

June 10, 2010



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**Reference: Review of Predicted Water Quality in Lightning and Christal Creeks
Associated with the BelleKeno 625 Water License Application**

Dear Mr. McIntyre;

I have completed a review of the water quality predictions for both Lightning Creek and Christal Creek provided by Access Consulting Group (May 2010). These predictions are presented as a series of graphs illustrating the current and predicted concentration downstream of the mine discharge into each respective water course (i.e. Lightning and Christal Creeks). Predictions are provided for each quarter of the year to represent the range in flow conditions and have been made for the following substances; ammonia, arsenic, cadmium, copper, lead, nickel, silver and zinc. These predictions are based on a mass balance model approach which incorporates concentration and flow of mine effluent as well as the flow and concentration of the receiving environment. The discharge concentrations used in the model represent maximum discharge criteria recommended by the Yukon Territory Government (Yukon Environment, June 2010; Table 1). These limits are equal to or less than the metal mining effluent limits prescribed to all metal mines in Canada under Metal Mining Effluent Regulations (Government of Canada 2002).

Minnow considered the predicted concentrations for both Lightning and Christal Creeks in the context of environmental protection of downstream biota and in light of existing impacts associated with past mining and current placer mining activities within these receivers. Specifically, the predicted concentrations were compared to the Canadian Water Quality Guidelines for the protection of aquatic life (CCME, 1999) or the baseline (existing) concentration whichever was higher. In the case of cadmium and zinc, the draft Canadian Water Quality Guidelines and associated toxicity database were used (Environment Canada 2009a,b). In instances where predicted values were higher than existing concentrations, the predicted value was compared to established toxicity thresholds. Guidelines and toxicity thresholds were adjusted for hardness where applicable based on existing hardness

concentrations¹. This approach was deemed protective because an increase in concentration is not necessarily associated with a proportional increase in toxicity.²

Discharge limits were deemed acceptable if they resulted in downstream concentrations that were:

- less than the CWQG for the protection of aquatic life;
- within the range of existing concentrations;
- were less than established toxicity thresholds; or
- resulted in no further species affected based on available toxicity data (cadmium and zinc only)

The influence of each of the mine discharges on the downstream receiving environment is discussed separately below.

Mine Water Discharge

Mine water will discharge to Lightning Creek via overland flow then reach the creek through sub-surface drainage. Mine effluent will be released at an average rate of 3 L/sec with a maximum anticipated discharge rate of 4.5 L/sec. Model predictions are based on a discharge rate of 3 L/sec and the recommended effluent criteria proposed by Yukon Environment (June 2010) with no attenuation provided through the subsurface flow, although up to 40 to 90 % attenuation has been observed in treated water that travels through soil in the Keno area. Therefore, model predictions are likely conservative. Model predictions for each quarter show that the highest incremental change over existing concentrations will occur during the first quarter of the year when flow and loadings from upstream sources is lowest. Concentrations for the first quarter (Q1) were evaluated along with the highest concentrations from quarters two to four (Q2 to Q4). These quarters were considered separately as the hardness in Q1 was higher (approximately 100 mg/L) than that observed in Q2 to Q4 (approximately 50 mg/L).

Of the mine related substances assessed, only nickel is not predicted to exceed the CWQG at any time during the year and thus the discharge criterion proposed for nickel is considered acceptable (Table 2). Current concentrations of most other substances (cadmium, copper, lead, silver and zinc) exceed the CWQG in Q2 to Q4 although most were below the guideline within Q1 with the exception of zinc. Therefore, concentrations of these substances will continue to exceed the CWQG in Lightning Creek following discharge from the BelleKeno Mine (Table 2). Concentrations of cadmium, copper, lead and zinc are predicted to be elevated relative to baseline in Q1 but within the range of baseline (current) conditions in Q2 to Q4. Concentrations

¹ For several metals (cadmium, copper, lead, nickel and zinc) toxicological effects are reduced with increasing hardness and CWQG have been developed based on this relationship.

