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April 23, 2007

Sarah Baines
Regulatory Officer
Wek'èezhìi Land and Water Board
#1 4905-48th Street
Yellowknife, NT X1A 3S3

Re: BHP Proposed Chloride Discharge Criterion for the Sable Kimberlite Pipe Development

Dear Ms. Baines:

The Water Resources Division of Indian and Northern Affairs Canada have reviewed the proposed limits for Chloride submitted by BHP in January 2007. We have also retained an expert to provide a technical review of BHP's proposal (see attached).

Water Resources is not convinced that what BHP has proposed is appropriate. Our key concerns are as follows: a discharge criterion at the edge of the mixing zone of 313 mg/L is higher than all other criterion proposed by all other sources in Rescan's report; Rescan identified that hardness is a main factor that influences Chloride toxicity but has not modified the proposed limit to compensate for the measured hardness of Horseshoe Lake; and finally, the approach used for estimating Chloride discharge criterion is not advocated in any of the guidance documents reviewed by Rescan.

The Water Resources Division would like to thank the Wek'èezhìi Land and Water Board for providing the opportunity to review and comment on BHP's Proposed Chloride Discharge Criterion for the Sable Kimberlite Pipe Development. We hope that the Board will find these comments useful.

Sincerely,

-original signed by-

Dr. Kathleen Racher
Manager
Water Resources Division

Review of the BHP Proposed Chloride Discharge Criterion

Prepared by
Zajdlik & Associates Inc.

Prepared for
N. Richea
INAC

April 20th 2007

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Table 1: List of Acronyms

Acronym	Definition
HC_5	Concentration hazardous to 5% of species
MVLWB	Mackenzie Valley Land and Water Board
SSD	Species sensitivity distribution
WLWB	Wek’èezhíi Land and Water Board

1 Introduction

BHP is requesting that they be allowed to discharge wastewater containing Cl to an environment where Cl is not usually detectable and without attempting to remove Cl from the wastewater prior to discharge. BHP has proposed to discharge Cl at a level predicted to be protective of the environment.

This review only assesses the safety of the Cl discharge criterion and does not endorse discharge of Cl over option 1) treatment of discharge or 2) discharge of Cl at levels consistent with the background in the receiving environment.

It is important to note that in a review of this nature; only concerns with the document are expressed resulting in an unbalanced perception. The document reviewed does have a strong structure with clear logical steps leading to a proposed criterion. There is a general discussion of uncertainty which is often not seen in documents of this type.

2 The Receiving Environment

BHP (2007) describes the receiving environment for the Sable kimberlite pipe in the Horseshoe watershed of the BHP claim block. Observations pertinent to this review from BHP (2007) are presented below.

- Background chloride in the Horseshoe watershed is < 1 mg/l (BHP, 2007)

- The predominant phytoplanktonic taxa in Horseshoe Lake are Bacillariophyceae, Chlorophyta, Chrysophyta, Cryptophyta and Cyanophyta.

- The three main taxonomic groups of zooplankton based on numeric abundance are rotifers, calanoid copepods, and cyclopoid copepods.

- The three main taxonomic groups of lake benthos based on numeric abundance are nematodes, dipterans and molluscs.

- The main taxonomic group of stream benthos based on numeric abundance are dipterans.

- The following upper trophic level fish are found in the Horseshoe watershed: round whitefish (*Prosopium cylindraceum*), lake trout (*Salvelinus namaycush*) and Arctic grayling (*Thymallus arcticus*). Lower trophic level fish are not identified.

3 Estimating Water Quality Criteria for Chloride

Various jurisdictions or individuals have estimated water quality criterion for chloride. Three estimates were reviewed by BHP, an additional estimate is also discussed below.

3.1 British Columbia

The BC ambient water quality guideline for chloride for the protection of aquatic life is 600 mg/L for a maximum exposure, and 150 mg/L for 30-day average exposure (BCMWLAP, 2003) BHP, (2007).

BHP rejected these criteria based on the application of a large safety factor in the case of the chronic criterion and the non site-specific nature of the guideline. However the lack of site-specificity of the BC guidelines are not discussed.

3.2 United States

The US EPA (1988) criteria for chloride are the final acute value of 1,720 mg/L and a chronic value of 230 mg/L. The value of 230 mg/l corresponds to a four day average that should not be exceeded more than once every 3 years.

BHP contends that the acute-to-chronic ratio used to adjust the final acute value in the absence of sufficient data to estimate a chronic criterion directly is poorly estimated as data are obtained form only one study with three species. In this study the acute-to-chronic ratio varied from 4 to 15.

