sampling event (if this is not already being done), to assess similarities between upstream and downstream water quality, and possible contributions of upstream water quality to observed objective excursions.

Further action will not be taken for minor objective excursions. Results of regular biological monitoring (i.e., EEM studies) will be used to assess whether water quality remains suitable for aquatic life in Prairie Creek.

4.3.2 Major Objective Excursion

Major excursions of objectives are defined as those with excursions greater than 1.5x RCA-derived objectives, or 5x objectives defined by CCME guidelines.

In the event of major excursions, the following actions will be taken:

- A water sample and a duplicate sample will be collected from Prairie Creek downstream of the mine discharge (at the downstream edge of the Initial Dilution Zone), to confirm the existence and magnitude of the excursion;

- Concurrently, a water sample will be collected from Prairie Creek upstream of the mine discharge, to allow comparison of upstream and downstream water quality; and

- Concurrently, a full characterization of effluent chemistry will be conducted, including all routinely monitored effluent-quality variables, to confirm that effluent chemistry meets permitted Effluent Quality Criteria.

If results of the above tests indicate excursion of one or more SSWQO, but effluent quality meets permit requirements, then further assessments will not be undertaken, and results of regular biological monitoring (i.e., EEM studies) will be used to assess whether water quality remains suitable for aquatic life in Prairie Creek.

If effluent testing indicates that effluent chemistry does not meet quality criteria, this will trigger action as outlined in Section 4.1.

4.4 Trigger #4: biological communities show effects

The federal EEM program provides regulatory guidance regarding how to assess the statistical and biological significance of biological effects observed through effects-based monitoring. If such effects are observed in Prairie Creek EEM monitoring, the frequency of monitoring will increase from every three years to every two years, and follow a tiered, investigative framework of: Confirmation of Effect, Investigation of Magnitude and Extent, Investigation of Cause, and, if the mine discharge is identified as the cause of an observed effect, Investigation of Solutions.

Given previous EEM-type surveys undertaken by Spencer *et al.* (2008) and Bowman *et al.* (2009), and the absence of other human activities on Prairie Creek in the vicinity of the mine, if effects are observed in an EEM study, it should be possible to move immediately to a combined Investigation of Cause or Investigation of Solutions phase in the subsequent EEM cycle.

Triggers for tissue-residue effects (in fish or invertebrates) are not precisely defined in EEM guidance, particularly for emerging metals of concern such as selenium. As such, instead of prescribing pre-defined triggers, fish-tissue results will be reviewed on a study-by-study basis, with recommendations for future studies discussed among regulators and other experts.

5.0 Annual Monitoring Reports

Mine staff will present an annual report to regulators, summarizing environmental performance over the past year. Where any action triggers have been activated in the previous year, these will be identified and described clearly, including additional collected data associated with such events, and any corrective actions taken.

EEM studies will be reported separately to Environment Canada, per MMER requirements. However, a broader group of regulators will be involved in EEM program design and review processes, and annual monitoring reports will make reference to relevant EEM studies as appropriate.

6.0 Adaptive Management / performance-based measures

This memo outlines a comprehensive strategy for monitoring effluent quality and potential effects of effluent discharges in the receiving environment. However, as direct and/or additional knowledge is gained of mine operations, actual effluent quality, and Prairie Creek chemistry and biology, it is appropriate to revisit this strategy regularly. This will ensure that the monitoring plan has appropriate focus, intensity and responsiveness, to ensure any effects of effluent released from the Prairie Creek Mine on the aquatic environment are effectively measured and understood.

We propose that representatives of Canadian Zinc Corp. and relevant regulators meet annually for at least the first two years of mine operations to review the performance of monitoring programs, and, potentially, to refine them where necessary.

7.0 Closure

We trust that the contents of this memo meet your requirements. If you have any questions or concerns, please do not hesitate to contact either myself for Martin Davies.

HATFIELD CONSULTANTS:

Approved by:		February 25, 2011
	John Wilcockson Project Manager	Date

Approved by:		February 25, 2011
	Martin Davies Project Director	Date

8.0 References

Barrett, T. 2010. Seasonal reproductive patterns and recommended sampling times for sentinel fish species used in environmental effects monitoring programs. Presentation given at 37th Annual Aquatic Toxicity Workshop, Toronto, Ontario, October 3-6, 2010.

Bowman et al. 2009. Regional Reference Variation Provides Ecologically Meaningful protection criteria for northern world heritage site. Integ Environ Assess and Manag 6:12-27.

Dubé, M. 2010. Aquatic Effects Monitoring Final Plan. Report prepared for Canadian Zinc, June 2, 2010.

Dubé M. and A. Harwood. 2010. Development of Site-Specific Water Quality Guidelines for Prairie Creek, NWT. Saskatchewan Research Council, Environment and Forestry. SRC Publication No. 10432-1E10.

Hatfield Consultants. 2010. Assessment of potential aquatic effects, Prairie Creek. Hatfield Consultants. Memo issued to Canadian Zinc Corp, December 2, 2010.

Hatfield Consultants. 2011. Prairie Creek Mine - assessment of potential aquatic effects. Hatfield Consultants. Memo issued on February 25th, 2011.

Spencer P., M. Bowman and M. Dube. 2008. A multitrophic approach to monitoring the effects of metal mining in otherwise pristine and ecologically sensitive rivers in Northern Canada. Integ Environ Assess and Manag 3:327-343.

APPENDIX P

Water Licence Approach

APPENDIX P
WATER LICENCE APPROACH

CZN's previously proposed strategy for discharging water to the receiving environment was explained in the DAR in Section 6.16.7 and Appendix 9, and in the First IR round reply, Appendix L. The strategy included maximizing treatment rates and discharge during periods of higher flows in Prairie Creek, and reducing rates in lower flow months. For process water, water would be stored during months when creek flows are typically lowest, and no process water would be treated and discharged. Treatment and discharge rates would be adjusted according to receiving water flows.

The traditional manner of discharge regulation (by the Mackenzie Valley Land and Water Board) is to set 'end of pipe' discharge limits for flow rate and parameter concentrations, also known as effluent quality criteria (EQC). The limits in conjunction effectively restrict concentration loadings entering the receiving environment. However, in the absence of seasonal variations in discharge limits, concentration loadings would potentially remain constant year round irrespective of the ability of the receiving environment to absorb them. This means that receiving water concentrations, after mixing of upstream flows with the discharge, would also vary seasonally. From the perspective of the aquatic environment, impacts will be minimized when downstream concentrations remain within an acceptable range and do not fluctuate substantially on a seasonal basis. CZN believed that the traditional manner of discharge regulation would not be suited to the proposed discharge strategy as inflexible limits on discharge rates would mean an inability to modify rates in tandem with variations in receiving water flows, and a consequent variation in downstream receiving water quality. CZN believed a modified regulatory instrument was required. However, concern was expressed regarding the increased regulator complexity that would necessarily result.

Since that time, CZN has completed further water treatment testing and water management and water balance review (see Appendix F). A slightly revised treated process water seasonal discharge plan has been developed, taking advantage of available storage capacity and the ability of the Mill to accept recycled process water after temporary storage. The plan still consists of maximizing treatment rates and discharge during periods of higher flows in Prairie Creek, and reducing rates in lower flow months. Simultaneously, CZN has evaluated the significance on water balance and discharge from a wide range of possible mine drainage flows. There is some capacity to store mine water temporarily, but in general the rate of mine water treatment and discharge will be similar to the rate of mine drainage at any given time. The water quality of the combined (blended) discharge from all streams, including four scenarios of mine drainage, is generated in Appendix F. Treated water results from September 2010 and January 2011 were used. Table P1 provides a summary of selected discharge water quality from Appendix F for those treated process water and treated mine water combinations that produced the highest parameter concentrations. The following observations are made:

- For all parameters except ammonia and nitrate, the highest concentrations occur for the 'Low Estimate' mine flow scenario, because higher concentrations exist in treated process water which are diluted less by the lower mine flows;

- Ammonia and nitrate concentrations are highest for the 'High K + PCAA' mine flow scenario, because higher concentrations exist in treated mine water;
- Concentrations for all parameters within a particular scenario do not vary significantly on a seasonal basis, largely because the treated process water discharge plan accounts for seasonal mine drainage and site runoff rates.

The consequences of these observations are as follows:

- A single Water Licence limit for each parameter can be selected to regulate discharge year-round, different limits for different seasons are not necessary;
- A Water Licence need not and should not include prescribed discharge rates since the rates that will occur will be directly related to mine drainage rates which may occur in a broad range (although a much higher degree of confidence is attached to the 'Best Estimate' scenario);
- A suitably selected Water Licence limit for each parameter will effectively deter the discharge of more treated process water than planned (unless treated water quality is better than expected) during the winter months, since mine water and site runoff dilution will be less, and the higher concentrations in the process water would exceed the limits. This is important from a regulatory viewpoint because winter is when higher receiving water concentrations could potentially occur.

