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REVIEW OF THE REVISED AQUATIC EFFECTS MONITORING PROGRAM (AEMP) FOR THE DIAVIK DIAMOND MINE

2007 DESIGN DOCUMENT

Report # 347-01

Prepared for:

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1.0 BACKGROUND

As a requirement of the Environmental Agreement for the Diavik Diamond Mine (Diavik) Project, the Environmental Monitoring Advisory Board (EMAB) was formed to provide an integrated and co-operative approach to the environmental management of the Project. The Board operates independently from Diavik Diamond Mines Inc. (DDMI) and the governments of Canada, the Northwest Territories and Nunavut. EMAB aims to assist Parties to the Environmental Agreement in the implementation of a common strategy to address environmental matters associated with the Diavik project. To this end, EMAB makes recommendations regarding environmental effects of the Diavik project and facilitates communication with Parties to the Agreement including Affected Communities.

For the last seven years, DDMI has implemented an Aquatic Effects Monitoring Program (AEMP) under the terms and conditions of Part K of DDMI's Type A Territorial Water Licence N7L2-1645, issued in 2000 and amended in 2004 (Water Licence). This AEMP is at centre of a long-term, monitoring strategy adopted by DDMI that continues to evolve over time to achieve its objectives. The main goal of the AEMP is to ensure that the Diavik project does not result in adverse environmental effects on the Lac de Gras ecosystem. Where impacts on Lac de Gras have been predicted or detected, mitigation measures have been put in place to prevent significant adverse effects. The program initially designed in 2001, comprises of a long-term annual monitoring program, and individual short-term specific effects studies initiated to address specific issues, provide quantitative answers to specific questions, or to address specific Water Licence requests (DDMI 2001).

In August 2005, DDMI submitted an application to the Mackenzie Valley Land and Water Board (MVLWB) for renewal of Water Licence N7L2-1645 which expires in August 2007. The Water License renewal application is now under the authority of the new Wek'èezhii Land and Water Board (WLWB) created under the Tlicho land claim. Therefore under its new jurisdiction, the WLWB held water licence renewal hearings in November 2006. At these hearings various interveners from all sectors raised concerns that the AEMP in its current form did not adequately fulfil the terms of the first Water Licence and the Environmental Agreement. The hearings resulted in DDMI being requested to redesign of the AEMP to address project related effects on Lac de Gras and fulfil other conditions outlined in the first Water Licence and the Environmental Agreement. Furthermore, the WLWB issued DDMI with a Terms of Reference (TOR) for the revised AEMP design document that was developed in consultation with the various parties/agencies and an independent peer reviewer.

To continue the consultation process, North/South Consultants Inc. (North/South) has been contracted by EMAB to provide a technical review of the 2007 AEMP design document.

2.0 INTRODUCTION

The primary objective of this technical review was to assess whether Sections 4 through 6 met the requirements laid out in Sections 4 through 6 in the TOR issued by the WLWB. In essence, our review examined whether the revised AEMP study design and the details of that design are adequate to:

- "*Determine the short and long-term effects in the aquatic environment resulting from the Project, test impact predictions, measure the performance of operations and evaluate the effectiveness of impact mitigation*" (Water Licence N7L2-1645, 2000, amended 2004).
- "*Establish or confirm thresholds or early warning signs" and "Trigger action by adaptive mitigation measures where appropriate*" (Environmental Agreement).
- Whether the revised AEMP has achieved a good balance between scientific defensibility and cost-effectiveness.

However, it should be noted that the final version of the review reflects additional direction from the WLWB following the technical workshop.

In order to conduct an accurate and comprehensive review, sections 1 through 3 of the revised AEMP document and the eight appendices, were consulted, but were not subject to review. This scope was developed with EMAB, in accordance with the main purpose of the review and the resources available. The review primarily serves to establish and document outstanding technical concerns with the AEMP study design, including additional information that is required. These and other issues were discussed at the WLWB board-facilitated technical workshop in Yellowknife during early March 2007. Discussions at the workshop were then considered when finalizing this review.

In general this AEMP design document is a great improvement on the original design document released in 2001. It is generally well written and organized, though it could benefit from an organizational review to address concerns raised at the AEMP workshop. As emphasised by DDMI, there has been a notable increase in the scope of the AEMP, and technical points brought up by various reviewers have been incorporated to varying degrees. There has also been a notable effort to follow the TOR set by the WLWB, and to incorporate recognized frameworks and decision criteria where appropriate. Furthermore, rationale has been provided to support the revised design which greatly facilitates the communication of ideas. This design document represents a significant move forward and a genuine effort by DDMI to address the key concerns of various regulatory agencies and stakeholders. It should also be noted that this document was produced according to a tight schedule in order to implement the AEMP in March/April 2007.

That said, our technical review of this document (also according to a tight schedule to facilitate implementation) raises a number of significant issues and areas where there is insufficient information to assess the adequacy of the study design. Where possible, throughout this review we have provided recommendations to improve the AEMP design. These are clearly articulated in the following sections, to the extent possible given the time available.

3.0 STUDY DESIGN

This section represents an overview of the overall study design and related issues, more specific issues with respect to AEMP components are discussed in sections 5 through 10.

3.1 BACKGROUND

From the WLWB 2007 TOR:

"*Provide a detailed discussion and rationale of choice of study design and specific sampling sites for the AEMP that would detect any project related effects and allow causation to be assigned.*" WLWB TOR, 2007.

Any design must:

" *a) meet the requirements of the TOR*"

b) have enough statistical power to demonstrate differences between nearfield and reference sites that are equal to or smaller than the critical effect sizes; and

c) Be able to demonstrate the spatial extent of effects in mid-field and far-field environments in subsequent inventories after any effects are observed and confirmed in the nearfield environment". WLWB TOR, 2007.

The proposed study design takes the form of a hybrid between a control impact design and a radial gradient design. This formed a compromise between those stakeholder that advocated the adoption of a radial gradient design and DDMI that advocated the adoption of a control impact design.

"*The program design should provide sufficient data to*:

- *Test for spatial effects between areas or sites in Lac de Gras within any one year of sampling;*
- *Discriminate and interpret seasonal changes (i.e., open water and ice covered periods);*
- *Test for temporal changes between two or more sampling years; and*
- *Assess confounding factors or stressors in the study design*" WLWB TOR, 2007.

3.2 MAIN REVIEW POINTS

3.2.1 AEMP Objectives and Problem Formulation

- The AEMP objectives should be more clearly stated and should reflect objectives described in the Water Licence and the Environment Agreement. The objectives have become somewhat buried in this large document.

- The problem formulation issues raised at the workshop should be addressed, including a list and evaluation of chemical stressors of potential concern. During workshop discussions DDMI indicated that the document may need to be re-organized and revised in order for this information to be more clearly conveyed to the reader.

3.2.2 Study Design Selection

- The nested gradient design outlined in the TOR was not discussed by DDMI. The reviewer realises that this specific design was not prescribed and that the design proposed by DDMI was one of the possible designs. However a brief comparison of the pros and cons of the two designs or more designs would be useful.

- The study design seems to be more reliant on the control-impact component than the radial gradient component, though this meets the TOR requirement to: "*have enough statistical power to demonstrate differences between nearfield and reference sites that are equal to or smaller than the critical effect sizes*." The radial gradient component has not been emphasized as much as the control impact component in the design document. Similarly, the role of the mid-field sites and how data collected from these sites will be used and when, has not been as clearly described, compared to the near-field and far-field sites. In some cases samples are scheduled to be taken but the reader is unclear as to whether the samples will be analysed and the information used. DDMI clarified at the workshop that data collected at mid-field sites would undergo annual evaluation. However, this point and how the mid-field data will be used in determining an effect and triggering action, needs to be clearly described in the AEMP design document.

3.2.3 Reference and Exposure Site Selection, the Reference Lake Issue and Regional Monitoring

Reference and Exposure Site Selection

Issue and Concern: The locations of near-field and mid-field exposure sites were mainly based on the conclusions of the 2005 plume delineation study conducted during the open water period and also under ice, and water depth. DDMI proposes that the actual effluent exposure at these sites be confirmed by a plume delineation studies in 2009 and AEMP data from the first three years (barium and conductivity as indicators). It is important that the actual effluent exposure at these sites be

determined and verified as soon as possible to allow for any site changes and to ensure consistency. It will already be 2009 by the time three years have passed and the planned plume delineation study is conducted. Potentially the AEMP may not be finalized until six years post-production and ten years post-construction. It would be highly advantageous to confirm the adequacy of the sampling locations as soon as possible or at least before 2009.

Recommendation: Actual effluent exposure at all sites should be evaluated as soon as possible. This could be conducted through a second plume study prior to 2009, and/or through the evaluation of barium levels at the various sites during April 2007 onwards. The discussion at the AEMP workshop tended to focus on the latter as it would be preferable to confirm, at least on a preliminary basis, whether the reference and mid-field sites are receiving effluent. DDMI should submit a plan for confirming effluent exposure using barium as a tracer, at all monitoring sites, in April 2007 onwards. It is important that we do not rely on one sampling event as water quality and effluent plumes are ephemeral. We need to be sure that these sites consistently either receive no effluent (far-field/reference sites), some exposure to effluent (mid-field sites) or >1 % effluent (near-field sites). As barium will be measured at least twice per year, this should be evaluated and confirmed on a yearly basis.

As suggested at the workshop it would be valuable for DDMI to add some additional sites for barium sampling beyond the mid-field to assess the extent of the plume under ice. Should the barium monitoring prove to inconclusive, fail to clearly confirm effluent exposure at the monitoring sites, and/or fail to determine the maximum extent of the plume, then a second plume delineation study should be conducted before 2009. If this is deemed necessary then the plume study should address data gaps identified in the last study, verify the findings of the last study and document the full extent of the effluent plume. As noted previously by North/South, conductivity measurements will likely prove to be unreliable, however barium would likely be appropriate. Other options, such as Rhodamine WT dye, also exist.

