Overview of the BHP Proposed AEMP

Prepared by
Zajdlik & Associates Inc.

Prepared for
R. Chouinard
INAC

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Table 1: List of Acronyms

Acronym	Definition
AEMP	Aquatic Effects Monitoring Program
DOC	dissolved organic carbon
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
PCA	principal components analysis
TOC	total organic carbon

1 Introduction

This document investigates the Aquatic Effects Monitoring Program (AEMP) proposed by BHP (Rescan, 2006b) and briefly examines the three-year AEMP review. This document is not a formal, comprehensive review of the AEMP but rather discusses issues noted during an AEMP Technical Review Information Session hosted by BHP on Nov. 21-22 in Yellowknife. Investigation of these issues has led to other areas requiring attention. These issues are flagged and discussed within the time available.

This document is intended to aid BHP in improving the AEMP that will be submitted to the Wek'eezhii Land and Water Board by December 31, 2006 as per the requirements set out in Part I of the MV2003L2-0013 Water License.

One of the issues that arose during the Nov. 21-22 meeting is the lack of direction for the AEMP. BHP is collecting large amounts of data[1], but has no criteria in place for assessing whether they have collected "sufficient" data, nor how to adaptively manage the project from the perspective of the AEMP results. During the technical review meeting Chris Hanks (Rescan) candidly mentioned that the latter item has been discussed by BHP in the past.

The water license (BHP, 2005) has the following requirements relevant to criteria for the AEMP:

- Part I, Item 2(e) "statistical design criteria, including a description of sampling frequencies for each parameter that ensures both accurate characterization of short-term variability and the collection of sufficient data to establish long-term trends"

- Part I, Item 2(g) "a description of evaluation criteria for the Aquatic Effects Monitoring Program and approaches to amend and refine the Aquatic Effects Monitoring Program"

- Part I, Item 2(h) "a description of how the results of the Aquatic Effects Monitoring Program will be incorporated in the overall adaptive management strategies employed by the Licensee"

Further discussion during the Nov. 21-22 AEMP presentation, revealed that the word "sufficient" used in the paragraph above has not been defined. Without a definition of this word, a reviewer cannot say that the AEMP is "good" or "bad" or that it meets it's stated goal or goals. Conversely BHP cannot say "We are collecting more samples than necessary" or demonstrate in a quantitative manner that the AEMP is "good".

[1] some of which may not be necessary, (Zajdlik, 2004).

BHP has noted changes in the receiving environment but without numeric criteria, reviewers or stakeholders cannot say that the proponent is having deleterious effects on the environment. Neither can the proponent say "the integrity of the ecosystem has not been affected by BHP activities"; a statement that reflects BHP's Environmental Policy (BHP, 1995).

Defining criteria that allow the BHP AEMP to labelled as "good" or bad" is both necessary and beneficial for all stakeholders.

The literature that comprises the background to the BHP AEMP was searched for discussions regarding:

1. BHPs general environmental policy;
2. the goal of the AEMP;
3. measurable targets set by reviewers; and,
4. absolute requirements of the BHP water license (MVLWB, 2005),

in order to define the requisite criteria. The information obtained is summarized in section 2.

Sections 3 and 4 discuss concepts that have been used in developing assessment/action criteria for various Canadian environmental monitoring programs.

Section 5 reviews BHP's impact predictions to see whether the concepts of valued ecosystem components or measurement endpoints were used in the impact predictions.

Section 6 discusses effect sizes for measurement endpoints for specific valued ecosystem components that should form the basis of impact predictions.

Sections 7 and 8 summarize this information and provide recommendations, respectively.

Note that only those portions of the documents pertaining to aquatic effects were investigated. All of the comments made in this document pertain to aquatic effects monitoring unless otherwise stated.

2 Background Document Review

2.1 Environmental Policy

BHP's environmental policy (BHP, 1995 Volume 3, pg. 1) makes the following statements that are relevant from the perspective of setting criteria for an AEMP.

"Components of the policy specify the following:

- legal compliance, and, in the absence of adequate legal protection for the environment, application of standards that minimize adverse impacts from operations;

- establishment of management systems to identify, control and monitor environmental risks arising from its operation,

- etc."

The key concepts in these statements are:

- comply with legal standards: Legal standards are an absolute against which environmental performance can be assessed.

