North/South Consultants Inc.

440, 1121 Centre St. NW
Calgary, Alberta T2E 7K6
Tel: (403) 410-4068
Fax: (403) 410-5633
Email: kkroeker@nscons.ca
Web: www.nscons.ca

REVIEW OF THE 2006 DIAVIK DIAMOND MINE AQUATIC EFFECTS MONITORING PROGRAM (AEMP)

Report # 317-01

Prepared for:

Environmental Monitoring Advisory Board (EMAB)
P.0. Box 2577,
Yellowknife,
NT X1A 2P9

Prepared by:

North/South Consultants Inc.

In association with:

Clearwater Environmental Consultants

August 2006

EXECUTIVE SUMMARY

From 2001 to 2005 Diavik Diamond Mines Inc. (DDMI) has been conducting an Aquatic Effects Monitoring Program (AEMP) under the terms and conditions of Part K of their Type A Territorial Water Licence N7L2-1645 (Water Licence). The AEMP is part of a long-term, iterative monitoring strategy adopted by DDMI that continues to evolve over time to ensure the integrity of the Lac de Gras aquatic ecosystem. The main goal of the AEMP is to ensure that the Diavik Diamond Mine Project (the Project) does not result in adverse environmental effects on the Lac de Gras aquatic ecosystem. Where impacts on Lac de Gras have been predicted or detected, mitigation measures have been put in place to prevent significant adverse effects.

In August 2005, DDMI submitted for renewal of their Water Licence, which expires in August 2007. The Water License renewal application is now under the authority of the new Wek'èezhii Land and Water Board (WLWB), which met in March 2006 to review issues relating to DDMI's existing AEMP. As a result, a re-evaluation of the existing AEMP was deemed necessary to address concerns expressed by reviewers (DDMI 2006). In April, 2006, DDMI submitted a revised AEMP developed in consideration of issues raised through the Diavik Technical Committee (DTC). The DTC is comprised of representatives from federal and territorial regulatory agencies, First Nation communities and other stakeholders. It is DDMI's intent to implement the revised AEMP in summer 2006, following WLWB approval (DDMI 2006).

The Environmental Monitoring Advisory Board (EMAB), formed to provide an integrated and co-operative approach to the environmental management of the Diavik Diamond Mine Project, contracted North/South Consultants Inc. (North/South) to provide this technical review of DDMI's proposed 2006 AEMP.

The previous DDMI AEMP (2001-2005) determined potential effects of the Project by comparing the monitoring results of current years to baseline data and thresholds established during the environmental assessment process. The 2006 AEMP takes a different approach by adopting the environmental effects monitoring (EEM) guidelines as applied to the metals mining industry (MMEEM; EC 2002). In the MMEEM approach, project related effects are determined by comparing values of assessment endpoints in the areas exposed to effluent to values in a reference area unaffected by effluent.

The following is a summary of the main concerns and recommendation in regards to the 2006 DDMI AEMP:

- A reference lake would be a helpful addition in identifying aquatic changes resulting from the mine. A reference area for comparison to the exposed area is an integral part of the MMEEM program.

- The plume delineation was not conducted under a variety of wind conditions and current regimes as required by the MMEEM to identify the maximum extent of the plume
- As the plume delineation did not identify the maximum extent of the plume, Reference area A may be affected by effluent from Diavik and therefore unsuitable as a reference area. The other reference areas may be affected by Ekati.
- Sample sizes, and supporting power analyses should be re-examined. The sample sizes are based on effect sizes and/or thresholds that may be too large to provide early warning of change in Lac de Gras.
- Sample frequency is inadequate for the initial years of the program. Benthic invertebrates, sediment and fish should be sampled and statistically analyzed on an annual basis for the first three years.
- The water samples collected annually at four seasons should be analyzed statistically to detect changes in water quality rather than relying solely on the triennial samples taken in conjunction with the benthic and fish programs.
- More sites from the 2001 AEMP should be retained for continuity and trend analysis
- Community input should be sought for appropriate species for fish usability studies

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF APPENDICES

Page

1.0 INTRODUCTION

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

From 2001 to 2005, DDMI has been conducting an Aquatic Effects Monitoring Program (AEMP) under the terms and conditions of Part K of DDMI's Type A Territorial Water Licence N7L2-1645 (Water Licence). The AEMP is part of a long-term, iterative monitoring strategy adopted by DDMI that continues to evolve over time to ensure the integrity of the Lac de Gras aquatic ecosystem. The AEMP is comprised of a long-term annual monitoring program, and individual short-term specific effects studies initiated to address specific issues, provide quantitative answers to specific questions, or to address specific Water Licence requests (DDMI 2001).

The main goal of the AEMP is to ensure that the Diavik project does not result in adverse environmental effects on the Lac de Gras aquatic ecosystem. Where impacts on Lac de Gras have been predicted or detected, mitigation measures have been put in place to prevent significant adverse effects.

In August 2005, DDMI submitted an application to the Mackenzie Valley Land and Water Board (MVLWB) for renewal of Water Licence N7L2-1645 which expires in August 2007. It was requested that the renewal be issued for a further fifteen years to coincide with the expected duration of the project (DDMI 2005). The Water License renewal application is now under the authority of the new Wek'èezhii Land and Water Board (WLWB) created under the Tlicho land claim. The WLWB met in March 2006 to review issues relating to DDMI's existing AEMP. As a result, a re-evaluation of the existing AEMP was deemed necessary to address concerns expressed by reviewers (DDMI 2006). In April, 2006, DDMI submitted a revised AEMP developed in consideration of issues raised through the Diavik Technical Committee (DTC). The DTC is comprised of representatives from federal and territorial regulatory agencies, First Nation communities and other stakeholders. It is DDMI's intent to implement the revised AEMP in summer 2006, following WLWB approval (DDMI 2006).