Issue and Concern: Based on a cursory review of information given in the design document, the within-lake reference areas FF1 and FF3 in the northern and southern areas of Lac De Gras appear to not be influenced by human related activities to any degree. However, these areas have not been sampled before and therefore it is important that natural variability be adequately characterized as soon as possible. The reference area FF2 is located to the south west of the inlet of Lac de Gras from Lac du Sauvage (the Narrows). The integrity of this reference location has previously been debated because of a possible influence from discharges from EKATI Misery operations to Lac du Sauvage and Diavik operations within Lac de Gras. Indeed at the workshop, a preliminary evaluation of exisiting barium data indicated that reference area FF2 may indeed be exposed to effluent from Diavik.

Recommendation: This should be confirmed and appropriate action taken. Other reviewers at the workshop raised the prospect of investigating a ‘back-up’ reference area

in case FF2 is deemed to be invalid. This would mean that the number of reference areas could be maintained at three, ensuring a robust design. DDMI should explore this option.

Issue and Concern: Information on water quality, sediment quality and physical habitat characteristics are not available for all the reference sites and some of the mid-field sites. This is of major concern as these sites are currently uncharacterized. Reference sites in particular are pivotal to the success of the AEMP and natural variability between sites could seriously undermine the ability to detect effects, if not properly controlled.

Recommendation: All new sites, and particularly reference sites, should be characterized as soon as possible. If sites prove to be unsuitable then immediate action should be taken to remedy this.

3.2.4 Spatial and Temporal Comparisons, Determination of an Effect

Issue and Concern: DDMI indicates that the suggested number of stations for the near-field and far-field/reference areas reflects a statistical power of 85%, which is less than the desired goal of 90% power indicated elsewhere in the document and committed to by DDMI at the workshop.

Recommendation: DDMI should increase the number of sampling sites to achieve a minimum of 90% power. See Section 7 for more discussion with respect to benthic invertebrate monitoring.

Issue and Concern: Due to various inadequacy and inconsistencies associated with the baseline data collected prior to 2000, these data will not be brought forward to the new AEMP design. The data collected in 2000 is more compatible with subsequent post-construction data. However, as outlined in Table 1.3-1, mine construction started in 2000. This did not involve dike construction but did involve some other fairly large project relates construction activities. Thus can DDMI justify the use of data collected in 2000 as baseline data to evaluate the effects of the project on a temporal basis?

Recommendation: DDMI should further clarify the use of 2000 data as baseline data in temporal analysis.

Issue and Concern: DDMI indicates that temporal analysis cannot be carried out for another 5 year in order to accumulate enough data for each site/area (2012). While that is true for new sites, there are some sites in the near-field and mid-field that are being maintained (i.e., are being carried over from the old AEMP). Several years of data for all components are available for these sites. Furthermore, the results of the temporal comparisons do not seem to trigger any monitoring or management actions. Only some spatial comparisons appear to have the ability to trigger monitoring or management actions.

Recommendation: DDMI should conduct appropriate temporal comparisons at near-field and mid-field sites using existing data. At a minimum this could be conducted using water quality data but potentially data from other components also (e.g., benthic invertebrates). The temporal analyses can be strengthened over time and expanded to other components, with the collection of monitoring data under the 2007 AEMP. Thresholds and effect criteria should be set for temporal comparisons and the current decision making framework should be expanded to include temporal comparisons. The determination of an effect should trigger monitoring or management actions.

3.2.5 Data Analysis, Guidelines and Effect Sizes, Decision Rules, and Triggers

Issue and Concern: Why wait until three years of monitoring has passed before evaluating the data to determine if early warning/low effect levels have been reached, given that "*the evaluation of effects will largely be based on within-year spatial variation*". Surely DDMI will have sufficient information from the 1st year of monitoring to determine any spatial difference between near-field, mid-field and far-field/reference areas. Then mitigation measures could be implemented after one year not three years. This is especially important given that the mine has already been operating for a number of years. However, on p473 DDMI states that indeed the data collected for all components will be evaluated annually to determine the occurrence of early/warning/low level effect. Finally, the reviewer fails to see why EIA predictions can't be confirmed on a yearly basis.

Recommendation: The reviewer would like confirmation that data from all components will be evaluated annually and an integrated approach taken. Also EIA predictions should be subject to confirmation on an annual basis.

Issue and Concern: DDMI states on p417 that "*If an effect is found in the NF area, this design will allow a graphical and statistical evaluation of the spatial extent of the effect*". However, the text on p405 suggests that the mid-field water quality data is really only used when a moderate level effect has been observed in the near-field. Why are the mid-field data not to be examined when an early-warning level effect has been observed in the near-field? One would expect that the observation of an effect, albeit a low level effect, in the near-field would trigger the examination of mid-field data to assess the scale and magnitude of that effect. Why wait until a moderate level effect has been observed in the near-field? Also what happens if an early warning level effect is detected at the mid-field sites and the near-field sites at the same time? This does not seem to have been accounted for in the effect levels defined on p405. In general the use of the mid-field data and its role in triggering further action or defining effect levels remains fairly unclear.

In spite of the statement on p398 that the measurement endpoints in Table 4.3-8 (p399- 400) will be carried forward into the AEMP, some do not appear on Table

4.3-9 on guidelines and effects sizes (p402-403), specifically community composition and abundance of planktons, specific benthic invertebrate community endpoints, and specific fish quality endpoints.

Recommendation: Since mid-field data are to be evaluated on an annual basis as verbally communicated by DDMI in the workshop, we would like to see that clarified in the AEMP design document. The nature of the annual evaluation should be as clear as possible. DDMI should review and revise the use of the mid-field data and its role in triggering further action or defining effects. One suggestion would be to revise the effect levels given in Table 4.3-9. One example of a modification the could be made is: Water Chemistry: A moderate effect could be defined as a statistical difference between mid-field and reference areas, in addition to benchmarks being exceeded in the near-field. In short, we recommend that the effects levels given in Table 4.3-9 be revised in consultation with stakeholders.

The Reference Lake Issue and Regional Monitoring

The issue of whether a reference lake is essential to the study design and whether one can reasonably be found has been addressed to a greater extent in this document, compared to previous documents. Still although the regional lake comparison is useful, it stops short of addressing whether there is an appropriate reference lake. In fact of p74 DDMI concludes that "*overall levels of general parameters in Lac de Gras did correspond to levels in the nearby lakes and BHPB sites*". However on p 417 DDMI states that "*A suitable reference lake, outside of Lac de Gras, could not be found during the baseline studies conducted prior to 2000. It is inherently difficult to find another lake in the region with similar characteristics in terms of size and water quality as Lac de Gras."* So presumably it is the size of Lac de Gras that is the main limitation to finding a suitable reference lake not water quality.

Overall, the rationale for not selecting a reference lake(s) is not clearly stated. The discussion throughout the document is somewhat fragmented and there is not a clear link between the regional lake comparison and the statements indicating there is no suitable reference lake.

Issue and Concern: Discussion at the workshop seemed to indicate that the majority of participants had accepted the study design without a reference lake. While consensus on this issue is a step forward, the reviewer is concerned that the current monitoring design does not consider the impact of regional effects on aquatic effects monitoring in Lac de Gras (e.g, climate change, long range contaminant transport via the atmosphere).

Recommendation: To address this gap it is important that DDMI participate and encourage the development of regional reference areas to be monitored as part of a cooperative multi-sector initiative. DDMI has committed to participating in such a program but expects it to be led by government. We want to highlight the importance of such an initiative to aquatic effects monitoring in Lac de Gras.

3.3 OTHER REVIEW POINTS

- The decision-making is set so that triggering an early warning level does not trigger increased monitoring from every three years back to annual. Could DDMI further clarify their position?

- Figure 4.3-11 (AEM Phases Applied to Each Measurement Endpoint) – Some basic monitoring is to be conducted on an annual basis (e.g., water quality monitoring in the near-field and the far-field) but this is not clearly indicated in this figure.

- On p474, second paragraph, the sentence "*the AEMP data would be evaluated using statistical or qualitative analysis to identify changes*……" should be changed to "the AEMP data would be evaluated using statistical **and** qualitative analysis to identify changes……"

- P418, 2nd paragraph states that "*multiple reference areas…can also provide insight into the variability within reference areas*". Does DDI mean **between** reference areas? This would be a valuable comparison to make.

- Where it has been stated that it is **likely** that something is not that case and rationale has been provided, that reasoning should be verified within the first three years of monitoring. This would be somewhat similar to verifying EIA predictions.

- Do we know how planned operations/expansion at the Ekati Misery mine will affect the mine discharge into the Cujo/Lac du Sauvage watershed and ultimately Lac du Sauvage? For example, is the effluent discharge likely to increase?

- Valued ecosystem components (VECs) are defined in a varying manner throughout section 4. On p364, VECs include fish, fish habitat, water quality, sediment quality, lake productivity, planktonic and benthic invertebrate communities, and the use of fisheries resources in Lac de Gras. On p376, VECs are slightly different, and do not include, e.g., benthic invertebrates and sediment quality. These two components are similarly missing from the linkage diagram on p382, which impedes an integrated assessment of the different components. In the table presenting VECs and their respective measurement endpoints on p399, sediment quality is not mentioned as a measurement endpoint for eutrophication, even though nitrogen measurement has been added to the monitoring program.

- In the table 4.3-2, which summarizes historical studies concerning effects, does not include sediment quality, benthic or plankton. These monitoring components should be added to the table.

- On p429 there seem to be words missing from the bottom left box in the figure

- Will the results of the SES and Fisheries Authorization studies be involved in the consideration of monitoring effort or to trigger management actions? This is not clear.