- If legal standards do not exist apply standards that minimize adverse effects: The phrase "minimize adverse effects" speaks to the degree of allowable risk of not detecting an effect using an AEMP.

- Management systems to control environmental risk: This item speaks to the purpose of an AEMP as an element of the management system.

2.2 Environmental Management Plan

BHP makes the following statement regarding their environmental management philosophy. "It is the intent of the Proponent to develop the project so as to minimize negative impacts to the associated valued ecosystem components (VECs)." (BHP, 1995 Volume 3, section 3.1). The following statements regarding their environmental management plan are extracted from BHP (1995).

- "The Environmental Management Plan (EMP) contains the programs and policies that will be implemented to preserve ecosystem integrity as well as to prevent and mitigate any potential environmental impacts associated with all phases of project development, operation, decommissioning and closure. The EMP is based on

information obtained from baseline studies conducted on site (1993 to 1995), available regional data and traditional environmental knowledge. The plan takes into account the northern setting of the project within a tundra environment." (BHP, 1995 Volume 3, pg. 1).

- "The Environmental Management Plan (EMP) for the proposed NWT Diamonds Project is comprised of the integrated policies and programs that will be implemented to preserve the integrity of the claim block ecosystem. "(BHP, 1995 Volume 3, Section 1.3).

BHP makes the following statement in the context of environmental impact assessment:

"The NWT Diamonds Project has been designed to ensure that the residual effects of project activities will not cause any extensive degradation of the chemical or physical qualities of water, soils or the atmosphere of the ecosystems within the claim block. Therefore, the NWT Diamonds Project will not jeopardize ecological integrity through degradation of water, soil and air." (BHP, 1995 Volume IV, pg. 1.7).

The phrases "preserve ecosystem integrity" and "not jeopardize ecological integrity" are relevant from the perspective of setting criteria for an AEMP.

2.3 Purpose, Goals and Criteria for Environmental Monitoring

BHP makes the following statement regarding the purpose of environmental monitoring:

- "The Environmental Monitoring Plan has been designed to determine compliance with government guidelines and permit requirements, the accuracy of predicted environmental impacts and the effectiveness of mitigative actions." (BHP, 1995 Volume 3, pg. 10, also section 10).

The goal of BHP's environmental monitoring program is stated below:

- "The monitoring plan is designed to provide adequate data for monitoring a range of water management parameters related to all phases of the NWT Diamonds Project." (BHP, 1995 Volume 3, Section 10.1.1).

Finally, criteria for environmental monitoring are mentioned in the following sentence:

- "Monitoring requires measurements that are statistically valid with adequate reference control to distinguish between project-related impacts and natural changes in the environment (such as cyclic changes in lemming abundance). (BHP, 1995 Executive Summary, pg. 46).

The statements relevant from the perspective of setting criteria for an AEMP are:

1. "designed to determine compliance with government guidelines and permit requirements, the accuracy of predicted environmental impacts and the effectiveness of mitigative action" While none of these statements are quantifiable they contain elements that when defined, may be used to assess the utility of the AEMP.

2. The phrases "adequate data" and "statistically valid" can be defined. There are many suitable conventions that describe "adequacy of data" and statistically valid". These might be adopted or serve as a basis for discussion.

2.4 Summary

BHP has an environmental policy that discusses compliance with legal standards, minimizing environmental impacts where no such standards exist and managing the operation so as to control or mitigate environmental risks. The policy is translated into an environmental plan that is intended to follow the environmental policy in the context of the site-specific northern environment. The goal of the environmental plan is to "preserve the integrity of the claim block ecosystem".

While the statements themselves are admirable, they are not actionable because key phrases such as "minimize negative impacts" have subjective connotations. Other phrases such as "integrity of the claim block ecosystem" require that a concept such as "integrity" can measured.

3 Valued Ecosystem Components

When an ecosystem is being monitored it is not necessary to take measurements from every biotic and abiotic element of the ecosystem. Elements of the ecosystem to measure can be selected through a combination of criteria including, sensitivity to the contaminants of potential concern by virtue of either or both of habitat preference and toxicological sensitivity, social or political relevance, cost-effectiveness, etc. The elements so selected are known as value ecosystem components (VECs). These concepts are thoughtfully articulated in section 1.3.2 (BHP, 1995 Volume II). Table 1.1-1 (BHP, 1995 Volume II) summarizes VECs. With respect to the aquatic environment specific reference is made to fish, water quality and aquatic habitat. It is not clear whether the VEC, biodiversity refers to the aquatic environment.