North/South Consultants Inc. (North/South) was contracted by EMAB to provide a technical review of DDMI's 2006 AEMP.

2.0 EVALUATION OF THE 2006 AEMP

The 2006 AEMP presented by DDMI represents a departure from the AEMP approved in 2001 by the MVLWB. In brief, the 2006 AEMP has adopted the environmental effects monitoring (EEM) approach recommended by AQUAMIN, a multi-stakeholder group concerned with the Aquatic Effects of Mining in Canada (AQUAMIN 1996). The EEM approach, as applied to the metals mining industry, is presented in detail in the *Metal Mining Guidance document for Aquatic Effects Monitoring* (MMEEM; EC 2002). The principal difference between the approach used for the previous AEMPs and that used in the proposed 2006 AEMP is in how potential effects of the DDMI mine on water quality are assessed. In the previous AEMPs (2001-2005), potential effects of the Project were determined by comparing the monitoring results of current years to baseline data and thresholds established during the environmental assessment process. In the MMEEM approach, project related effects are determined by comparing values of assessment endpoints in the areas exposed to effluent to values in a reference area unaffected by effluent. The 2006 AEMP is divided into Part 1: Water Chemistry Monitoring, and Part II: Biological Monitoring.

2.1 OBJECTIVES

Objectives of the 2006 AEMP are stated several times in different fashions. The stated objective of the 2006 AEMP is to:

> *"…evaluate the effects of the Mine effluent on the primary valued ecosystem components (VECs) of Lac de Gras: fish, fish habitat, (including water quality, sediment quality and benthic invertebrate communities) and the use of fisheries resources"* (p. 3)

Objectives of the water quality monitoring portion are stated specifically on page 46:

> *"…to collect information about water quality and trophic status in Lac de Gras and provide supporting information for the assessment and interpretation of the results of biological monitoring"*

Specific objectives of the benthic and fish program follow implicitly from the initial stated objective of determining potential effects of mine effluent on fish, fish habitat and fisheries resources. It is noted that while determination of trophic status and changes in trophic status are indicated as a goal, this is to be accomplished only by measurements of total phosphorus and chlorophyll *a*.

2.2 BASELINE INFORMATION

Baseline water quality, sediment and fish health data were collected from 1994-2000. In previous AEMP studies (2001-2005), the data from water quality, sediment, benthic and fish sampling programs were compared to the baseline data in order to detect changes attributable to DDMI activities. This approach was criticized for a variety of reasons, including:

- the baseline water quality data were collected at varying times of the year and varying locations from 1994-2000;
- the baseline water quality data were pooled for all years and all seasons into a single statistic; this procedure may not be appropriate given the occurrence of seasonal variability for at least some water quality parameters and because sampling frequency was disproportionate over the years (Zajdlik & Associates 2005);
- sampling sites, sampling times, methods of data collection were inconsistent between years; and,
- detection limits were often lower in the older, baseline data.

In contrast to previous years, the 2006 AEMP focuses on comparisons between exposed and reference areas to detect environmental effects as outlined in the MMEEM program (EC 2002). Baseline data are to be used for temporal or spatial comparisons if a water quality issue is identified. While falling into the MMEEM framework, this change in approach has the unfortunate result that DDMI will abandon many of the stations that comprised the baseline and previous monitoring studies. This represents a loss in the continuity of the monitoring data and reduced ability to detect temporal changes. DDMI, in effect, is starting its monitoring from the beginning.

2.3 REFERENCE ZONES

In previous monitoring years, the AEMP did not include a separate reference or control lake because of difficulties in finding a suitable lake. Although DDMI was required by its water license from the MVLWB (N7L-2-1645) to monitor an appropriate control site in Lac de Gras or in a nearby lake, this item was excluded in their 2001 AEMP with the justification that it would use its baseline database as the basis from which to measure change, coupled with far-field monitoring (North/South 2005).

A reference or control lake is essential to evaluate any potential changes observed in Lac de Gras. Without an appropriate reference lake, it may not be possible to determine if changes observed in the study area are the result of project operations or the result of other unrelated factors (e.g., regional changes, climate effects). The inclusion of a reference lake would be in DDMI’s best interest as it could avoid reaching false conclusions that the project was responsible for observed effects when external factors are really the cause. The inclusion of a reference lake is standard practice for EEM programs. Where no suitable reference area on the same water body is available, then the reference area should be located in an adjacent water body with similar characteristics (EC 2002).

In the 2006 AEMP, while no separate reference lake is proposed, three reference sites were included:

- Reference A (northeast end of Lac de Gras at the inlet from Lac du Sauvage) for the annual routine water quality sampling program, triennial benthic study, triennial fish study and the sediment study in support of the latter two studies;
- Reference B (West side of Lac de Gras) for the triennial benthic, fish and sediment monitoring program; and,
- Reference C (Coppermine River) for the water sampling program in support of the benthos and fish studies.

It has not been established that Reference A is completely outside of the mine effluent plume while References B and C are potentially affected by DDMI and/or Ekati. As described below in the section on plume delineation (Section 2.6), effluent plumes in lakes are transient in nature and their shape and extent vary with wind strength and direction. Wind induced currents were not taken into account during effluent plume delineation and the maximum extent of the plume was not accurately determined. The statement in the 2006 AEMP justifying Reference A as a reference site, that *"…as the inflow is from Lac du Sauvage in the Northeast, the mine effluent is therefore unlikely to travel north to the narrows* (p. 49)*"* is unsubstantiated. From the information available, currents in Lac de Gras have not been well characterized. In DDMI's EIA, lake circulation and effluent dispersion were simulated with RMA 2 and RMA 11. From the information available, there were very few field measurements of currents to test or 'ground-truth' the modelling results.