4.0 INTEGRATION, CUMULATIVE EFFECTS ASSESSMENT, ADAPTIVE MANAGEMENT AND AEMP REPORTING

4.1.1 Integration of Components

Issue and Concern: The main objective of the AEMP is stated on p414 as "*the evaluation of the potential effects of the mine discharge, with the understanding that there are monitoring programs (i.e., special effect studies) already in place to detect potential effects from other mine-related stressors*". The text then refers to Section 6 for a discussion as to how all monitoring results will be integrated to evaluate potential combined effects from all mine-related stressors. However, this is not really discussed to any degree in Section 6 and the reader is still unclear as how the results of these SES will be integrated into the overall evaluation of project related effects. Similarly, p417 describes the overlap at three stations (4E, 2D, 6E) between the AEMP and the dike monitoring programs. However, it is not clear how the results will be integrated and whether the methodologies are compatible.

The weight of evidence approach is described briefly at the beginning of Section 4 from a theory perspective but the application of this approach and how this will be done is not clearly laid out. So we know that DDMI intends to use this approach to some extent but we do not know how.

> **Recommendation:** Given that integration is vital to the success of this program, there needs to be a clearer, more comprehensive discussion of the application of the weight of evidence approach. We need to have clearer idea of how all the pieces of information will be brought together in an organized fashion to evaluate project-related effects.

Issue and Concern: Eutrophication is perhaps the primary stressor likely to affect the aquatic health of Lac de Gras and potentially alter the pristine status of the lake. Furthermore, DDMI states on p358 that "*Biological effects measures are given higher weight in decision making than measures of exposure that do not take into account bioavailability*". North/South has previously recommended that the issue of eutrophication be discussed in a discrete section that integrates chemical, physical and biological information. However, the AEMP design document does not propose such an approach.

> **Recommendation:** We recommend the inclusion of a discrete section in the AEMP reviewing all monitoring components in terms of potential nutrient enrichment. It is recommended that this would include a discussion of *all* nitrogen compounds and phosphorus in water, related water quality variables, sediment quality, phytoplankton, zooplankton, and benthic invertebrates. At a minimum, it would be most effective to examine water quality, sediment quality, and phytoplankton data collectively to appropriately assess potential nutrient enrichment effects.

4.1.2 Cumulative Effects Assessment/Multiple Stressors

Issue and Concern: It remains unclear as to how the effects-based cumulative effects assessment framework (Figure 4.4-2) will be applied within the revised AEMP. Cumulative effects assessment in general and this specific framework are discussed in section 4.4.6, mainly from a somewhat theoretical and regulatory standpoint. The actual application of these concepts and frameworks to the revised AEMP requires additional clarification. Furthermore, DDMI predicted no cumulative effects from Ekati in the Environmental Assessment; they do not include this prediction explicitly and it's not clear how they will verify it.

Recommendation: The cumulative effects assessment section in the AEMP design document should be reviewed and revised, taking discussion at the workshop into consideration.

4.1.3 Adaptive Management

Issue and Concern: Adaptive management as it pertains to the AEMP requires more discussion in the AEMP design document. DDMI indicated at the workshop that a separate Adaptive Management Plan will be drafted, potentially as a condition of the new licence, but gave no time frame for completion of the plan.

Recommendation: Adaptive Management and mitigation are critical to the success of the AEMP and need to be addressed to a greater extent in the design document. For example, Figure 4.3-11 (AEM Phases Applied to Each Measurement Endpoint) – The application of appropriate management options box should be linked back into AEMP monitoring to indicate that the AEMP also monitors the effectiveness of management/mitigation.

It is important that the AEMP is designed within an adaptive management framework as the two are inherently connected. The success of the AEMP and the adaptive management framework depends of that connection and the adequacy of one another. The two cannot operate independently of each other. For example, if an effect is found through the AEMP it has to be clear to stakeholders what management/monitoring/ mitigation actions are likely to be taken to alleviate that effect. Likewise, the AEMP should monitor the success of any management/mitigation measures, and if they are not working they should be changed. On cannot assume that management/mitigation measures are guaranteed to work.

4.1.4 Reporting and Quality Assurance/Quality Control

- The QA/QC plan is to be developed after the AEMP is approved (p422). This needs to be stated in the individual monitoring component sections.

- The QA/QC plan should be available for review after completion, although the summary of components looks fairly comprehensive for some components. The adoption of data quality objectives is a good move forward.

- It would be highly beneficial for the QA/QC plan to be completed and reviewed well before the summer sampling season.

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5.0 WATER QUALITY

5.1 MAIN REVIEW POINTS

5.1.1 Water Quality Sampling in Lac De Gras

Sampling: Frequency, Seasonality and Parameter Selection

Issue: DDMI has proposed that water quality sampling will only be conducted twice per year (i.e., once under ice in April and once during open water in August).

Why of Concern: In previous reviews of annual AEMP reports North/South and other reviewers recommended that sampling be increased from twice per year to four times per year to better capture seasonality and increase sampling effort. Rescan (2004) indicated this frequency would then be similar to the effort expended by EKATI for their monitoring in Lac de Gras. We were therefore pleased to see that DDMI proposed quarterly water quality sampling in the 2006 revised AEMP design document; i.e., during,

- April (late ice-cover)
- Early July (early ice-free)
- Late August (ice-free)
- December/January (early ice-cover)

However, in the current 2007 AEMP design document this has been scaled back to twice per year; once in April under late ice cover and once during the open water period (not specified but verbally communicated by DDMI to be late August). In the AEMP design document, DDMI did not provide adequate rationale to support this reduction in sampling effort per site. It is especially important during the first 3 years to adequately characterize monitoring sites and assess seasonal and inter-annual variability, particularly for the three new reference areas for which no data currently exist. It is acknowledged that total phosphorus, total nitrogen, chlorophyll a and *in situ* parameters will be measured three times during the open water period, presumably at all sites.

Recommendation: It is important that the reference/FF, mid-field, and near-field sites are adequately characterized, particularly given that many sites and even entire areas are new with no existing data. We accept DDMI's rationale that April likely represents the 'worse case' scenario and it is impossible to monitor everything, all of the time. Furthermore, we realize the importance of balancing scientific defensibility and cost-effectiveness, in the design of a monitoring program. However, given the lack of baseline data, for many sites and entire areas (i.e., reference/FF areas) we feel it is important to adequately characterize seasonal variability during the initial years of sampling. Once seasonality has been adequately characterized then the decision can be made as to whether sampling should be conducted bi-annually or four times per year.

Issue: Only total nutrient forms will be measured three times in the euphotic zone during the open water period, presumably at all sites. This is in addition to algal biomass as chlorophyll *a* and routine *in situ* parameters. More bioavailable dissolved nutrient forms will not be measured (e.g., nitrate, dissolved phosphorus, orthophosphate).

Why of Concern: If DDMI only looks at total phosphorus and nitrogen in the euphotic zone monthly during the open water period, and only measured dissolved nutrients at mid-depth twice per year, the following is of concern:

- There is limited information on the seasonal variability in dissolved nutrient forms that are more readily available for uptake by plants in the lake.
- It is more difficult to link phytoplankton biomass/community composition to concentrations of dissolved nutrients. There will be no measurement of dissolved nutrients in the euphotic zone to support the evaluation of phytoplankton communities.
- It is less likely that conductivity will indicate depth profiles for nutrients compared to other parameters such as some trace metals and major ions.

This issue was raised as a concern by several parties at the workshop, particularly if water quality sampling is only going to go ahead twice per year.

Recommendation: DDMI should consider adding dissolved nitrogen and phosphorus parameters to the open water monthly sampling program. This would further integrate the phytoplankton and water quality sampling programs and aid interpretation. It would also strengthen the characterization of seasonal water quality, particularly at new monitoring sites. This is recommendation is of particular importance if the core water quality sampling described in the previous issue is only going to go ahead twice per year.

Sampling: Vertical Gradients

Issue: DDMI has proposed that discrete vertical water quality sampling will only be undertaken when any of the conductivity levels measured in situ at depth exceed 23 µS/cm.

Why of Concern: The rationale given in the text does not provide enough confidence that vertical gradients only exist for water quality parameters when conductivity levels exceeds 23 µS/cm. Some sites on Lac de Gras exhibit stratification and some parameters have been shown to or may vary with depth. Furthermore, it is less likely that conductivity will indicate depth profiles for nutrients compared to other parameters such as some trace metals and major ions. Finally, some substances, including nutrients, accumulate in lake sediments and phosphorus can be released back into the water column under anoxic or hypoxic conditions. Thus, TP concentrations (as other parameters) may vary across depth where stratification occurs.

Recommendation: In addition to examining the conductivity profile at each site, DDMI should examine previous discrete depth data for vertical gradients, where available. Unfortunately, these data maybe limited due to sampling mainly being conducted at mid-depth during the original AEMP. Where information is not available, discrete depth sampling should be conducted at some or all sites (including mid-depth), at least initially to obtain seasonal depth profiles for measured parameters. This information would allow DDMI to determine whether vertical gradients exist before deciding whether it is sufficient to only sample at mid-depth. It would also be of value to measure the depth profiles of other *in situ* parameters in addition to conductivity, such as dissolved oxygen, temperature and pH (this could be done using a multi-meter).

5.1.2 Evaluation of Water Quality in Lac De Gras

Nitrate

Issue: Nitrate is not listed as a Contaminant of Potential Concern (COPC) on p82 or an evaluated parameter, and not listed as a Stressor of Potential Concern (SOPC) on p383. The 10 parameters listed on p82 are: ammonia, nitrogen, TP, chloride, aluminium, arsenic, barium, cadmium, nickel, zinc, TSS.