Therefore, a single Water Licence limit for each parameter would satisfactorily regulate discharge year-round during normal flow conditions in Prairie Creek. However, the issue of abnormally low creek flows remains. Attempting to regulate for abnormally low creek flows would introduce regulatory complexity. The consequence of not regulating for such flows would potentially mean higher receiving water concentrations in winter months and associated potential impacts. These impacts have been assessed in Appendix D and are not considered to be significant, more so because suitable habitat for over-wintering fish (deep pools) is notably absent for at least several kilometres downstream. An alternative is for the Mine to voluntarily monitor creek flows and undertake to reduce or stop the discharge of treated process water if flows are abnormally low. The vested interest in doing this would be avoiding higher receiving water concentrations which could negatively influence the results of the aquatic effects monitoring program (AEMP). CZN would be prepared to assume this voluntary responsibility.

Table P2 is a revised version of Table L1 from Appendix L of the first IR round reply. The table provides end of pipe concentrations consisting of the limits in CZN's existing Water Licence, the Metal Mine Effluent Regulation (MMER) limits, and proposed limits for a new Water Licence for mine operations. The intent of the proposed limits is to avoid the discharge of water that could be acutely toxic to aquatic life, maintain operational flexibility and ensure that EQC can reasonably and consistently be achieved.

The suitability of the proposed Water Licence limits would be subject to review based on the SNP program and reports, and on a suitable AEMP which would include an Environmental Effects Monitoring (EEM) program. It is suggested that this review be done annually after completion of annual reports, and adaptive management actions be considered at that time. Necessary changes to the Water Licence would occur with renewal every 5 years.

TABLE P1: HIGHEST CONCENTRATIONS OF SELECTED PARAMETERS IN BLENDED DISCHARGE

Scenario	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Low Est Worst	As	0.0039	0.0028	0.0028	0.0034	0.0037	0.0035	0.0035	0.0035	0.0034	0.0039	0.0039	0.0040
Best Est Worst		0.0036	0.0028	0.0028	0.0032	0.0034	0.0032	0.0032	0.0032	0.0032	0.0034	0.0036	0.0036
High K Worst		0.0034	0.0028	0.0028	0.0031	0.0032	0.0031	0.0030	0.0031	0.0030	0.0032	0.0033	0.0034
High K + PCAA Worst		0.0029	0.0028	0.0028	0.0028	0.0030	0.0030	0.0030	0.0030	0.0029	0.0030	0.0029	0.0029
Low Est 2011	Cd	0.00445	0.00004	0.00004	0.00439	0.00469	0.00469	0.00469	0.00469	0.00454	0.00446	0.00437	0.00459
Best Est 2011		0.00307	0.00004	0.00004	0.00278	0.00308	0.00311	0.00311	0.00311	0.00300	0.00265	0.00300	0.00320
High K 2011		0.00225	0.00004	0.00004	0.00204	0.00224	0.00172	0.00167	0.00172	0.00172	0.00169	0.00210	0.00225
High K + PCAA 2011		0.00028	0.00004	0.00004	0.00029	0.00109	0.00127	0.00125	0.00128	0.00111	0.00068	0.00045	0.00040
Low Est Worst	Cu	0.0188	0.0072	0.0072	0.0173	0.0187	0.0180	0.0180	0.0180	0.0174	0.0187	0.0186	0.0192
Best Est Worst		0.0152	0.0072	0.0072	0.0135	0.0147	0.0143	0.0143	0.0143	0.0139	0.0140	0.0150	0.0155
High K Worst		0.0130	0.0072	0.0072	0.0118	0.0127	0.0112	0.0109	0.0112	0.0109	0.0115	0.0126	0.0130
High K + PCAA Worst		0.0078	0.0072	0.0072	0.0078	0.0098	0.0101	0.0099	0.0101	0.0096	0.0089	0.0083	0.0081
Low Est 2010	Hg	0.00038	0.00001	0.00001	0.00037	0.00040	0.00040	0.00040	0.00040	0.00038	0.00038	0.00037	0.00039
Best Est 2010		0.00026	0.00001	0.00001	0.00024	0.00026	0.00027	0.00027	0.00027	0.00026	0.00023	0.00026	0.00027
High K 2010		0.00019	0.00001	0.00001	0.00018	0.00019	0.00015	0.00015	0.00015	0.00015	0.00015	0.00018	0.00019
High K + PCAA 2010		0.00003	0.00001	0.00001	0.00003	0.00010	0.00011	0.00011	0.00011	0.00010	0.00006	0.00004	0.00004
Low Est 2011	Pb	0.057	0.002	0.002	0.060	0.062	0.064	0.064	0.064	0.063	0.057	0.056	0.058
Best Est 2011		0.039	0.002	0.002	0.038	0.041	0.043	0.043	0.043	0.042	0.034	0.039	0.041
High K 2011		0.029	0.002	0.002	0.029	0.030	0.024	0.024	0.024	0.025	0.022	0.027	0.029
High K + PCAA 2011		0.005	0.002	0.002	0.005	0.015	0.018	0.018	0.018	0.016	0.010	0.007	0.006
Low Est 2010	Se	0.0098	0.0033	0.0033	0.0094	0.0100	0.0098	0.0098	0.0098	0.0096	0.0098	0.0097	0.0100
Best Est 2010		0.0078	0.0033	0.0033	0.0072	0.0077	0.0076	0.0076	0.0076	0.0074	0.0072	0.0077	0.0080
High K 2010		0.0066	0.0033	0.0033	0.0061	0.0065	0.0057	0.0056	0.0057	0.0056	0.0057	0.0063	0.0066
High K + PCAA 2010		0.0037	0.0033	0.0033	0.0037	0.0048	0.0051	0.0050	0.0051	0.0048	0.0042	0.0039	0.0038
Low Est Worst	Zn	0.259	0.017	0.017	0.261	0.275	0.277	0.277	0.277	0.269	0.260	0.255	0.267
Best Est Worst		0.184	0.017	0.017	0.170	0.185	0.189	0.189	0.189	0.183	0.161	0.180	0.191
High K Worst		0.138	0.017	0.017	0.129	0.139	0.111	0.109	0.111	0.111	0.108	0.130	0.138
High K + PCAA Worst		0.030	0.017	0.017	0.031	0.075	0.086	0.085	0.086	0.077	0.052	0.039	0.037
Low Est 2011	NH4 N	0.62	0.69	0.69	0.47	0.54	0.46	0.46	0.46	0.44	0.61	0.62	0.62
Best Est 2011		0.64	0.69	0.69	0.55	0.59	0.54	0.54	0.54	0.53	0.64	0.64	0.64
High K 2011		0.65	0.69	0.69	0.59	0.62	0.62	0.60	0.62	0.59	0.66	0.66	0.65
High K + PCAA 2011		0.69	0.69	0.69	0.68	0.66	0.64	0.62	0.64	0.62	0.68	0.68	0.68
Low Est 2011	NO3 N	4.56	5.35	5.35	3.42	3.93	3.32	3.32	3.32	3.22	4.47	4.58	4.54
Best Est 2011		4.81	5.35	5.35	4.14	4.43	4.01	4.01	4.01	3.95	4.83	4.82	4.79
High K 2011		4.96	5.35	5.35	4.47	4.68	4.71	4.56	4.71	4.46	5.02	4.98	4.96
High K + PCAA 2011		5.31	5.35	5.35	5.24	5.03	4.88	4.76	4.88	4.79	5.23	5.28	5.29
Low Est 2011	Total P	0.045	0.003	0.003	0.044	0.047	0.046	0.046	0.046	0.045	0.045	0.044	0.046
Best Est 2011		0.032	0.003	0.003	0.029	0.032	0.032	0.032	0.032	0.031	0.028	0.031	0.033
High K 2011		0.024	0.003	0.003	0.022	0.024	0.019	0.018	0.019	0.019	0.019	0.023	0.024
High K + PCAA 2011		0.006	0.003	0.003	0.006	0.013	0.015	0.015	0.015	0.013	0.009	0.007	0.007
Low Est 2011	TDS	1682	700	700	1578	1688	1639	1639	1639	1595	1676	1664	1713
Best Est 2011		1375	700	700	1253	1345	1319	1319	1319	1289	1277	1359	1404
High K 2011		1191	700	700	1103	1168	1046	1023	1046	1026	1065	1158	1191
High K + PCAA 2011		753	700	700	751	924	954	940	955	907	841	790	780