2.4 GENERAL STUDY DESIGN

While earlier DDMI monitoring programs compared monitoring results to baseline values and/or threshold values established in the impact assessment to detect effects, the 2006 AEMP proposes adoption of the EEM approach currently applied nationally to the pulp and paper industry and metal mines, where effects are determined by comparing water chemistry, benthic population parameters and fish health parameters in exposed areas to those in a reference area. In doing so, DDMI will be abandoning a number of its long-term monitoring stations. While DDMI is commended for adapting the EEM approach it is recommended that DDMI retain some of its long-term stations in order to maintain continuity of its database.

Although the exposure/reference approach adopted in this AEMP is consistent with MMEEM guidance, it is arguably more appropriate for river than lake applications. Given the large size of Lac de Gras and the probable dynamic nature of currents within it, the extent of the effluent zone of influence may be more appropriately assessed using a gradient approach. Specifically, DDMI should consider using a radial sampling design, with integration of key monitoring components such as water quality, sediment quality and benthic invertebrates.

2.5 EFFLUENT CHARACTERIZATION

Part of the EEM process involves a detailed characterization of the mine effluent discharge to Lac de Gras. In previous AEMPs, DDMI reported the results of the effluent chemistry monitoring under its Surveillance Network Program (SNP) as set forth by its Water License. As effluent characterization is integral to the EEM program (EC 2002), effluent characterization was added to the 2006 AEMP. While DDMI is commended for presenting a characterization of its effluent, the list of parameters did not include the results of effluent toxicity (at least it was not reported), nor did it calculate mass loadings to the lake. The EEM guidance document recommends that mines calculate monthly mass loadings of monitored parameters in order to determine mass effects on lake chemistry.

2.6 PLUME DELINEATION

Effluent plume delineation is a requirement of the MMEEM program (EC 2002). Although promised as early as 2001 (DDMI 2001), the plume delineation was only reported in 2005 (DDMI 2005) using conductivity and barium as the key tracers (DDMI 2005). The results of the 2005 study are reported in the 2006 AEMP but with few details.

A few criticisms can be levelled at the plume delineation study. First, as the conductivity of the effluent is about 500 µS/cm during the open water period (700 µS/cm during the ice-cover period), and background levels are about 10-30 µS/cm, conductivity can, in theory, be used to delineate the effluent plume. However, the 1% effluent level, defined in the MMEEM program as the outer boundary of the plume, would be only about 5 µS/cm, a value that is not greatly above background levels, and sometimes difficult to distinguish from the background with a field instrument. Use of Rhodamine WT as a tracer, although more costly, would have been far more accurate. There is essentially no background level of the dye to correct for. At a typical injection concentration of about 100 µg/L and a detection limit of about 0.005 µg/L, the 1 % effluent level would have been easily detected with far greater precision.

Second, there was no attempt to examine the effects of wind-induced currents on the extent and shape of the plume. The plume delineation should have been done under a variety of wind conditions in order to determine the maximum extent of the plume. As indicated above, effluent plumes in lakes are transient in nature and their shape and extent vary with wind strength and direction. As far as our information is available, the only study of lake circulation and lake currents was taken as part of a modelling exercise during the EIA. There was little attempt to test these models with real current data (ground-truthing). The MMEEM guidance document actually recommends concurrent tracking of lake currents with drogues during the plume delineation process (See EC 2002; Page 3-18). This step was not done for the DDMI delineation.

Third, from the two figures provided in the AEMP (Figures 2.6-1 and 2.6-2), it appears that only 22 sites were sampled for conductivity to delineate the plume over an area 3.5 km by 2.5 km. Given this large area, this small number of samples may have been insufficient to determine the pattern of effluent plume dispersion in sufficient detail.

2.7 WATER CHEMISTRY MONITORING

2.7.1 Sampling Locations and Sampling Schedule

The 2006 AEMP proposes three routine water quality stations each in Exposure A (edge of mixing zone), Exposure B (within 1% effluent zone of plume) and in Reference Area A (inlet from Lac du Sauvage). This program is referred to as Part 1. Water samples for Part 1 will be collected at three depths, four times during each year:

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

The Part 2 water quality monitoring program consists of water quality samples collected in support of the Benthos and Fish Health surveys. Samples will be collected at Exposures A, B, and C (beyond the 1% effluent zone) and at Reference A, B, and C stations. The Part 2 program is consistent with the general MMEEM design, comparing exposed to reference areas to detect mine related effects. The supportive water quality sampling for the benthos and fish studies will be conducted once (in late August) on a triennial basis. The timing and frequency of sampling correspond to the MMEEM program as described in the guidance document (EC 2002). Sample numbers at each station were determined by power analysis.

2.7.2 Power Analyses and Sample Numbers

The sample numbers required to detect changes in water quality variables were determined by power analysis conducted on conductivity, aluminum, barium and nickel. The sample numbers, calculated by Diavik's power analysis, may be too low to detect subtle changes in water quality. For example, in the power analyses, the effect size was taken as twice the median of the annual means. This means that the number of samples was set to detect a concentration difference double that of the median baseline concentration with a given level of confidence. This 'doubling' criterion is presumably based on the 'environmental effects criterion' proposed in the MMEEM guidance document where an effect is indicated when a key parameter is increased by a factor of two (See Section 2.7.5). However, this criterion does not take into account the dilute and oligotrophic nature of Lac de Gras. In a dilute lake like Lac de Gras, setting the sample numbers to detect a doubling of a parameter such as conductivity or phosphorus may represent, already, a significant change in lake chemistry. In the case of phosphorus, for example, Diavik (1998) reported a median concentration of 0.004 mg/L between 1994 and 1995 in their Environmental Impact Assessment (EIA). Doubling this concentration would exceed the threshold value set in the EIA for Total P (0.005 mg/L) and approach the predicted concentration at their innermost modeled plume boundary (0.01km^2) of 0.0092 mg/L. According to the criteria presented in the EIA, this doubling of Total P would represent an effect of 'high magnitude'. Surely it would be preferable to detect changes below this level. It is recommended that the power analysis be reviewed and DDMI consider increasing sample numbers in order to detect smaller changes in key water quality variables, especially in those having the highest degree of variability. The more variable a parameter, the greater the number of samples required to detect a given change. .

