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REVIEW OF THE DIAVIK DIAMOND MINE AQUATIC EFFECTS MONITORING PROGRAM (AEMP) 2009 ANNUAL REPORT

Technical Memorandum # 367-10-01

Prepared for:

Environmental Monitoring Advisory Board (EMAB)
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1.0 APPROACH TO THE 2009 AEMP REVIEW

A technical review was conducted of the core components of the DDMI 2009 AEMP, i.e., effluent and water chemistry, sediment chemistry, and benthic invertebrates. Additional components of the AEMP included in the review were dust deposition and the weight of evidence (WOE) analysis. Fisheries Authorization and Special Effects Studies (SES) commented on included fish palatability, health, and tissue chemistry, plankton SES, and eutrophication indicators. Reviews were conducted by North/South Consultants Inc. (North/South) personnel with knowledge and experience in each of the areas.

The following review focused on a general overview of the results. Emphasis was placed on identifying results that may indicate any substantive environmental changes observed since the previous year of monitoring (DDMI 2009), and on identifying potential 2009 AEMP (Rio Tinto 2010) implementation concerns considering the core aspects of the revised AEMP study design (DDMI 2007). In addition, recommendations for the 2009 AEMP Annual Report provided by the Wek'èezhìi Land and Water Board (WLWB) (WLWB 2009, 2010) were taken into consideration. However, this review is not intended to be comprehensive.

Review criteria employed for the components included, but were not necessarily limited to:

- Assessment of completeness relative to the approved AEMP design and any follow up recommendations;
- Suitability of the study design (e.g., spatial area and site selection; seasonality; replication) and continuity between AEMP years;
- Effectiveness and relevance of the sampling methodologies used;
- Appropriate analytical parameters measured at detection limits below relevant guideline and/or benchmark levels, and transparency in reporting (e.g., agreement of information presented in non-technical summary with various attached technical appendices);
- Appropriate laboratory processing techniques and taxonomic identification, and transparency in reporting (e.g., inclusion of a detailed appendix);
- Adequate quality assurance/quality control procedures and transparency in the presentation of methodologies and results (e.g., inclusion of a detailed appendix);
- Appropriate data analysis techniques sufficient to address AEMP objectives and requirements;
- Appropriate interpretation and discussion of results sufficient to address AEMP objectives and meet all requirements, and recognition of certainty and uncertainty; and/or

- Relevance, accuracy and justification of conclusions drawn and importance of any recommendations made.

The combination of review criteria depended on applicability to the specific AEMP component under review.

The following review comments are based on the more detailed technical appendices, but generally reflect what was brought forward to the 2009 Annual Report. Section 2.1 provides an overall summary impression of the 2009 AEMP Annual Report and main review points noted for each component; Section 2.2 provides a more detailed technical review of each specific AEMP component. For ease of review, a summary of the detailed technical review and recommendations are provided in Section 2.3 as a review matrix along with 2009 AEMP evaluation comments and key points for EMAB to consider (Table 2-1).

2.0 EVALUATION OF THE 2009 AEMP

2.1 SUMMARY AND KEY POINTS

General Impression

- Overall, the approach and presentation of results is clear and consideration of the majority of important information in the main body of the Annual Report as a non-technical summary greatly enhances the ability of the reader to evaluate the overall effects detected in the AEMP. In particular, the addition to most components of an effects summary table in the main body of the Annual Report that summarizes the effect-level designations improves one's ability to evaluate the overall effects detected in the 2009 AEMP and continues to be an excellent addition to AEMP reporting.

- It appears that the majority of effects observed to date were predicted during the Environmental Assessment (EA) process and, as such, there are no major concerns at this time. However, key recommendations from previous reviews (WLWB 2009, 2010) not addressed in the 2009 AEMP will need to be revisited in either the Three-Year AEMP Summary or the Three-Year AEMP Design Review (whichever is appropriate), where they will benefit from additional discussion by interested parties.

- Recommendations provided in the technical appendices are sound. As part of the Three-Year AEMP Summary and/or Design Review, it would be beneficial if DDMI would carry forward any recommendations provided in technical appendices to date and provide a rationale for accepting or rejecting each recommendation (e.g., to be reconsidered in the Three-Year Summary with the benefit of multiple years of analysis and recommendations) and provide a summary table of all recommendations for ease of future review(s) and consideration.

Dust Deposition

- A potential reporting error was noted: it appears the deposition rates in Appendix I for the snow survey were based on total sampling surface areas from the 2008 report instead of being based on 2009 '# of Core Samples' – if true, all deposition rates, except three, are incorrect and underestimated. Since these values are carried forward throughout Appendix I and the Annual Report, all data analysis/interpretation would require rework.

- There was no qualification of snow water chemistry based on QA/QC duplicate samples. This should be reported in Appendix I to assess field sampling and within-laboratory precision (e.g., inclusion of relative percent differences [RPDs] for duplicates). This should be done annually so adjustments can be implemented where necessary.

- The WLWB recommendation of adding a discussion on the potential effects of additional phosphorus on surface water quality entailed a comparison of the estimated/derived annual total phosphorus (TP) loading from dust deposition on snow for Zone 1-4 compared to the total estimated natural watershed loading. The result was that TP loadings from dust add approximately 110 kg to Lac de Gras surface area encompassing

Zones 1-4 combined. This was compared to 4,447 kg of natural annual loading. There is no further discussion of this additional loading to the study area. It would be useful to include a discussion of total loading from dust relative to other mine sources (e.g., NIWTP loading rates).

- Why not also present other parameters in snow water chemistry results other than those discussed? Since a metals scan has been conducted, perhaps mercury should be reported as well.

- Are there any inferences on why dustfall decreased in 2009?

Effluent and Water Chemistry

- It would be beneficial to provide some discussion on the potential implications of the extended Open 2 sampling period on the analysis and interpretation of the results.

- The results of the 2009 effluent quality monitoring programs indicate that the concentrations and loading of a number of water quality variables were notably higher in October 2009 (and to a lesser extent September). This observation is explained to be a result of the additional diffuser that became operational in September 2009. The 2009 AEMP sampling program was largely complete prior to the installation of second diffuser (sampling ended September 20 and the diffuser became operational on September 17); therefore, there is little or no data in the 2009 report to assess potential effects of this additional diffuser. It is recommended that monitoring results be reviewed regularly to ensure that any emerging issues are identified as soon as possible. It is also recommended that the increase in loading observed for a number of parameters in September and October 2009 be considered when describing potential increasing trends.

- In general, discussion linking temporal trends in effluent loading and quality are not closely linked to the lake water quality monitoring data. This discussion would be helpful for the reviewer to get a clear sense of the effects of the Mine effluent.

- The report indicates that for the 2009 effluent reporting period, the total load of phosphorus discharged to Lac de Gras was the highest since 2002; the load was approximately double the 2008 load. The authors note that the increased loading in September and October 2009 reflects the additional loading from the second diffuser. However, high loading was also observed prior to that period. Can the authors indicate why loading increased substantively in 2009 and what future loading rates are expected?

Sediment Chemistry

- It is indicated that temporal and spatial analysis of sediment quality results will be limited to exposure versus reference area comparisons until additional years of data are collected. It is indicated that the change in methodology to collection of the upper 1 cm of sediment for metals analysis limits the amount of data available for comparison. However, there are data for nutrients from previous years of monitoring that could be examined for temporal and spatial changes and it is recommended that this be considered for the next

AEMP and the Three-Year Summary. The observation of moderate and high level eutrophication effects through analysis of plankton and nutrients in water further supports a more in-depth analysis of the sediment nutrient data.

Benthic Invertebrates

- The comparison of reference areas in 2009 to investigate natural variation in benthic invertebrate community variables is a helpful addition to AEMP reporting.

- The discussion of the potential toxicological effects on benthic invertebrates is somewhat limited and will require additional discussion as part of the Three-Year AEMP Summary. As the potential toxicological effects do not appear to be related to the Mine discharge, it may be helpful to ask what else could reasonably be influencing the benthic community to aid in the understanding of these effects.

- The physical habitat parameters measured (e.g., size of sediment particles) only weakly explained the benthic invertebrate community observed; these weak relationships usually mean that something we are not measuring or have not considered is influencing the numbers and/or types of benthic invertebrates seen in Lac de Gras. This analysis would likely benefit from a more thorough integration of the sediment chemistry results.

Fish

- No dike monitoring studies, fish salvage programs, or fish habitat utilization surveys were undertaken in 2009. The 2007 fish studies are scheduled to be repeated in 2010, including the slimy sculpin survey.

- There was a 2009 fish mercury joint study with the Department of Fisheries and Oceans (DFO) to investigate a possible linkage between enrichment and mercury concentrations in slimy sculpin, which will be included in the 2010 AEMP Annual Report.

- Fish Authorization Studies were limited to ‘Fish Palatability, Fish Health, and Fish Chemistry Surveys’ in 2009.

    - Future palatability surveys should maximize use of available fish. A similar recommendation was made by the DFO (WLWB 2009), and it is understood that this point will be discussed between the WLWB, DFO and DDMI prior to future palatability surveys.

    - The report should include a rationale and process for sample selection, and biological data for rejected fish should be provided.

    - The palatability rating system should be reviewed.

    - DDMI should provide an explanation of what analyses are planned for the fish tissues metals data, and when these analyses will occur.

Plankton Special Effects Study

- DDMI concluded there were weak positive relationships between mean water column barium concentration (an indicator of exposure to Mine effluent) and total phytoplankton biomass in each open-water period.

- A qualitative comparison of phytoplankton summary statistics was neither attempted in the Annual Report nor Appendix XI. A cursory review of these data indicate an increase in abundance of Chrysophyceae (yellow-green or yellow-brown algae), Cryptophyceae (cryptomonads), and Dinophyceae (dinoflagellates) in the NF and MF1; and an increase in NF diatoms compared to other sampling locations during the Open 2 period. Biomass of Chlorophyceae (green algae) and Chrysophyceae were notably higher in the NF and MF1 in comparison to other areas during the Open 2 season. Although a thorough review of the data will occur after three years of data collection, such cursory comparisons would help with WOE observations and perhaps substantiate the phytoplankton relationship to barium concentrations.

- It was noted that there were indications of a potential shift in zooplankton community composition at the level of major group along the Mine effluent concentration gradient and that 2008 and 2009 results suggest there may be a slight eutrophication effect within the NF and MF areas.

- The plankton QA/QC procedures are not explicit and would benefit from a table of calculations added as an appendix to Appendix XI.

- Investigating the differences observed between original and re-counts for FFA-2 and NF-3 zooplankton samples is suggested as each had over 20% difference in abundance.

Eutrophication Indicators

- In comparison to 2008, a smaller area was affected by increased TP concentrations; however the area with increased phytoplankton biomass (as measured by chlorophyll *a*) was larger. The most commonly reported effect of nutrient enrichment on aquatic ecosystems is an increase in algal biomass. Typically, there is a positive correlation between total phosphorus and phytoplankton biomass in lakes and reservoirs, although the precise relationship may vary between lakes. Consideration of eutrophication response variables (e.g., chlorophyll *a*) is important, as not all lakes and reservoirs exhibit the same relationship between nutrients and phytoplankton. The simplest "model" relating nutrients (i.e., phosphorus) to phytoplankton abundance is a linear regression between total phosphorus (TP) and chlorophyll *a*. Since the precise relationship between these parameters is site-specific, it would be beneficial to conduct a regression analysis between TP and chlorophyll *a* for Lac de Gras using available information.

Weight of Evidence

- Given that the overall severity of nutrient enrichment is considered mild by the WOE analysis, Appendix XV recommends that follow-up beyond the existing AEMP is not considered necessary at this time. However, the WOE considers nutrient enrichment to have a high degree of permanence (Appendix XV, Table 3-7), which seems somewhat inconsistent with the recommendation of no follow-up at this time. The reviewers agree with Hutchinson Environmental Sciences Ltd. (HESL) recommendations that DDMI forecast the nutrient loads over the remaining life of the mine; and DDMI develop a predictive model of spatial distribution of P in Lac de Gras that is calibrated to loads and measured concentration over the past 5 years and which is then related to loadings predicted for future years.