² Generally, some species (typically algae and invertebrates) will be affected at low concentrations of a contaminant, then a substantial increase is required to result in impacts to additional species.

in Q1 are not predicted to exceed toxicity thresholds (Table 2). Concentrations of arsenic and silver are predicted to be elevated over baseline throughout the year (Q1 to Q4), however, all of the predicted concentrations are well below established toxicity thresholds (Table 2). Based on the toxicity literature used to derive the new draft cadmium and zinc CWQG, no additional species will be affected over current conditions (Table 2). Ammonia concentrations are predicted to exceed the CWQG in Q1. However, ammonia toxicity is associated with the un-ionized fraction of total ammonia, the portion of which is a function of temperature and pH. The current CWQG assume a constant temperature of 10 C which overestimates the un-ionized fraction during Q1. Using an un-ionized concentration 0.02 mg/L (OMEE, 1994) as an effect threshold and measured pH and temperature within each quarter in Lightning Creek, the predicted total ammonia concentrations are well below the toxicity threshold (Table 2).

Based on the predicted concentrations, discharge from the BelleKeno 625 Mine will result in increased concentrations of mine related substances downstream in Lightning Creek (particularly in Q1) but these concentrations will not exceed established toxicity thresholds or in the case of cadmium and zinc will not result in any additional effects to biota. Therefore, the proposed discharge criteria should provide adequate protection for the existing biota within Lightning Creek.

Mill Sedimentation Pond

Runoff water from the mill area will be collected and treated if necessary, in a sedimentation pond which will discharge to Christal Creek on an as needed basis. Fresh water supply for the mill will be taken from the sedimentation pond although this water use has not been addressed in model predictions of loadings (flow and concentrations) from the pond and as such the predicted loads and resulting downstream concentrations likely represent a conservative estimate. Predictions were provided for each quarter based on regional hydrology prorated for the drainage area of the sedimentation pond and effluent criteria recommended by Yukon Environment (June 2010). The predicted concentrations were highest in either Q2 or Q4 and as such the assessment of effects focused on the predicted concentrations for these quarters.

Most substances currently exceed CWQG in Christal Creek with the exception of copper and nickel (Table 3). Thus concentrations of most substances are predicted to continue to exceed CWQG in Christal Creek. Copper and nickel are predicted to remain below the CWQG for the protection of aquatic life and thus the proposed discharge criteria for these substances are adequate to ensure protection of aquatic biota in the downstream environment (Table 3). Of the remaining substances modeled only concentration of arsenic and silver are expected to be elevated above the existing concentrations. Concentrations of cadmium, lead and zinc are expected to be within the range of background and thus no additional effects to biota are expected (Table 3). Arsenic and silver concentrations are predicted to be greater than existing concentrations however, these elevated concentrations do not exceed established toxicity thresholds and therefore effects to downstream biota are not expected (Table 3).

Therefore, the predicted concentrations of most substances are expected to be comparable to existing concentrations within Christal Creek downstream of the sedimentation pond discharge. Where concentrations are expected to be higher than existing concentrations, they are substantially less than toxicity thresholds. Therefore, the proposed discharge criteria should provide adequate protection for the existing biota within Christal Creek.

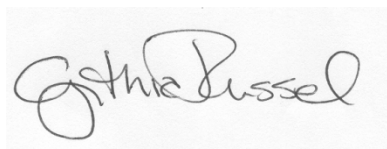
Summary

Access Consulting Limited have completed revised model predictions based on expected discharge flow within each quarter of the year and recommended effluent discharge criterion provided by Yukon Environment for both the BelleKeno 625 mine discharge and the mill sedimentation pond. The proposed criteria are adequate to ensure the protection of resident biota downstream since concentrations are either comparable to existing concentrations or less than established toxicity thresholds.

I trust this review is adequate for your purposes. However, should you have any questions or require any additional information, please do not hesitate to contact me.