TABLE P2: PROPOSED WATER LICENCE LIMITS

Parameter	Existing P Ck Licence		MMER			Proposed P Ck Licence	
	Max. Average	Max. Grab	Monthly	Composite	Grab	Max. Average	Max. Grab
Ammonia N	5	10	-	-	-	2	4
Nitrate N	-	-	-	-	-	10	20
Total Arsenic	0.5	1	0.5	0.75	1.0	0.01	0.02
Total Cadmium	0.005	0.01	-	-	-	0.01	0.02
Total Copper	0.1	0.2	0.3	0.45	0.6	0.03	0.06
Total Lead	0.15	0.3	0.2	0.3	0.4	0.1	0.2
Total Mercury	0.02	0.04	-	-	-	0.001	0.002
Total Selenium	-	-	-	-	-	0.02	0.04
Total Zinc	0.3	0.6	0.5	0.75	1.0	0.5	1.0
Total Suspended Solids	15	30	15	22.5	30	15	30
Total Petroleum Hydrocarbons	5	10	-	-	-	5	10
Total Phosphorous	-	-	-	-	-	0.1	0.2
TDS	-	-	-	-	-	2000	3000
pH	6-9.5		6-9.5			6-9.5	

All concentrations mg/L except pH

APPENDIX Q

Fish use/Habitat, Exfiltration
Trench and Downstream

Golder Associates

February 2011

FISH HABITAT CHARACTERIZATION OF PRAIRIE CREEK

Zone of Influence of the Proposed Catchment Pond Discharge (Ex-Filtration Trench Option)

Submitted to:
David Harpley
VP Environment & Permitting Affairs
Canadian Zinc Corporation
1710 650 West Georgia Street
Vancouver, BC V6B 4N9

REPORT

Report Number: 08-1365-0081

Golder Associates

Table of Contents

1.0 BACKGROUND

Golder Associates Ltd. (Golder) was retained by Canadian Zinc Corporation (CZN) to provide an assessment of the aquatic habitat at, and within, the downstream zone of influence of a proposed discharge outfall in Prairie Creek. The ex-filtration trench outfall consists of a perforated-pipe embedded in a pervious backfill trench (NHCL; December 22, 2010). The trench would be constructed in the Prairie Creek channel, 25 m upstream of the Harrison Creek confluence. The specific tasks were outlined in a memo from CZN (January 22, 2011) which relate to information requested by Fisheries and Oceans Canada (DFO) in IR Number: DFO_03 (July 22, 2010) and IR Number: DFO_2-3 (October 29, 2010). With respect to the DFO Information requests, our assessment is restricted to Item # 2 (July 22, 2010) which requested "Specifics of fish use and type of habitat within the area of influence from the construction and operation of the diffuser" (i.e., CZN is currently proposing to use an ex-filtration trench rather than a diffuser), and Item #3 (October 29, 2010) which stated "Specifics on fish use and type of habitat within the area of influence (including the mixing zone) from the construction and operation of the outfall option are required. This document does not discuss in detail any potential effects on fish populations due to the effluent discharge within the downstream mixing zone. It is our understanding that this component is being addressed in a separate document by others.

2.0 DESCRIPTION OF EX-FILTRATION TRENCH

It is our understanding that the ex-filtration trench will extend 9 m into the channel, relative to the wetted channel edge at the normal summer flow of 12 m^3/s (NHCL, February 11, 2011). This will include a 1 m section extending from the left downstream (north) bank into the near shore portion of the channel, and an 8 m section (which contains the perforated pipe) which extends out into the channel with a perpendicular orientation. The average wetted channel width at the crossing location in this area during baseflow conditions is in the order of 25 m (estimated from air photos). Construction of the trench will involve excavating to a depth of 1.2 m below the streambed, and will require disturbance of a 4.6 m wide section of stream bed over the length of the trench. Based on the hydraulic design parameters provided by NHCL (Draft; December 22, 2010), the area of affected aquatic habitat will be 4.6 X 8.0 = 36.8 m^2.

The trench will be capped with native bed material, with screened material (i.e., fines removed to improve percolation) used in the outer portion of the trench (i.e., 8 m section that contains the perforated pipe). The intent of the placement approach and materials will be to restore the stream bed with no loss of habitat value (NHCL; December 22, 2010 and NHCL; February 11, 2011).

3.0 HABITAT CHARACTERIZATION OF EX-FILTRATION TRENCH AREA

Habitat type and characteristics for the proposed ex-filtration trench site was determined from a number of sources, including:

- ground and aerial level digital photographs of the site provided by CZN;
- Parks Canada (2008/2009) habitat data at seven sites on Prairie Creek (nearest site 100 m downstream of Harrison Creek confluence) provided by Parks Canada (Appendix A);
- high-resolution Google Earth imagery; and
- previous habitat assessments in the area by Golder Associates.

The outfall entry point (and site of the proposed ex-filtration trench) is located in a long (estimated length of 200 m) section of Run habitat, varying between shallow (R3) to moderately deep (R2) cover types. The lengthy Run section is located between upstream and downstream-situated riffle/rapid areas. Stream depth at the site during the summer-fall base flow periods likely ranges between 25 cm and 100 cm depending on location relative to the thalweg and channel perimeter. Stream velocities at base flow are expected to be between 0.5 m/s and 1.0 m/s in most locations across the channel at the proposed site. The stream bed at the site is made up largely of cobble and boulder material with low fines (silt, sand) content. Site conditions are illustrated in Photos 8-10 (Appendix A) which shows the crossing from the air, and from the right upstream bank looking upstream and downstream.

4.0 FISH UTILIZATION OF EX-FILTRATION TRENCH AREA

Fish types, distribution and abundance are described based on results obtained by CZN and other investigators for sections of Prairie Creek in the area and tributaries entering nearby. Several studies have been conducted in the Prairie Creek system north of the Nahanni National Park Reserve ("NNPR") between 1980 and 2009 (Appendix A: CZN summary document; February, 2011).

- Based on the available data, the major species of interest in the immediate area of the mine site include Bull Trout, Mountain Whitefish and Slimy Sculpin. Of the three species, Slimy Sculpin appears to be the most widespread of the three, having been recorded on numerous occasions in mainstem Prairie Creek (upstream and downstream of the mine site) and in some tributaries.
- Bull Trout are of primary importance because of their limited distribution and subsequent designation as a "may be at risk" species in the Northwest Territories. Bull Trout have been recorded on a sporadic basis in mainstem Prairie Creek upstream and downstream of the mine site, and in the mouth and lower sections of tributaries such as Big Quartz Creek (approx. 2.5 km downstream of the proposed trench site), Galena Creek (approx. 1.0 km downstream of the proposed trench site), Harrison Creek (25 m downstream of the proposed trench site) and Funeral Creek (approx. 7.5 km upstream of the proposed trench site). The only documented occurrence of Bull Trout spawning occurs upstream of the mine site in Funeral Creek. No evidence of spawning in Prairie Creek has been found. Current knowledge suggests that the Bull Trout inhabiting Funeral Creek and the mainstem are resident (i.e., not undertaking annual, defined movements between the spawning areas and feeding/overwintering areas situated beyond the upper reaches of Prairie Creek.
- Mountain whitefish are known to reside in mainstem Prairie Creek, primarily upstream of the mine site. Spawning is suspected to occur in these upper reaches. A number of other species (Arctic Grayling, Northern Pike, Burbot, Round Whitefish, White Sucker, Longnose Sucker, Lake Chub) are known to reside in the lower reaches of Prairie Creek within the former boundary of the Nahanni National Park and near the confluence with the South Nahanni River.

Based on the available fish distribution data and the type and suitability of aquatic habitat present at the site of the proposed ex-filtration trench, fish utilization of the directly affected area (within the proposed trench alignment, and immediate construction area) is expected to be as follows:

- Bull Trout – Use of the area for "Spawning and Rearing" is very unlikely due to the large substrate and high stream velocities which are outside the preferred ranges of Bull Trout for these parameters, the lack of suitable adult holding areas near the site, absence of suitable rearing areas for young-of-the-year nearby, and the tendency for spawning to occur in tributaries (except Harrison where large culverts form a barrier) which in many cases provide ground water input in addition to the above-mentioned parameters. Use of the site for "Adult Feeding and Holding" is also unlikely due to the absence of suitable deep-water, low-velocity holding habitat with adequate in-stream cover. Similarly, use of the area for "over-wintering" is not expected due to the absence of deep, low-velocity holding areas. The possibility of the construction and placement of an ex-filtration trench interfering with the "migration" of Bull Trout past the site is very low, given that the site will be isolated during the construction to reduce/prevent sediment release into the channel, and a substantial portion of the channel will remain open and accessible (i.e., velocities maintained at levels which are acceptable for migrating fish). In addition, the stream bed at the site will be returned to a condition similar to the natural state as part of the construction procedures.