BHP discusses the following VECs in the aquatic environment.

- "Water quality has been identified as a valued ecosystem component due to its importance to aquatic and terrestrial ecosystems and to the human populations that depend upon them." (BHP, 1995 Volume IV, pg. 2.21).

- "Fish have been identified as a valued ecosystem component due to their intrinsic value as well as their importance as a food source, and to a lesser extent, for their

associated recreation value." (BHP, 1995 Volume IV, Section 3.1, pg. 1). Specifically, "Lake trout and arctic grayling have been identified as valued ecosystem components." (BHP, 1995 Volume II, pg. 3.5).

This list does not include other components of the ecosystem that if adversely affected by the Project, will also affect fish. The list includes benthic macroinvertebrates, periphyton, zooplankton and phytoplankton. One or more of these ecosystem components should be explicitly labelled as a VEC as they provide an early warning system of potential effects on fish and may be more sensitive to project-related effects than fish. The exclusion of these components as explicitly named VECs could be construed as scientifically negligent. We do acknowledge that BHP is monitoring phytoplankton, zooplankton and benthos.

4 Measurement Endpoints

Measurement endpoints describe some measurement of a VEC. For example a measurement endpoint for fish might be the ratio of body size to weight or condition factor. Stressed fish may not be as heavy as unstressed fish, resulting in a change in condition factor due to the Project. Examples for water quality abound; each contaminant released to the environment may be measured and each measurement comprises a measurement endpoint.

Aside from the potential effect of angling in reducing the average size at age is mentioned, no measurement endpoints are explicitly stated for fish, in the Environmental Impact Statement (EIS).

With respect to water quality, BHP, 1995 Volume IV, Section 2.4 discusses measuring sedimentation and suspended solids. Al and Ni are also identified as analytes that should be measured. Nitrates are discussed due their use as explosives but dismissed as a potential problem.

Despite the fact that measurement endpoints were not mentioned in the EIS it is clear that many elements of the aquatic ecosystem have been measured and will continue to be measured. (See for example, Rescan 2006b).

The omission of measurement endpoints in the EIS is not critical in and of itself but coupled with a lack of effect sizes (discussed in section 6) does comprise a fundamental omission with respect to purposefully and effectively monitoring the aquatic environment.

5 Impact Predictions

The water license (MWLB, 2005, Part I, Item 2(j)) requires "a comparison of effects in the aquatic environment to those predicted in the EIS and an assessment and rationale of how the results of this comparison are incorporated into revisions to the Aquatic Effects Monitoring Program." Sections 5.1through 5.5 summarize the effects predicted in the EIS.

5.1 Water Quality

5.1.1 Predictions

BHP (1995, Volume IV, pg. 1.6) made the following general statement regarding environmental effects: "In the majority of cases, the results of the environmental impact assessment for the proposed NWT Diamonds Project suggest that the residual effects on valued ecosystem components (VECs) will be negligible. This judgement is largely based on the fact that the local, unavoidable damages caused to terrestrial and aquatic habitats represent effects on a very small fraction of the affected habitat types within the claim block, and an even smaller impact on the Southern Arctic Ecozone."

Aside from this statement the only other prediction regarding water quality pertains to Al and Ni. Following a modelling exercise, Rescan (BHP, 1995 Volume IV, pg. 2.36) states: "Clearly, discharge from cell E during Years 1 to 18 can proceed without impact to the receiving environment. Moreover, conservative estimates of water quality within Cell E indicate that discharge of this water will not increase concentrations of Al or Ni (the only metals of environmental concern in the discharge) sufficiently to even approach applicable federal criteria for the protection of aquatic life for these parameters."

5.1.2 Mitigation

No mitigation was proposed for water quality following the predictions above. Note that strong efforts (not discussed here) to prevent the receiving environment from becoming contaminated were discussed in the EIS.

5.2 Aquatic Habitat Loss

5.2.1 Predictions

Some loss is expected due to dewatering (BHP, 1995 Volume IV, Section 3.1.1).

5.2.2 Mitigation

Addressed through DFO no net loss policy and "establishment of a habitat fund for offsite enhancement of habitat and productivity" and creation of the Panda diversion channel.