Why of concern: Nitrate is routinely measured, and nitrification (conversion of ammonia to nitrate) has been shown to occur in the effluent plume. Algal growth in the lake is primarily limited by phosphorus but nitrogen compounds also play a role in lake ecology that has often been poorly understood. Nitrate predominates in oxygenated environments such as Lac de Gras which typically has low levels of nitrite. Furthermore, nitrate is readily available for uptake by plants and animals in the lake, unlike total nitrogen which is a measure of both particulate and dissolved nitrogen compounds. Currently the only nitrogen compound listed to be of concern is ammonia, which along with total phosphorus represent the nutrient parameters. To highlight the importance of evaluating nitrate levels in Lac de Gras, North/South stated the following in a review of the AEMP in 2005: "*It is not clear why the AEMP and the SNP reports do not include any consideration, discussion, or summary of nitrate monitoring results. While there is considerable attention granted to nitrite, which is consistently low in the study area, none of the nitrate data are evaluated. We feel this is a notable omission for several reasons:*

- *Nitrate is a bioavailable form of nitrogen and as such, is readily taken up by aquatic plants and algae;*
- *Nitrate is the end product of nitrification;*
- *Nitrite is very unstable and is rapidly converted to nitrate;*
- *Nitrate is a component of the ammonium nitrate explosive used at DDMI;*
- *Ammonia levels have been high in the effluent; and*
- *Nitrate is toxic to aquatic life."*

Recommendation: Nitrate should be listed as a Contaminant of Potential Concern (COPC), an evaluated parameter, and a Stressor of Potential Concern (SOPC). We acknowledge that DDMI verbally clarified that the parameters identified in the AEMP were only selected for program design purposes, and did not reflect the actual parameters that would be evaluated in the AEMP. However, it is likely that these parameters will provide the base for the routine evaluation of water quality and we would like to see nitrate levels evaluated.

Use of Mid-Field Water Quality Data

Issue: DDMI states on p417 that "*if an effect is found in the NF area, this design will allow a graphical and statistical evaluation of the spatial extent of the effect*". At the workshop DDMI communicated verbally that mid-field water quality data would be analysed on an annual basis, both spatially with near-field and far-field/reference sites, as well as over time. Upon review, this does not seem to have been effectively communicated in the design document. Also what happens if an early warning level effect is detected at the mid-field sites and the near-field sites? This does not seem to have been accounted for in the effect levels defined on p405.

Why of concern: We agree with the premise that an effect is most likely to first occur in the near-field area and the mid-field data primarily serve to determine the scale and magnitude of that effect. However, we feel that the effect levels may not account for the scenario where an early warning effect occurs in both the near-field and mid-field areas by the time it is detected. Why wait until a moderate level effect has been observed in the near-field to consider the mid-field?

Recommendation: Since the mid-field data are to be evaluated on an annual basis as verbally communicated by DDMI in the workshop, we would like to see that clarified further in the AEMP design document. The nature of the annual evaluation of water quality data should be as clear as possible. DDMI should clarify how the scenario described above will be accommodated within the effect level categories described on p405. In short, the use of the mid-field data and its role in triggering further action or defining effects should be reviewed and revised.

Guidelines, Effect Sizes and Benchmarks

Issue: The reviewer remains uncertain as to the relevance and applicability of the generic EEM doubling criterion to the protection against short and long term project-related effects on Lac de Gras. At the workshop one reviewer commented that a 2-fold increase was not the basis of the power analysis.

Why of concern: Will this doubling criterion protect the water quality in Lac de Gras, a pristine northern lake? Many of the mainly southern waterbodies evaluated under the EEM program are moderately impaired and are not pristine. The reader is given no rationale and therefore has limited confidence that this criterion will protect water quality in Lac de Gras.

Recommendation: DDMI needs to provide more rationale as why this criterion is applicable beyond the fact it is proposed as a generic guideline by EEM. Could DDMI not come up with a criterion based on our understanding of Lac de Gras? Alternatively we could rely more on other criterion such as detecting statistical differences between areas, discharge limits for the effluent, effluent toxicity tests and benchmarks, and drop this doubling criterion all together. The latter may prove to be the most preferable option. Removal of the doubling criterion was committed to by DDMI at the AEMP workshop and the AEMP design document should be revised accordingly.

Issue: The whole lake total phosphorus threshold proposed by DDMI (i.e., "*TP concentrations of > 0.0005 mg/L in > 20% of the surface area of Lac de Gras*") is based on EIA predictions made in 1998.

Why of concern: Although the EIA threshold was 5 µg/L total phosphorus based on the scientific knowledge at the time (boundary between ultra-oligotrophic and oligotrophic lakes), it is necessary to update this threshold consistent with current scientific knowledge. Other EIA thresholds have been updated according to updates in CCME guidelines (referred to as 2006 Canadian Water Quality Guidelines). Furthermore DDMI states that "f*or 'waters of superior quality', such as Lac de Gras, the CCME non-degradation policy states that degradation of the existing water quality should always be avoided*."

Recommendation: We recommend the whole lake total phosphorus threshold be updated to read: TP concentrations of > 0.0004 mg/L in > 20% of the surface area of Lac de Gras. Thus total phosphorus concentrations should not exceed 4 µg/L in > 20% of the surface area of Lac de Gras. This is consistent with the current CCME 2004 trigger value to protect the ultra-oligotrophic status of lakes in Canada.

Issue: For some parameters DDMI has proposed replacing Canadian national water quality guidelines (CCME) with water quality guidelines from other jurisdictions, as water quality thresholds or benchmarks (Appendix IV). The rationale given for deviating from national guidelines was insufficient and the two guidelines were not compared.

Why of concern: It is important that any deviations from national guidelines be transparent and fully justified. The proponent and the reviewer needs to reach the same conclusion that the guideline selected is the most appropriate to protect water quality in the lake.

Recommendation: Further rationale should be provided when DDMI has proposed water quality guidelines from other jurisdictions to replace Canadian water quality guidelines (e.g., ammonia). Both guidelines being considered need to be stated and the advantages of replacing the CCME guideline must be clear.

Issue: DDMI has proposed water quality effect levels that include the failure of toxicity tests at the early/warning low level. It is not stated whether this refers to acute or chronic tests.

Why of concern: The MMEEM program advocates the use of sub-lethal (chronic) toxicity testing of effluents as a line of evidence in the evaluation of effects. It is the reviewers understanding that DDMI is currently conducting acute toxicity testing of Diavik effluent. Acute and chronic toxicity testing can provide quite different results, with chronic toxicity testing end-point typically more sensitive.

Recommendation: DDMI should clarify the exact nature of the effluent toxicity tests referred to in Table 4.3.8., the endpoints measured, and the frequency of toxicity testing. A rationale should be provided to justify the use of this type of toxicity testing, and assuming it only refers to acute testing, then the benefits of also incorporating chronic toxicity testing should be discussed. How DDMIs chosen approach fits into the EEM approach, should also be discussed.

Trophic Status of Lac De Gras

Issue: In Appendix IV, DDMI proposes that the trophic status of Lac de Gras be re-classified from ultra-oligotrophic to oligotrophic, in line with the CCME 2004 phosphorus guidance document.

Why of concern: There has not been sufficient rationale provided to support such an important change. For example, DDMI has stated that "*Lac de Gras has a mean baseline concentration of total phosphorus less than 0.005 mg/L*". This is not really helpful when the ultra-oligotrophic/oligotrophic boundary is 0.004 mg/L. The document then goes on to provide total phosphorus concentrations for various locations and time periods as ranges (e.g., "*ranged from less than 0.001 mg/L (detection limit) to 0.010 mg/L*"). It would be more appropriate to provide a measure of central tendency such as the mean concentration with associated variance. It is possible most phosphorus concentrations are below 0.004 µg/L with only one value above 0.004 µg/L. In which case, Lac de Gras would be classified as ultra-oligotrophic. The entire rationale is unclear and so the reclassification proposal is currently unsubstantiated.

Recommendation: We recommend that Lac de Gras remain classified as an ultra-oligotrophic lake unless DDMI can provide a solid case for reclassifying the trophic status of the lake. At the workshop DDMI stated that they would not consider Lac de Gras as an oligotrophic lake. These contradictory views (AEMP design document vs. verbal assurances at the workshop) need to be reconciled in the AEMP design document.

5.2 OTHER REVIEW POINTS

- It would be helpful if DDMI could provide further details of the statistical analysis for water quality data described on p444, as currently it is only described in one sentence. This was deemed to be appropriate at the workshop but it would be helpful to provide more detail/explanation/rational so that a wider audience can understand

the proposed analysis. This is important given the role of this analysis in defining the effect levels.

- The list of parameters that have been measured since 1994 appears to be incomplete with parameters missing (e.g., sulphate, chloride, dissolved or orthophosphate, etc.). It is important that the reader has a complete understanding of the water quality parameters intended to be measured. Could DDMI provide a complete list of the water quality parameters that will be measured in the AEMP with detection limits as appropriate?

- Detection limits adopted in 2000 have been maintained in the original AEMP through 2006, and adopted for the revised AEMP. It is important that all these detection limits are below the appropriate water quality guidelines/thresholds. In the example of cadmium this is not the case. Did DDMI look into a more specialized laboratory would be able to provide lower detection limits that would be below the cadmium threshold? This is of importance given that cadmium is a trace metal of particular concern for this project.

- DDMI states on p64 that the final TOR requested that levels of dissolved metals should be evaluated but that historical data were not available. Should DDMI not be measuring dissolved metals as well as total metals to some extent, in the revised AEMP? This is also of relevance because DDMI is proposing to replace the current total aluminium threshold with a dissolved aluminium threshold.

- The summary and evaluation of monthly mass loadings from the mine effluent discharge in this design document is a good addition and provides context for the design of the AEMP. Similarly it would be of benefit to provide similar summaries on an annual basis during AEMP reporting to aid the evaluation of lake water quality and other components.

6.0 SEDIMENT QUALITY

Sediment quality monitoring has been described generally in sufficient detail, and the section has improved greatly from previous AEMP documents. Increase in sampling stations within each of the three areas is welcome, although a power analysis should be conducted as soon as adequate data are available. A complete list of measured parameters has been added with respective method detection limits. The inclusion of this list strengthens the section greatly, while information on the method detection limits increases the transparency of reporting. In addition, nitrogen has been added to the parameter list, which allows for evaluation of potential eutrophication effects in the sediments of Lac de Gras.

6.1 MAIN REVIEW POINTS

6.1.1 Sediment Sampling Methods

Issue: The depth of sediment layer for the contaminant analysis has been changed from 5 cm to 2 cm due to concerns of 5 cm being too deep to be sensitive to temporal change. This is a welcome change and responds to a number of previous review comments.