- In the 2009 AEMP, the possibility that nutrient enrichment effects are masking toxicological effects was to be considered and/or discussed (note this has also been recommended in Section2.2.4 above). Golder acknowledges this potential relationship in Section 5.3, but provides little discussion. While it is understood why the WOE examined the two hypotheses (Toxicological Impairment and Nutrient Enrichment) distinctly, effects of these two pathways may interact. Simply put, nutrient enrichment typically causes increases in productivity, while toxicological effects might reduce productivity. The possibility that nutrient enrichment effects are masking toxicological effects needs to be further addressed and DDMI should consider integrating the plankton special effects study (investigating community composition changes in plankton) as a tool to define effects.

2.2 SPECIFIC AEMP COMPONENT REVIEWS

2.2.1 Dust Deposition

Relevant materials reviewed included:

- 2009 Annual Report, Section 2.0
- Appendix I: 2009 Dust Deposition Report

The objective of the dust monitoring program is to measure the amount of dustfall at various locations around the mine and to determine the chemical characteristics of the dust deposited on the surface of Lac de Gras. The dust deposition monitoring program incorporates two methods of monitoring:

- Snow core surveys to collect snow samples for total suspended solids (TSS) analysis, and;
- Permanent dust collection gauges to gather samples of airborne particles.

In addition to the dust deposition program, chemical characteristics of snow core samples taken from sites on Lac de Gras (compared to collection sites on land) were determined at an analytical laboratory.

WLWB recommendations for the 2009 Dust Deposition Report included:

- Adding a figure and discussion of the TP in snow water, including the potential effects of additional phosphorus on surface water quality; and

- Add snow water sulphate results to Appendix.

The following comments are based on Section 2.0 of the Annual Report, its corresponding detailed Appendix I, and WLWB recommendations.

- In general, the 2009 dust monitoring sampling program was executed successfully, with only a couple of samples not being reportable.

- The Annual Report and Appendix I closely followed 2008's format with the following changes:

    - The 2009 study discontinued using the temporary dust collectors. The dust sampling methodology along with the intent of the program will be assessed during the Three-Year AEMP Design Review.

    - The WLWB recommendation of adding snow water sulphate results to the 2009 report was followed and appears in Appendix I's Appendix III. However, there is no summary/discussion brought forward in the main text of Appendix I or the Annual Report.

    - The WLWB recommendation of adding a 2009 snow water TP figure (in Appendix I) and discussion was followed.

    - The WLWB recommendation of adding a discussion on the potential effects of additional phosphorus on surface water quality entailed a comparison of the estimated/derived annual TP loading from dust deposition on snow for Zone 1-4 compared to the total estimated natural watershed loading. This discussion is only in the Annual Report and is vague in terms of the calculations used. As such, calculation details added to Appendix I would be beneficial. The result was that TP loadings from dust add approximately 110 kg to Lac de Gras surface area encompassing Zones 1-4 combined. This was compared to 4,447 kg of natural annual loading. There is no further discussion of this additional loading to the study area. It would be useful to include a discussion of total loading from dust relative to other mine sources (e.g., NIWTP loading rates) and to provide more insight in regard to lake load comparisons (e.g., compare loadings per standardized surface area – whole lake compared to each zone amount – for a better perspective of the localized inputs).

- It would have been of interest to derive the annual TP loadings from annual dustfall rates calculated from dust gauges since they give a more accurate measurement of annual dust deposition compared to snow water (as stated in Appendix I). An annual TP loading could be derived over the same area (Zone 1-4) using a combined average deposition rate for all dust gauges (minus average amounts from control gauges).

- A potential reporting error was noted: it appears the deposition rates in Appendix I for the snow survey were based on total sampling surface areas from the 2008 report instead of being based on 2009 '# of Core Samples' – if true, all deposition rates, except three, are incorrect and underestimated. Since these values are carried forward throughout Appendix I and the Annual Report, all data analysis/interpretation would require rework.

- There was no qualification of snow water chemistry based on QA/QC duplicate samples. This should be reported in Appendix I to assess field sampling and within-laboratory precision (e.g., inclusion of relative percent differences [RPDs] for duplicates). This should be done annually so adjustments can be implemented where necessary.

- It would be advisable to consider inclusion of both a field and trip blank as well as a minimum of one equipment blank, particularly given the low analytical detection limits applied to this program. Equipment blanks may include rinsate blanks for core tubes and/or sampling containers.

- Are there any inferences on why dustfall decreased in 2009?

- Would it be beneficial to determine rates of metal deposition rather than just discuss concentrations in snow? Is there any correlation between metals and TSS in snow samples? This would add additional information about the validity of data and relationship to the Mine activities versus other issues/causes.

- Why not also present other parameters in snow water chemistry results other than those discussed? Since a metals scan has been conducted, perhaps mercury should be reported as well.

- Since remodelling of dust deposition rates has been on-going, have there been any explanations of why the current dustfall deposition exceeds predicted rates (even at control sites)?

- General reporting notes/errors:

    - It would be useful to include some additional data in Appendix I indicating the filter size used for the analysis of TSS. While it is clearly stated that the samples collected at the snow monitoring sites for TSS were filtered (presumably using a standard sized filter for TSS analysis, such as 1.5 µm) the description of the dust gauge analysis was not presented. Were the dust gauge and snow samples analysed using the same analytical method? If the same method was applied, it may be beneficial to compare rates of deposition using a similar time period rather than comparing calculated annual rates. As the authors noted, differences might indeed be expected due to collection of samples during different periods. If different TSS analyses were used, direct comparison should not be conducted.

    - The discussion of nitrite is not reported in the snow quality section of the Annual Report (as well as sulphate - noted above).

    - The lab data results for TP in snow were omitted in Appendix I's appendix.

- It would be useful to have error bars on zone average figures.
- Definition of SA has typo in Appendix I: SA of sample = SA of core $(dm)^2$ 8 * # of cores…- remove '8';
- Annual Report Sec. 2.3.1 paragraph 2 – Dustfall deposition rates for the five stations located within 100 m…– there were only four stations sampled in 2009 (same error in Appendix I); and
- Appendix I - pg. 14 paragraph 2 – Dusfall deposition rates for the six stations located between 1001 m and 2500 m of mining operations ranged from 10 mg/dm/y at SS5-5…– should be at SS2-4.

2.2.2 Effluent and Water Chemistry

Relevant materials reviewed included:

- 2009 Annual Report, Section 3.0
- Appendix II: Effluent and Water Chemistry Report in Support of the 2009 AEMP Annual Report for the Diavik Diamond Mine, NWT

The purpose of the water quality monitoring component of the revised AEMP was to describe the water chemistry of Lac de Gras spatially and temporally. The primary objective of this assessment was to determine if the Diavik Diamond Mine had an effect on the water chemistry of Lac de Gras in 2009, and to classify any observed effect as low, moderate, or high. Guidelines for establishing the magnitude of effects are defined in Table 4.3-10 of the AEMP Design Document.

WLWB recommendations for the 2009 Effluent and Water Chemistry Report included:

- All nutrient samples were to be analyzed by one lab (quality assurance issues were identified in prior years due to the use of two different labs).

The following comments are based on the more detailed Appendix II, but reflect what was brought forward to Section 3.0 of the Annual Report.

- Suggest adding that effluent was not chronically toxic to the Appendix II executive summary and in the conclusions section of the main report.
- Would the authors be able to comment on the potential implications of the extended Open 2 sampling period regarding the analysis of the monitoring results? The Open 2 period spanned more than one month (August 4 to September 7) and the end of the period actually overlapped with the beginning of the Open 3 period (September 3 to 20). For example, would comparing data collected at one site on September 7 to data collected at a site sampling on August 4 be appropriate? The report indicates that there were logistical and weather issues during the Open 2 period (common issues for field programs), however, it would be useful to discuss how this affects the data analysis and

interpretation. The raw data provided in Appendix V-I indicate that water temperature had dropped considerably by the end of August relative to early August. Furthermore, some sites were sampled approximately 1 week apart between the Open 2 and 3 periods (e.g., MF3-6). It would be beneficial to provide some discussion regarding whether this affects analysis of the results.

- For parameters that are largely not detected (e.g., <5% detection rate), which are discarded from further analysis (p. 7), it may be beneficial to track the percent detection over time to determine if there is an indication of an increase.

- Section 2.3 (Appendix II) indicates that a pseudo-trend analysis was conducted by comparing the means of 2009 and 2008 data. This approach seems reasonable given that, as indicated, a statistical trend analysis can not be undertaken at this time. We would suggest also including the parameters for which loading increased after commissioning of the second diffuser. Although there are no AEMP data to assess the effects of the increased loads, we believe it is important to identify this issue for future consideration.

- It would be beneficial to include a description of the statistical comparisons (i.e., regressions) for the MF sites in the methods section. The first description of the methods for these data appears on p. 65.

- Section 2.8.1.2 indicates that the statistical analyses for the open-water season were conducted using "depth-integrated data". Could the authors clarify how the data were integrated (i.e., were data from the three depths averaged?)?

- Section 3.3.1 provides a discussion of changes in annual loads for variables included in the Water Licence. While it is understood that on an annual basis loading of some parameters decreased in 2009 relative to earlier study years, in some cases loads appear to have increased in fall after the second diffuser became operational. Are these increased loads observed in September and primarily October 2009 expected to continue in the future?

- Section 3.3.1 indicates that monthly loading rates were calculated for the parameters listed in Table 2-2 (parameters for which there are effluent discharge criteria). However, loads for several of these parameters are not presented (i.e., lead, BOD, oil and grease, and fecal coliform bacteria).

- The results of the 2009 effluent quality monitoring programs indicate that the concentrations and loading of a number of water quality variables were notably higher in October 2009. This observation is explained to be a result of the additional diffuser that became operational in September 2009. Effluent data analysis included in the report extended only through October, therefore there are limited data presented after the diffuser was installed. However, the available data (i.e., increased effluent loading) discussed in the report indicate that effects of the effluent may increase (or already have increased) in Lac de Gras. The AEMP sampling program was largely complete prior to the installation of second diffuser (sampling ended September 20 and the diffuser became operational on September 17); therefore, there is little or no data in the 2009 report to assess potential effects of this additional diffuser. It is recommended that monitoring results be reviewed regularly to ensure that any emerging issues are identified as soon as possible.

- In Section 3.4, it is indicated that "Of the 22 variables with AEMP benchmarks, only TP had validated concentrations above the benchmark." Could the authors clarify what is meant by "validated"? In addition, it is indicated that the analytical detection limit for silver is equivalent to the benchmark concentration for the protection of aquatic life (a common issue for water quality studies); however there is no further discussion provided. Was silver detected or were all concentrations below detection?

- Although it is acknowledged that this information was possibly not available at the time that the AEMP Design Document was drafted, it may be beneficial to adopt the proposed CCME (released December 2009) boron water quality guideline for the protection of aquatic life (short-term guideline of 1.5 mg/L) in AEMP reports. It is also noted that concentrations measured in the 2009 AEMP in Lac du Gras were well below this guideline.

- P. 51 indicates: "Non-detectable results were only obtained during the ice-cover season, while approximately 77% of the data for the other three seasons consisted of non-detectable values." This statement seems to be in error (or requires further clarification).

- It is indicated that there were QA/QC issues respecting ammonia data collected in reference areas, but that this does not affect the interpretation of spatial trends (p. 54). It would be useful to clarify why there is no issue here.

- Some discussion regarding seasonal differences in lake water quality compared to seasonal effluent quality and loading would be beneficial. Due to the volume of information discussed in Appendix II linkages between effluent and lake data are not clearly made.

- Can the authors speculate on why manganese concentrations were lowest during the ice-cover season in the lake (Figure 3-39), but monthly loading was relatively high at this time (and higher than the open-water season)?

- There appears to be a discrepancy between the calculated monthly loads of molybdenum discharged from the NIWTP (Figure 3-15) and the AEMP water quality monitoring data (Figure 3-40). The load of molybdenum increased over the open-water period and by October was more than four times the loading in winter, yet the lake monitoring data indicate effects were generally greatest in winter or at a minimum were not higher in fall. Can the authors speculate regarding this apparent discrepancy?