- Mountain Whitefish – Use of the area for "Spawning and Rearing" is a possibility based on the type and suitability of habitat at the site (i.e., moderate-depth Run habitat in association with Riffle/Rapid areas and holding areas immediately upstream and downstream of the site. Significant use of the site for "Adult Feeding and Holding" is unlikely due to the absence of suitable deep-water, low-velocity holding habitat. If Mountain Whitefish are using the area for feeding, it is more likely that they would be selecting habitats upstream or downstream of the trench, closer to the Riffle/Rapid complexes which provide more favourable feeding/holding conditions. The use of the proposed trench area for "overwintering" is very unlikely due to the absence of deep, low velocity holding areas in the immediate area. The possibility of the construction and placement of an ex-filtration trench interfering with the "migration" of Mountain Whitefish past the site is very low, given that the site will be isolated during the construction to reduce/prevent sediment release into the channel, and a substantial portion of the channel will remain open and accessible (i.e., velocities maintained at levels which are acceptable for migrating fish). In addition, the stream bed at the site will be returned to a condition similar to the natural state as part of the construction procedures.

- Slimy Sculpin - Use of the area for "Spawning and Rearing" is possible given the availability of substrate and velocity conditions within their preferred range at the site, and based on their widespread distribution in the Prairie Creek mainstem. However, it seems more likely that they would select habitats in tributaries for this purpose. Use of the specific site for "Adult Feeding and Holding" is also possible, but the selection of suitable habitats more closely associated with tributaries (confluence areas, lower reaches) seems more likely. The use of the proposed trench area for "overwintering" is very unlikely due to the absence of deep, low velocity holding areas in the immediate area. The possibility of the construction and placement of an ex-filtration trench interfering with the "migration" of Slimy Sculpin past the site is very low, given that the site will be isolated during the construction to reduce/prevent sediment release into the channel, and a substantial portion of the channel will remain open and accessible (i.e., velocities maintained at levels which are acceptable for migrating fish). In addition, the stream bed at the site will be returned to a condition similar to the natural state as part of the construction procedures, and Slimy Sculpin are not noted for undertaking large-scale, defined migrations.

5.0 HABITAT CHARACTERIZATION AND FISH UTILIZATION OF DOWNSTREAM AREAS

For the purposes of this assessment we have assumed the downstream zone of influence from the construction and operation of the ex-filtration trench outfall will extend to Galena Creek (approx. 1.0 km downstream from the proposed construction site). Our assumption is that the measures taken to prevent and control sediment input into the active channel during construction will be adequate to protect downstream habitats, and will not extend to Galena Creek (Pers. Comm. CZN). Also, we assume that the effluent stream entering at the mine site will be significantly diluted upon reaching Galena Creek (Pers. Comm. CZN).

6.0 SUMMARY OF POTENTIAL IMPACTS ON FISH AND FISH HABITAT

Direct (excavation/installation) and indirect (downstream effects) impacts from construction are not expected due to the implementation of mitigation “best practices”, and the likelihood (based on existing information on fish distribution and abundance in the area) that the site does not contain important or critical habitat (spawning, rearing, overwintering) for key fish species (Bull Trout, Mountain Whitefish, Slimy Sculpin). It is the intention of CZN to carry out additional site-specific habitat and fish investigations prior to construction in the trench area and direct downstream zone of influence as part of detailed design and to further develop mitigation techniques.

Report Signature Page

GOLDER ASSOCIATES LTD.

Jim O'Neil, B.Sc., P.Biol.
Senior Fisheries Biologist, Principal

JO/jr

APPENDIX A

Ex-Filtration Trench Area Fish and Fish Habitat Information (CZN, February 2011)

PRAIRIE CREEK MINE
EXFILTRATION TRENCH AREA
FISH AND FISH HABITAT INFORMATION

FISH HABITAT INFORMATION

The aquatic habitat in Prairie Creek below the Mine was described by Beak (1981) as follows: "Prairie Creek in this section exhibited a trellis drainage pattern, a deep U-shaped valley with steep mountains paralleling the creek on both sides. In several areas, the creek occupied the whole valley flat. The creek gradient was steep, causing a fast-flowing character with numerous white rapids in its course and very little pool development. Substrates on the banks and creek bed were composed mainly of boulders, cobbles and pebbles with very little gravel." The reaches below the Mine were categorized as migration habitat.

The proposed location of an outfall from the Prairie Creek Mine Catchment Pond into Prairie Creek in the form of an exfiltration trench is 25 m upstream of the Harrison Creek confluence.

In 2008 and 2009 surveys, Parks Canada collected habitat and stream data at 7 sites on Prairie Creek, from 2.9 km upstream to 3.17 km downstream of the Harrison Creek confluence (Figure 1). The nearest location to the proposed outfall was 100 m downstream of the Harrison Creek confluence. Habitat data are summarized in Table 1 (these data and photos were provided by Garry Scrimgeour of Parks Canada on January 26, 2011). Photographs of the locations (Photos 1 through 7) are appended in order from upstream to downstream.

As part of studies in support of access road repairs along Prairie Creek just upstream of the mine site, Golder Associates classified habitat at a number of sites (document dated November 12, 2008), the nearest one of which was just upstream of the airstrip (Section A).

Canadian Zinc (CZN) has taken photos of the outfall location and of Prairie Creek downstream (see Photos 8 through 12). The creek is typified by a broad single channel of relatively even depth at the outfall location. There is a riffle approximately 150 m downstream after which the channel narrows. After about another 50 m, the channel breaks into a series of braids for about 300 m. There is then a narrower single channel for about 200 m just upstream of Galena Creek. At the start of this narrower section, there is a pool adjacent to the right bank created by scour after a bedrock outcrop. The main channel is against the left bank at this location. This pool is the only one along this reach of the creek. The creek continues downstream of Galena Creek in a series of broad braids until reaching Quartz Creek, after which the channel narrows.

FISH INFORMATION

Fisheries Studies 1980-2005

Several studies have been conducted in the Prairie Creek system north of the Nahanni National Park Reserve ("NNPR") since 1980, including Ker Priestman (July, 1980), Beak Consultants (March, April, May, September 1981), Rescan (May-June, September 1994), and Mochnacz (August 2001). The dates and key findings of these studies are summarized in Table 2 in chronological order.

By the end of the 2001 fieldwork, it was known that both bull trout (*Salvelinus confluentus*) and mountain whitefish (*Prosopium williamsoni*) spawn in good numbers in Prairie Creek upstream of the Mine Site, most likely in Funeral Creek. Arctic grayling (*Thymallus arcticus*) are known to inhabit lower Prairie Creek, but were not found upstream of the original NNPR boundary. Each of these species is a salmonid, the first two are fall spawners and the last spawns in spring. Slimy sculpin (*Cottus cognatus*), a forage species, inhabits the main stem creek and some tributaries above and below the Mine. Other key findings of past studies are discussed below. In addition, CZN has learned that a survey by Fisheries and Oceans Canada detected spawning bull trout in Funeral Creek on August 15, 2005 (Ernie Watson, pers.comm.).

Fish Populations

As noted above, Prairie Creek is known to contain bull trout, mountain whitefish and slimy sculpin, both above and below the Mine Site. It was speculated by Mochnacz (2001) that bull trout may reside in Prairie Creek, based on the data showing multiple age classes of this char species in the main creek, as well as in/at the mouth of Big Quartz Creek, Galena Creek and Funeral Creek. However, before 2006, only one bull trout was found in the Prairie Creek drainage basin up to the Funeral Creek confluence, and this was at the mouth of Galena Creek. Mochnacz (2001) also suggested that the bull trout population in Funeral Creek may be a resident population as the creek has multi-aged char and pools in winter.

Other species known to utilize the lower reach of Prairie Creek within the NNPR and near the confluence with the South Nahanni River include: Arctic grayling, round whitefish (*Prosopium cylindraceum*), northern pike (*Esox lucius*), burbot (*Lota lota*), white sucker (*Catostomus catostomus*) and lake chub (*Couesius plumbeus*). None of these species has been found north of the NNPR boundary.