Why of concern: Peramaki and Stone (2005) were able to section sediment cores from deep water sites in Lac de Gras into 1 cm sections. According to methodologies provided in this paper the cores were not frozen prior to sectioning into 1 cm intervals contrary to what DDMI indicated at the workshop. Potentially, 1 cm cores maybe feasible unless there are other logistical constraints or DDMI has information that was not included in the Peramaki and Stone (2005) paper. In other words, other investigators have successfully been able to sample deep water sites in Lac de Gras for 1 cm sections of sediment cores. The question is whether this is reasonable to bring into a routine monitoring program? Based on Lac de Gras sediment dating by Peramaki and Stone (2005), 1 to 5 cm core sections represent sediment from the following time periods (also see p 109 of the AEMP design document):

- 1 cm = 1994
- 2 cm = 1988
- 3 cm = 1980
- 4 cm = 1969
- 5 cm = 1957

Baseline data has been collected at the mine since 1994 and mine construction/operations began in 2000/2001. So can we detect changes in sediment quality by sectioning sediment that has been accumulating since the mid-late 1980s? DDMI acknowledges the

ineffectiveness of evaluating sediment quality in the top 5 cm horizon but does not provide a clear basis for evaluating sediment quality in the top 2 cm horizon. Furthermore, there is no discussion of evaluating sediment quality in the top 1 cm horizon as Peramaki and Stone (2005) did, both in terms of increased relevance and logical issue that may impede sampling during a routine sampling program. There was obviously a reason Peramaki and Stone (2005) evaluated sediment quality in the upper 1 cm horizon. It is likely evaluation of the upper 1 cm horizon could provide more accurate and recent information (approximately from mid-1990s onwards), due to the documented slow sedimentation rates in Lac de Gras.

This issue deserves further consideration to provide a defensible basis for evaluating sediment quality and to try and measure this indicator in as robust a fashion as possible. We need to balance scientific defensibility with logistics and reasonable effort. In addition, the subsampling frequency (composite of 3 core samples) may be too low to account for within-station variability.

Recommendation: We recommend that DDMI consider the pros and cons of sampling 1cm vs. 2 cm sediment horizons in Lac de Gras. Furthermore, DDMI should evaluate the usefulness and relevance of the information acquired from these two horizons, in consideration of the time periods they represent. Overall, there should be more detailed discussion and rationale to support the chosen sediment sampling depth and the number of subsamples taken.

Issue: Currently the sediment chemistry and the physical nature of the sediment (i.e., particle size and organic carbon) are evaluated separately from different samples, taken at different depths.

Why of concern: This is presumably due to logistical considerations and sample requirements from the analytical laboratory. However, by adopting this approach there maybe issues in data interpretation, particularly given the very different time periods represented by these depths (differing by decades). Often supporting physical characteristics aid the evaluation of trace metals in sediments, but this would be limited given the current approach.

Recommendation: This issue should be considered when re-evaluating the sampling depth for sediment quality. It would be preferable for physical characteristics to be determined at the same depth as sediment chemistry. However, the logistics should be discussed along with the ramifications for data interpretation.

6.1.2 Data Interpretation

Issue: The comparison of sediment quality monitoring data to the CCME Interim Sediment Quality Guidelines is excluded from the AEMP on the basis that guideline exceedences will not drive management decisions and because some guidelines are already exceeded in Lac de Gras. This guideline comparison is also left out from the evaluation of effect level for sediment quality (p402). When this issue was raised at

the workshop, DDMI seemed to indicate that they would consider CCME guideline comparisons but this is contrary to a statement made on p449 of the AEMP design document; i.e., "*metals concentrations will not be compared to the CCME (2002) Interim Sediment Quality Guidelines".*

Why of concern: Comparison to CCME sediment quality guidelines is a standard practice in the evaluation of sediment quality data and was conducted by Peramaki and Stone (2005). From Peramaki and Stone (2005):

"*National sediment quality guidelines have been developed to interpret possible effects of sediment–associated metals in aquatic ecosystems (CCME, 1999). The Interim Sediment Aquatic Guideline (ISGQ) indicates a level that likely has no effect on the majority of sediment dwelling organisms. The Probable Effects Level (PEL) indicates a level that is likely to affect aquatic biota adversely. Metal (As, Cu, Hg, Pb) concentrations in dated sediment cores are compared to the ISGQ and PEL of the CCME aquatic sediment guidelines in Figures 1 to 4, respectively. Lead and Hg concentrations of sediment in the four study lakes are below the ISQG guidelines for the protection of aquatic life and therefore pose little risk to biota (Figures 3 and 4). Levels of Cu are above the ISQG in Lac de Gras, Desteffany and Point Lake (Figure 2). The PEL for As is exceeded in surface sediment collected from Lac de Gras, Point Lake and Daring Lake."*

Peramaki and Stone also correctly discussed the limitations of applying national sediment quality guidelines to northern environments; i.e., from Peramaki and Stone (2005):

"While numeric sediment quality guidelines may offer a proxy for potential toxicity, guidelines have not been developed specifically for northern environments and current guidelines may not be applicable in some cases (Puznicki, 1997). Consequently, a comprehensive assessment of bottom sediments using the Sediment Quality Triad (Chapman, 1991) should be conducted to measure impacts of metals in lake sediments on biota. The Sediment Quality Triad includes sediment chemical analysis, examination of in situ benthic community composition and measurement of sediment toxicity. In addition, bioaccumulation measurements should be conducted using lake sediment to determine whether metals are bioavailable, if there is a measured response and if the metals are causing the response (Borgman et al., 2001)."

Thus, while sediment quality guideline comparisons have their limitations (e.g., natural exceedences, applicability to northern environments, bioavailability) they still represent a valid line of evidence within a weight of evidence approach to risk characterization. They should not however be the only line of evidence used as recommended by Peramaki and Stone (2005). Sediment chemistry evaluation (i.e., guideline comparisons and comparison to reference areas [natural background]) should be interpreted along with benthic community composition and an evaluation of sediment toxicity/bioaccumulation. An integrated approach such as this should address many of the limitations associated with sediment quality guideline comparisons, rather than ruling them out all together.

Furthermore, existing sediment quality data collected by DDMI in Lac de Gras has limited value with respect to characterizing background sediment quality for the new AEMP program for the following reasons:

- Existing sediment quality data represent the upper 5 cm horizon while data to be collected under the revised AEMP will represent the upper 2 cm (or possibly 1 cm) sediment horizons.

- Sediment quality will be evaluated at new reference sites and some new mid-field and near-field sites. Although there is some overlap in near-field and mid-field sampling sites between the 2001 and 2007 AEMPs. The new sites have been selected based on depth data and sediment quality has not been characterized due to a lack of data. Sediment quality data is often naturally variable.

Consequently, we are reliant on data collected from 2007 onwards to characterize sediment quality at these sites, and cannot depend on previously collected data. So, background sediment quality will be defined by the 2007 AEMP reference sites, which have not previously been sampled. This is a different situation from the assessment of water quality.

Recommendation: We recommend that sediment chemistry be compared to CCME Sediment Quality Guidelines and issues such as natural exceedences discussed. We also recommend that DDMI consider the results of the Peramaki and Stone (2005) study that showed that similar to other lakes in the Copper Mine River Basin, Lac de Gras sediments have been enriched with some metals from atmospheric inputs. Overall we recommend that a sediment quality triad approach be applied to sediment quality and benthic invertebrate assessment of Lac de Gras, as recommended by Peramaki and Stone (2005) and Wenning and Ingersoll (2002), among other authors.

6.1.3 Sediment Toxicity/Bioaccumulation

Issue: It is unclear from the AEMP design document whether sediment toxicity tests are going to be used in the sediment quality evaluation. Further discussion at the workshop revealed that DDMI potentially intends to conduct sediment toxicity/bioaccumulation test, where required. However, when and where that would happen remains unclear. Furthermore, one reviewer suggested that these tests be conducted instead of benthic invertebrate community monitoring and DDMI pointed out deficiencies associated with that approach.

Why of concern: Based on the previous issue discussed above, some assessment of sediment toxicity and/or bioaccumulation would be warranted as part of the sediment quality triad approach to sediment quality assessment. These tests would provide a measure of ecologically relevant effects (e.g., survival, growth) and the bioavailability of contaminants in sediments and sediment pore waters. These tests would be conducted according to standard protocols using midge larvae or amphipods, which are fairly

representative of the benthic invertebrate community in Lac de Gras. Information provided by these tests will complement and serve to address some of the deficiencies associated with benthic invertebrate monitoring or sediment quality monitoring in Lac de Gras. Sediment bioaccumulation tests will provide information at the individual level which is very useful and can be an early warning, as well as information on contaminant bioavailability. However individual level effects do not necessarily translate into community level effects (as measured by benthic invertebrate monitoring) and there is a large amount of literature dedicated to this topic. Thus in our view these tests provide a different kind of information that would complement the proposed program. To drop benthic invertebrate community monitoring and rely solely on sediment bioaccumulation tests may not be wise.

Recommendation: Consistent with the sediment quality tried approach and the interpretation of various lines of evidence through a weight of evidence approach; DDMI should conduct sediment bioaccumulation/toxicity studies at a subset of the near-field and/or mid-field sites. This would determine if current levels of contaminants in the sediment and sediment pore waters (which are currently uncertain) are being bioaccumulated by benthic invertebrates and whether these are likely to cause effects at the individual level. Benthic invertebrate community monitoring at these sites will determine if any observed affects are translated up to the community level. So sediment bioaccumulation/toxicity tests would serve both to aid in the evaluation of sediment quality and act as an early warning indicator of potential effects to the benthic invertebrate community.

6.2 OTHER REVIEW POINTS

- Dike monitoring will continue to use the upper 5 cm to assess change. How will this compatibility issue be resolved?

- In 2001-2006, three core samples were collected at each sampling locations (areas). These three samples should be treated as subsamples, and so there is one sample per area for these years. However, the n is given as 3 in the table on p111.