Yours truly,

MINNOW ENVIRONMENTAL INC.

A handwritten signature in black ink that reads "Cynthia Russel". The signature is written in a cursive style with a large initial 'C'.

Cynthia Russel, B.Sc.
Senior Aquatic Ecologist, President

Attached: Tables 1-3

References:

Access Consulting Group May 2010 Access Quarterly Mass Loading Models provided in excel format to Minnow Environmental May 31, 2010

CCME (Canadian Council of Ministers of the Environment) 1999. Canadian Water Quality Guidelines for the Protection of Aquatic Life, Winnipeg Manitoba, CCME.

Environment Canada 2009a. Canadian Water Quality Guidelines (CWQG): Zinc Scientific Supporting Document (Draft January 2009). Ecosystem Health – Science Based Solutions. National Guideline and Standards Office, Environment Canada, Ottawa.

Environment Canada 2009b. Canadian Water Quality Guidelines (CWQG): Cadmium Scientific Supporting Document (Draft January 2009). Ecosystem Health – Science Based Solutions. National Guideline and Standards Office, Environment Canada, Ottawa.

Government of Canada. 2002. Metal Mining Effluent Regulations. Canada Gazette, Part II. Vol. 136, No. 13. Wednesday, June 19, 2002.

OMOE (Ontario Ministry of Environment and Energy). 1994. Policies, Guidelines, Provincial Water Quality Objectives of the Ministry of the Environment and Energy (Ontario), July 1994.

Yukon Environment June 2010 Intervention for Type A Water License Application QZ09-092 Alexco Keno Hill Mining Corporation.

Table 1: Proposed Discharge Criteria

Substance	Units	MMER Limits	Proposed Discharge Criteria	
			Lightning Creek	Christal Creek
			Mine Discharge	Sedimentation Pond Discharge
Ammonia	mg/L	NA	5	5
Arsenic	mg/L	0.5	0.1	0.1
Cadmium	mg/L	NA	0.01	0.01
Copper	mg/L	0.3	0.1	0.1
Lead	mg/L	0.2	0.2	0.2
Nickel	mg/L	0.5	0.5	0.5
Silver	mg/L	NA	0.01	0.02
Zinc	mg/L	0.5	0.5	0.5

NA - not applicable

Table 2: Predicted concentrations in Lightning Creek relative to CCME guidelines, background and toxicity thresholds.

Substance	Units	Quarter ²	Current Concentration	Proposed Discharge Criteria - revised	Predicted Concentration	CCME Guideline	Exceeds Guideline Currently	Predicted to Exceed Guideline ¹	Within range of existing concentration ⁴	Toxicity Threshold ³	Above Threshold	Species potentially currently effected	Species potentially effected over current
Ammonia ⁵	mg/L	Q1	-	0.1	0.168	0.137	-	yes	-	5.12	No		
		Q2-Q4	-		0.0343		-	no	3.39				
Arsenic	mg/L	Q1	0.0026	0.1	0.005	0.005	no	yes	no	0.35	No		
		Q2-Q4	0.0038		0.006		no	yes	no				
Cadmium	mg/L	Q1	0.000067	0.01	0.00037	0.00021	no	yes	no	NA		<i>Daphnia magna, Ceriodaphnia dubia, Hyalella azteca</i>	
		Q2-Q4	0.00029		0.00032	0.0001	yes	yes	yes				
Copper	mg/L	Q1	0.00076	0.1	0.00431	0.002	no	yes	no	0.0065	No		
		Q2-Q4	0.0096		0.00995		yes	yes	yes				
Lead	mg/L	Q1	0.001	0.2	0.008	0.001	no	yes	no	0.012	No		
		Q2-Q4	0.007		0.007		yes	yes	yes				
Nickel	mg/L	Q1	0.00066	0.5	0.01763	0.065	no	no	no	0.012	No		
		Q2-Q4	0.00363		0.006515		no	no	yes				
Silver	mg/L	Q1	0.000048	0.01	0.000403	0.0001	no	yes	no	0.0035	No		
		Q2-Q4	0.000176		0.000203		yes	yes	no				
Zinc	mg/L	Q1	0.0172	0.5	0.025	0.016	yes	yes	no	NA		<i>P. subcapitata, Eperous latifolium</i>	<i>Chlorella vulgaris</i>
		Q2-Q4	0.0327		0.034	0.012	yes	yes	yes			<i>P. subcapitata, Eperous latifolium, Ceriodaphnia Dubia, Chlorella vulgaris, Daphnia magna, Potamopyrgus jenkinsi</i>	