- The lack of discussion or presentation of data for water quality variables other than phosphorus for the Surveillance Network Program (SNP) discussion (Section 3.4) and the lack of presentation of effluent quality data (i.e., concentrations over time) prevent a reviewer from gaining a clear understanding of how effluent quality varies over time and ultimately, how the effluent data link to lake water quality results. This is particularly critical given that Section 3.3.1 indicates that the effluent loads for a number of parameters increased in fall 2009 (coinciding with installation of the second diffuser), but the reviewer has no ability to determine how this additional loading affected water quality in the mixing zone. It would be very useful to integrate this information.

- The discussion (Section 4) is very useful. Although there is a clear indication that loading of TP and metals and metalloids "tended to be highest in September and October 2009…likely the result of the second water treatment plant stream and associated diffuser increasing the volume of effluent discharged during these months", there is no discussion of what these increases did to ambient water quality in Lac de Gras. It appears as though the majority of the AEMP sampling was completed prior to operation of the second diffuser, however, are there SNP data that could be discussed here for these two months? In general, discussion of temporal trends in effluent loading and quality are not closely linked to the lake water quality monitoring data. This discussion would be helpful for a reviewer to get a clear sense of the impacts of the additional effluent (recognizing this began near the end of the reporting period).

- The report indicates that for the 2009 effluent reporting period, the total load of phosphorus discharged to Lac de Gras was the highest since 2002; the load was approximately double the 2008 load. The authors note that the increased loading in September and October 2009 reflects the additional loading from the second diffuser. However, high loading was also observed prior to that period. Can the authors indicate why loading increased substantively in 2009 and what future loading rates are expected?

- While it is agreed that there is a lack of aquatic toxicological information for calcium, potassium, magnesium, and strontium, which renders assessing the ecological effects of increases in these parameters extremely difficult, there is no rationale provided to substantiate/explain the conclusion that: "no significant ecological degradation can be attributed to the increased levels of calcium, magnesium, potassium, or strontium in Lac de Gras waters near the mine discharge" (p. 71.). Could an explanation of how this conclusion was reached be provided? For instance, are concentrations well within ranges observed in other comparable freshwater ecosystems? Does the ecological monitoring information indicate there has not been ecological degradation due to any Project-related changes?

- There is no discussion provided regarding dissolved oxygen (DO) monitoring results other than a reference to the FF2 area in winter (see Section 3.5.3). Were CCME DO guidelines met at all sites? Was there any indication that the Project is affecting DO? Were there spatial differences in DO conditions? Similar comment would apply to pH and conductivity. Suggest including this discussion in Section 3.5.3 and summarizing in Section 4.

- Suggest carrying the fourth conclusion bullet (Appendix II, Section 5, p. 77) forward into the main report (i.e., p. 30, Section 3.4) and to the Appendix II executive summary. The observation that a number of parameters are, based on visual comparisons, increasing over time is very important and should be identified in the main report. We would further suggest that a statement be added indicating that the loading of numerous water quality variables increased notably in fall of 2009 and further increases in nutrient and metal concentrations in the lake since that time might be expected. That is, there is no explicit discussion stating that this additional loading would be expected to increase the magnitude of the effects to water quality. The sentence that reads: "The concentrations of iron and TP at the NF area were lower in 2009 than observed in previous years" (Appendix II, p. 77) is misleading. While the accuracy of the statement is not disputed, the critical point is that the NF area was sampled prior to commissioning of the second effluent stream – i.e., prior to when loading of TP increased dramatically. Therefore TP concentrations would mathematically, have to have increased in the NF area in late 2009.

- Strongly agree with the recommendation to review water quality results in a timely fashion (i.e., as results are received, p. 77). This is standard QA/QC practice and will improve the strength of the program. It is further recommended that the data be regularly reviewed to enable identification of any issues as early as possible. This could be done through regular generation of scatter plots, for example.

- Also agree with the second recommendation to revisit the moderate effect level criteria given the MF site distribution (p. 77).

- It would be useful to discuss the results of the field blanks and the trip blanks together; if contamination is observed in both samples, you can exclude field sampling as the source of contamination. It would also be useful to identify the sites where field blanks and equipment blanks were prepared; is there any indication of issues for samples prepared in certain areas?

- The 2009 QA/QC results appear to indicate an issue with ammonia, and possibly aluminum and lead, contamination associated with equipment and/or site exposure and/or sample handling. What steps are being taken to try to identify the source of the contamination and/or to address the issue?

- A few editorial comments to consider as follows:

    - It would be useful to specify an actual percentage of data points below detection as a threshold for Step 3a of the Substance of Interest (SOI) identification process (p. 7);

    - The use of "mixing zone boundary" is somewhat confusing. It would be useful to state what sites (i.e., NF or SNP) are being discussed throughout the various sections of the document. Although a minor point, is it appropriate to refer to the SNP monitoring sites as at the mixing zone boundary when data collected from these sites and NF sites indicate that the effluent is not mixed across depth?

    - Table 3-1 indicates that the AEMP aquatic life benchmarks for mercury are 0.026 and 0.004 mg/L. Should this read "µg/L"?;

    - The discussion of nitrite on p. 30 appears to be in error. It is indicated that loads of nitrite increased in the open-water period, but that this was likely due to increased nitrification, resulting in conversion of nitrite to nitrate. Wouldn't this result in a reduction in loads of nitrite?

- P. 66 indicates that there was "no clear seasonal pattern" respecting concentrations of SOIs without benchmarks at MF sites. Table 3-8 however indicates that potassium is higher in the ice-cover season.

2.2.3 Sediment Chemistry

Relevant materials reviewed included:

- 2009 Annual Report, Section 4.0
- Appendix III: Sediment Report in Support of the 2009 AEMP Annual Report for the Diavik Diamond Mine, NWT

The objectives of the sediment monitoring component of the 2009 AEMP were to provide supporting environmental information for interpretation of the benthic invertebrate community survey, and to determine whether the mine has influenced the sediment chemistry of Lac de Gras and, if so, to classify any effect as low, moderate, or high.

WLWB recommendations for the 2009 Sediment Quality Report included:

- Mercury analysis of sediments to be done at a detection limit of 10 ng/g.
- To consider toxicity-related effects to benthic organisms from levels of some elements in the sediments could be potentially masked by nutrient enrichment effects.

The following comments are based on the more detailed Appendix III, but reflect what was brought forward to Section 4.0 of the Annual Report.

- A lower fraction of duplicate sediment samples (5%) than planned (10%) was collected in 2009 for nutrients and particle size analysis (p. 4). This should be corrected in future sampling programs.
- It is unclear whether duplicate samples comprised 10% or 5% of the total number of sediment sampling sites sampled using a corer (p. 5). This should be clarified.
- It would be beneficial to include a homogenate duplicate (i.e., composite sample of multiple grabs or cores, split into two samples following homogenization) to examine the efficacy of the homogenization procedure.
- Since comparison was made to the Ontario sediment quality guidelines (which is excellent), consider also comparing selenium to the British Columbia Ministry of Environment (2006) sediment quality guideline (2.0 µg/g d.w.).

- It is indicated that temporal and spatial analysis of sediment quality results will be limited to exposure versus reference area comparisons until additional years of data are collected. It is indicated that the change in methodology to collection of the upper 1 cm of sediment for metals analysis limits the amount of data available for comparison. However, there are data for nutrients from previous years of monitoring that could be examined for temporal and spatial changes and it is recommended that this be considered in the report. As noted above, the observation of moderate and high level eutrophication effects through analysis of plankton and nutrients in water further supports a more in-depth analysis of the sediment nutrient data.

2.2.4 Benthic Invertebrates

Relevant materials reviewed included:

- 2009 Annual Report, Section 5.0
- Appendix IV: Benthic Invertebrate Report in Support of the 2009 AEMP Annual Report for the Diavik Diamond Mine, NWT

The primary objective of this assessment was to determine if effects are occurring to the benthic invertebrate community of Lac de Gras due to the Diavik Diamond Mine and, if so, to classify these effects as early warning/low, moderate, or high in magnitude as per defined criteria.

WLWB recommendations for the 2009 Benthic Invertebrate Report included:

- Examine the variation between reference areas to confirm patterns noted in the 2008 AEMP.
- Further discuss the potential toxicological effects on benthos, including the possibility that nutrient enrichment may be masking such toxic effects.

The following comments are based on the more detailed Appendix IV, but typically reflect what was brought forward to Section 5.0 of the Annual Report.

- Results of the 2009 AEMP indicate a range of effect magnitudes on the benthic invertebrate community depending on the variable (i.e., community descriptor or metric) analyzed; the type of effect detected was most consistent with nutrient enrichment.
- It is recommended that all scientific names used be checked for current validity using the Integrated Taxonomic Information System (ITIS 2010), or some other regularly updated source of current taxonomic information.
- Additional explanation concerning the method used for outlier identification/removal during regression analysis would be helpful (Appendix IV, p. 33).
- The discussion of the potential toxicological effects on benthic invertebrates is somewhat limited (Appendix IV, p. 53) and will require additional discussion as part of the Three-

Year AEMP Summary (also see comment in Section 2.2.8). As the potential toxicological effects are not conclusively related to the Mine discharge (i.e., sediment chemistry SOIs identified in Appendix III [those related to Mine discharge only] have not reached AEMP benchmarks or known toxicity thresholds), it may be helpful to ask what else could reasonably be influencing the benthic community to aid in the understanding of these effects. For example, one could look at the naturally elevated metals in the sediments in terms of their toxicity to the benthic invertebrates found in Lac de Gras.

- The comparison of reference areas in 2009 to investigate natural variation in benthic invertebrate community variables is a welcome and helpful addition to AEMP reporting. It would be helpful to have a description of the physical and chemical attributes (e.g., substrate composition/compaction, water depth, sediment chemistry, etc.) of each reference area readily accessible (e.g., similar to Appendix IV, Table 3-1, but with important sediment chemistry parameters included) to aid in the interpretation/understanding of any of the differences observed among reference areas (for e.g., Appendix IV, Table 2-2, p. 9).

- The physical habitat parameters measured (e.g., size of sediment particles) only weakly explained the benthic invertebrate community observed; these weak relationships likely indicate that something we are not measuring or have not considered is influencing the numbers and/or types of benthic invertebrates seen in Lac de Gras. This analysis would likely benefit from a more thorough integration of the sediment chemistry results – further discussion/inclusion as part of the Three-Year AEMP Summary would be beneficial.

- The recommendations discussed by Golder in Appendix IV are sound. They should be revisited during either the Three-Year AEMP Summary or the Three-Year AEMP Design Review (whichever is appropriate), in addition to those items already identified for inclusion (WLWB 2009), where they may benefit from additional discussion by interested parties.

2.2.5 Fish

No dike monitoring studies, fish salvage programs, or fish habitat utilization surveys were undertaken in 2009. The 2007 fish studies are scheduled to be repeated in 2010, including the slimy sculpin survey.

There was a 2009 fish mercury joint study with the DFO to investigate a possible linkage between enrichment and mercury concentrations in slimy sculpin, which will included in the 2010 AEMP Annual Report.

Fish Authorization Studies were limited to 'Fish Palatability, Fish Health, and Fish Chemistry Surveys' in 2009 (Section 4.1.4).

Relevant materials reviewed included:

- 2009 Annual Report, Section 7.1
- Appendix X: Diavik Diamond Mine Community-based Monitoring (CBM) Camp Report – Fish Palatability 2009

This section focuses on the fish palatability study conducted in 2009 to obtain feedback from community members regarding the taste, texture and general condition/health of lake trout from Lac de Gras. Compared to Section 7 of the Annual Report, Appendix X provides a more detailed discussion of the community based survey and two additional appendices to Appendix X provide the raw data for the palatability survey (i.e., individual participant fish quality assessment record sheets) and fish tissue chemistry survey (i.e., analytical lab reports).