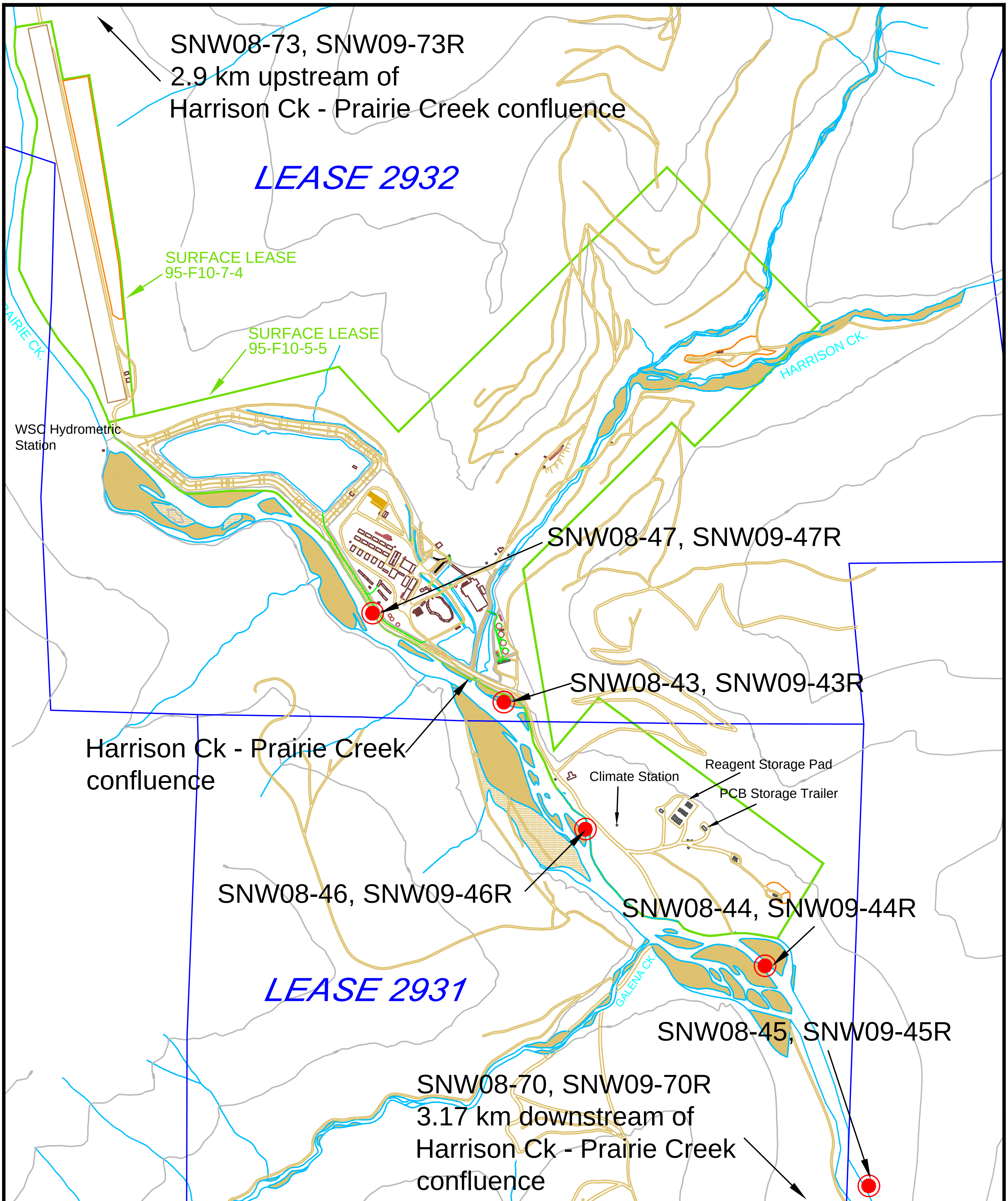
Fish in Prairie Creek do not move far up the tributary streams because the streams are relatively steep, flows are often ephemeral (dry in summer, frozen in winter) and have very low primary and secondary production (algae and benthic invertebrates).

Post-2005 Aquatic Studies

During the course of 2006 work, a number of bull trout were found just upstream and downstream of Galena Creek, a western tributary to Prairie. A single trout was found in lower Galena Creek, and 1-2 trout in lower Harrison Creek. In all cases, trout observations were not associated with spawning habitat. A survey of lower Galena Creek was undertaken in late August/early September 2006 to support a revised road alignment west of a Prairie Creek crossing location. No evidence of fish presence or spawning was found (see Bathurst document dated November 3, 2006 attached).

A study was initiated in 2006 by the University of Saskatchewan in conjunction with INAC to document a reference condition for algal, benthic invertebrate and fish communities in the South Nahanni River, including upstream and downstream of the Prairie Creek Mine, based on the sentinel species slimy sculpin. Sampling was conducted from August 21-September 2, 2006, and reported on in “Final Report on the 2006 Prairie Creek Monitoring Program, June 5, 2007, authors Paula Spencer et. al. A summary of fish species captured is documented in Table 3. For all sites, slimy scuplin were the only species captured in sufficient numbers to justify their use as a sentinel monitoring species. Note, no grayling were captured and only low numbers of bull trout.

The study has been continued by the university in collaboration with Parks Canada, with completion in 2009. Further reports are not yet available.



Legend

Minesite Infrastructure
Watercourse
Property Roads
Habitat Data Sites

Scale

0 100 200 300 400 500

Metres

CANADIAN ZINC CORPORATION

Scale: As Shown

Contour Interval: 125m

File Name: Habitat_Data.dwg

Date: January 2011

PRAIRIE CREEK MINE

Figure 1:

Habitat Data Sites, Parks Canada

Table 1: Prairie Creek Site Habitat Data, Parks Canada

Site	Date	Location (Distance from Prairie Creek-Harrison Creek Confluence)	% Bedrock visual est.	% Boulder visual est.	% Cobble visual est.	% Gravel visual est.	% Pebble visual est.	% Sand visual est.	% Silt+Clay visual est.	Bankfull-Wetted Depth (cm)	Channel Depth - avg (cm)	Channel Depth - max (cm)
SNW08-43	10-Aug-08	0.1 km downstream	0	1	44	2	53	0	0	85	24.8	100
SNW08-44	10-Aug-08	1.08 km downstream	0	0	46	8	46	0	0	65	26.4	60
SNW08-45	10-Aug-08	1.69 km downstream	0	0	53	0	47	0	0	55	18.9	50
SNW08-46	10-Aug-08	0.54 km downstream	0	0	60	0	40	0	0	65	25.1	70
SNW08-47	10-Aug-08	0.31 km upstream	0	3	59	2	36	0	0	45	23.8	60
SNW08-70	13-Aug-08	3.17 km downstream	0	0	34	3	63	0	0	55	30.7	60
SNW08-73	13-Aug-08	2.9 km upstream	0	0	35	10	55	0	0	55	26.9	70
SNW09-43R	12-Aug-09	0.1 km downstream	0	3	58	3	36	0	0	77.6	23.7	90
SNW09-44R	14-Aug-09	1.08 km downstream	0	0	45	6	49	0	0	66	22.7	70
SNW09-45R	14-Aug-09	1.69 km downstream	0	1	55	4	40	0	0	60	28.1	60
SNW09-46R	12-Aug-09	0.54 km downstream	0	0	63	5	32	0	0	80	24	60
SNW09-47R	12-Aug-09	0.31 km upstream	0	1	37	6	56	0	0	62	27.4	170
SNW09-70R	14-Aug-09	3.17 km downstream	0	0	45	8	47	0	0	55	28.8	70
SNW09-73R	14-Aug-09	2.9 km upstream	0	2	35	11	52	0	0	78	25.2	70

Table 1: Prairie Creek Site Habitat Data, Parks Canada

Site	Dominant Streamside Vegetation	Habitats - pools (Binary)	Habitats - rapids (Binary)	Habitats - riffles (Binary)	Habitats - straight run (Binary)	Macrophyte (% Range)	Periphyton coverage (Category)	Riparian - coniferous trees (Binary)	Riparian - deciduous trees (Binary)	Riparian - grasses/ferns (Binary)
SNW08-43	2	0	1	1	1	0	2	1	1	1
SNW08-44	2	0	1	1	1	0	1	0	1	1
SNW08-45	2	0	1	1	1	0	1	1	1	1
SNW08-46	3	0	1	1	1	0	2	0	0	1
SNW08-47	2	0	0	1	1	0	1	0	0	1
SNW08-70	2	0	1	1	1	0	1	1	0	1
SNW08-73	3	0	1	1	1	0	1	1	1	1
SNW09-43R	2	0	1	1	1	0	3	1	1	1
SNW09-44R	2	0	1	1	1	0	2	0	1	1
SNW09-45R	2	0	1	1	1	0	2	1	1	1
SNW09-46R	2	0	1	1	1	0	3	0	1	1
SNW09-47R	2	0	1	1	1	0	2	0	1	1
SNW09-70R		0	0	1	0	0	2	0	1	1
SNW09-73R	2	0	1	1	1	0	2	0	1	1

Table 1: Prairie Creek Site Habitat Data, Parks Canada

Site	Riparian - shrubs (Binary)	Substrate - 2nd dominant size	Substrate - dominant size category	Substrate - embeddedness category	Substrate - surrounding material	Velocity (Avg) (m/s)	Velocity (Max) (m/s)	Width - Bankfull (m)	Width - Wetted (m)	Wolman D50 (median size) (cm)	Wolman dg (geometric mean diameter)
SNW08-43	1	5	6	3	3	0.52	1.18	62	44.4	6	5.5
SNW08-44	1	5	6	3	2	0.51	1.2	41.6	23	6	5.3
SNW08-45	1	5	6	4	3	0.52	1.37	57	27.2	7	7
SNW08-46	1	5	6	4	3	0.48	1.19	58.8	28.6	8.5	7.6
SNW08-47	1	5	6	4	3	0.45	0.94	39.4	22.2	8	7.7
SNW08-70	1	6	5	4	3	0.56	1.11	47.8	20	5	4.8
SNW08-73	1	6	5	4	3	0.58	1.39	49	40.6	5	4.4
SNW09-43R	1	5	6	3	2	0.57	1.1	60.8	50.2	7	7.6
SNW09-44R	1	5	6	4	2	0.78	1.1	47.8	31.8	6	5.5
SNW09-45R	1	5	6	4	2	0.65	1.2	62	27.4	8	6.6
SNW09-46R	1	7	6	4	2	0.54	1.05	71.6	25.4	8	6.9
SNW09-47R	1	6	5	4	2	0.72	0.9	31.8	21	6	5.3
SNW09-70R	1	5	6	4	3	0.85	1.1	41.4	24.6	6	5.4
SNW09-73R	1	6	5	4	3	0.61	1.42	60.4	41.2	5	4.6