5.3 Aquatic Habitat Modification

5.3.1 Predictions

Some effects of sedimentation are expected during construction of bridges, roads, culverts and stream crossings, construction of diversion channel. BHP feels that effects will be temporary once losses due to these activities stop. (BHP, 1995 Volume IV, Section 3.1.2.1).

"The overall impact of turbidity and sedimentation will be minor, fairly localized and short term. From initial construction through the decommissioning phase, habitat may be affected at times by sedimentation and turbidity, but only in localized areas. However, wind and ice action will redistribute sediments and tend to return shorelines to their original condition as the finer fractions will be redeposited in deeper waters. As lake trout spawning habitat is abundant in most lakes, other areas will be available if one site is degraded through sedimentation." (BHP, 1995 Volume IV, Section 3.1.2.3)

5.3.2 Mitigation

Mitigation is through management of construction processes and monitoring. (BHP, 1995 Volume IV, Section 3.1.2.2).

5.4 Aquatic Habitat Degradation

The likelihood of aquatic habitat degradation is "low". Training in spill response and contingency planning will be used to mitigate the effects of spills. Geotechnical inspections of dams will be used to ensure viability of dams. Monitoring will be used to assess effects of seepage at an early stage (BHP, 1995 Volume IV, Section 3.1.8).

5.5 Predictions of Cumulative Effects

The only cumulative effect pertaining to water quality, hydrology, aquatic habitat or fish is "decreased fish productivity resulting from local habitat degradation" (BHP, 1995 Volume IV, Table 5.6-1. This effect was predicted to be "minor" (BHP, 1995 Volume IV, Table 5.7-1).

Potential cumulative effects will be assessed through monitoring (BHP, 1995 Volume IV, Section 5.8).

5.6 Summary

The EIS makes only very general qualitative predictions regarding impacts to the aquatic environment. These qualitative predictions preclude comparison of impact predictions in the AEMP as required by the water license (part I 2(j)). These comparisons were not found upon examining Rescan (2002, 2006a).

6 Effect Sizes

The size of biological or chemical change that is significant from an ecological, sociological or political perspective is known as an effect size. Effect sizes are almost always driven by the best professional judgement of biologists, ecologists, etc. familiar with the general receiving environment. Effect sizes are often strongly debated by stakeholders before an agreement is reached.

The federal metal mining environmental effects monitoring programs (Environment Canada, 2002) provides effect sizes for various measurement endpoints in the aquatic receiving environment. These may or may not be applicable to the Ekati facility but are certainly a reasonable starting point at least.

Statistical hypothesis testing is often criticized because it tests for "statistical" significance which may or may not be ecologically, sociologically or politically significant. Statistical tests can be used with effect sizes to test using statistical tools whether an allowable effect size has been exceeded. This approach marries the objective hypothesis test with a stakeholder-approved effect size and allows uncertainty to be acknowledged.

More importantly from the perspective of assessing environmental performance, statistical tools can be used to determine if the statement "no effect was observed" is a reasonable statement, given the data. Such a statement is reasonable if the probability that the environment really is affected, when a claim of no effect is made, is low. This probability, known as the Type II error rate, can be estimated using statistical tools.

The type II error rate is (along with other criteria) a statistical design criterion as required under MVLWB(2005, Part I, Item 2(e)[2]).

[2] "statistical design criteria, including a description of sampling frequencies for each parameter that ensures both accurate characterization of short-term variability and the collection of sufficient data to establish long-term trends;"

7 Summary: Assessing Environmental Performance

The environmental performance of the Ekati Diamond mine with respect to the aquatic receiving environment beyond the dilution zone has been assessed by comparing water quality measurements with CCME guidelines and comparing biological measurements with similar measurements from reference lakes. Some comparisons have been made over time and others over distance from the Long Lake containment facility.

None of the comparisons made refer to effect sizes. None of the comparisons made refer to type II error rates. As of 2005, no water quality parameters exceeded CCME guidelines (Rescan, 2006a) although increases in 8 water quality parameters were noted. One change was noted in sediment quality and one change was noted in a biological variable.

None of the changes noted were assessed in the context of ecological, sociological or political relevance; i.e. in the context of an effect size. None of the conclusions regarding lack of effects were couched in terms of type II error rates.