- The palatability studies were conducted on only four fish, each prepared in a different manner. It is difficult to interpret the results from such a small survey since it is likely that fish quality is highly variable within any population, regardless of location or lake condition. Many factors can influence the eating quality of a fish: fish size; diet; time of year; water temperature; condition/maturity (e.g., pre-spawner, spawner, non-spawner); sex (note that all the tested fish were males); etc. Furthermore, an individual fish may rate higher or lower when prepared by one method versus another (e.g., a fatty fish might taste better if cooked by one method, while a less fatty fish may taste better if cooked by a different method). The results would be easier to interpret if they were based on a larger sample size, although we recognize the desire to limit the number of lake trout that are captured and killed for study purposes. That said, there were an additional 15 lake trout captured that could have been used in the palatability tests, even with some tissue removed for chemical analyses.
    - Recommendation: Future palatability surveys should maximize use of available fish. A similar recommendation was made by the DFO (WLWB 2009), and it is understood that this point will be discussed between the WLWB, DFO and DDMI prior to future palatability surveys.
- The report states that 19 lake trout were captured, but that only 10 were selected for assessment. Tissue samples were collected from the 10 fish for mercury and other chemical analysis, including the four fish that were used for taste sampling. The report does not provide a rational for sub-sampling what was already a fairly small sample size (i.e., 19 fish). Furthermore, it does not describe the selection process. Were the 10 sampled fish selected randomly, based on size or appearance, or based on some other criteria? No biological data are provided for the fish that were rejected. Fish palatability may be affected by size and mercury content has been shown to be related to size as well (i.e., larger fish tend to have higher mercury concentrations).
    - Recommendation: The report should include a rationale and process for sample selection, and biological data for rejected fish should be provided.
- We agree with community members that the consumption quality assessment forms are a little confusing and should be reviewed. The rating categories all refer to the appearance

or 'look' of the fish being sampled. Taste and texture should be provided as assessment options, at least for the 'Eating' portion of the survey. As a general comment, palatability assessments are typically based on 'blind' tests (i.e., the tasters do not know which fish the taste sample comes from). The intent is to avoid introducing inadvertent bias to the palatability assessment that could result from awareness of a fish's origin, external and internal appearance, parasite burden or conditions of preparation. In this case, however, the monitoring program is community-based and we assume that the survey design was based on community preference (e.g., assessment of the fish eating experience as a continuum, from capture to consumption).

  - Recommendation: We agree that the palatability rating system should be reviewed.

- The title of Section 7.1.4 refers to 'Fish Tissue Chemistry Surveys' and the report indicates that samples for testing for mercury and other metals were collected from the 10 assessed fish. The laboratory results for these tests are provided in Appendix X (sub-appendix B). However, the report provides only a brief discussion of the mercury analysis and no discussion of the other metals analysis results. If a more detailed analysis of these data is to be conducted or presented at a later date, this should have been indicated in the report.

  - Recommendation: DDMI should provide an explanation of what analyses are planned for the fish tissues metals data, and when these analyses will occur.

2.2.6 Plankton Special Effects Study

Relevant materials reviewed included:

- 2009 Annual Report, Section 7.2
- Appendix XI: Plankton Report in Support of the 2009 AEMP Annual Report for the Diavik Diamond Mine, NWT

The main objective of the Plankton Special Effects Study (SES) was to determine the feasibility and utility of using community composition and biomass (calculated) as sensitive metrics to detect DDMI-related effects on the Lac de Gras ecosystem (i.e., for phytoplankton = to verify the appropriateness of using chlorophyll *a* as a surrogate measure of the phytoplankton community; for zooplankton = to verify the use of biomass as an indicator). To meet this goal, three main objectives were addressed:

- Fill gaps in available baseline data on plankton community composition;
- Assess potentially mine-related changes in phytoplankton and zooplankton community composition over time; and
- Over the initial three years of the revised AEMP it will be determined if a single, open-water sample is adequate to describe community metrics and, if so, the best single period of the open-water season will be determined.

WLWB recommendations for the 2009 Plankton SES included:

- Compare data from 2009 to that collected in 2007 and 2008 and discuss any apparent trends over that time.

The following comments are based on the more detailed Appendix XI, but reflect what was brought forward to Section 7.2 of the Annual Report.

- The 2009 plankton report presented data from phytoplankton collected during 2008 and data from zooplankton collected during 2009. Although phytoplankton was collected during 2009, the results are not yet available and will be reported in the 2010 AEMP report.

2008 Phytoplankton (represents the first year of results for the three year SES using accepted SOPs):

- Inclement weather combined with the large distance to some of the stations resulted in some samples not being collected during Open 2 and Open 3 periods. This was minimal and did not impair the study.

- A comparison of taxa present was made between areas and no Mine-related effect on taxonomic richness was surmised.

- Relative abundance and biomass of each major taxonomic group were qualitatively compared between areas for the three sampling periods with basic inferences on the data provided.

- The 2008 phytoplankton data were qualitatively compared to the historical data (the historical data was summarized in the 2008 AEMP report [DDMI 2009]) = 2008 dominant phytoplankton groups were similar to previous years.

- A qualitative comparison of the 2008 phytoplankton total biomass relative to mean water column barium concentrations was completed for each sampling area as another assessment of Mine-related effects = weak positive relationships indicating a Mine-related response. This will be assessed in subsequent monitoring years when additional data are available.

- Comparative statistics were provided for the 2009 phytoplankton data (e.g. mean, median, min/max, standard deviation, standard errors), but no qualitative observations were made.

- A cursory look at the summary statistics indicates an increase in abundance of Chrysophyceae (yellow-green or yellow-brown algae), Cryptophyceae (cryptomonads), and Dinophyceae (dinoflagellates) in the NF and MF1; and an increase in NF diatoms compared to other sampling locations during the Open 2 persiod. Biomass of Chlorophyceae (green algae) and Chrysophyceae were notably higher in the NF and MF1 in comparison to other areas during the Open 2 season. Although a thorough review of the data will occur after three years of data collection, such cursory comparisons would help with WOE observations and substantiate the phytoplankton relationship to barium concentrations. Detailed analysis is planned in 2011.

- QA/QC = 10% of submitted samples were re-counted to verify counting efficiency. DDMI does not set a threshold value to assess the re-counts based on the inherent variability associated with the plankton samples (DDMI could expand on this explanation; coldwater/ultra-oligotrophic lakes such as Lac de Gras typically have low abundances of individual phytoplankton species, with many species considered rare, that can skew differences in re-counts when the counts are zero/one individuals [i.e., when one individual counted in a subsample equates to many individuals/litre of sample]). The reviewer is fine with this since DDMI did evaluate anomalies in re-counts. The proportion of each taxon was calculated and the occurrence of dominant species was assessed for consistency between each QCed sample pair. The QA/QC procedures are not explicit and would benefit from a table of calculations added as an appendix to Appendix I. DDMI assessed differences in relative abundance biomass between 10 duplicate phytoplankton samples – two of the ten had large differences, which was explained as isolated and unexplainable and the 2008 data were determined to be valid.

2009 Zooplankton (represents the second year of results for the three year SES using accepted SOPs):

- All stations were successfully sampled in each sampling period.

- A comparison of taxa present was made between areas and no Mine-related effect on taxonomic richness was indicated.

- Relative abundance and biomass of each major taxonomic group were qualitatively compared between areas for the three sampling periods and to 2007 and 2008 results. It was noted that there were indications of a potential shift in community composition at the level of major group along the Mine effluent concentration gradient and that 2008 and 2009 results suggest there may be a slight eutrophication effect within the NF and MF areas. Detailed analysis is planned in 2011.

- A qualitative comparison of the 2009 zooplankton total biomass relative to mean water column barium concentrations was completed for each sampling area as another assessment of mine-related effects = no relationship was clear.

- Comparative statistics were provided for the 2009 zooplankton data (e.g. mean, median, min/max, standard deviation, standard errors), but no qualitative observations were made. No differences between sampling areas were obvious with a cursory look at this data. Detailed analysis is planned in 2011.

- QA/QC = same methodology as for phytoplankton. 10% of submitted samples were re-counted to verify counting efficiency. Again, the QA/QC procedures are not explicit and would benefit from a table of calculations added as an appendix for transparency. Generally, there was good agreement between the original and re-counts, but a threshold value could likely be assigned to zooplankton as this community is generally not as patchy in its distribution as phytoplankton. Findlay and Kling (1998) suggest replicate counts should be within ± 20% of the first count for phytoplankton and this could be even lower for zooplankton. Investigating the differences observed between original and re-counts for FFA-2 and NF-3 zooplankton samples is suggested as each had over 20% difference in abundance between counts - redoing the count/biomass calculations for these samples is likely necessary for QA/QC.

2.2.7 Eutrophication Indicators

Relevant materials reviewed included:

- 2009 Annual Report, Section 7.4
- Appendix XIII: Eutrophication Indicators Report in Support of the 2009 AEMP Annual Report for the Diavik Diamond Mine, NWT

The overall objective of this assessment was to determine if effluent from the Diavik Diamond Mine is having an effect on concentrations of nutrients, chlorophyll *a* and zooplankton biomass in Lac de Gras.

WLWB recommendations for the 2009 Eutrophication Indicators Report included:

- Compare data from 2009 to that collected in 2007 and 2008 and discuss any apparent trends over that time.
- Include an update on any information DDMI has on ways to optimize the NIWTP to enhance phosphorus removal.

The following comments are based on the more detailed Appendix XIII, but generally reflect what was brought forward to Section 7.4 of the Annual Report.

- The criteria used to classify an outlier are not provided (Appendix XIII, Section 2.2.1).
- The affected area of the lake based on chlorophyll *a* represents 28% of the lake surface area. The area of the lake showing effects on TP throughout the water column is approximately 11% of the total lake area (a reduction in comparison to 2008). Golder notes that the smaller affected area in 2009 reflects the smaller TP concentrations observed in 2009 in comparison to 2008; however, this smaller TP extent is potentially related to the increased chlorophyll *a* extent. The most commonly reported effect of nutrient enrichment on aquatic ecosystems is an increase in algal biomass, which is often expressed as chlorophyll *a* concentration. Typically, there is a positive correlation between total phosphorus (and often nitrogen) and phytoplankton biomass or chlorophyll *a* in lakes and reservoirs, although the precise relationship may vary between lakes. Consideration of eutrophication response variables (e.g., chlorophyll *a*) is critical, as not all lakes and reservoirs exhibit the same relationship between nutrients and phytoplankton. The simplest "model" relating nutrients (i.e., phosphorus) to

phytoplankton abundance is a linear regression between total phosphorus (TP) and chlorophyll *a*. Since the precise relationship between these parameters is site-specific, it would be beneficial to conduct a regression analysis between TP and chlorophyll *a* for Lac de Gras using available information. Predicted future effects of the effluent discharges on phosphorus concentrations in the lake could then be used to estimate effects on phytoplankton using this linear regression relationship.

- The mine is having a moderate-level effect on chlorophyll *a* and TP, and a high-level effect on zooplankton (Appendix XIII, pg. 29); however Table 5-1 (Appendix XIII) indicates an early warning/low level effect for zooplankton. Additionally, Section 7.4.4 and Table 7.4 of the non-technical summary also assigns an early warning/low level effect to zooplankton. Please clarify the level of effect observed for zooplankton in 2009.

- See comments regarding the extended duration of the Open 2 period presented under Section 2.2.2 Effluent and Water Chemistry (i.e., how does this affect the analysis and interpretation of the results)? Also see the final recommendation provided in Section 5.2; the reviewer agrees that field sampling should be conducted to minimize lag time between the first and last areas sampled during any given sampling period.

- Why was a different approach for the treatment of data reported below the analytical detection limit (Appendix XIII, p. 8) adopted relative to the water and effluent quality data analysis (Appendix II, p. 9)? It is acknowledged that both approaches are valid and common practice, but it is unclear why the deviation in approach occurred.

- It would be useful to provide a discussion of the loads and concentration of nutrients in effluents and how they related to observed nutrient concentrations in the lake, particularly seasonally, in Section 3.1. Although it is indicated that effluent and lake water quality varied seasonally, there is no explicit discussion linking the two. Conceptually, higher concentrations of dissolved nutrients observed in winter may reflect either or both higher effluent loading or relatively low productivity and subsequently lower uptake of dissolved nutrients in winter. In this instance it would appear the latter may be true, but there is insufficient data presented here to adequately examine this question. Figure 3-2 in Appendix II indicates that TP loading was highest in the open-water season and Figure 3-23 (Appendix II) indicates that concentrations of TP were highest in effluent in fall. However on p. 13 (Appendix XIII) it is indicated that the seasonal variations in effluent concentrations are reflected as higher concentrations of nutrients in the NF area in winter. This appears to be a discrepancy.