2.7.3 Water Quality Parameter List

The proposed water quality monitoring parameter list should be adequate to study water quality changes in the lake, unless there are chemicals in the effluent that have not been reported in the effluent characterization.

2.7.4 Sampling Methodology

Water samples are to be collected at three depths across the water column: 2 m from the bottom, mid-depth, and 2 m below the water surface. Depth integrated samples are proposed for total phosphorus and chlorophyll *a* and will be collected over the top 10 m of water. Vertical profiles (the reviewer assumes the profiles will be at 1 m intervals) will be taken of field parameters (oxygen, pH, temperature, conductivity, turbidity). While DDMI is commended for standardizing the method of sample collection and incorporating vertically integrated sampling of total phosphorus and chlorophyll *a* the water quality monitoring program should incorporate discrete depth sampling (or integrated sampling techniques) for *all* parameters when vertical gradients are observed.

2.7.5 Determination of Environmental Effects

The four-step approach to determining potential effects of the mine on water quality has been abandoned in the 2006 AEMP in favour of the two-fold criterion described above where an effect is indicated when a key parameter is increased by a factor of two (See Section 2.7.2). This two-fold criterion should be re-examined for its relevance, despite its inclusion in the MMEEM guidance document. As indicated above in Section 2.7.2, a two-fold increase in total phosphorus or conductivity may be highly significant in a dilute, oligotrophic lake like Lac du Gras and a significant effect in a key parameter might have been detected earlier if this criterion were lowered. Phosphorus presents an important example as eutrophication is recognized as a potential effect of mining activities. As indicated in Section 2.7.2, a doubling of phosphorus concentration will not only result in an exceedance of the threshold value for Total P (0.005 mg/L) set in Diavik's EIA but also an effect considered to be 'high' in magnitude as judged by the criteria established in the EIA, itself. The published literature indicates that arctic lakes (like temperate lakes) are clearly susceptible to eutrophication even at very low levels of phosphorus input. These levels may not result in significant and measurable increases in total P in water column although the effects on phytoplankton and primary production are significant.

Schindler et al. (1974) studied eutrophication by phosphorus and nitrogen in Meretta Lake, near Resolute Bay (NWT). The addition of nitrogen and phosphorus in sewage to Meretta Lake resulted in significant increases in chlorophyll *a* and changes in the phytoplankton community structure. The addition of only 0.005 mg/L Total P/week to water collected from pristine Char Lake, where the initial concentration was less than 0.005 mg/L, resulted in significant increases in chlorophyll *a*. In Meretta Lake, a large amount of the phosphorus (46%) disappeared during the winter, presumably retained by the sediments. Welch et al. (1989) fertilized four small arctic lakes at Saqvaqjuac, NWT for three years with phosphorus and nitrogen. Background concentrations of Total P in the lakes ranged from 0.004 mg/L to 0.010 mg/L. After fertilization, significant and rapid changes in phytoplankton species and phytoplankton production were observed although the mean open water concentrations of total P increased by only 0.003-0.006 mg/L. Obrien et al. (2005) fertilized one half of a partitioned arctic lake in Alaska. The addition of phosphorus and nitrogen resulted in increases in sestonic biomass, chlorophyll *a*, primary productivity, microplankton (e.g., rotifers) and macrozooplankton. Oxygen consumption by sediments increased. Despite these significant biological changes, phosphorus concentrations in the water column (0.003 mg/L) did not increase over six years of the experiment because of strong uptake by sediments.

These results support the contention that a doubling in concentration of some parameters, for example Total P, may be too insensitive to use as an indication of environmental effects, especially in the context of an AEMP where the goal is to detect trends before these effects are observed.

Another feature of the data analysis proposed by DDMI is that no formal (statistical) analysis will be conducted on the annual water quality monitoring program (Part 1). Analysis will include simply 'qualitative comparisons' between exposure and reference areas to determine those parameters having differences in exposure of a factor of two or more, and comparison of parameters regulated by the DDMI water license to ambient thresholds established in the original EIA. Statistical analyses will only be conducted on water quality parameters collected during the triennial benthic/fish monitoring program. Analyses will include analysis of variance to detect spatial differences (exposed vs. reference) and regressions to detect temporal changes. Parameters at least twice the concentration in the exposed area versus the reference areas will be noted.

Failure to analyze the seasonal and yearly data means that much of the data collected as part of the water quality program will be either underutilized or not utilized at all. There will be no quantification of yearly or seasonal variability in the key parameters and early warnings of change that may be evident on a yearly basis will be missed.

It is therefore recommended to include the annual water quality samples in the formal statistical analysis. The samples are being taken anyway and the data should be used appropriately. Why do the power analysis to determine the sample numbers required to detect differences only to decide not to conduct the analyses? Analyses of these data would help establish seasonal variability in key parameters, a better estimate of year-to-year variability and an earlier indication of potential changes/differences between the exposed and reference areas.

Regression analysis proposed as a method of determining temporal changes in the water quality data from the triennial fish and benthic studies may be a rather poor way of detecting trends. One or two years of no-change in a parameter or a reverse change could render a regression statistically insignificant. Formal trend analysis may be more appropriate.

Field quality control for the AEMP consists of a field blank, travel blank, equipment blank, and a duplicate sample so that the quality control (QC) effort represents 10% of the total number of water quality samples. Field and travel blank parameter concentrations would be considered significant if they are greater than five times the corresponding method detection limit (MDL), while duplicate sample parameter concentrations are to be considered significant if the difference is greater than 20%. Ultra-low metals analysis is to be used only for low turbidity samples from Exposure C and References A and B.