- It would be helpful to have some photos of sediment cores representative of the various sites to support the sediment description.

- On p110, metals are not mentioned as measured parameters in 2005 monitoring, only TP, TKN, TOC. However, 2005 metal data are presented in table 2.6-7.

- Frequency and intensity of sampling are not discussed in the sediment quality section 5.3. In the general sampling frequency section (p420), it is stated that the number of stations per area is based on water quality and benthic invertebrate power analysis. For the remaining components, a power analysis will be conducted during the first AEMP cycle or as soon as sufficient data are available. It is assumed that this is true for sediment quality but this should be clarified in the text. An adequate number of stations is essential for the ability to detect change.

- In the interpretative framework, it is stated if a difference is observed between areas that "*a determination will be made*" to identify the likely cause. No overview is given for the determination process or factors that will be included in the process. The determination process should be clearly explained in the AEMP.

- Nitrogen is listed in the table for method detection limits but it is referred to as total Kjehldahl nitrogen in the text. The measured parameter should be identified clearly.

- The study objectives and inclusion rationale in Section 5.3 state that sediment quality is monitored as supporting information for benthic invertebrate survey and eutrophication effects evaluation. In the valued ecosystem component (VEC) table on p399, also fish habitat, health, abundance and quality for consumption are linked to sediment quality, and they should be added to section 5.3.

- Statistical analysis should include all measured parameters, as opposed to only key parameters. In addition, mid-field data should be included in all data analysis in order to use all collected data efficiently. Details of the method for temporal and spatial trend evaluation should be discussed.

7.0 BENTHIC INVERTEBRATES

Benthic invertebrate monitoring program is presented in a streamlined fashion and mostly in sufficient detail. The number of subsamples (6) per station follows the MMEEM recommendations. As noted based on the previous monitoring results, variation in the benthic invertebrate community structure reflects habitat variation in Lac de Gras. In response, monitoring stations within all three areas have been selected from a narrow depth range (18-22 m), which should improve the comparability between areas. The initial annual monitoring for the first three years should provide reliable information on the natural variability of the benthic invertebrate community in Lac de Gras, with future sampling effort evaluated after the initial period. The integration of water and sediment quality data with invertebrate data is well described in the text.

7.1 MAIN REVIEW POINTS

7.1.1 Sampling Methods

Issue: It is stated that the number of benthic invertebrate sampling stations per area is based on a generic power analysis summarized in MMEEM (Lowell 1997; EC 2002). The number of stations per area (5 for near-field, 4 for mid-field and far-field/reference areas) does not fully comply with the MMEEM) recommendations (5 samples when α=0.10 and 1-ß=0.90 to detect a difference of 2 SD) based on the generic power analysis. DDMI indicates that the suggested number of stations for the near-field and far-field/reference areas reflects a statistical power of 85%, which is less than the desired goal of 90% power indicated elsewhere in the document and committed to by DDMI at the workshop.

Why of concern: Essentially DDMI has committed to α of 0.10 and statistical power of 90% to detect a significant effect or a difference of 2 SD, both in the AEMP design document and then at the workshop. It is therefore of concern that their current sampling design likely does not allow the achievement of these goals. DDMI should start off with a design that they are confident will provide the required and desired level of statistical power. Furthermore it would be advantageous to have a sufficient number of sampling sites in the reference areas to adequately characterize these areas and assess variability within those areas. These reference areas are new and have not been previously characterized for any of the AEMP components. Furthermore, due to issues with baseline data, spatial comparisons to the reference areas are pivotal to the success of this AEMP.

Recommendation: We recommend that DDMI increase the number of reference sites to 5 in each of the three reference areas, and each of the three mid-field areas. As this is an integrated design, this would apply to benthic invertebrate monitoring as well as all other AEMP components.

Issue: The new AEMP benthic invertebrate monitoring stations have been selected from a narrow depth range of 18 to 22 m. A narrow depth range is an improvement compared to the previous AEMP design, where varying depth affected the BIC results. However, the current AEMP monitoring design for benthic invertebrates does not include sampling in shallower depths.

Why of concern: The current sampling design results in a disconnect between the benthic invertebrate and slimy sculpin monitoring, due to the different sampling depths between the programs (BI: deep, fish: shallow). It is understandable that slimy sculpin sampling is conducted in shallower depths, since the species utilize shallow shore habitats in Lac de Gras. It is stated in the AEMP that based on previous studies, "*invertebrate abundance and richness generally declined with increasing water depth with a sharp decline between 15 m and 20 m*". It is also noted that "*the sediment based component of the food web…would likely contribute most to overall productivity in the shallower areas of the lake.*" In contrast to the deep (18-22 m) sampling depth chosen in the 2007 AEMP design, relatively shallow benthic invertebrate sampling depths have been previously included in the dike monitoring special effect studies.

It is also understood that benthic invertebrate sampling may be difficult in shallower depths in Lac de Gras due to lack of suitable substrate and suitable depths within near-, mid- and far-fields.

Recommendation: More detailed rationale should be give for the benthic invertebrate sampling depth. Furthermore, the ecological significance of the chosen depth range should be discussed. If benthic invertebrate sampling in shallow areas proves not to be feasible for monitoring purposes, slimy sculpin stomach contents studies could be conducted instead. Stomach contents would provide information on a selected part of the benthic invertebrate community and a link to lower trophic community changes in shallower depths.

7.1.2 Interpretative Framework

Issue: As stated on p453 of the AEMP design document, an observed statistical difference between areas will not directly point to a Mine-related effect on the benthic invertebrate community. Instead, multiple conditions have to apply in the areas exposed to the effluent.

Why of concern: Five conditions are listed but no distinction is made if all or only some of the conditions have to apply simultaneously for an effect to be considered likely. DDMI verbally indicated at the workshop that not all five conditions have to apply for an effect to be determined. Of particular concern is the fourth condition, where a stressor has to be documented at a sufficient level to account for the observed biological effect. This may not be fulfilled in all cases. For example, multiple stressors may be acting simultaneously or all potential stressors may not be monitored. In these cases, the benthic community provides an early warning signal, which should be further investigated. This condition also contradicts previous statements by DDMI that they will investigate

ecologically driven effects (i.e., the ecological value-initiated risk hypotheses described on p363).

The last condition is also of concern, and states that there should be "*a lack of a confounding influence due to physical habitat or other potential effects related to the mine or another nearby development*". The first part of the sentence is fine but the last part referring to a lack of potential effects related to the mine or another nearby development is of concern. If this proves to be true, a discussion should take place about station positioning in Lac de Gras and a possible need for a reference lake. In the workshop DDMI agreed to removing "*or other potential effects related to the mine or another nearby development*".

It also seems strange that these conditions were not defined to this extent for any of the other AEMP components and DDMI admitted that they may have been 'jumping the gun a bit' with this list of conditions for defining an effect on benthic invertebrate communities in Lac de Gras.

Recommendation: We recommend clarifying the conditions that need to apply for a Mine-related BIC effect evaluation and incorporating verbal commitments made at the workshop. There should be consistency between AEMP components with respect to data interpretation. DDMI should adopt decision making criteria that reflect the following statement made by DDMI on p 358, i.e., "*Biological effects measures are given higher weight in decision making than measures of exposure that do not take into account bioavailability* ".

Issue: Benthic community variables, that will be included in the data analysis, do not include evenness and diversity indices. However on p408 DDMI states that these metrics will be used.

Why of concern: The two indices were included in the 2006 AEMP study design document, but omitted from the current AEMP without rationale. These indices are recommended by MMEE, and are routinely used in other project specific and regional monitoring programs.

Recommendation: We recommend including evenness and diversity indices in the benthic invertebrate community data analysis and reporting.

7.2 OTHER REVIEW POINTS

- Due to problems in previous years, significant effort should be made to keep the time of benthic invertebrate sampling as constant as possible. The proposed sampling period from late August to early September can be difficult to keep constant due to weather conditions. Sampling during ice-cover may have specific logistical and safety issues, as indicated by DDMI, but it is nevertheless conducted routinely for other northern mine AEMPs (e.g., Snap Lake). We would like to see further discussion on what efforts will be made to keep the sampling period constant.

- Objective for data analysis and interpretation refers to evaluating change in the near-field area and estimating the spatial extent of a possible change. Far-field/reference area and especially mid-field area data should be incorporated more clearly in the objective. Accordingly, data from mid-field areas should be included in all data analysis.

- Temporal data will be evaluated only by visual means due to large year-to-year variation, and no statistical analysis will be conducted. However, there is value in trying to analyze temporal patterns after a few years of consistent monitoring. Firstly, natural variability may be smaller due to the larger number of stations included in the AEMP, and secondly, understanding the natural fluctuations may prove valuable at some point in time. We would like to see temporal analysis of the benthic invertebrate data, at least initially.

- On p453 para2, sediment quality data is mentioned. It should be replaced with benthic invertebrate data.

- On p420, reference is made again to the power analysis, but the EEM document, where it is derived, is not cited. It should be mentioned that the reference is to a generic power analysis, not an analysis on the existing data.

8.0 PLANKTON AND PERIPHYTON COMMUNITIES

8.1 MAIN REVIEW POINTS

Issue: Periphyton has been omitted from the AEMP mainly due to poor results from the Snap Lake AEMP periphyton special study, and the recommendation by DDMI to omit monitoring using artificial substrates for the following reasons:

- This method selects a particular component of the periphyton community and loose colonizers will not be represented
- Strong wind and wave action will be issues due problems associated with properly anchoring artificial substrates.

Why of concern: The rationale for omission of periphyton monitoring on natural substrates was initially deemed to be sufficient, based on the following. In Snap Lake, periphyton samples were collected from 1 and 2 m depth contours, and periphyton biomass was found to be variable. As a consequence, monitoring of periphyton was removed from the Snap Lake Water License requirements. According to the integrated description of Lac de Gras, wave action and ice scour inhibit periphyton growth within the first few meters of the littoral zone, and light attenuation probably inhibits the growth in the deeper areas. Sampling of periphyton may prove to be difficult and resource consuming in the deeper areas of Lac de Gras.