3.3 EVS Risk Assessment

EVS Tier 1 risk assessment (EVS, 2004) used the SSD approach to estimate acute and chronic objectives of 1,369 mg/L and 180 mg/L, respectively. This dataset excluded taxonomic groups that were not found in sub-arctic environments. The chronic value was estimated by applying the US EPA (1988) acute-to-chronic ratio of 7.594 to the acute SSD result. BHP (2007) disagrees with this number on the basis of 1) an acute-chronic-ratio based upon one study and 2) inclusion of 5 short –term datasets using in the dataset used to derive the acute SSD HC_5 because the response measured for these tests was not lethality.

BHP's removal of the algal results is unwarranted for the reason stated; however removal of the algal results is warranted on the basis of the following statement from CCME (2006) regarding derivation of water quality criteria using SSDs:

*All toxicity tests with **Algae** are considered long-term exposure tests because of the length of the algal life cycle compared to the duration of the exposure.*

3.4 Environment Canada

Environment Canada (1999) assessed the toxicity of road salt to various components of the biosphere including aquatic ecosystems. They estimated an HC_5 of 210 mg/l based on median lethal concentrations. Environment Canada (1999) concludes that “Aquatic ecosystems experiencing such chloride levels (210 mg/l) are expected to be impaired.”

BHP did not review this document.

3.5 BHP Approach

BHP conducted acute and chronic toxicity tests using 9 genera that included data two fish, cladocera, and oligochaetes, and one rotifer, one dipteran, and one amphipod. An acute criterion using a dataset comprised of these acute toxicity test results and additional[1] toxicity test results. The HC_5 estimated from this dataset was higher than that of some observed chronic test results therefore a chronic value was estimated using the HC_5 estimated from the chronic dataset.

The chronic dataset used by BHP is comprised of results from the 9 toxicity tests described above, data “ in US EPA (1988) for *Daphnia*, rainbow trout and fathead minnows, values for algal species summarized by EVS (2004) and values for *Nitzchia* summarized in the BC Water Quality Guidelines (BCMWLAP, 2003)”.

It is not clear exactly what data from the first two of the documents cited were included in the dataset nor is it clear which observations (if any) were omitted, based on the text provided. This information may be contained in Appendix A, but this document was not available for review[2]. As dataset composition is one of the primary practical challenges in estimating water quality criterion as illustrated by BHP’s concern regarding single observations, this potential omission is of concern.

BHP (2007) states that the 10 most sensitive chronic values of the dataset compiled above, were used to estimate the HC_5. This selection process does not follow the methodology for estimating water quality guidelines in the documents cited by BHP. Additionally the methodology used by BHP to estimate the HC_5 is inconsistent with those documents.

The potential effect of toxicity modifying factors such as hardness on the estimated water quality criterion is discussed in section 3.3.4 but this rightful concern does not appear in the executive summary of BHP (2007). If the HC_5 was estimated under hardness conditions of 80 to 100 mg/L (as CaCO3) and exposure to Cl is at much lower hardness’ in the Horseshoe lake ecosystem then the protective effects of hardness claimed by BHP (2007) will not occur. The consequence is that the estimated HC_5 will be underprotective.

[1] The source of these additional toxicity test results is not clear.
[2] A search of the MVLWB and WLWB public registries for this document was unsuccessful.

3.6 Summary

BHP's recommended criterion is the highest of the criteria presented by BHP and is also higher than another chloride threshold developed in Canada, reviewed herein. The species used to develop the criterion are not clear based upon available documentation and the method used to estimate the HC_5 is inconsistent with the cited documents. The potential effect of modifying factors is discussed but no practical methods are presented to deal with these effects.

4 Modelling Water Flow

Evaluation of water flow models is not within the area of expertise of B. Zajdlik. However use of predicted values arising from models is an area of considerable familiarity. The following observations are made regarding the estimates of dilution provided by BHP.

- Pit water discharge was modelled for open water conditions. The effect of ice on pit water discharge should be assessed particularly given the relative lengths of the ice-cover and open-water seasons. Wind-induced dilution will be almost nil[3] during the ice-cover season.

- Daily flows are estimated for only a fraction of the calendar year. It is not clear what if any consideration was given to water flows for the remaining 7 months of the year.

- BHP (2007) states that yearly flow to Horseshoe Lake should be equivalent to the natural flow because the catchment area will be unchanged. While this may be true it assumes that overland flow is driven by the surficial catchment only. This assumption will be incorrect if substantive ground-water flow is encountered, which would be altered by pit-dewatering.

- The second paragraph of section 2.5 is confusing. There seems to be an implication that Horseshoe Lake is unfrozen during the winter but the following sentence discusses discharge of pit water to the frozen Horseshoe Lake. It may be that operations/dewatering are restricted to certain times of the year?