The 1985 EPA blank acceptance criterion of five times the MDL should be reviewed and reduced. The current method of determining the MDL is to use the results of low level spikes and determine the concentration equivalent to two standard deviations at the lowest spiking level. This ensures a 95% probability that a value at the MDL is real and not just noise (avoids false positives). Five times the MDL corresponds to 10 standard deviations. This would be a highly significant concentration (relative to noise levels) and significantly different from the MDL. The blank concentration should be much less than five times the MDL.

There should also be a protocol established for corrective actions to deal with any issues of contamination indicated by the quality control samples. The AEMP only calls for flagging unusual (out-of-control) quality control results. Flagging the samples does nothing to correct a problem.

The ultra-low metals analysis should be used for all samples. This analysis, presumably using inductively coupled plasma mass spectroscopy (ICP-MS), can be used for any water sample, especially if the sample is filtered and digested in nitric acid/aqua regia (even turbid water samples). While it may make no practical sense to use ICP-MS when metals levels are high, even then, the sample is simply diluted and run on-scale.

2.8 SEDIMENT QUALITY

In the 2006 AEMP, five sediment quality stations are proposed in Exposure B and C areas. These samples are to be taken in late August in support of the triennial benthic and fish studies. Results in the exposed areas are to be compared to Reference areas A and B to identify potential differences.

Sediment parameters include total metals, total organic carbon, total phosphorus and particle size. However, the actual metals to be analyzed are not specified. DDMI should specify its parameter list and consider adding TKN and soluble nitrates to the list of analytes. Lake eutrophication is considered a potential effect of mine discharge and sediment nitrogen would likely increase during eutrophication. It therefore makes sense to analyze specifically for forms of nitrogen that would indicate this effect.

The sediment samples will consist of composite samples of the top 3 to5 cm of sediment from three Ekman grabs collected for TOC and particle size analysis. The particle size determinations and TOC are to be used in interpreting the results of the benthic invertebrate study. Additionally, a composite of the top 5 cm of sediment from three samples at each station will be collected with a gravity-feed corer for metals analysis.

Although analysis of the upper 5 cm of sediment is standard practice (e.g., is consistent with application of CCME sediment quality guidelines), the sensitivity of this method in lakes with very low rates of sediment accumulation is questionable. The first 5 cm of sediment may represent decades of sediment accumulation. Differences between exposed and reference sites will be very difficult to detect. Finer sediment sections near the sediment-water interface, representing more recently deposited sediments, should be sampled.

Despite the efforts expended on power analyses for water quality parameters, there has been no reported attempt to determine the variability and sample numbers required to detect changes in sediment parameters. In fact, sediments at a single station often exhibit a higher degree of horizontal and vertical variability in chemical parameters than water samples. If detection of differences between exposed and reference stations is a goal, a power analysis should be applied to determine the variability in sediment chemical parameters and the sample numbers required to detect changes.

DDMI states that comparisons will be made between exposed and reference areas to identify differences. However, no statistical methods or effects criteria for sediments are mentioned. DDMI should state explicitly its methods of analysis and effects criteria.

As well, no quality control samples are proposed for the sediment program. As a minimum, duplicate sediment samples should be taken to represent about 10% of the sampling effort.

2.9 BENTHIC INVERTEBRATE COMMUNITY

For the 2006 AEMP DDMI has adopted the MMEEM program (EC 2002). As such, the stated objective of the 2006 AEMP's benthic invertebrate community (benthos) monitoring was to determine if the effluent has affected the benthos within the receiving environment. Rather than AEMP comparisons to baseline data (as was attempted for the 2001-2005 AEMP), the 2006 AEMP focuses on comparisons between two exposure (Exposure B and C) areas and two reference (Reference A and B) areas (areas depicted in Figure B.1). Specific questions related to the 2006 AEMP objective were:

- *"Are benthic invertebrate community measurement endpoints statistically significantly different between the exposure and the reference areas?*
- *Are benthic invertebrate community measurement endpoints statistically significantly different between exposure areas?"*

This is somewhat different than the objectives and mandate of the approved previous AEMP design or the Water License requirements, i.e., "*…measure short and long-term effects in the aquatic environment resulting from the project…"*. However, both AEMPs similarly state that the benthic invertebrate community will be monitored to detect long-term trends.

The MMEEM recommendation for biological monitoring (i.e., fish, fish tissue, and benthic invertebrate community) is a tiered approach. This assesses the combined results of fish, fish tissue, and benthic invertebrate monitoring in one year compared to previous sampling results. The 2006 AEMP follows this design and has adopted the three-year cycle 'Surveillance Monitoring' which is conducted when the following standard MMEEM stipulations are met:

- no effects have been found in fish, fish tissue and the benthos;
- an effect has been found in one or two of these three in one year; or
- the magnitude, geographic extent and cause of the effects are known

Monitoring may be shortened to two years if:

- an effect has been found in fish, fish tissue, and the benthos (has to be all three);

- two consecutive studies find the same effect on fish, fish tissue, or benthos; and,
- if there are changes in the mine operations or environmental conditions that result in an increased potential to have an effect on the aquatic environment.

The MMEEM also stipulates that to implement a three-year monitoring cycle requires previous biological monitoring information that can determine if there are effects on fish, fish tissue or the benthic invertebrate community. Based on the previous AEMP's limitations in results (e.g., low number of sampling sites, fluctuating sampling periods, and the resulting high among and within area, and within year variability in benthos) it is recommended that an annual database be initially established for the new benthic invertebrate sites and areas prior to implementing a three-year monitoring cycle. We recommend three years of consecutive benthic invertebrate community monitoring.