- In general, it would be useful to have an integrated discussion linking nutrients in effluent and nutrients in the lake. This would assist with a thorough assessment of the linkage between the Project effluent and nutrients in Lac de Gras.

- Were sites thermally stratified in winter? It is indicated (p. 19) that DO was low at depth at site FF2 and that this may reflect a combination of the input at the surface as water freezes and the uptake of oxygen at the bottom as organic matter decomposes. Winter DO depth profiles such as this generally reflect the lack of reaeration of the water column due to the presence of ice in combination with sediment oxygen demand. This also often occurs where thermal stratification is established.

- It is indicated on p. 21 that "algal growth occurred very quickly following ice-out in the exposure areas...". However, as chlorophyll *a* was not measured prior to ice-out, this statement can not be substantiated.

- It would be useful to provide a figure illustrating the TP concentrations at NF, FF, FF2 and reference areas for the open-water period in addition to the figure for the ice-cover period (i.e., Figure 4-3).

- For eutrophication indicators (phosphorus, chlorophyll a and zooplankton biomass), data from 2009 was to be compared to 2007 and 2008, and any apparent trends over that time period were to be discussed; this discussion appears in the non-technical summary (Section 7.4) only (i.e., this recommendation for the 2009 AEMP is not addressed in Appendix XIII).

- An update on any information DDMI has on ways to optimize the NIWTP in enhancing phosphorus removal was to be provided; this discussion appears in the non-technical summary (Section 7.4) only (i.e., this recommendation for the 2009 AEMP is not addressed in Appendix XIII).

- The recommendations discussed by Golder in Appendix XIII are sound. They should be revisited during either the Three-Year AEMP Summary or the Three-Year AEMP Design Review (whichever is appropriate), in addition to those items already identified for inclusion (WLWB 2009), where they may benefit from additional discussion by interested parties.

2.2.8 Weight of Evidence

Relevant materials reviewed included:

- 2009 Annual Report, Section 9.0

- Appendix XV: Weight-of-Evidence (WOE) Assessment in Support of the 2009 AEMP Annual Report for the Diavik Diamond Mine, NWT

The objectives of the WOE assessment were two-fold:

- To apply a standardized process to evaluate strength of evidence for potential toxicological impairment and nutrient enrichment effects in the aquatic ecosystem of Lac de Gras; and

- To summarize the AEMP findings in a semi-quantitative manner that provided broad AEMP conclusions, which could inform decision-making for ongoing environmental stewardship of Lac de Gras.

WLWB recommendations for the 2009 WOE Report included:

- Consider/discuss the possibility that nutrient enrichment effects are potentially masking toxicological effects.

The following comments are based on the more detailed Appendix XV, but reflect what is brought forward to Section 9.0 of the Annual Report.

- Consider adding the results of assessment of TP results in water to the executive summary. It is acknowledged that larger and more consistent effects were observed for chlorophyll *a* and total nitrogen (TN). However, given the significance of TP in eutrophication it would be useful in the interest of thoroughness to include this information here.

- Given that the overall severity of nutrient enrichment is considered “mild” by the WOE analysis, Appendix XV recommends that scientific investigative follow-up beyond the existing AEMP studies is not considered necessary at this time, although Golder considers eutrophication to have a high degree of permanence (Table 3-7, Appendix XV), which seems somewhat inconsistent with the recommendation of no follow-up at this time. The reviewers continue to note that this recommendation may be somewhat dismissive of the current degree of nutrient enrichment in Lac de Gras and the potential influence of this enrichment on mercury methylation processes (as commented on in the review of the 2008 AEMP Annual Report and to be investigated in the SES on Possible Effects of Enrichment on Mercury Uptake), in addition to our somewhat poor understanding of the long-term consequences of eutrophication on nutrient-poor Arctic ecosystems. These concerns are reflected in the 26 April 2010 memorandum provided by Hutchinson Environmental Sciences Ltd. (HESL) regarding phosphorus EA predictions vs. measured effects at the mine (WLWB investigation of nutrient enrichment, WLWB 2010). HESL recommendations included:

    - DDMI forecast the nutrient loads over the remaining life of the mine; and

    - DDMI develop a predictive model of spatial distribution of P in Lac de Gras that is calibrated to loads and measured concentration over the past 5 years and which is then related to loadings predicted for future years.

  The following was brought up during DDMI’s 2009 AEMP presentation to EMAB (May 19, 2010): the capacity of the treatment plant has doubled; due to the shift to underground mining, ground water processing will increase (which is the main source of phosphorus); and there will be a 20% increase in effluent compared to 2009 loadings for the remaining life of the mine. Based on this, plus the large increase in 2009 TP loading observed when the new diffuser came on line, the reviewers agree with both of the HESL recommendations.

- An additional follow-up item to the above point is for clarification concerning how the term “mild” nutrient enrichment was defined. While the reviewers would agree that the data do not indicate substantive nutrient enrichment, the use of a subjective term without a clear definition of how Golder determined a magnitude of “mild” is somewhat questionable. A shift in trophic categories and a relatively large increase in nutrients and chlorophyll *a* relative to reference areas two years in a row (2008 and 2009 AEMPs) might be argued to support more than a "mild" designation.

- In the 2009 AEMP, the possibility that nutrient enrichment effects are masking toxicological effects was to be considered and/or discussed (note this has also been recommended in Section2.2.4 above). Golder acknowledges this potential relationship in Section 5.3, but provides little discussion. While it is understood why the WOE examined the two hypotheses (Toxicological Impairment and Nutrient Enrichment) distinctly, effects of these two pathways may interact. Simply put, nutrient enrichment typically causes increases in productivity, while toxicological effects might reduce productivity. The possibility that nutrient enrichment effects are masking toxicological effects could be further addressed by integrating the plankton special effects study (investigating community composition changes in plankton) as a tool to define effects, which was also recommended by HESL.

2.3 TECHNICAL REVIEW AND RECOMMENDATIONS SUMMARY TABLE

Table 2-1 Technical review matrix of the 2009 Diavik Diamond Mine Incorporated (DDMI) Lac de Gras Aquatic Effects Monitoring Program (AEMP) Annual Report with evaluation comments and key points for EMAB to consider.

2009 AEMP Component	Detailed Technical Review and Recommendations	Evaluation Comments and Key Points for EMAB

Dust Deposition	• In general, the 2009 dust monitoring sampling program was executed successfully, with only a couple of samples not being reportable.
	• The Annual Report and Appendix I closely followed 2008's format with the following changes:
	  ○ The 2009 study discontinued using the temporary dust collectors. The dust sampling methodology along with the intent of the program will be assessed during the Three-Year AEMP Design Review.
	  ○ The WLWB recommendation of adding snow water sulphate results to the 2009 report was followed and appears in Appendix I's Appendix III. However, there is no summary/discussion brought forward in the main text of Appendix I or the Annual Report.
	  ○ The WLWB recommendation of adding a 2009 snow water TP figure (in Appendix I) and discussion was followed.
	  ○ The WLWB recommendation of adding a discussion on the potential effects of additional phosphorus on surface water quality entailed a comparison of the estimated/derived annual TP loading from dust deposition on snow for Zone 1-4 compared to the total estimated natural watershed loading. This discussion is only in the Annual Report and is vague in terms of the calculations used. As such, calculation details added to Appendix I would be beneficial. The result was that TP loadings from dust add approximately 110 kg to Lac de Gras surface area encompassing Zones 1-4 combined. This was compared to 4,447 kg of natural annual loading. There is no further discussion of this additional loading to the study area. It would be useful to include a discussion of total loading from dust relative to other mine sources (e.g., NIWTP loading rates) and to provide more insight in regard to lake load comparisons (e.g., compare loadings per standardized surface area – whole lake compared to each zone amount – for a better perspective of the localized inputs).
	• It would have been of interest to derive the annual TP loadings from annual dustfall rates calculated from dust gauges since they give a more accurate measurement of annual dust deposition compared to snow water (as stated in Appendix I). An annual TP loading could be derived over the same area (Zone 1-4) using a combined average deposition rate for all dust gauges (minus average amounts from control gauges).
	• A potential reporting error was noted: it appears the deposition rates in Appendix I for the snow survey were based on total sampling surface areas from the 2008 report instead of being based on 2009 '# of Core Samples' – if true, all deposition rates, except three, are incorrect and underestimated. Since these values are carried forward throughout Appendix I and the Annual Report, all data analysis/interpretation would require rework.
	• There was no qualification of snow water chemistry based on QA/QC duplicate samples. This should be reported in Appendix I to assess field sampling and within-laboratory precision (e.g., inclusion of relative percent differences [RPDs] for duplicates). This should be done annually so adjustments can be implemented where necessary.
	• It would be advisable to consider inclusion of both a field and trip blank as well as a minimum of one equipment blank, particularly given the low analytical detection limits applied to this program. Equipment blanks may include rinsate blanks for core tubes and/or sampling containers.
	• Are there any inferences on why dustfall decreased in 2009?
	• Would it be beneficial to determine rates of metal deposition rather than just discuss concentrations in snow? Is there any correlation between metals and TSS in snow samples? This would add additional information about the validity of data and relationship to the Mine activities versus other issues/causes.
		• DDMI is aware of the error in dust deposition rate for the snow survey – these results should be available for EMAB evaluation.
		• There was no qualification of snow water chemistry based on QA/QC duplicate samples. This should be reported in Appendix I to assess field sampling and within-laboratory precision (e.g., inclusion of relative percent differences [RPDs] for duplicates). This should be done annually so adjustments can be implemented where necessary.
		• The WLWB recommendation of adding a discussion on the potential effects of additional phosphorus on surface water quality entailed a comparison of the estimated/derived annual total phosphorus (TP) loading from dust deposition on snow for Zone 1-4 compared to the total estimated natural watershed loading. The result was that TP loadings from dust add approximately 110 kg to Lac de Gras surface area encompassing Zones 1-4 combined. This was compared to 4,447 kg of natural annual loading. There is no further discussion of this additional loading to the study area. It would be useful to include a discussion of total loading from dust relative to other mine sources (e.g., NIWTP loading rates).
		• Why not also present other parameters in snow water chemistry results other than those discussed? Since a metals scan has been conducted, perhaps mercury should be reported as well.
		• Are there any inferences on why dustfall decreased in 2009?

2009 AEMP Component	Detailed Technical Review and Recommendations	Evaluation Comments and Key Points for EMAB
Dust Deposition (continued)	• Why not also present other parameters in snow water chemistry results other than those discussed? Since a metals scan has been conducted, perhaps mercury should be reported as well. • Since remodelling of dust deposition rates has been on-going, have there been any explanations of why the current dustfall deposition exceeds predicted rates (even at control sites)? • General reporting notes/errors: o It would be useful to include some additional data in Appendix I indicating the filter size used for the analysis of TSS. While it is clearly stated that the samples collected at the snow monitoring sites for TSS were filtered (presumably using a standard sized filter for TSS analysis, such as 1.5 µm) the description of the dust gauge analysis was not presented. Were the dust gauge and snow samples analysed using the same analytical method? If the same method was applied, it may be beneficial to compare rates of deposition using a similar time period rather than comparing calculated annual rates. As the authors noted, differences might indeed be expected due to collection of samples during different periods. If different TSS analyses were used, direct comparison should not be conducted. o The discussion of nitrite is not reported in the snow quality section of the Annual Report (as well as sulphate - noted above). o The lab data results for TP in snow were omitted in Appendix I's appendix. o It would be useful to have error bars on zone average figures. o Definition of SA has typo in Appendix I: SA of sample = SA of core (dm)2 8 * # of cores…- remove '8'; o Annual Report Sec. 2.3.1 paragraph 2 – Dustfall deposition rates for the five stations located within 100 m…– there were only four stations sampled in 2009 (same error in Appendix I); and o Appendix I - pg. 14 paragraph 2 – Dusfall deposition rates for the six stations located between 1001 m and 2500 m of mining operations ranged from 10 mg/dm/y at SS5-5…– should be at SS2-4.	