Export Created By:	Garry Scrimgeour	
Date Created:	1/25/2011 - 10:05:49 AM	
Study Name	**Description**	**Study Admin**
National Parks - South Nahanni	Following CABIN protocols - lead by Garry Scrimegour	Stephanie Strachan
Habitat Variables Selected:		
Name	**Description**	**Unit**
Temperature	Temperature	Degrees Celsius
Embeddedness	Embeddedness	Category(1-5)
Conductivity	Conductivity	uS/cm
Bottom Dissolved Oxygen	Bottom Dissolved Oxygen	mg/L
pH	pH	pH
Logging Score	Logging Score	PercentRange
Bank Full Width	Bank Full Width	m
Wetted Width	Wetted Width	m
Max Channel Depth	Maximum Channel Depth	cm
Avg Channel Depth	Average Channel Depth	cm
Max Velocity	Maximum Velocity	m/s
Avg Velocity	Average Velocity	m/s
Slope	Slope	m/m
Presence of Grasses	Grasses	Binary
Macrophyte Score	Macrophyte Score	PercentRange
Presence of Shrubs	Shrubs	Binary
Presence of Deciduous Trees	Deciduous Trees	Binary
Presence of Coniferous Trees	Coniferous Trees	Binary
Dominant Substrate	Dominant Substrate in Sample	Category(0-9)
2nd Dom. Substrate	Second Dominant Substrate in Sample	Category(0-9)
Surrounding Material	Surrounding Material In Sample	Category(0-9)
Rapid in Reach	Presence of Rapid in Reach	Binary
Riffle in Reach	Presence of Riffle Reach	Binary
Straight Run in Reach	Presence of Straight Run in Reach	Binary
Pool in Reach	Presence of Pool in Reach	Binary
Turbidity	Turbidity	NTU
% Canopy Coverage	% Canopy Coverage	PercentRange
Perimeter of Upstream Drainage Area	Perimeter of Upstream Drainage Area	Km

Median Particle Size	Median Particle Size (Wolman)	cm
Geometric Mean Particle Size	Geometric Mean Particle Size (Wolman)	cm
Drainage Area	Drainage Area	km^2
Visual % Estimate of Sand	visually estimated % of reach area occupied by sand	%
Visual % Estimate of Gravel	visually estimated % of reach area occupied by gravel	%
Visual % Estimate of Pebble	visually estimated % of reach area occupied by pebble	%
Visual % Estimate of Cobble	visually estimated % of reach area occupied by cobble	%
Visual % Estimate of Boulder	visually estimated % of reach area occupied by boulder	%
Visual % Estimate of Bedrock	visually estimated % of reach area occupied by bedrock	%
Periphyton Coverage	Periphyton coverage on substrate from 1=rocks not slippery, no colour to 5=rocksmostly obscured by algal mat, dark colour	Category(1-5)
Stream density	Stream density	m/km^2
Visual % Estimate of Silt+Clay	visually estimated % of reach area occupied by silt+clay	%
Bedrock Geology – Sedimentary (%)	Percentage of Sedimentary Bedrock	%
Precip Total JAN (mm)	Total Precipitation in January	mm
Precip Snowfall JAN (mm)	Total Snowfall in January	mm
Precip Rainfall JAN (mm)	Total Rainfall in January	mm
Precip Total JUN (mm)	Total Precipitation in June	mm
Precip Snowfall JUN (mm)	Total Snowfall in June	mm
Precip Rainfall JUN (mm)	Total Rainfall in June	mm
Precip Total ANNUAL (mm)	Annual Total Precipitation	mm
Precip Snowfall Total ANNUAL (mm)	Total Annual Snowfall	mm
Precip Rainfall Total ANNUAL (mm)	Total Annual Rainfall	mm
Temp Mean JAN (deg C)	Mean Temperature in January	Degrees Celsius
Temp Min JAN(deg C)	Min Temperature in January	Degrees Celsius
Temp Max JAN (deg C	Max Temperature in January	Degrees Celsius
Temp Mean JUN (deg C)	Mean Temperature in June	Degrees Celsius
Temp Min JUN (deg C)	Min Temperature in June	Degrees Celsius
Temp Max JUN (deg C)	Max Temperature in June	Degrees Celsius
Landcover Forest (%)	Percentage of Forest Landcover	%
Landcover Ice (%)	Percentage of Ice cover	%
Bedrock Geology - Intrusive (%)	Percentage of Intrusive Bedrock	%
Dominant Streamside Vegetation	Dominant Streamside Vegetation: 1-ferns/grasses, 2-shrubs, 3 deciduous trees, 4 coniferous trees.	Category (1-4)
Bankfull-Wetted Depth	Height from water surface to Bankfull	cm
Sinuosity	The ratio of distance measured along a watercourse between two points, divided by the straight line distance between the same two points.	Undefined

Table 2: Field Dates and Key Findings For Fisheries Work in the Prairie Creek System

FIELD DATES	RESEARCHER	KEY FINDINGS
July 21-25, 1980	Ker Priestman	Dry braided channels indicating flooding and high energy system; no barriers in main stem; Harrison Creek steep, no pools, subsurface in summer; low metals in fish tissue
March 13-27, 1981	Beak	Winter survey; tributaries frozen; ice bridge survey (before/after break-up); metals low in fish tissue; benthic invertebrate density very low
April 8, 1981	Beak	Helicopter survey of access road crossings before break-up; photographs
May 21-25, 1981	Beak	High water levels after break-up; benthos low densities; arctic grayling not above park; metals low
September 22-26, 1981	Beak	Bull trout (BT) and mountain whitefish (MW) spawning in hundreds upstream of Mine; BT may be resident; catch numbers showed MW>slimy sculpin>BT; increased metals in fish from July 1980 indicates variable levels
May 30-June 1, 1994	Rescan	Prairie Creek flows: 18 cms at 1.4 m/s on 31 May [likely too fast to ford]
September 12-16, 1994	Rescan	Bull trout in Galena and Quartz creeks near mouths; Harrison almost dry/subsurface; Prairie Creek upstream of Mine looks good for fish spawning; metal levels low in fish; about 40 good holding/over wintering pools in main stem creek from park to headwaters; only slimy sculpin found upstream
August 13-14, 2001	Mochnacz	Bull trout in Funeral Creek; arctic grayling in Prairie Creek below Mine; sedimentation is main concern re bull trout

Table 3: Number of fish caught per species at Prairie Creek sites (2006)

Prairie Creek Sites	Slimy sculpin	Arctic grayling	Bull trout
Prairie Ck, Upstream	47	-	-
Prairie Ck, High Exposure	72	-	5
Prairie Ck, Low Exposure	32	-	2
Total	151	0	7

Photo 1: Site 73, 2.9 km upstream of Harrison Creek

Photo 2: Site 47, 0.31 km upstream of Harrison Creek

Photo 3: Site 43, 0.1 km downstream of Harrison Creek

Photo 4: Site 46, 0.54 km downstream of Harrison Creek

Photo 5: Site 44, 1.08 km downstream of Harrison Creek

Photo 6: Site 45, 1.69 km downstream of Harrison Creek

Photo 7: Site 70, 3.17 km downstream of Harrison Creek

Photo 8: Looking upstream from the exfiltration trench location

Photo 9: Looking downstream from the exfiltration trench location

Photo 10: Exfiltration trench location and immediate downstream area

Photo 11: Merged photo panorama from the exfiltration trench location to ~350 m downstream

Photo 12: Merged photo panorama from ~350 m downstream of the exfiltration trench location to just upstream of Quartz Creek

BATHURST

INLET LODGE • DEVELOPMENTS • ARCTIC SERVICES

November 3, 2006

Canadian Zinc
Prairie Creek Project
Suite 1710, 650 West Georgia Str.
Vancouver BC
V6B 4N9

Attn: David P. Harpley, P. Geo.
Vancouver B.C.