Based on MMEEM recommendations, the 2006 AEMP proposes to monitor five stations each in Exposure B and C and Reference A and B areas. These would be true replicate area stations as the distance between these stations will be at least 20 metres. The previous AEMP considered three sampling stations in each of it's near-, mid-, and far-field areas as replicate stations even though they had the same GPS coordinates and depth. This represents station replicates not area replicates and would not be representative of those areas (North/South 2005).

Although, the 2006 AEMP focuses on comparisons between exposure and reference areas, it would still be beneficial to evaluate long-term temporal trends in the benthic community. Although comparable benthos baseline data are lacking, two of the 2000 to 2005 AEMP sites overlap with the 2006 AEMP sites, and are comparable for temporal trend assessment and to assess cumulative effects on Lac de Gras.

At each of the five stations in each area, six sub-samples will be collected within a 10 x 10 m area and these sub-samples will be combined into one composite sample. Samples with be taken with an Ekman grab then sieved through a 250 µm mesh to separate sediment fines from the benthic organisms. Benthic invertebrate samples will be shipped to a qualified taxonomist for identification and enumeration. Identification will be to the lowest practical taxonomic level.

Supporting environmental data includes physical site descriptions (water depth, substrate type), dissolved oxygen (DO), specific conductance, temperature, and pH. Substrate characteristics (particle size and organic carbon) and chemistry will be measured concurrently as described above in the preceding Sediment Quality section (Section 2.8).

As was conducted during the previous AEMP, benthos sampling will be performed during late August or early September. This is generally standard practice (Rosenberg *et al*. 2001; EC 2002); however, based on the difficulty obtaining samples over similar periods within and between years during this time of year as observed in the AEMP to date, it would be worth investigating sampling during ice-cover. This would ensure sampling the benthic community during a consistently stable period that would reduce temporal variability between sites and between years.

The benthic invertebrate community survey is based on a Control/Impact design to detect differences between exposure and reference areas. The null hypothesis is that there is no difference in the benthos exposed to mine effluent relative to benthos in reference areas that are not exposed to effluent (DDMI 2006). Following standard MMEEM recommendations, benthic invertebrate community descriptors used to determine effects include: total invertebrate density; taxon richness; relative abundance; presence/absence; evenness; Simpson's Diversity index (SDI), and the Bray-Curtis index (BCI).

Prior to completing statistical analysis, the benthos data will screened for outliers (by visual examination of box-and-whisker and linear regression plots of the transformed data). Studentized residuals (SR) from the linear regression analyses will also be used as a screening tool and observations with an SR>2 will be checked for validity. Complete documentation will be provided for the screening (i.e., if outliers are removed).

Following MMEEM guidelines, an effect will be determined by whether or not a statistically significant difference occurs between the reference and exposure areas for total density, richness, SDI, and BCI. Spatial trends in other variables will also be evaluated for interpretation of monitoring results. It is not stated in the 2006 AEMP which other variables will be evaluated, but the reviewer assumes that water depth, DO, specific conductance, and sediment particle size as these will be presented as part of the benthos analysis results.

A Spearman correlation matrix will be generated to determine if there are correlations between the benthos and environmental variables. Analysis of variance (ANOVA) will be used to determine if there is a statistically significant difference between Exposure B and Exposure C compared to Reference A and Reference B, and between Reference A and Reference B [Alpha (α) and beta (β) will be set at 0.1 and Power at 90% (1-β)]. If the ANOVA results are statistically significant, planned comparisons will be performed to compare reference and exposure areas. Sensitivity of statistical comparisons will also be examined by computing percentage differences between reference and exposure area means. This approach relies on multiple lines of evidence for evaluating change and as such should be effective in detecting effluent effects.

Quality assurance/quality control (QA/QC) measures are described well in the 2006 AEMP for field operations, laboratory procedures, sample management, data management and analysis, and reporting. Specifically for the benthos component, the laboratory analysis of benthic invertebrate samples will incorporate invertebrate 90% removal efficiency in 10% of the samples collected and taxonomic references will be establishment. This follows standard MMEEM recommendations and we conquer that the QA/QC stipulated for the benthos is appropriate.

2.10 FISH HEALTH

The overall objective of the Fish Health component of the AEMP is clearly stated in Section 6.4.1 as "*…to assess potential effects of effluent on the growth, reproduction, survival, and condition of fish. Monitoring of mercury concentrations within fish tissue is an indicator of fish usability"*. Specific objectives are to answer the questions:

- "*Are the differences in measurement endpoints for fish health between exposure areas and reference areas greater than 20% to 30% (as per EC 2002)?"*
- *"Has there been a change in fish usability due to the treated Mine effluent?"*

The measurement endpoints given for fish health are: abundance (catch per unit effort [CPUE]; length, weight, and age; size-at-age; condition; relative liver and gonad weight; and tissue chemistry. For this AEMP, DDMI proposes a definition for an ecologically relevant effect size for fish health as:

> *"…a measurement endpoint value in the Exposure B that is different by a factor of 20% to 30%, or greater, from the value in Reference A."*

As a rationale for selecting this definition, DDMI states that it is based on the MMEEM and is relevant for liver and relative gonad size. Although no effect sizes were specifically discussed for the other endpoints, it was implied that effect sizes for changes to fish population size previously defined in the EA (DDMI 1998) and the Comprehensive Study Report (CSR; Government of Canada 1999) would be adopted (i.e., negligible effect = change of less than 1%; high effect = change in fish population of greater than 20%).

As a general comment, DDMI has adapted MMEEM guidance for the design of the AEMP and in doing so is taking a relevant, accepted and defensible approach to assessing the effects of its effluent on fish health. It is not as clear, however, how this approach will address its second stated objective (i.e., assessing change in fish usability) since only slimy sculpin will be considered. Although selection of slimy sculpin as the target species for assessing effluent effects has merit due to its relatively sedentary nature, it is not a species that is used by resource harvesters. Furthermore, slimy sculpin is a small, short-lived omnivorous species that may not show the effects of long term bioaccumulation, as would other species such as lake trout.