2009 AEMP Component	Detailed Technical Review and Recommendations	Evaluation Comments and Key Points for EMAB
Effluent and Water Chemistry	• Suggest adding that effluent was not chronically toxic to the Appendix II executive summary and in the conclusions section of the main report. • Would the authors be able to comment on the potential implications of the extended Open 2 sampling period regarding the analysis of the monitoring results? The Open 2 period spanned more than one month (August 4 to September 7) and the end of the period actually overlapped with the beginning of the Open 3 period (September 3 to 20). For example, would comparing data collected at one site on September 7 to data collected at a site sampling on August 4 be appropriate? The report indicates that there were logistical and weather issues during the Open 2 period (common issues for field programs), however, it would be useful to discuss how this affects the data analysis and interpretation. The raw data provided in Appendix V-I indicate that water temperature had dropped considerably by the end of August relative to early August. Furthermore, some sites were sampled approximately 1 week apart between the Open 2 and 3 periods (e.g., MF3-6). It would be beneficial to provide some discussion regarding whether this affects analysis of the results. • For parameters that are largely not detected (e.g., <5% detection rate), which are discarded from further analysis (p. 7), it may be beneficial to track the percent detection over time to determine if there is an indication of an increase. • Section 2.3 (Appendix II) indicates that a pseudo-trend analysis was conducted by comparing the means of 2009 and 2008 data. This approach seems reasonable given that, as indicated, a statistical trend analysis can not be undertaken at this time. We would suggest also including the parameters for which loading increased after commissioning of the second diffuser. Although there are no AEMP data to assess the effects of the increased loads, we believe it is important to identify this issue for future consideration. • It would be beneficial to include a description of the statistical comparisons (i.e., regressions) for the MF sites in the methods section. The first description of the methods for these data appears on p. 65. • Section 2.8.1.2 indicates that the statistical analyses for the open-water season were conducted using “depth-integrated data”. Could the authors clarify how the data were integrated (i.e., were data from the three depths averaged?)? • Section 3.3.1 provides a discussion of changes in annual loads for variables included in the Water Licence. While it is understood that on an annual basis loading of some parameters decreased in 2009 relative to earlier study years, in some cases loads appear to have increased in fall after the second diffuser became operational. Are these increased loads observed in September and primarily October 2009 expected to continue in the future? • Section 3.3.1 indicates that monthly loading rates were calculated for the parameters listed in Table 2-2 (parameters for which there are effluent discharge criteria). However, loads for several of these parameters are not presented (i.e., lead, BOD, oil and grease, and fecal coliform bacteria). • The results of the 2009 effluent quality monitoring programs indicate that the concentrations and loading of a number of water quality variables were notably higher in October 2009. This observation is explained to be a result of the additional diffuser that became operational in September 2009. Effluent data analysis included in the report extended only through October, therefore there are limited data presented after the diffuser was installed. However, the available data (i.e., increased effluent loading) discussed in the report indicate that effects of the effluent may increase (or already have increased) in Lac de Gras. The AEMP sampling program was largely complete prior to the installation of second diffuser (sampling ended September 20 and the diffuser became operational on September 17); therefore, there is little or no data in the 2009 report to assess potential effects of this additional diffuser. It is recommended that monitoring results be reviewed regularly to ensure that any emerging issues are identified as soon as possible. • In Section 3.4, it is indicated that “Of the 22 variables with AEMP benchmarks, only TP had validated concentrations above the benchmark.” Could the authors clarify what is meant by “validated”? In addition, it is indicated that the analytical detection limit for silver is equivalent to the benchmark concentration for the protection of aquatic life (a common issue for water quality studies); however there is no further discussion provided. Was silver detected or were all concentrations below detection? • Although it is acknowledged that this information was possibly not available at the time that the AEMP Design Document was drafted, it may be beneficial to adopt the proposed CCME (released December 2009) boron water quality guideline for the protection of aquatic life (short-term guideline of 1.5 mg/L) in AEMP reports. It is also noted that concentrations measured in the 2009 AEMP in Lac du Gras were well below this guideline. • P. 51 indicates: “Non-detectable results were only obtained during the ice-cover season, while approximately 77% of the data for the other three seasons consisted of non-detectable values.” This statement seems to be in error (or requires further clarification).	• It would be beneficial to provide some discussion on the potential implications of the extended Open 2 sampling period on the analysis and interpretation of the results. • The results of the 2009 effluent quality monitoring programs indicate that the concentrations and loading of a number of water quality variables were notably higher in October 2009 (and to a lesser extent September). This observation is explained to be a result of the additional diffuser that became operational in September 2009. The 2009 AEMP sampling program was largely complete prior to the installation of second diffuser (sampling ended September 20 and the diffuser became operational on September 17); therefore, there is little or no data in the 2009 report to assess potential effects of this additional diffuser. It is recommended that monitoring results be reviewed regularly to ensure that any emerging issues are identified as soon as possible. It is also recommended that the increase in loading observed for a number of parameters in September and October 2009 be considered when describing potential increasing trends. • In general, discussion linking temporal trends in effluent loading and quality are not closely linked to the lake water quality monitoring data. This discussion would be helpful for the reviewer to get a clear sense of the effects of the Mine effluent. • The report indicates that for the 2009 effluent reporting period, the total load of phosphorus discharged to Lac de Gras was the highest since 2002; the load was approximately double the 2008 load. The authors note that the increased loading in September and October 2009 reflects the additional loading from the second diffuser. However, high loading was also observed prior to that period. Can the authors indicate why loading increased substantively in 2009 and what future loading rates are expected?

2009 AEMP Component	Detailed Technical Review and Recommendations	Evaluation Comments and Key Points for EMAB
Effluent and Water Chemistry (continued)	• It is indicated that there were QA/QC issues respecting ammonia data collected in reference areas, but that this does not affect the interpretation of spatial trends (p. 54). It would be useful to clarify why there is no issue here. • Some discussion regarding seasonal differences in lake water quality compared to seasonal effluent quality and loading would be beneficial. Due to the volume of information discussed in Appendix II linkages between effluent and lake data are not clearly made. • Can the authors speculate on why manganese concentrations were lowest during the ice-cover season in the lake (Figure 3-39), but monthly loading was relatively high at this time (and higher than the open-water season)? • There appears to be a discrepancy between the calculated monthly loads of molybdenum discharged from the NIWTP (Figure 3-15) and the AEMP water quality monitoring data (Figure 3-40). The load of molybdenum increased over the open-water period and by October was more than four times the loading in winter, yet the lake monitoring data indicate effects were generally greatest in winter or at a minimum were not higher in fall. Can the authors speculate regarding this apparent discrepancy? • The lack of discussion or presentation of data for water quality variables other than phosphorus for the Surveillance Network Program (SNP) discussion (Section 3.4) and the lack of presentation of effluent quality data (i.e., concentrations over time) prevent a reviewer from gaining a clear understanding of how effluent quality varies over time and ultimately, how the effluent data link to lake water quality results. This is particularly critical given that Section 3.3.1 indicates that the effluent loads for a number of parameters increased in fall 2009 (coinciding with installation of the second diffuser), but the reviewer has no ability to determine how this additional loading affected water quality in the mixing zone. It would be very useful to integrate this information. • The discussion (Section 4) is very useful. Although there is a clear indication that loading of TP and metals and metalloids “tended to be highest in September and October 2009…likely the result of the second water treatment plant stream and associated diffuser increasing the volume of effluent discharged during these months”, there is no discussion of what these increases did to ambient water quality in Lac de Gras. It appears as though the majority of the AEMP sampling was completed prior to operation of the second diffuser, however, are there SNP data that could be discussed here for these two months? In general, discussion of temporal trends in effluent loading and quality are not closely linked to the lake water quality monitoring data. This discussion would be helpful for a reviewer to get a clear sense of the impacts of the additional effluent (recognizing this began near the end of the reporting period). • The report indicates that for the 2009 effluent reporting period, the total load of phosphorus discharged to Lac de Gras was the highest since 2002; the load was approximately double the 2008 load. The authors note that the increased loading in September and October 2009 reflects the additional loading from the second diffuser. However, high loading was also observed prior to that period. Can the authors indicate why loading increased substantively in 2009 and what future loading rates are expected? • While it is agreed that there is a lack of aquatic toxicological information for calcium, potassium, magnesium, and strontium, which renders assessing the ecological effects of increases in these parameters extremely difficult, there is no rationale provided to substantiate/explain the conclusion that: “no significant ecological degradation can be attributed to the increased levels of calcium, magnesium, potassium, or strontium in Lac de Gras waters near the mine discharge” (p. 71.). Could an explanation of how this conclusion was reached be provided? For instance, are concentrations well within ranges observed in other comparable freshwater ecosystems? Does the ecological monitoring information indicate there has not been ecological degradation due to any Project-related changes? • There is no discussion provided regarding dissolved oxygen (DO) monitoring results other than a reference to the FF2 area in winter (see Section 3.5.3). Were CCME DO guidelines met at all sites? Was there any indication that the Project is affecting DO? Were there spatial differences in DO conditions? Similar comment would apply to pH and conductivity. Suggest including this discussion in Section 3.5.3 and summarizing in Section 4.	

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Effluent and Water Chemistry (continued)	• Suggest carrying the fourth conclusion bullet (Appendix II, Section 5, p. 77) forward into the main report (i.e., p. 30, Section 3.4) and to the Appendix II executive summary. The observation that a number of parameters are, based on visual comparisons, increasing over time is very important and should be identified in the main report. We would further suggest that a statement be added indicating that the loading of numerous water quality variables increased notably in fall of 2009 and further increases in nutrient and metal concentrations in the lake since that time might be expected. That is, there is no explicit discussion stating that this additional loading would be expected to increase the magnitude of the effects to water quality. The sentence that reads: “The concentrations of iron and TP at the NF area were lower in 2009 than observed in previous years” (Appendix II, p. 77) is misleading. While the accuracy of the statement is not disputed, the critical point is that the NF area was sampled prior to commissioning of the second effluent stream – i.e., prior to when loading of TP increased dramatically. Therefore TP concentrations would mathematically, have to have increased in the NF area in late 2009. • Strongly agree with the recommendation to review water quality results in a timely fashion (i.e., as results are received, p. 77). This is standard QA/QC practice and will improve the strength of the program. It is further recommended that the data be regularly reviewed to enable identification of any issues as early as possible. This could be done through regular generation of scatter plots, for example. • Also agree with the second recommendation to revisit the moderate effect level criteria given the MF site distribution (p. 77). • It would be useful to discuss the results of the field blanks and the trip blanks together; if contamination is observed in both samples, you can exclude field sampling as the source of contamination. It would also be useful to identify the sites where field blanks and equipment blanks were prepared; is there any indication of issues for samples prepared in certain areas? • The 2009 QA/QC results appear to indicate an issue with ammonia, and possibly aluminum and lead, contamination associated with equipment and/or site exposure and/or sample handling. What steps are being taken to try to identify the source of the contamination and/or to address the issue? • A few editorial comments to consider as follows: o It would be useful to specify an actual percentage of data points below detection as a threshold for Step 3a of the Substance of Interest (SOI) identification process (p. 7); o The use of “mixing zone boundary” is somewhat confusing. It would be useful to state what sites (i.e., NF or SNP) are being discussed throughout the various sections of the document. Although a minor point, is it appropriate to refer to the SNP monitoring sites as at the mixing zone boundary when data collected from these sites and NF sites indicate that the effluent is not mixed across depth? o Table 3-1 indicates that the AEMP aquatic life benchmarks for mercury are 0.026 and 0.004 mg/L. Should this read “µg/L”?; o The discussion of nitrite on p. 30 appears to be in error. It is indicated that loads of nitrite increased in the open-water period, but that this was likely due to increased nitrification, resulting in conversion of nitrite to nitrate. Wouldn’t this result in a reduction in loads of nitrite? o P. 66 indicates that there was “no clear seasonal pattern” respecting concentrations of SOIs without benchmarks at MF sites. Table 3-8 however indicates that potassium is higher in the ice-cover season.	