However, the utility of monitoring periphyton on artificial substrates was discussed at the workshop. DFO provided comments from Dr. Turner, a recognized algal expert from the Freshwater Institute in Winnipeg that was involved in the Snap Lake study. Comments specific to periphyton monitoring were:

"*The issue of measuring the potential impact on the benthic algal components of the littoral zone or periphyton (section 5.6, p. 457-458) is challenging. In 2004 I advised Golder both in the design of the special effects study of benthic algal composition in Snap Lake, and in training Katherine Gerein at the Experimental Lakes Area in the SCUBA-based sampling techniques needed to sample natural benthic biofilms. Because of logistics, costs and regulations related to occupational health and safety, it was deemed impractical to sample in the north using SCUBA, and snorkel-based sampling apparently proved suboptimal for a variety of reasons.*

I wonder though about the decision to abandon this line of inquiry altogether. It is correct that the use of artificial substrata as an alternative colonization surface will likely result in the development of a community that differs from the natural one. However, in the absence of data on the effects of mine activities on natural biofilms, using a surrogate approach is arguably preferable to doing without any information on this ecosystem component.

As an aside, it should be clarified that the statement that periphyton has only recently been used as an indicator of lake health should be restricted to natural biofilms.

Periphyton that have developed on artificial substrata have been used as indicators of ecosystem change for many years (e.g. see review articles by Sladeckova 1962 or Aloi 1990).”

Recommendation: On balance, we agree with Dr. Turner that effectively monitoring natural periphyton communities in northern lakes such as Snap Lake has proven to be difficult and there appears to be no reason to think that doing so in Lac de Gras would be any easier. However, periphyton are important to the primary productivity of the lake and it may be advisable to investigate the potential for monitoring using artificial substrates to monitor periphyton communities in Lac de Gras. This should be undertaken in consultation with DFO to utilize all available expertise. Thus it may be premature to exclude the periphyton component completely before all avenues have been investigated.

Issue: Monitoring of phytoplankton communities: Evaluation of community composition and biomass as sensitive and robust AEMP indicators, by conducting a Special Effects Study (SES) using archived samples (2001-2006). The objectives of the plankton SES study given on pages 455 and 458, with respect to phytoplankton, are to “*assess potential changes in phytoplankton community composition and verify appropriateness of using chlorophyll* a *as a surrogate measure of the phytoplankton community*”.

Why of concern: DDMI has proposed that phytoplankton community composition samples be taken monthly during the open water period (i.e., June, July, August) for the first three years. This represents an increased sampling effort compared to that implemented from 2001 to 2006, and also there is far more sampling at reference locations. Consequently, although the proposed phytoplankton SES study will give some indication of natural variability in phytoplankton community metrics in Lac de Gras, it is likely that results from the first three years of monitoring under the 2007 program will provide more relevant information.

The use of 2007-2009 monthly sampling data (June, July, and August) is also supported by the fact that phytoplankton sampling from 2001 to 2006 was mostly carried out in August. So by only using the historical data from archived samples, DDMI will not be able to adequately evaluate variability within the open water season. Also many of the sites/areas are different from those proposed for the 2007 AEMP design, especially reference areas. Finally, the historical data were only collected at mid-field and far-field/reference sites, not near-field sites. Given the importance of the near-field sites to the 2007 study design, it is important that variability in phytoplankton composition and biomass be evaluated at the near-field sites also using 2007-2009 data.

It is important to realize that the purpose of the phytoplankton SES study is to assess the effectiveness of both community composition and biomass parameters as AEMP endpoints. This is in reference to monitoring potential nutrient enrichment effects, potential toxic effects from contaminants such as trace metals (e.g., cadmium), as well as the availability of food for upper trophic levels such as invertebrates (both in terms of quantity and type of phytoplankton).

Recommendation: We recommend that the plankton community composition samples in the 2007 program, be submitted for analysis immediately after collection and the results evaluated. When sufficient information is available regarding variability in Lac de Gras, then thresholds and effect sizes for monitoring of phytoplankton communities (biomass and/or community composition) can be determined. By this time there should be sufficient information to collectively decide whether plankton community composition and biomass can be effectively monitored in Lac de Gras. On the other hand, if it is possible to set effect sizes now then DDMI should do so.

We recommend that DDMI commit to monitoring phytoplankton biomass and community composition as part of the 2007 AEMP program unless they can show that phytoplankton community composition is not a sensitive and robust indicator. Thus both indicators will be measured unless one is shown to be ineffective. If necessary the archived 2001-2006 samples may be processed to provide additional information but the 2007-2009 samples should be given priority.

Issue: Monitoring of zooplankton communities: Evaluation of community composition and biomass as sensitive and robust AEMP indicators, by conducting a Special Effects Study (SES) using archived samples (2001-2006). The objectives of the plankton SES study given on pages 455 and 458, with respect to zooplankton, are to "*assess potential changes in zooplankton community composition and verify the use of biomass as an indicator of the zooplankton community*".

Why of concern: It is important to realise that the purpose of the zooplankton SES study is to assess the effectiveness of both community composition and biomass parameters as AEMP endpoints. This is in reference to monitoring potential nutrient enrichment effects, potential toxic effects from contaminants such as trace metals (e.g., cadmium), as well as the availability of food for upper trophic levels such as fish (both in terms of quantity and type of zooplankton).

Growth and survival of larval fish is often dependant on the presence of particular species or life stage of zooplankton being available immediately after emergence, and in adequate densities. Freeberg et al. (1990) showed that food availability in the first 7 weeks of life was a major determinant of year-class strength in lake whitefish. North/South (in YEC 1998) reported that newly hatched lake whitefish in a Yukon lake showed a strong preference for larger copepod nauplii and early instar copepodids; graduating to larger copepodids and adults copepods; and eventually to cladocera. Smaller zooplankton (e.g., rotifers and small nauplii) were not selected, and cladocera did not become a major prey item until several weeks after emergence.

Furthermore, DDMI concluded that zooplankton biomass was not a sensitive parameter based on retrospective power analysis. A relatively large number of samples were required to detect a 50% change in zooplankton biomass. Thus reliance solely on zooplankton biomass to determine the health of zooplankton communities in Lac de Gras has to be questioned. Of additional concern is the fact that zooplankton biomass has exhibited an overall decrease over time at all sites, even though it is not deemed to be a

sensitive indicator. If community composition is more sensitive, then it is of primary importance to evaluate if there have been shifts in the types if zooplankton in the lake (i.e., community composition), and determine resulting impacts on fish populations.

Recommendation: On balance, we recommend that DDMI commit to measuring zooplankton biomass and community composition for the 2007 AEMP. The importance of zooplankton community composition to fish populations and the acknowledged insensitivity of the zooplankton biomass indicator, have led us to conclude that DDMI cannot rely solely on biomass. Furthermore, the integrated description of Lac de Gras revealed that benthic invertebrate community composition in Lac de Gras exhibits large natural variability. It would then be of value to have another biological indicator that looks at the community composition of secondary consumers, and subsequent effects on tertiary consumers such as fish.

That said it is still important to evaluate the sensitivity and robustness of zooplankton community composition as an AEMP indicator. Thus we recommend that the zooplankton community composition samples in the 2007 program should be submitted for analysis immediately after collection and the results evaluated. When sufficient information is available regarding variability in Lac de Gras, then thresholds and effect sizes for monitoring of zooplankton communities (biomass and/or community composition) can be determined. On the other hand, if it is possible to set effect sizes now then DDMI should do so.

Biomass should continue to be measured to see if the downward trend continues past 2007. It may be of value to also analyze the archived samples to compare community composition during the observed decline in biomass.

9.0 FISH COMMUNITIES AND CONTAMINANTS IN FISH TISSUES

The majority of the main comments raised by EMAB at the workshop were verbally accepted by DDMI as reasonable. Therefore they are presented here in the original bulleted format submitted prior to the workshop. This format of comments was also necessary due to time constrictions.

9.1 MAIN REVIEW POINTS

9.1.1 Study Design

- Fish health survey and contaminant monitoring are not incorporated into section 4.4.2, which describes the location of sampling stations. The number of fish sampling stations for each area is given in table 4.4-1 but it is not indicated, where stations will be located other than for the general area, and no rationale is given for the selection of sites. Furthermore, sampling frequency is presented as "*1 year*" for all fish studies. The frequency should be clarified (annual/once every 3 years) for each of the study components. Same sampling frequency is given for fish palatability and contaminant sampling, even though in section 5.9 it is indicated that the frequency will be different (annual for lake trout palatability/metal analysis, once every 3 years for sculpin tissue analysis). Fish community/health sampling frequency is unclear both in table 4.4-1 and in section 5.8. Sampling frequency and locations for all fish studies should be clarified.

- In addition, fish tissue concentration data should be ideally collected in a synoptic manner with other supporting parameters (e.g., benthic invertebrates, sediment and water quality). In sections 5.8.2 and 5.9.2, the season (spring/summer/late open water) of fish sampling for the AEMP is not discussed. The time of sampling should be identified for both fish community/health and tissue contaminant monitoring, and efforts should be made to link the fish monitoring component to other components in the AEMP.

- It is not clear why fish community/health and/or tissue metal level data are only collected from near-field and far-field/reference areas, when all other monitoring components include sampling also in the mid-field area. Rationale should be provided for excluding mid-field area from the study design.

9.1.2 Fish Communities Component

- The rationale for selecting slimy sculpin as a sentinel species is well presented. Although it is unfortunate that a suitable large species is not included as well, the rationale provided for such exclusion is appropriate. The description of field methodology and for collection of sentinel species information (Section 5.8.2) is adequate and appropriate.

- The exclusion of a reference lake remains unfortunate, but acceptable if, in fact, no suitable reference lake exists despite of vigorous attempts to find one. However, DDMI has not yet provided information describing the level of effort put towards finding a reference lake, nor the criteria used to arrive at the conclusion that no regional lakes were suitable.