Another disadvantage of focussing on slimy sculpin is that it may be difficult to assess target measurement endpoints related to population size (i.e., abundance, CPUE) and growth parameters (i.e., length/weight/age, size-at-age, and condition), all of which rely on getting a representative sample of the population(s) as a whole. This is not always achievable using electrofishing techniques, particularly on large lakes where sampling conditions can be problematic and highly variable. Age-based analyses (i.e., population structure, recruitment, mortality and growth) are also inherently more difficult when short-lived species are used.

In line with the MMEEM approach, the AEMP will focus on comparisons between exposure and reference sites, rather than comparisons to baseline data. Although a reference lake(s) would have been preferable, even according to MMEEM guidance (EC 2002), DDMI has opted to use a reference site within Lac de Gras due to on-going difficulty in identifying a suitable reference lake for the project. The approach involves sampling at Exposure B (exposed to at least 1% effluent) and Reference A, located at northeast end of Lac de Gras (inlet from Lac du Sauvage). Although appropriate in principle, the approach relies heavily on clear delineation of the effluent plume, a prerequisite that may still be in some doubt (see Section 2.6).

As discussed, adult and juvenile slimy sculpin have been chosen as the sentinel fish species to be monitored for fish health. Specific parameters that are to be measured for the fish health assessment include: CPUE, length, weight, age, physical abnormalities, and liver weight. Data will be summarized by sample size, mean, median, min, max, standard deviation, and standard error. Condition factors and liver somatic indices will be calculated and also summarized. For the internal fish health assessment, 20 each of adult males, adult females, and juveniles will be sacrificed. Additional non-lethal sampling of 100 sculpin in each sampling area will be conducted for age distribution, growth and condition information. The proposed timing and frequency for the fish health component is once every three years, with the potential to change to once every six years. Sampling will be concurrent with other AEMP physical and biological components in late August to early September.

Slimy sculpin has been chosen as the sentinel fish species for the monitoring program. As a relatively sedentary species, the choice is both appropriate and in line with MMEEM guidance for monitoring effluent effects on fish. However, the use of this species to assess fish usability is questionable and the AEMP does not elaborate on how this will be done. Although not part of the AEMP, the document does discuss another DDMI monitoring program that is conducted in compliance with the *Fisheries Authorization* that does have direct relevance to the usability question. Fish palatability studies are conducted annually using Lac de Gras lake trout. According to the AEMP, lake trout that are sacrificed for the palatability studies are also analysed for tissue mercury content. Since these studies have direct relevance to the assessment of fish usability, a stated objective of the AEMP, the AEMP would benefit from inclusion of the annual results.

Similarly, the AEMP objectives and study design purport to examine ‘fish’ abundance and various life history parameters, yet only slimy sculpin will be examined within the framework of the AEMP. Presumably population effects on other species, including species that are more directly important to resource harvesters, will be inferred in part from the slimy sculpin results, but the validity of this may be questionable. For one thing, the MMEEM approach selectively assesses the effects of effluent on a sentinel species, to the exclusion of other project related effects that may be affecting other species. Examples could include: sedimentation effects from roads, dykes, dredging activity and/or dust fallout; nutrient loading; contaminant leaching from dykes; and changes to the composition of zooplankton community. It is recognized that a number of these issues are being addressed through separate studies required under the *Fisheries Authorization*. The *Fisheries Authorization* also requires DDMI to monitor fish populations and indices of fish health every five years (Section 10.0.1 of the *Fisheries Authorization*). Although these studies are conducted separately from the AEMP, inclusion of their results would address AEMP objectives and strengthen the program.

Fish health surveys will be conducted concurrently with other monitoring components and although this is appropriate, DDMI has correctly pointed out that the survey timing (i.e., late August to early September) may make accurate gonad weight measurements difficult in slimy sculpin, as gonad development may be limited at this time of year.

Determination of condition will be based largely on non-sacrificed individuals. This may present a problem in that calculation of condition may be confounded by occurrence of *Ligula intestinalis*, a common internal parasite of forage fish species that has been reported by DDMI and appears to be quite common in Lac de Gras (35% infestation rate according to DDMI). The parasite can represent a significant portion of a fish's weight but is difficult to detect or confirm without sacrificing the host. On an individual level, undetected presence of this parasite can lead to calculation of a high condition factor when a fish is actually in poor health due to the parasite burden. Furthermore, DDMI correctly points out that *Ligula* may also affect reproduction, which could further confound interpretation of health assessments.

In Section 6.4.8 (Data Analysis), DDMI states that they will use summary calculations and/or statistical analyses of a number of parameters (i.e., physical abnormalities, age, total body weight, length and liver weight) to assess three fish responses: survival, energy storage and energy use. They define survival as *"…a measure of the effect of the difference in the mean age of all fish between different areas (i.e., exposure and reference)."* They propose to statistically analyse for differences in mean age and variability in age between the exposure and reference sites. This approach, however, may be easily confounded by variables other than survival (e.g., variable strength among juvenile year classes; variable recruitment). It is more usual to define survival, or survival rate, as the number of fish alive after a specified time interval, divided by the initial number. Survival and mortality (reciprocal terms) are usually estimated through analysis of catch curves (i.e., age distribution curves). Regardless of analysis method, it will be important that the samples be representative of the whole populations at the exposure and reference sites, a requisite that may be difficult to achieve.

Given the technical uncertainties regarding the sentinel species program discussed above, DDMI should consider conducting the program annually for three years, rather that starting with a triennial cycle. This would allow for evaluation of the program, and adaptation if required, early in the program.