At the end of the day, this makes it very difficult to quantitatively assess the BHP AEMP. It is a comprehensive program, large amounts of data are being thoughtfully collected and there is a quality assurance program in place. Yet without the dual criteria of effect sizes and type II error rates all that can be said about the AEMP is:

"The AEMP looks pretty good",

or perhaps,

"The AEMP doesn't look very good."

Each of these statements can only be made by an expert or experts familiar with that receiving environment. Each of the statements is subjective in the sense that "good" has a subjective connotation. Neither statement is very helpful from the perspective of evaluating the redesigned AEMP or providing criteria for evaluating the revised AEMP.

The recommendations section, below discusses a way forward.

8 Recommendations

The evaluation and redesign of an AEMP must be made in the context of what is acceptable to stakeholders. The EIS written in 1995 fails in this regard because the amount of change that was acceptable to stakeholders was not defined. Change (from the perspective of the aquatic receiving environment) includes the magnitude of change and the spatial extent of the change.

Perhaps large changes within a very short distance are acceptable (for example, draining a lake). Perhaps small changes over a very large distance are unacceptable. In any case, words such as "short" and "large" must be defined so that an AEMP can be evaluated and if necessary redesigned. Clearly defined statements regarding what is acceptable and not also provides clear guidance to the proponent. This allows the proponent to take timely mitigative action if necessary, but also to point out the success of their mitigative actions if so indicated.

I therefore suggest that the EIS be updated from the perspective of aquatic effects monitoring[3]. At least one EIS for a Diamond Mine in the NWT, written since 1995 includes a discussion of measurement endpoints and what changes in a measurement endpoint reflects a deleterious change. This EIS also includes a quantifiable discussion of the spatial extent of expected changes. The combination of spatial extent and magnitude of change was used by stakeholders to clearly define what effects are acceptable and what effects are unacceptable. These discrete criteria allow reviewers to asses whether the AEMP is "good" or "bad". The proponent is also able to say unequivocally, "We are doing a good job in protecting the environment" if all measurement endpoints fall within the criteria. Stakeholders can feel comfortable that the environment is being protected to the level agreed upon.

Updates to the EIS should include:

1. Additions of benthos to the list of VECs.

2. An explicit list of measurement endpoints.

3. A list of effect sizes.

4. Acceptable Type I and II error rates. This recommendation addresses Part I, Item 2(e) of the water license (MVLWB, 2005) with respect to statistical design criteria.

The combination of items 3 and 4, above are consistent with MVLWB (2005, Part I, Item 2(g)): "a description of evaluation criteria for the Aquatic Effects Monitoring Program

[3] An update for other environmental programs may also be required.

and approaches to amend and refine the Aquatic Effects Monitoring Program". These updates should be included in the following sections of the AEMP, although perhaps only at the three-year review stage:

1. **Experimental design:** These concepts rationalize the experimental design and allow reviewers to critically evaluate the design and the proponent to strongly defend the design.

2. **Conclusion:** The conclusion of "no effect" is strengthened when changes fall within the limits agreed upon by stakeholders.

3. **Adaptive Management:** Inclusion of quantifiable changes that indicate adaptive management is necessary or not, helps the proponent in managing the process, demonstrating due diligence and provides assurance to stakeholders. Moreover, the link between these quantifiable changes and adaptive management are required under MVLWB (2005, Part I, Item 2(h)[4]).

Finally, the results of an AEMP are used in an Adaptive Management Plan. Since effect sizes are not currently part of the BHP AEMP, the Adaptive Management Plan as it currently stands, should be reviewed.

[4] "a description of how the results of the Aquatic Effects Monitoring Program will be incorporated in the overall adaptive management strategies employed by the Licensee"

9 Citations

Burd, B.J. 2002. Evaluation of mine tailings effects on a benthic marine infaunal community over 29 years. Mar. Env. Res. 53(5):418-519.

Environment Canada. 2002. Metal Mining Guidance Document For Aquatic Environmental Effects Monitoring, June 2002.

Rescan. 2002. 2002 Aquatic Effects Monitoring Program (AEMP) Technical Report.

Rescan. 2006a. Ekati Diamond Mine Aquatic Effects Monitoring Program (AEMP) Summary Report. July 2006. Project #696-7

Rescan. 2006b. Ekati Diamond Mine AEMP Re-evaluation and proposed program for 2007-2009. Prepared for BHP Billiton, November, 2006.