2009 AEMP Component	Detailed Technical Review and Recommendations	Evaluation Comments and Key Points for EMAB
Sediment Chemistry	• A lower fraction of duplicate sediment samples (5%) than planned (10%) was collected in 2009 for nutrients and particle size analysis (p. 4). This should be corrected in future sampling programs. • It is unclear whether duplicate samples comprised 10% or 5% of the total number of sediment sampling sites sampled using a corer (p. 5). This should be clarified. • It would be beneficial to include a homogenate duplicate (i.e., composite sample of multiple grabs or cores, split into two samples following homogenization) to examine the efficacy of the homogenization procedure. • Since comparison was made to the Ontario sediment quality guidelines (which is excellent), consider also comparing selenium to the British Columbia Ministry of Environment (2006) sediment quality guideline (2.0 µg/g d.w.). • It is indicated that temporal and spatial analysis of sediment quality results will be limited to exposure versus reference area comparisons until additional years of data are collected. It is indicated that the change in methodology to collection of the upper 1 cm of sediment for metals analysis limits the amount of data available for comparison. However, there are data for nutrients from previous years of monitoring that could be examined for temporal and spatial changes and it is recommended that this be considered in the report. As noted above, the observation of moderate and high level eutrophication effects through analysis of plankton and nutrients in water further supports a more in-depth analysis of the sediment nutrient data.	• It is indicated that temporal and spatial analysis of sediment quality results will be limited to exposure versus reference area comparisons until additional years of data are collected. It is indicated that the change in methodology to collection of the upper 1 cm of sediment for metals analysis limits the amount of data available for comparison. However, there are data for nutrients from previous years of monitoring that could be examined for temporal and spatial changes and it is recommended that this be considered for the next AEMP and the Three-Year Summary. The observation of moderate and high level eutrophication effects through analysis of plankton and nutrients in water further supports a more in-depth analysis of the sediment nutrient data.

2009 AEMP Component	Detailed Technical Review and Recommendations	Evaluation Comments and Key Points for EMAB
Benthic Invertebrates	• Results of the 2009 AEMP indicate a range of effect magnitudes on the benthic invertebrate community depending on the variable (i.e., community descriptor or metric) analyzed; the type of effect detected was most consistent with nutrient enrichment. • It is recommended that all scientific names used be checked for current validity using the Integrated Taxonomic Information System (ITIS 2010), or some other regularly updated source of current taxonomic information. • Additional explanation concerning the method used for outlier identification/removal during regression analysis would be helpful (Appendix IV, p. 33). • The discussion of the potential toxicological effects on benthic invertebrates is somewhat limited (Appendix IV, p. 53) and will require additional discussion as part of the Three-Year AEMP Summary (also see comment in Section 2.2.8). As the potential toxicological effects are not conclusively related to the Mine discharge (i.e., sediment chemistry SOIs identified in Appendix III [those related to Mine discharge only] have not reached AEMP benchmarks or known toxicity thresholds), it may be helpful to ask what else could reasonably be influencing the benthic community to aid in the understanding of these effects. For example, one could look at the naturally elevated metals in the sediments in terms of their toxicity to the benthic invertebrates found in Lac de Gras. • The comparison of reference areas in 2009 to investigate natural variation in benthic invertebrate community variables is a welcome and helpful addition to AEMP reporting. It would be helpful to have a description of the physical and chemical attributes (e.g., substrate composition/compaction, water depth, sediment chemistry, etc.) of each reference area readily accessible (e.g., similar to Appendix IV, Table 3-1, but with important sediment chemistry parameters included) to aid in the interpretation/understanding of any of the differences observed among reference areas (for e.g., Appendix IV, Table 2-2, p. 9). • The physical habitat parameters measured (e.g., size of sediment particles) only weakly explained the benthic invertebrate community observed; these weak relationships likely indicate that something we are not measuring or have not considered is influencing the numbers and/or types of benthic invertebrates seen in Lac de Gras. This analysis would likely benefit from a more thorough integration of the sediment chemistry results – further discussion/inclusion as part of the Three-Year AEMP Summary would be beneficial. • The recommendations discussed by Golder in Appendix IV are sound. They should be revisited during either the Three-Year AEMP Summary or the Three-Year AEMP Design Review (whichever is appropriate), in addition to those items already identified for inclusion (WLWB 2009), where they may benefit from additional discussion by interested parties.	• The comparison of reference areas in 2009 to investigate natural variation in benthic invertebrate community variables is a helpful addition to AEMP reporting. • The discussion of the potential toxicological effects on benthic invertebrates is somewhat limited and will require additional discussion as part of the Three-Year AEMP Summary. As the potential toxicological effects do not appear to be related to the Mine discharge, it may be helpful to ask what else could reasonably be influencing the benthic community to aid in the understanding of these effects. • The physical habitat parameters measured (e.g., size of sediment particles) only weakly explained the benthic invertebrate community observed; these weak relationships usually mean that something we are not measuring or have not considered is influencing the numbers and/or types of benthic invertebrates seen in Lac de Gras. This analysis would likely benefit from a more thorough integration of the sediment chemistry results.

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Fish	• The palatability studies were conducted on only four fish, each prepared in a different manner. It is difficult to interpret the results from such a small survey since it is likely that fish quality is highly variable within any population, regardless of location or lake condition. Many factors can influence the eating quality of a fish: fish size; diet; time of year; water temperature; condition/maturity (e.g., pre-spawner, spawner, non-spawner); sex (note that all the tested fish were males); etc. Furthermore, an individual fish may rate higher or lower when prepared by one method versus another (e.g., a fatty fish might taste better if cooked by one method, while a less fatty fish may taste better if cooked by a different method). The results would be easier to interpret if they were based on a larger sample size, although we recognize the desire to limit the number of lake trout that are captured and killed for study purposes. That said, there were an additional 15 lake trout captured that could have been used in the palatability tests, even with some tissue removed for chemical analyses.
	    o Recommendation: Future palatability surveys should maximize use of available fish. A similar recommendation was made by the DFO (WLWB 2009), and it is understood that this point will be discussed between the WLWB, DFO and DDMI prior to future palatability surveys.
	• The report states that 19 lake trout were captured, but that only 10 were selected for assessment. Tissue samples were collected from the 10 fish for mercury and other chemical analysis, including the four fish that were used for taste sampling. The report does not provide a rational for sub-sampling what was already a fairly small sample size (i.e., 19 fish). Furthermore, it does not describe the selection process. Were the 10 sampled fish selected randomly, based on size or appearance, or based on some other criteria? No biological data are provided for the fish that were rejected. Fish palatability may be affected by size and mercury content has been shown to be related to size as well (i.e., larger fish tend to have higher mercury concentrations).
	    o Recommendation: The report should include a rationale and process for sample selection, and biological data for rejected fish should be provided.
	• We agree with community members that the consumption quality assessment forms are a little confusing and should be reviewed. The rating categories all refer to the appearance or 'look' of the fish being sampled. Taste and texture should be provided as assessment options, at least for the 'Eating' portion of the survey. As a general comment, palatability assessments are typically based on 'blind' tests (i.e., the tasters do not know which fish the taste sample comes from). The intent is to avoid introducing inadvertent bias to the palatability assessment that could result from awareness of a fish's origin, external and internal appearance, parasite burden or conditions of preparation. In this case, however, the monitoring program is community-based and we assume that the survey design was based on community preference (e.g., assessment of the fish eating experience as a continuum, from capture to consumption).
	    o Recommendation: We agree that the palatability rating system should be reviewed.
	• The title of Section 7.1.4 refers to 'Fish Tissue Chemistry Surveys' and the report indicates that samples for testing for mercury and other metals were collected from the 10 assessed fish. The laboratory results for these tests are provided in Appendix X (sub-appendix B). However, the report provides only a brief discussion of the mercury analysis and no discussion of the other metals analysis results. If a more detailed analysis of these data is to be conducted or presented at a later date, this should have been indicated in the report.
	    o Recommendation: DDMI should provide an explanation of what analyses are planned for the fish tissues metals data, and when these analyses will occur.
		• Future palatability surveys should maximize use of available fish. A similar recommendation was made by the DFO (WLWB 2009), and it is understood that this point will be discussed between the WLWB, DFO and DDMI prior to future palatability surveys.
		• The report should include a rationale and process for sample selection, and biological data for rejected fish should be provided.
		• The palatability rating system should be reviewed.
		• DDMI should provide an explanation of what analyses are planned for the fish tissues metals data, and when these analyses will occur.

2009 AEMP Component	Detailed Technical Review and Recommendations	Evaluation Comments and Key Points for EMAB
Plankton SES	2008 Phytoplankton (represents the first year of results for the three year SES using accepted SOPs): • Inclement weather combined with the large distance to some of the stations resulted in some samples not being collected during Open 2 and Open 3 periods. This was minimal and did not impair the study. • A comparison of taxa present was made between areas and no Mine-related effect on taxonomic richness was surmised. • Relative abundance and biomass of each major taxonomic group were qualitatively compared between areas for the three sampling periods with basic inferences on the data provided. • The 2008 phytoplankton data were qualitatively compared to the historical data (the historical data was summarized in the 2008 AEMP report [DDMI 2009]) = 2008 dominant phytoplankton groups were similar to previous years. • A qualitative comparison of the 2008 phytoplankton total biomass relative to mean water column barium concentrations was completed for each sampling area as another assessment of Mine-related effects = weak positive relationships indicating a Mine-related response. This will be assessed in subsequent monitoring years when additional data are available. • Comparative statistics were provided for the 2009 phytoplankton data (e.g. mean, median, min/max, standard deviation, standard errors), but no qualitative observations were made. • A cursory look at the summary statistics indicates an increase in abundance of Chrysophyceae (yellow-green or yellow-brown algae), Cryptophyceae (cryptomonads), and Dinophyceae (dinoflagellates) in the NF and MF1; and an increase in NF diatoms compared to other sampling locations during the Open 2 persiod. Biomass of Chlorophyceae (green algae) and Chrysophyceae were notably higher in the NF and MF1 in comparison to other areas during the Open 2 season. Although a thorough review of the data will occur after three years of data collection, such cursory comparisons would help with WOE observations and substantiate the phytoplankton relationship to barium concentrations. Detailed analysis is planned in 2011. • QA/QC = 10% of submitted samples were re-counted to verify counting efficiency. DDMI does not set a threshold value to assess the re-counts based on the inherent variability associated with the plankton samples (DDMI could expand on this explanation; coldwater/ultra-oligotrophic lakes such as Lac de Gras typically have low abundances of individual phytoplankton species, with many species considered rare, that can skew differences in re-counts when the counts are zero/one individuals [i.e., when one individual counted in a subsample equates to many individuals/litre of sample]). The reviewer is fine with this since DDMI did evaluate anomalies in re-counts. The proportion of each taxon was calculated and the occurrence of dominant species was assessed for consistency between each QCed sample pair. The QA/QC procedures are not explicit and would benefit from a table of calculations added as an appendix to Appendix I. DDMI assessed differences in relative abundance biomass between 10 duplicate phytoplankton samples – two of the ten had large differences, which was explained as isolated and unexplainable and the 2008 data were determined to be valid. 2009 Zooplankton (represents the second year of results for the three year SES using accepted SOPs): • All stations were successfully sampled in each sampling period. • A comparison of taxa present was made between areas and no Mine-related effect on taxonomic richness was indicated. • Relative abundance and biomass of each major taxonomic group were qualitatively compared between areas for the three sampling periods and to 2007 and 2008 results. It was noted that there were indications of a potential shift in community composition at the level of major group along the Mine effluent concentration gradient and that 2008 and 2009 results suggest there may be a slight eutrophication effect within the NF and MF areas. Detailed analysis is planned in 2011. • A qualitative comparison of the 2009 zooplankton total biomass relative to mean water column barium concentrations was completed for each sampling area as another assessment of mine-related effects = no relationship was clear. • Comparative statistics were provided for the 2009 zooplankton data (e.g. mean, median, min/max, standard deviation, standard errors), but no qualitative observations were made. No differences between sampling areas were obvious with a cursory look at this data. Detailed analysis is planned in 2011. • QA/QC = same methodology as for phytoplankton. 10% of submitted samples were re-counted to verify counting efficiency. Again, the QA/QC procedures are not explicit and would benefit from a table of calculations added as an appendix for transparency. Generally, there was good agreement between the original and re-counts, but a threshold value could likely be assigned to zooplankton as this community is generally not as patchy in its distribution as phytoplankton. Findlay and Kling (1998) suggest replicate counts should be within ± 20% of the first count for phytoplankton and this could be even lower for zooplankton. Investigating the differences observed between original and re-counts for FFA-2 and NF-3 zooplankton samples is suggested as each had over 20% difference in abundance between counts.	• DDMI concluded there were weak positive relationships between mean water column barium concentration (an indicator of exposure to Mine effluent) and total phytoplankton biomass in each open-water period. • A qualitative comparison of phytoplankton summary statistics was neither attempted in the Annual Report nor Appendix XI. A cursory review of these data indicate an increase in abundance of Chrysophyceae (yellow-green or yellow-brown algae), Cryptophyceae (cryptomonads), and Dinophyceae (dinoflagellates) in the NF and MF1; and an increase in NF diatoms compared to other sampling locations during the Open 2 period. Biomass of Chlorophyceae (green algae) and Chrysophyceae were notably higher in the NF and MF1 in comparison to other areas during the Open 2 season. Although a thorough review of the data will occur after three years of data collection, such cursory comparisons would help with WOE observations and perhaps substantiate the phytoplankton relationship to barium concentrations. • It was noted that there were indications of a potential shift in zooplankton community composition at the level of major group along the Mine effluent concentration gradient and that 2008 and 2009 results suggest there may be a slight eutrophication effect within the NF and MF areas. • The plankton QA/QC procedures are not explicit and would benefit from a table of calculations added as an appendix to Appendix XI. • Investigating the differences observed between original and re-counts for FFA-2 and NF-3 zooplankton samples is suggested as each had over 20% difference in abundance.