- It is not clear whether inputs to the model such as bathymetry, bed resistance, wind field, hydrographic boundary conditions etc. were entered as fixed values, a range of values or values representing a worst-case scenario.

- The 21-day dilution minimum is predicted at a 100m distance from the discharge of Two Rock Stream into Horseshoe Lake. This dilution rate is presented as an absolute value rather than a predicted value with associated imprecision.

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[3] Wind over large frozen bodies of water can induce flexing of ice. This effect on mixing of water is likely negligible in large lakes and even less so in small lakes such as Horseshoe Lake.

5 Integrating Effluent Dilution and Toxicity Test Results

BHP (2007) uses a simple calculation to determine what the effluent discharge criterion should be. The calculation assumes that a 21-day average is equivalent to the static exposure from which the acute and chronic HC_5 values were estimated. Unfortunately averages of time-varying exposures are not usually equivalent to constant exposures. This was demonstrated in 1969 for phenol and Zn (Brown et al, 1969). Also see Thurston et al, (1981) for the effects of inconstant ammonia exposure, Seim et al, (1984) for a discussion regarding episodic Cu exposure and Siddens et al, (1986) for a comparison of fluctuating and constant Al exposures. Generally, the level of exposure required to protect against fluctuating exposures is lower than that required to provide equivalent protection during static exposures.

The 21day average was selected to represent the results of chronic exposures in laboratory toxicity tests. It is not clear that a 21 day average is appropriate. The effects of using an alternate exposure period should be discussed.

6 Conclusions

1. There are three methods to prevent Cl from affecting the receiving environment. These are a) treatment and removal prior to discharge, b) discharge at levels commensurate with the natural background and c) discharge at a level predicted to be protective of the environment. BHP has chosen the latter of these three options.

2. Dataset composition is one of the primary practical challenges in estimating water quality criterion. This is illustrated in the discussions in BHP (2007) regarding single toxicity test results in:

   - section 3.2.1 regarding the *Ceriodaphnia dubia* EC50
   - section 3.2.3 regarding the *Nitchia* EC50

   It is critical that BHP provide the rationalization for each datum comprising a toxicity test dataset prior to estimating a water quality criterion. Without assurance that observations were discarded or included following due consideration, any water quality guidelines derived will be subject to debate.

3. The approach used to estimate the acute and chronic criterion for chloride presented in Figure 3.3-1 and 3.3-2 is not the approach advocated in the documents cited (ANZECC, 2000; RIVM, 2005 and Schneider *et al* 2006). The approach used by BHP is also not that advocated in CCME (2006) or in the supporting document Zajdlik (2006).

   There are numerous theoretical flaws in the approach that was used by BHP to estimate chloride criteria. BHP should recalculate the chloride criteria in a manner consistent with the cited documents and/or the additional documents provided above.

4. The HC_5 of 313mg/l estimated by BHP (2007) is higher than that proposed by BCMWLAP, (2003), US EPA (1988) and (EVS, 2004). The US EPA value of 230 mg/l corresponds to a four day average that should not be exceeded more than once every 3 years. BHP's proposed criterion is higher at 313 mg/l and corresponds to a longer 21-day average.

   Environment Canada (1999) concludes that "Aquatic ecosystems experiencing such chloride levels (210 mg/l) are expected to be impaired."

5. The Bacillariophyceae which are one on the predominant phytoplanktonic taxa in receiving environment (BHP, 2007) may be particularly sensitive to chloride shifts (Dixit et al, 1999). Therefore a lower value may be required to protect this predominant taxon. (Note that Dixit refers to the Diatomaceae which may not comprise the majority of the Bacillariophyceae in the Horseshoe watershed.)

6. One factor that modifies Cl toxicity was identified by BHP. No provision to incorporate the effect of hardness was proposed by BHP. Given that the hardness under which the toxicity tests were conducted is likely one order of magnitude greater than that of the receiving water, the adequacy of the proposed criterion should be demonstrated.

7. Some of the assumptions made by BHP regarding modeling and discussed in section 4 should be addressed. These may affect the utility of the predicted dilution factors.

8. The predicted dilution factors do not acknowledge imprecision or variation of model input parameters. There may be therefore be considerable unacknowledged variation in the dilution factor used. This variability is addressed through qualitative statements by BHP but a more complete investigation is warranted.

9. The 21day time period over which dilution was averaged was selected to represent the results of chronic exposures in laboratory toxicity tests. It is not clear that a 21 day average is appropriate. The effects of using an alternate exposure period should be discussed.

7 Citations

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