¹ based on predictions from Access

² Q1 value used with a hardness of 100 mg/L and the highest value from Q2 to Q4 used with a hardness of 50 mg/L

³ toxicity threshold based on CCME 1999 rationale document

⁴ predicted concentration is within 10% of existing concentration

⁵ Ammonia toxicity is associated with the un-ionized fraction which is a function of pH and temperature. The CCME limit assumes a temperature of 10C however the temperature in Lightning Creek in Q1 will be much lower than 10C. The predicted concentrations are well below toxicity thresholds for un-ionized ammonia.

Table 3: Predicted concentrations in Christal Creek relative to CCME guidelines, background and toxicity thresholds.

Substance	Units	Quarter ²	Current Concentration	Proposed Discharge Criteria - revised	Predicted Concentration	CCME Guideline	Exceeds Guideline Currently	Predicted to Exceed Guideline ¹	Within range of existing concentration ⁴	Toxicity Threshold ³	Above Threshold	Species potentially currently effected	Species potentially effected over current
Arsenic	mg/L	Q2	0.0065	0.1	0.0072	0.005	yes	yes	no	0.35	No		
		Q4	0.0173		0.0177		yes	yes	no				
Cadmium	mg/L	Q2	0.00194	0.01	0.00202	0.00024	yes	yes	yes	NA		<i>Daphnia magna, Ceriodaphnia dubia, Hyalella azteca, Oncochrynochus mykiss, Chironomus tentans, Cottus bairdi, Salmo salar, Salvelinus confluentus</i>	
		Q4	0.00327		0.00332		0.00043	yes	yes				
Copper	mg/L	Q2	0.0019	0.1	0.00259	0.003	no	no	no	0.0065	No		
		Q4	0.0034		0.00382		0.004	no	no				
Lead	mg/L	Q2	0.021	0.2	0.022	0.004	yes	yes	yes	0.012	No		
		Q4	0.12		0.121		0.007	yes	yes				
Nickel	mg/L	Q2	0.00301	0.5	0.0064	0.11	no	no	yes	0.012	No		
		Q4	0.00332		0.0053		0.15	no	no				
Silver	mg/L	Q2	0.00022	0.02	0.000353	0.0001	yes	yes	no	0.0035	No		
		Q4	0.00107		0.001154		yes	yes	yes				
Zinc	mg/L	Q2	0.22	0.5	0.225	0.00114	yes	yes	yes	NA		<i>P. subcapitata, Eperous latifolium, Ceriodaphnia Dubia, Chlorella vulgaris, Daphnia magna, Potamoopyrgus jenkinsi, Tanytarsus dissimilis, Brachionus havanaensis, Chlorella pyrenoidosa, Oncochrynochus mykiss, Scenedesmus quadricauda, Chironomus riparius, Cottus bairdi, Hydra viridissima</i>	
		Q4	0.317		0.3202		0.00251	yes	yes				

¹ based on predictions from Access

² Q2 selected as it is the quarter with lowest hardness and in some instances the highest concentrations. Q4 also assess as it had the highest concentrations when Q2 did not. A hardness of 120 mg/L was used for Q2 and a hardness of 250 mg/L was used for Q4 as these represent the lowest hardness in each respective quarter.

³ toxicity threshold based on CCME 1999 rationale document

⁴ predicted values within 10% were considered within the range of background