- As described, data analysis and the interpretive framework represent a significant improvement over previous versions of the AEMP. Most concerns raised by EMAB in reviewing earlier versions appear to have been addressed.

- The use of carcass weight (CW) rather than total body weight (TBW) is appropriate (p464), given the potentially confounding factor of *Ligula* infestation. It may be useful to also calculate using TBW as well, however, at least for condition factor (K). A minimum of 100 sculpin also will be captured and sampled non-lethally from each site, and the length and weight information will be used to analyze a number of parameters as per Table 5.8-2 (e.g., Condition). Since the calculations for the much larger non-lethal survey data will have to rely on TBW instead of CW, calculating both for the lethal survey would provide useful context.

- In table 4.3-8 and on p461, slimy sculpin abnormalities ("*e.g, wounds, tumours, parasites, fin fraying, gill parasites or lesions*") are identified as a measurement endpoint for the fish community and/or quality monitoring component (not clear to which component the endpoints belong). Inspection of Deformities, Eroded Fins, Lesions and Tumours (DELT) procedure sounds very similar, and has a well-established protocol (e.g., Sanders *et al.* 1999). The use of this protocol and the establishment of management thresholds is recommended.

- In the overview of predicted residual effects on fish, the comment comparing the relative magnitude of direct project related effects and angling mortality is inappropriate [i.e., *"It is interesting that, in a purely ecological context, the mortality of thousands of fish a year would be considered an effect of very high magnitude. However, because angling results in a social benefit (i.e., recreation and fish harvest) and is legislated in the Federal* Fisheries Act, *as long as the activity is sustainable (as is predicted for Lac de Gras), the effect is estimated to be low."*]

- There are discrepancies between Table 4.3-8 (Measurement Endpoints) and Table 4.3-9 (Measurement Endpoint Benchmarks). Specifically, the following endpoints are not carried through to the second table:

    - Phytoplankton abundance
    - Phytoplankton composition
    - Zooplankton abundance
    - Zooplankton composition
    - Lake trout tissue metal concentrations

- Slimy sculpin abnormalities
- Fish habitat

- According to p408, no thresholds for decision-making/management have been established for fish abnormalities and tissue metals concentrations (hence exclusion from Table 4.3-9?), although monitoring will continue. It is therefore not clear how monitoring information can or will be used to determine effect. On the same page it is stated that no thresholds for decision-making/management have been established for fish palatability, although Table 4.3-9 appears to suggest that a statistical difference between near-field and far-field/reference sites may be used.

- In Table 4.3-9 (p403) under Guidelines and Effect Sizes for Fish Population Health (Moderate Level Effect), the effect size appears to be ± 2 SD. The same is stated near the bottom of p407. However, in Section 5.8.5 the critical effect size is given as 20% - 30% difference in parameters between near-field and far-field/reference sites. The effect size should be clearly and consistently communicated.

9.1.3 Contaminants Residues in Fish Tissues Component

- In general, the section is very brief, and the description of sampling methods and interpretative framework could be more detailed. Possible links between the fish community/health study and contaminant monitoring or links to other monitoring components (e.g., benthic invertebrates, sediment) are not presented or discussed, although they could provide a more integrated approach to AEMP fish monitoring.

- In section 4.3.8.3 on biological benchmarks, it is stated that no increases in fish metal concentrations were predicted in the EA and "*neither effluent chemistry or slimy sculpin tissue analysis suggest that Cd or Hg released from Mine activities pose a risk to Lac de Gras fishery*". Based on this rationale, no thresholds for decision-making/management have been set for either slimy sculpin or lake trout studies. If no thresholds are set for the monitoring, the question arises whether the monitoring is at all meaningful. If an effect is observed, management actions should be in place to conduct further investigation on, e.g. the extent of the effect. In the workshop, it was agrees that there is no sense in monitoring for the sake of monitoring.

- According to the AEMP design, 3 to 5 slimy sculpins from 5 stations in near field and far field/REF areas will be analyzed (sex not identified), which may prove to be inadequate to account for variability in different individuals. MMER EEM (EC 2002) recommends that "*tissue analyses should be conducted on 8 samples (to achieve 95% power) of a single species from the exposure area and the reference area.*" We recommend that the EEM recommendations would be followed in the study design or that the smaller sample size.

- It is not clear, if the lethal sampling for the fish community survey (60 sculpins per station) and metal analysis (a total of 15-25 sculpins per station) are conducted simultaneously, or if the same fish could be used for the community survey and

metal analysis. Sampling frequency, once every three years, has been chosen in order to "*prevent an effect on sculpin populations due to sampling*". Consequently, combining the fish for lethal sampling would decrease the total number of sacrificed fish, if it were feasible. Discussion on whether the sampled sculpins could be used for both community and contaminant studies is recommended.

- For the fish community survey, it is noted that data will be subdivided into male, female and juvenile fish data sets, which "*is important because the different energetic requirements associated with reproduction tend to result in differences in body length, body weight, and liver size*." For the tissue residue survey, no similar distinction is made, even though MMEEM recommends that tissue "*samples should be of one sex and age class*." It is recommended the sex and age of the fish used for the tissue analysis should be discussed and standardized.

- Fish tissues, which will be used for the metal analysis, are not identified. Tissue type (whole body, muscle, liver etc.) and sampling method should be presented in detail, especially due to previous concerns about the sampling procedures and handling. In addition, if different tissues are to be used for slimy sculpin and lake trout, it should be mentioned.

- Metals, which will be analyzed from fish tissue samples, should be listed and their method detection limits should be presented. For example, it is not clear whether mercury will be included in the analysis.

- The interpretative framework section for contaminant residues in fish is generally ambiguous.

- Rationale for excluding mercury from the tissue analysis is given ($\geq$ 0.10 µg/L in effluent), and it is compared to the existing effluent water quality data. However, 0.10 µg/L seems to refer to the first EEM only, and later on in the document MMEEM states that "*if a mine is detecting levels of mercury greater than or equal to 0.05 µg/L as part of effluent characterization (Chapter 6), the mine will do a fish tissue analysis."* The lower value should be used, since the AEMP design will be used for several years and not only for one initial year. In addition, it is not pointed out to the reader that the detection limit has been partly over the rationale limit (0.2 µg/L). In conclusion, if mercury will be omitted from the analyzed parameters at any point in time, a very detailed rationale should be given.

- Only concentrations of metals of potential concern (COPCs) will be statistically analyzed in slimy sculpin tissues but rationale for the selection of these metals is not given and they are not identified.

- Normality of the data should be tested prior to parametric analysis.

- Lake trout tissue metal level data are not mentioned in the interpretive framework, even though they will be presumably analyzed.

9.2 OTHER REVIEW POINTS

9.2.1 Contaminants Residues in Fish Tissues Component

- Target sample size for lake trout used for metal analysis is not presented.
- Rationale for using composite tissue samples (3-5 individuals) for slimy sculpin metal analysis is not provided. What is the tissue requirement for the proposed analysis method?
- Several issues in the description of the Lac de Gras aquatic environment (which was not specifically reviewed) hindered the review of the study design sections, e.g.:
    - Data obtained in 2000 and 2001 for slimy sculpin tissue metal analysis are included in the baseline studies. However, the exclusion of these data has been previously recommended (North/South 2004) due to, e.g. inadequate sample size. The recommended power analysis for sample size has not been attempted on the 2004 data, which were more extensive.
    - Figures 2.10-12 to 16 should include information on the sampling date (1996) and number of samples per species and sex.
    - Figure 2.10-17 seems to have a legend missing, and possibly other components as well.
    - In section 2.10.8, it is not explained where fish were sampled in 1996. Discussion (section 2.10.8.3) on consumption guidelines is unclear. Apparently, levels in different tissues are compared, but it is not clear which tissue is discussed in each sentence.

10.0 SPECIAL EFFECTS AND FISHERIES AUTHORIZATION STUDIES

10.1 MAIN REVIEW POINTS

- Have the various technical issues identified in previous reviews by DFO, North/South, and others been resolved? Have these issues that limited the quality of the data collected been considered in the synthesis of results? Confidence in the conclusions fed into the AEMP design should be expressed and any limitations identified. For example there was an opportunity in Table 4.3.2. for the TSS study but no limitations were identified despite limitations being identified in the text (see section 3). However, some limitations were described on p386.

- In general, information provided in this design document regarding the SES and Fisheries Authorization studies is often fragmented, within, and between text and tables. It would be valuable for DDMI to provide a better synthesis of the information that provides information on whether identified issues have been resolved, and the limitations of results being transferred to the AEMP. This is particularly true for baseline information. We recognize that all these studies cannot and should not be described in detail in this design document but the current synthesis does not provide the all the necessary information in a consistent format.

- How the results of these studies will be integrated into the AEMP and its decision frameworks that trigger management, mitigation and monitoring actions, remains unclear (see review comments for the Study Design Section 1).

- The dike monitoring programs are said to have made "*substantial contributions*" for mine-related effects monitoring and be an "*integral components*" of the AEMP. However, practically no input of the dike monitoring special studies is apparent in the sediment and benthic invertebrate AEMP components in sections 4 and 5.

- The results of sediment deposition study (2001) are presented for sediment traps, whereas for the sediment tile component, only the study objectives are given. As only sediment tile study results are presented, it is not known how previous comments have been addressed. For the sediment trap study, North/South comments are briefly presented, but there is no indication of how or if they have been addressed.

- It is not clear why benthic invertebrate results before and after construction of the A418 dike (2004 and 2006) were not available for this report.

- "*DDMI will monitor TSS daily at discrete depths during dredging and A21 dike construction in 2008 to ensure that established target thresholds are not exceeded at monitoring locations around the dredging activities.*" (p469). Although daily monitoring will enable detection of threshold exceedences, the text does not provide a discussion of how non-exceedence will be ensured or how TSS will be managed if exceedences do occur.

11.0 REFERENCES

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