Re: Canadian Zinc – Prairie Creek Project
Prairie and Galena Creek Fording

Mr. Harpley;

Bathurst Inlet Developments (Craig Thomas) with the assistance of Canadian Zinc staff (Chris Hurcan) visited the Prairie Creek Mine Site between August 15 and August 16, 2006 to complete a field monitoring survey associated with Canadian Zinc's fording of both Prairie and Galena creeks. Additionally, mine site staff further monitored the fords crossings through the remaining weeks of August and into the first week of September (August 25 to September 7, 2006). During this time three separate surveys were completed. The focus of all surveys was based on visual observations at specific ford locations that 1) crossed Prairie Creek for access to the Galena Creek access road; and 2) crossed Galena Creek at three different locations.

Surveys between August 15 and 16 were completed prior to any fording activity by the company (i.e., returning drilling equipment and machinery to mine site) to confirm the presence or absence of bull trout (primarily spawning adults), bull trout spawning redds and/or deposited bull trout eggs. A pole mounted 'D' net using a kick and drift method was also used in areas of either creek where habitat conditions were potentially suitable for bull trout spawning. Post fording monitoring surveys (August 25 to September 7) were completed to further assess if bull trout were actively using the fords areas at this time of the year for spawning. The additional information would hopefully assist in the scheduling of further activities in the ford locations for future years.

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Monitoring Results

Prairie Creek Ford

Monitoring of the Prairie Creek ford resulted in three separate surveys on August 15 and three separate surveys completed on August 16. Each survey consisted of approximately two hours of visual observations along the width of the ford alignment and over the width of the creek crossing. The survey included observations immediately upstream (5-10 m) of the alignment and downstream (20-30m) of the alignment crossing of the creek. In areas of the creek that were surveyed, where water depth and habitat conditions were potentially suitable for spawning, the 'D' net was used to confirm the presence or absence of bull trout eggs deposited in the creek substrates.

At no time during any of the surveys or anywhere within the Prairie Creek survey area were bull trout, bull trout redds and/or eggs observed. Water velocities at and in the vicinity of the ford ranged from 1.5m/s (east to central portion of the Creek) to 4.0m/s (western portion of the Creek) and substrates along the ford alignment were a composition of cobble (~55%), gravel (~40%) and finer pebble (~5%). The ford alignment across the creek provided none to very limited in-stream cover and having extremely limited habitat diversity. Habitat conditions within the ford alignment or immediately downstream of the ford alignment were not observed as being suitable for bull trout spawning. Water temperature at the time of surveys completed on August 15 and 16 was 6C.

Three separate monitoring surveys or ford site observation, were completed by Prairie Creek mine staff on August 25, September 1 and September 7, respectively. Observations of the ford crossing conditions of Prairie Creek during these dates did not change from the previous monitoring dates. There were no observations of bull trout within the ford alignment, upstream or downstream. Observed substrate conditions in these areas did not suggest that redds were present in any monitored areas on or near the creek ford.

Galena Creek Ford

Galena Creek access road crossings, a total of three, were visually monitored for bull trout activity between August 15 and September 7.

The initial monitoring survey was completed on August 15 at which time the entire length of Galena Creek, between the Prairie Creek confluence and just upstream of the 3rd crossing of the "old" Galena access road, was observed for the presence/absence of bull trout. No trout were observed in this portion of the creek and there were no visible portions of the creek that supported redds. Each specific access road crossing of the creek (creek ford) was also monitored and the sections of the creek immediately upstream and downstream of these crossings were observed and no fish activity was noted. Each crossing of the creek consisted of primarily stable, hard packed substrates, and were relatively flat when compared to the natural incline (slope) of

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other portions (i.e., upstream and downstream) of the creek.

Galena Creek Crossing #1

This ford crossing of the creek is located nearest to the creek confluence with Prairie Creek. Fish habitat within the immediate crossing alignment consisted of a creek width of approximately 3-4m, a water depth of approximately 3-6" and water velocities of approximately 1-1.5m/s. Creek substrates were characterized by equal percentage of cobble and gravel with little to no fines. Habitat within the ford was primarily uniform with little to no diversity or cover. Upstream and downstream habitat conditions consisted of boulder, cobble and gravel substrates which provided riffle to cascade type fish habitat. Creek slope in both the upstream and downstream portion of the ford was approximately 7-10% verses 3-5% along the ford alignment that crosses the creek.

Galena Creek Crossing #2

Fish habitat within the immediate crossing alignment consisted of a creek width of approximately 5- 6m, a water depth of approximately 3-5" and water velocities of approximately 0.5-1m/s. Creek substrates were characterized by approximately 75% cobble and 25% gravel with little to no fines. Habitat within the ford was primarily uniform providing no diversity or cover. Upstream and downstream habitat conditions consisted of boulder, cobble and gravel substrates which provided riffle to cascade type fish habitat. Creek slope in both the upstream and downstream portion of the ford was approximately 5-10% verses 2-3% along the ford alignment that crosses the creek.

Galena Creek Crossing #3

Fish habitat within the immediate crossing alignment consisted of a creek width of as little as 2m in the upstream portion and as much as 6m in the downstream portion where the ford runs parallel, within the creek bed for approximately 5m. Water depth within the crossing location of the creek was approximately 4" and water velocities of approximately 1.5m/s. Creek substrates consisted primarily of cobble, some gravel with few boulders and little to no fines. Habitat within the ford was primarily uniform with little to no diversity or cover with the exception of several small boulders. Upstream and downstream habitat conditions consisted of boulder, cobble and gravel substrates which provided mostly cascade type fish habitat. Creek slope in both the upstream and downstream portion of the ford was approximately 7-10% or greater verses 1-3% along the ford alignment that crosses the creek.

Creek monitoring observations were recorded on three additional days; August 25, September 1 and September 7. On both August 25 and September 1, as per observations completed on August 15, the entire length of Galena Creek, between the Prairie Creek confluence and just upstream of the 3rd crossing of the "old" Galena access road, was observed for the presence/absence of bull trout. During this monitoring period one bull trout was observed (September 1) in riffle/cascade type habitat located between the 2nd and 3rd ford crossing. No spawning redds, or eggs were

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observed during the monitoring completed on these dates. On September 7 the creek, including approximately 500m of creek upstream of the 3rd Galena Creek crossing, was monitored for bull trout activity. Monitoring results produced no observations of trout, spawning redds or eggs.

As an attachment to this letter I have provided photographs of the Prairie Creek ford location and the three ford locations on Galena Creek. All photographs were taken during the August 15 and August 16 monitoring period.

I hope this adequately summarizes the information and results for the monitoring completed for both Prairie and Galena Creek fording. Should you have any questions please do not hesitate to contact me at (867) 873-2415.

Yours truly,

Craig J. Thomas
General Manager
Bathurst Inlet Developments Ltd.

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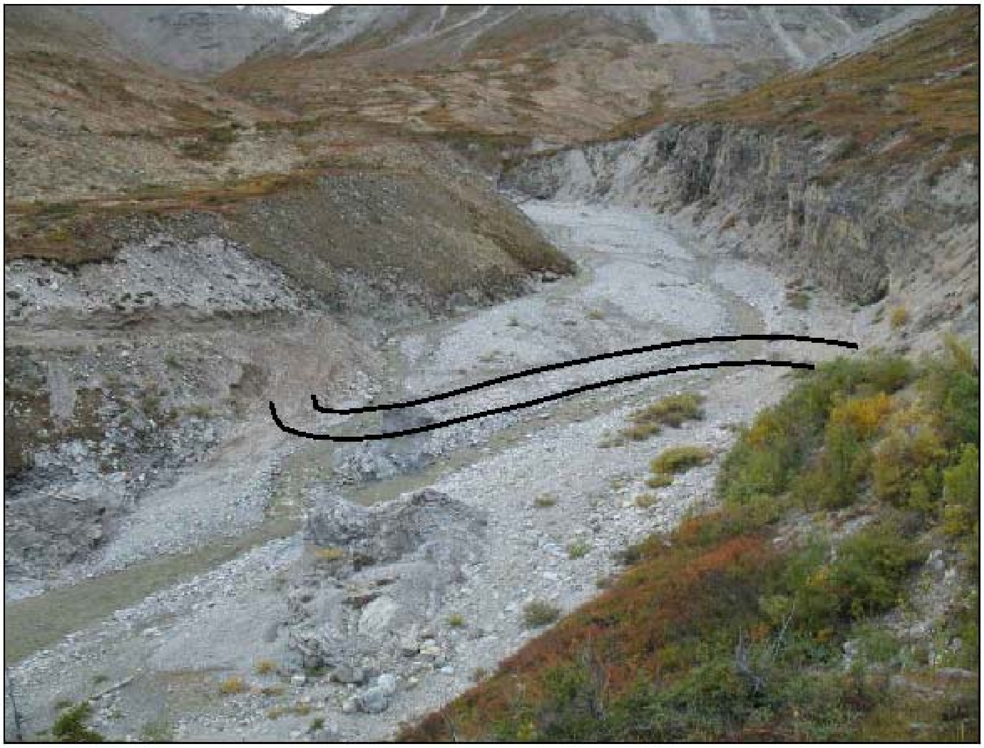
APPENDIX R