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Eutrophication Indicators	• The criteria used to classify an outlier are not provided (Appendix XIII, Section 2.2.1). • The affected area of the lake based on chlorophyll *a* represents 28% of the lake surface area. The area of the lake showing effects on TP throughout the water column is approximately 11% of the total lake area (a reduction in comparison to 2008). Golder notes that the smaller affected area in 2009 reflects the smaller TP concentrations observed in 2009 in comparison to 2008; however, this smaller TP extent is potentially related to the increased chlorophyll *a* extent. The most commonly reported effect of nutrient enrichment on aquatic ecosystems is an increase in algal biomass, which is often expressed as chlorophyll *a* concentration. Typically, there is a positive correlation between total phosphorus (and often nitrogen) and phytoplankton biomass or chlorophyll *a* in lakes and reservoirs, although the precise relationship may vary between lakes. Consideration of eutrophication response variables (e.g., chlorophyll *a*) is critical, as not all lakes and reservoirs exhibit the same relationship between nutrients and phytoplankton. The simplest "model" relating nutrients (i.e., phosphorus) to phytoplankton abundance is a linear regression between total phosphorus (TP) and chlorophyll *a*. Since the precise relationship between these parameters is site-specific, it would be beneficial to conduct a regression analysis between TP and chlorophyll *a* for Lac de Gras using available information. Predicted future effects of the effluent discharges on phosphorus concentrations in the lake could then be used to estimate effects on phytoplankton using this linear regression relationship. • The mine is having a moderate-level effect on chlorophyll *a* and TP, and a high-level effect on zooplankton (Appendix XIII, pg. 29); however Table 5-1 (Appendix XIII) indicates an early warning/low level effect for zooplankton. Additionally, Section 7.4.4 and Table 7.4 of the non-technical summary also assigns an early warning/low level effect to zooplankton. Please clarify the level of effect observed for zooplankton in 2009. • See comments regarding the extended duration of the Open 2 period presented under Section 2.2.2 Effluent and Water Chemistry (i.e., how does this affect the analysis and interpretation of the results)? Also see the final recommendation provided in Section 5.2; the reviewer agrees that field sampling should be conducted to minimize lag time between the first and last areas sampled during any given sampling period. • Why was a different approach for the treatment of data reported below the analytical detection limit (Appendix XIII, p. 8) adopted relative to the water and effluent quality data analysis (Appendix II, p. 9)? It is acknowledged that both approaches are valid and common practice, but it is unclear why the deviation in approach occurred. • It would be useful to provide a discussion of the loads and concentration of nutrients in effluents and how they related to observed nutrient concentrations in the lake, particularly seasonally, in Section 3.1. Although it is indicated that effluent and lake water quality varied seasonally, there is no explicit discussion linking the two. Conceptually, higher concentrations of dissolved nutrients observed in winter may reflect either or both higher effluent loading or relatively low productivity and subsequently lower uptake of dissolved nutrients in winter. In this instance it would appear the latter may be true, but there is insufficient data presented here to adequately examine this question. Figure 3-2 in Appendix II indicates that TP loading was highest in the open-water season and Figure 3-23 (Appendix II) indicates that concentrations of TP were highest in effluent in fall. However on p. 13 (Appendix XIII) it is indicated that the seasonal variations in effluent concentrations are reflected as higher concentrations of nutrients in the NF area in winter. This appears to be a discrepancy. • In general, it would be useful to have an integrated discussion linking nutrients in effluent and nutrients in the lake. This would assist with a thorough assessment of the linkage between the Project effluent and nutrients in Lac de Gras. • Were sites thermally stratified in winter? It is indicated (p. 19) that DO was low at depth at site FF2 and that this may reflect a combination of the input at the surface as water freezes and the uptake of oxygen at the bottom as organic matter decomposes. Winter DO depth profiles such as this generally reflect the lack of reaeration of the water column due to the presence of ice in combination with sediment oxygen demand. This also often occurs where thermal stratification is established. • It is indicated on p. 21 that "algal growth occurred very quickly following ice-out in the exposure areas...". However, as chlorophyll *a* was not measured prior to ice-out, this statement can not be substantiated. • It would be useful to provide a figure illustrating the TP concentrations at NF, FF, FF2 and reference areas for the open-water period in addition to the figure for the ice-cover period (i.e., Figure 4-3). • For eutrophication indicators (phosphorus, chlorophyll *a* and zooplankton biomass), data from 2009 was to be compared to 2007 and 2008, and any apparent trends over that time period were to be discussed; this discussion appears in the non-technical summary (Section 7.4) only (i.e., this recommendation for the 2009 AEMP is not addressed in Appendix XIII).	• In comparison to 2008, a smaller area was affected by increased TP concentrations; however the area with increased phytoplankton biomass (as measured by chlorophyll *a*) was larger. The most commonly reported effect of nutrient enrichment on aquatic ecosystems is an increase in algal biomass. Typically, there is a positive correlation between total phosphorus and phytoplankton biomass in lakes and reservoirs, although the precise relationship may vary between lakes. Consideration of eutrophication response variables (e.g., chlorophyll *a*) is important, as not all lakes and reservoirs exhibit the same relationship between nutrients and phytoplankton. The simplest "model" relating nutrients (i.e., phosphorus) to phytoplankton abundance is a linear regression between total phosphorus (TP) and chlorophyll *a*. Since the precise relationship between these parameters is site-specific, it would be beneficial to conduct a regression analysis between TP and chlorophyll *a* for Lac de Gras using available information.

2009 AEMP Component	Detailed Technical Review and Recommendations	Evaluation Comments and Key Points for EMAB
Eutrophication Indicators (continued)	• An update on any information DDMI has on ways to optimize the NIWTP in enhancing phosphorus removal was to be provided; this discussion appears in the non-technical summary (Section 7.4) only (i.e., this recommendation for the 2009 AEMP is not addressed in Appendix XIII). • The recommendations discussed by Golder in Appendix XIII are sound. They should be revisited during either the Three-Year AEMP Summary or the Three-Year AEMP Design Review (whichever is appropriate), in addition to those items already identified for inclusion (WLWB 2009), where they may benefit from additional discussion by interested parties.	

2009 AEMP Component	Detailed Technical Review and Recommendations	Evaluation Comments and Key Points for EMAB
Weight of Evidence	• Consider adding the results of assessment of TP results in water to the executive summary. It is acknowledged that larger and more consistent effects were observed for chlorophyll *a* and total nitrogen (TN). However, given the significance of TP in eutrophication it would be useful in the interest of thoroughness to include this information here. • Given that the overall severity of nutrient enrichment is considered “mild” by the WOE analysis, Appendix XV recommends that scientific investigative follow-up beyond the existing AEMP studies is not considered necessary at this time, although Golder considers eutrophication to have a high degree of permanence (Table 3-7, Appendix XV), which seems somewhat inconsistent with the recommendation of no follow-up at this time. The reviewers continue to note that this recommendation may be somewhat dismissive of the current degree of nutrient enrichment in Lac de Gras and the potential influence of this enrichment on mercury methylation processes (as commented on in the review of the 2008 AEMP Annual Report and to be investigated in the SES on Possible Effects of Enrichment on Mercury Uptake), in addition to our somewhat poor understanding of the long-term consequences of eutrophication on nutrient-poor Arctic ecosystems. These concerns are reflected in the 26 April 2010 memorandum provided by Hutchinson Environmental Sciences Ltd. (HESL) regarding phosphorus EA predictions vs. measured effects at the mine (WLWB investigation of nutrient enrichment, WLWB 2010). HESL recommendations included: o DDMI forecast the nutrient loads over the remaining life of the mine; and o DDMI develop a predictive model of spatial distribution of P in Lac de Gras that is calibrated to loads and measured concentration over the past 5 years and which is then related to loadings predicted for future years. The following was brought up during DDMI’s 2009 AEMP presentation to EMAB (May 19, 2010): the capacity of the treatment plant has doubled; due to the shift to underground mining, ground water processing will increase (which is the main source of phosphorus); and there will be a 20% increase in effluent compared to 2009 loadings for the remaining life of the mine. Based on this, plus the large increase in 2009 TP loading observed when the new diffuser came on line, the reviewers agree with both of the HESL recommendations. • An additional follow-up item to the above point is for clarification concerning how the term “mild” nutrient enrichment was defined. While the reviewers would agree that the data do not indicate substantive nutrient enrichment, the use of a subjective term without a clear definition of how Golder determined a magnitude of “mild” is somewhat questionable. A shift in trophic categories and a relatively large increase in nutrients and chlorophyll *a* relative to reference areas two years in a row (2008 and 2009 AEMPs) might be argued to support more than a “mild” designation. • In the 2009 AEMP, the possibility that nutrient enrichment effects are masking toxicological effects was to be considered and/or discussed (note this has also been recommended in Section2.2.4 above). Golder acknowledges this potential relationship in Section 5.3, but provides little discussion. While it is understood why the WOE examined the two hypotheses (Toxicological Impairment and Nutrient Enrichment) distinctly, effects of these two pathways may interact. Simply put, nutrient enrichment typically causes increases in productivity, while toxicological effects might reduce productivity. The possibility that nutrient enrichment effects are masking toxicological effects could be further addressed by integrating the plankton special effects study (investigating community composition changes in plankton) as a tool to define effects, which was also recommended by HESL.	• Given that the overall severity of nutrient enrichment is considered mild by the WOE analysis, Appendix XV recommends that follow-up beyond the existing AEMP is not considered necessary at this time. However, the WOE considers nutrient enrichment to have a high degree of permanence (Appendix XV, Table 3-7), which seems somewhat inconsistent with the recommendation of no follow-up at this time. The reviewers agree with Hutchinson Environmental Sciences Ltd. (HESL) recommendations that DDMI forecast the nutrient loads over the remaining life of the mine; and DDMI develop a predictive model of spatial distribution of P in Lac de Gras that is calibrated to loads and measured concentration over the past 5 years and which is then related to loadings predicted for future years. • In the 2009 AEMP, the possibility that nutrient enrichment effects are masking toxicological effects was to be considered and/or discussed (note this has also been recommended in Section2.2.4 above). Golder acknowledges this potential relationship in Section 5.3, but provides little discussion. While it is understood why the WOE examined the two hypotheses (Toxicological Impairment and Nutrient Enrichment) distinctly, effects of these two pathways may interact. Simply put, nutrient enrichment typically causes increases in productivity, while toxicological effects might reduce productivity. The possibility that nutrient enrichment effects are masking toxicological effects needs to be further addressed and DDMI should consider integrating the plankton special effects study (investigating community composition changes in plankton) as a tool to define effects.

3.0 REFERENCES

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