BHP. 1995. NWT Diamonds Project Environmental Impact Statement.

MVLWB. 2005. BHP Ekati Facility Water License #MV2003L2-1616.

Zajdlik, B.A. 2004. Review of the Ekati Diamond Mine 2002 Aquatic Effects Monitoring Program. Prepared for the IEMA Steering Committee.

Appendix 1: The 3-Year AEMP Review

This section briefly reviews the 3-Year AEMP review conducted by Rescan (2006b) and is NOT comprehensive. The goal of assessing the 3-Year AEMP review is to better understand the BHP AEMP so that constructive comments can be made as BHP submits an updated AEMP to the Wek'eezhii Land and Water Board.

Interpretation Tools

The following investigations were conducted by Rescan (2006b):

Table 2: Summary of Investigations Conducted by Rescan (2006b)

Investigation	Zooplankton	Lake Benthos	Stream Benthos	Lake Cladocera Only
Abundance versus Year by location	✓	✓	✓	
Richness versus Year by location	✓	✓	✓	
Richness versus 1st principal component using water or sediment quality data as appropriate (all years) by location	✓	✓	✓	
Richness versus 2nd principal component using water or sediment quality data as appropriate (all years) by location	✓	✓	✓	
Bray-Curtis Dissimilarity versus 1st principal component using water quality data (all years) by location	✓	✓	✓	✓
Bray-Curtis Dissimilarity versus 2nd principal component using water quality data (all years) by location	✓	✓	✓	✓
Cluster analysis on Bray-Curtis Dissimilarities	✓	✓ - by depth	✓	
Bray-Curtis Dissimilarity cumulative densities	✓	✓		✓

All investigations conducted by Rescan (2006b) described above (with the possible exception of the cluster analyses) present results on a per station basis. No analyses of yearly phytoplankton data were presented. No analyses of fish-related data were presented although this may be due to the availability of data as fisheries data is collected only on a 5-year cycle.

The following sub-sections discuss the two major efforts by Rescan (2006b) with respect to augmenting the yearly data interpretations.

Principal Components Analyses on Abiotic Variables

The 3-year AEMP review by Rescan (2006b) used a multivariate data interpretation tool – principal components analysis (PCA) to further investigate the data collected to date. This departs from the tools (univariate statistics, visual gradient analyses and best professional judgment) used to interpret the data on an annual basis.

Rescan (2006b) accepts the ancillary comments in articles not written for the purpose of evaluating ordination methods to justify their treatment of missing values. The option used by Rescan is to delete observations where a dataset is not complete. The effect of this is to lose much of the early data. The loss of this information must be borne in mind when accepting or rejecting Rescan's conclusion with respect to the utility of ordination relative to univariate methods.

Rescan (2006b, pg. 3-2) found that PCA on lake and stream water quality variables produced similar results. It would be helpful to see these results so that the reader can decide if they agree with the conclusion[5].

DOC and TOC are two critical variables (with respect to mitigation of potential metal toxicity). These variables were not included as ordination variables, (Rescan 2006b Table 3.1-1). These variables were omitted as they were not available for all years and inclusion of these variables would have resulted in the loss of substantive amounts of data (B. Friesen-Pankratz, Rescan, pers. comm. at BHP Meeting Nov. 22).

Data were combined across watersheds. I believe that data were analyzed separately by watershed and then combined following the similarity of results for each separate analysis. Again it would be helpful to see these results so that the reader can decide if they agree with this conclusion.

Data were also combined across years and seasons. There are clearly yearly effects (see for example Figure 7.4-2, Rescan, 2006b) and very likely seasonal effects.

PCA attempts to describe the major patterns of variability in a data set. The major pattern of variability of interest is the variation and co-variation of analytes across the exposure and reference lakes. The sensitivity of a PCA to this source of variation will be blunted by including other major sources of variability (yearly and seasonal) and minor sources of variability (potentially watersheds, streams and lakes). It is surprising that the PCA performed as well as it did, given these extra confounding sources of variability.

Rescan (2006b) concluded that the univariate analyses performed on a yearly basis and PCA performed on the accumulated data provide the same insights for water quality variables. I disagree with this conclusion for the following reason.