Road Crossing Photos


KM 22.5 Existing Sundog Creek crossing


KM 26.1 Sundog Creek


KM 27.8 Sundog Creek


KM 29.8 and 30.2 Sundog Creek


KM 32.1 and 32.4 Sundog Creek


KM 33.3 Sundog Creek

KM 35.0 Sundog Creek

KM 35.9 and 36.0 Sundog Creek

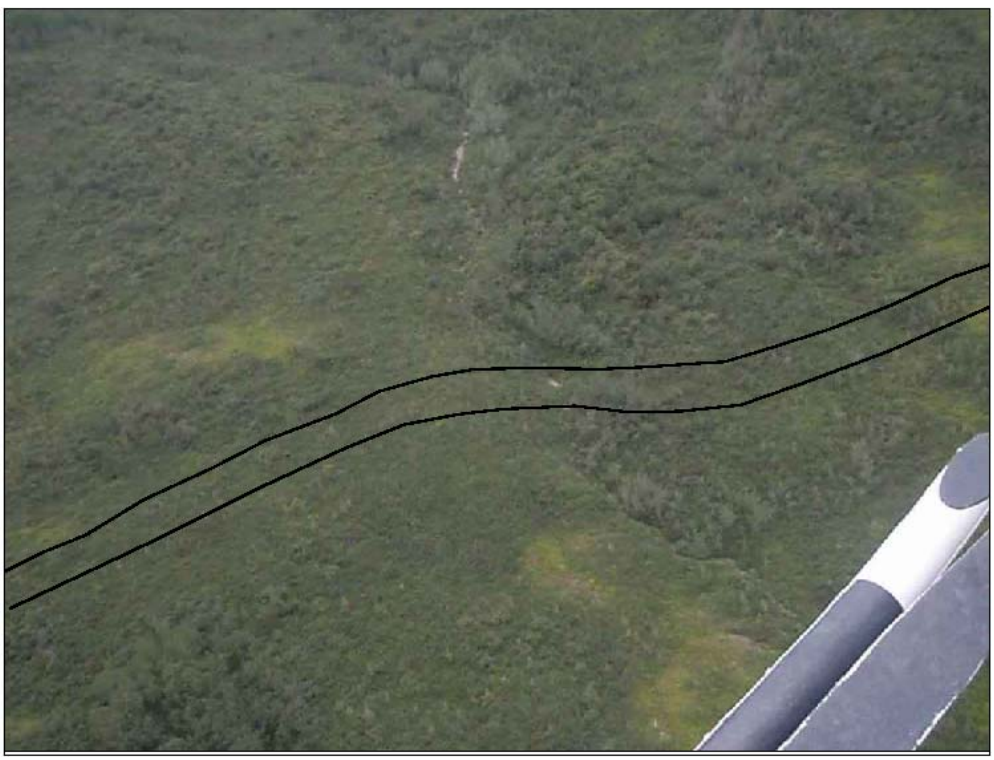

KM 38.0 Sundog tributary


KM 41.6 Sundog tributary

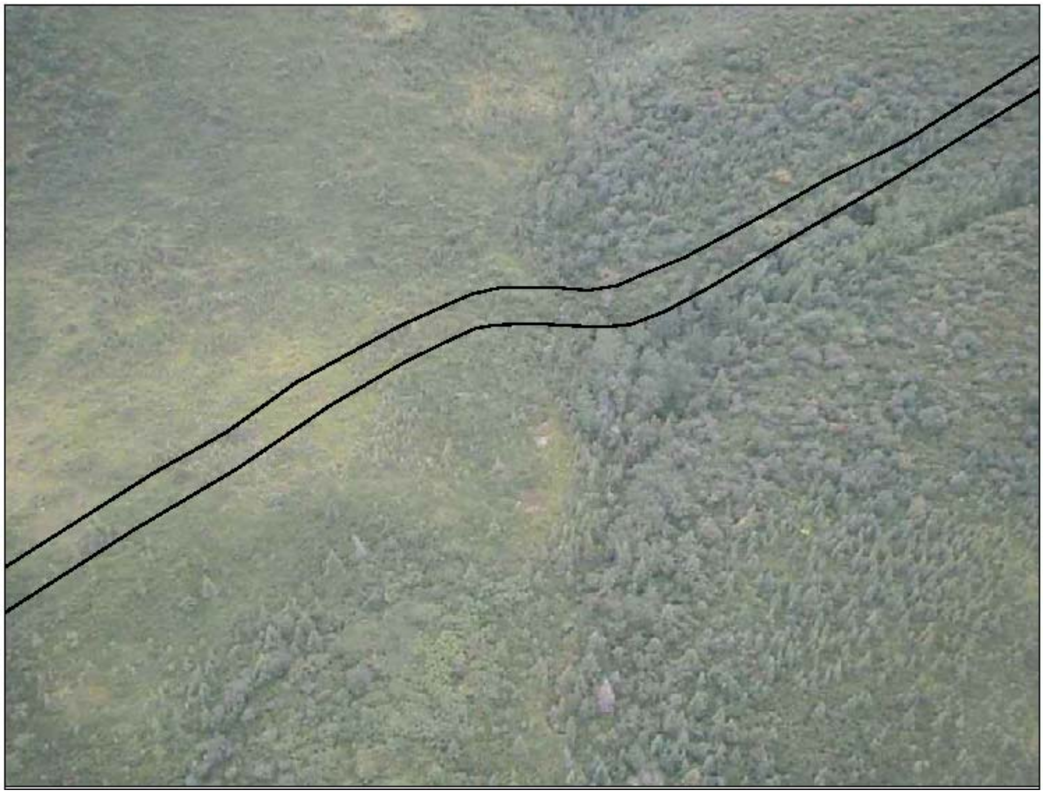
KM 51.2 Polje Creek

KM 86.0 Tetcela tributary

KM 88.5 Tetcela River



KM 110.0 Un-named creek tributary


KM 115.0 Un-named creek tributary


KM 120.0 Grainger River at Grainger Gap

APPENDIX S

Golder Associates Memo Re
Monitoring of WSP Slope Stability

TECHNICAL MEMORANDUM

DATE	10 January 2011	**PROJECT No.**	10-1376-0070
TO	Mr. Dave Harpley Canadian Zinc Corporation		
CC			
FROM	Dave Caughill, John Hull	**EMAIL**	Dave_Caughill@golder.com, John_Hull@golder.com

RESPONSE TO INFORMATION REQUESTS - ROUND 2 – PRAIRIE CREEK MINE, NWT

Introduction

The following is a response to an information request related to the Developers Assessment Report submitted by Canadian Zinc Corporation for the Prairie Creek Mine. This memorandum is in response to a request related to geotechnical issues and the Water Storage Pond.

Natural Resources Canada

IR Number: NRCan2-2
Subject: Stability of the Water Storage Pond (WSP)

Request (i):

Please indicate how information acquired from ongoing monitoring of piezometers and slope inclinometers will be utilized to determine when mitigation will be required to deal with potential instabilities of the north slope, including definition of criteria for intervention and selection of mitigation options.

Response:

Following reconstruction of the north slope above the Water Storage Pond (WSP), piezometers and slope inclinometers will be installed. These will be used to monitor pore pressure in the slope above and below the clay seam and for potential slope movement within or above the clay seam, respectively.

The location and depths of the instrumentation will be determined during final design. The instrumentation will be designed and monitored to provide information in order to assess and monitor the stability of the north slope above the pond and to help assess whether components of the design are functioning properly, such as water diversion ditches and other water control elements.

As part of final design, a monitoring and mitigation plan will be prepared. Included in this plan will be a schedule for reading instruments and preparation of a remedial action plan. The action plan will include criterion for action (such as a certain increase in water level or detection of slope movement), and actions to be undertaken if readings exceed initial caution levels and the warning levels as set out in the criterion. Actions that would be taken include, reporting to site environmental staff, senior mine management, reporting to internal (CZinc) engineers and/or external review engineers, along with increased frequency of readings, increased visual monitoring of the slope, and escalating actions related to stabilising the slope, as required.

The remedial works incorporated into the preliminary design to stabilize the slope consist of a combination of upslope un-loading (soil removal), placement of a fill buttress and apron in the pond footprint, and specification of a minimum pond water level. Detailed design and further analyses will confirm this approach and the stability of the revised slope. In the unlikely event of further slope instability that warrants further remedial action, options readily available would include further upslope un-loading and/or an increase in the minimum pond water level.

ORIGINAL SIGNED

ORIGINAL SIGNED

Dave Caughill
Associate, Senior Geotechnical Engineer

John Hull
Principal, Senior Geotechnical Engineer

DC/JH

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