[5] A brief discussion with B. Friesen-Pankratz (Rescan at BHP Meeting Nov. 22) indicates that this statement is likely reasonable.

Examination of results in table 3.1-6 (Rescan 2006b) identifies a series of analytes that have increased due to the LLCF discharge. Despite the blunted PCA, more variables are shown an increasing using the PCA. When reporting on univariate analyses results, Rescan does state for each analyte whether it is increasing or decreasing but highlights only a few analytes. The message that PCA gives is "a suite of 11 contaminant concentrations is increasing". Using the set of variables that were analyzed using both PCA and univariate analyses, the message that the univariate analyses gives is "a suite of 4 contaminant concentrations is increasing[6]".

Rescan (2006b) states that the univariate sediment analyses performed on a yearly basis and PCA performed on the accumulated sediment quality data are in general agreement. However, the ratio of analytes flagged by PCA versus univariate sediment quality analyses is almost identical to that for water quality variables. The multivariate analysis highlights a larger suite of contaminants whose concentrations are increasing in the receiving environment than the univariate analyses, at least as summarized.

Rescan's (2006b) conclusions about the relative merits of univariate versus multivariate analyses must also be examined in the context of:

1. Potential insensitivity of the ordinations due to the inclusion of sources of variability that at least obscure the comparisons of interest;

2. Potential confounding of conclusions due to the inclusion of multiple sources of variability; and,

3. Failure to extract some of the information contained in the ordinations.

Analyses on Biotic Variables

Cluster analyses were used to investigate biotic data but were dismissed by Rescan (2006b) as being uninformative. The cluster analyses have not been reviewed at this time.

The Bray-Curtis dissimilarity measure is used to summarize the biological communities. The authors acknowledge the influence of the sensitivity of this measure to the most abundant species but do not discuss this sensitivity when interpreting results.

Bray-Curtis dissimilarity measures are relative. Rescan (2006b) used all data from all reference lakes averaged over years to represent the "mean overall reference condition". Rescan (2006b) states that "this step is necessary in order to differentiate between "effects" from mining operations and natural shifts due to external factors".

[6] Note that Rescan does report on each analyte separately but not all increases are reported as such. The reason for this exclusion was not investigated.

An independent reviewer (C. Schwarz) was retained by BHP Billiton to "review and provide comments on the EKATI AEMP documents" (Rescan, 2006b). One recommendation was to use a Temporal-Spatial Level-by-time design. This recommendation is adopted in section 7.2 of Rescan (2006b). Rescan (2006b) states: "This approach (Temporal-Spatial Level-by-time) will improve the ability of the AEMP in detecting gradual increasing trends over time".

I agree with the recommendation made by C. Schwarz on this topic and the conclusion made by Rescan (2006b). It is important to acknowledge changes over time. The analysis advocated, makes spatial comparisons indexed by time, rather than collapsing over time.

The Bray-Curtis dissimilarities estimated by Rescan (2006b) do not adhere to this concept, collapsing the reference data over both time and space to estimate the "mean overall reference condition" and collapsing exposure data over time to create location-specific dissimilarities with the mean reference condition. This averaging procedure should not be used as it has the potential to obscure meaningful differences.

Summary

Rescan (2006b) concluded that:

- PCA performed on the accumulated data provide the same insights for water quality variables;

- the univariate sediment analyses performed on a yearly basis and PCA performed on the accumulated sediment quality data are in general agreement.

I cannot support these statements at this time due to the inclusion of numerous known sources of variability that potentially confound results.

The Bray-Curtis dissimilarity index is only one of many and provides only part of the picture. Its particular attributes can influence interpretation of the dataset; the influence of the choice of metric on conclusions should be discussed.

Use of the Bray-Curtis index suffers from collapsing data over time. Collapsing data over time contradicts the rationalization behind the temporal-spatial comparisons recommended by another reviewer and adopted by Rescan (2000b).

When the Bray-Curtis index is used to produce cumulative distributions following Burd, (2000) the effect of time, particularly for those lakes closest to the Long Lake Containment Facility is not included. Examination of Burd (2000) shows that the assumption of homogeneity is the "most important[7]" when applying this method.

[7] "The most important assumption in this method is that biotic factors for a given area (near-field, mid-field and far-field) were relatively homogeneous over time during mining or after mine closure, and therefore could be combined as described." Burd, (2002).