2.11 COMPARISON AND EVALUATION MATRIX

For ease of review, a comparison of the new 2006 AEMP with the previous 2001-2005 AEMP is provided in the following matrix table (Table 2-1). The matrix was separated into the following relevant AEMP component sections:

- AEMP objectives;
- baseline information;
- reference sites;
- study design; including sampling sites, parameters, timing/frequency, and methodologies;
- Quality Assurance/Quality Control (QA/QC); and,
- data analysis and the ability to detect change.

Summaries under these sections were tabulated for each respective AEMP for the matrix along with 2006 AEMP evaluation comments and recommendations.

Table 2-1 Review matrix of the 2006 Diavik Diamond Mine Incorporated (DDMI) Lac de Gras Aquatic Effects Monitoring Program (AEMP) with direct comparison to the 2001-2005 AEMP.

AEMP Objectives			
AEMP Components	**2001-2005 AEMP**	**2006 AEMP**	**2006 AEMP Evaluation**
Water Quality	• to measure changes in water quality over time in Lac de Gras (primary stressor is release of treated effluent)	• to "determine whether the treated mine effluent is having an effect on the water quality of Lac de Gras … and to provide indications of changes in the trophic status in Lac de Gras as represented by levels of total phosphorus and chlorophyll a ". • another stated objective of the water sampling program is to provide supporting environmental information for interpreting the benthic and fish surveys	• the overall objectives of both programs are similar as both aims to monitor change in the receiving environment • the 2006 stated objectives are much more clearly defined than in previous years
Plankton	• to monitor the effects of nutrient releases on plankton communities in Lac de Gras • due to their rapid turn-over rate, phytoplankton community would respond most rapidly to any nutrient addition • zooplankton, which feeds on the phytoplankton, respond rapidly to changes in the phytoplankton communities. These potential changes would be seen before any changes could be detected in fish <u>Specific comments</u>: • Plankton community biomass was monitored as part of the 2001-2005 AEMP; however, not analyzing plankton composition has been a long-standing criticism as it is a more sensitive indicator of eutrophication and metals effects	• plankton community structure is not included as a 'measurement endpoint', because 'the inherent variability within the plankton community limits its usefulness as a monitoring tool' • chlorophyll *a* and total phosphorous will be monitored as indicators of changes in trophic status of the lake	• trend analysis of AEMP sediment data (DDMI 2005) indicate that metals may be accumulating in the 2001-2005 AEMP's mid-field sediments sites • monitoring plankton community composition would provide additional early indications of metal contaminants and strengthen indications of eutrophication • however, plankton communities are not recommended components of Metal Mine Environmental Effects Monitoring (MMEEM; EC2002) and due to the variability within the plankton community, especially in a large lake such as Lac de Gras, quantitative monitoring would entail an exorbitant amount of effort • monitoring water quality (chlorophyll *a*, nutrients, and metals) in Lac de Gras is an adequate early warning metric to detect eutrophication and metals contamination
Sediment Quality	• one of the key monitoring indices to measure effects of environmental change	• to assess effects related to mining activities and to provide supporting environmental information for interpreting the benthic and fish surveys (p. 83)	• objectives are clearly stated in the 2006 AEMP; however, Water License or other regulatory requirements applicable to the AEMP are not mentioned
Benthic Invertebrate Community (Benthos)	• to monitor the benthic invertebrate community to measure effects of environmental change	• to determine if the effluent has affected the benthic invertebrate community • determine long-term trends	
Fish Health	• 2004 study conducted by DFO to assess effects from the constructed A154 dike on the health and tissue concentrations of metals in fish (slimy sculpin)	• assess potential effects of mining activities on the growth, reproduction, survival, and condition of fish • monitor mercury concentrations in fish tissue as an indicator of fish usability	

Table 2-1 Continued.

Baseline Information			
AEMP Components	**2001-2005 AEMP**	**2006 AEMP**	**2006 AEMP Evaluation**
Water Quality	• water quality data were collected at varying times of the year and varying locations from 1994-2000 • baseline water quality data were pooled for all years and all seasons into a single statistic <u>Specific Comments:</u> • this analysis may not be appropriate given the occurrence of seasonal variability for at least some water quality parameters and because sampling frequency was disproportionate over the years (as indicated in Zajdlik & Associates 2005) • the sampling sites, sampling times, and methods of data collection were inconsistent between years in the DDMI baseline program, which may limit the utility of the data	• rather than AEMP comparisons to baseline data, this AEMP focuses on comparisons between exposure and reference areas as outlined in the EEM program for the metals mining industry (MMEEM; EC 2002). • baseline data may be used for temporal or spatial comparisons if a water quality issue is identified (p. 54)	• in moving to the EEM approach, Diavik has abandoned many of the stations that comprised the baseline and previous monitoring studies. This represents a loss in the continuity of the monitoring data and reduced ability to detect temporal changes
Sediment Quality	• collected from 1996, 1997, 1999, and/or 2000 for at least three years of data from appropriately located sites in the near-, mid-, and far-field areas <u>Specific Comments:</u> • some data added to the baseline dataset from the Dike Baseline Monitoring Program in 2000 were not appropriately represented (triplicate samples were treated as independent samples)	• rather than AEMP comparisons to baseline data, this AEMP focuses on comparisons between exposure and reference areas	• both short and long-term effects on Lac de Gras sediment quality resulting from the Diavik project should continue to be evaluated both spatially and temporally as there is good baseline data available that is comparable to 2006 AEMP sampling locations
Benthic Invertebrate Community (Benthos)	• benthic invertebrate data were collected from 1994 to 2001; however due to changes in sampling and processing methodologies, sampling designs, and compounding dike construction effects, only one year of appropriate baseline data is available for the mid- and far-field areas and no comparable baseline data exists for near-field sites • one year of baseline data is not sufficient to assess post-construction impacts on benthos	• rather than AEMP comparisons to baseline data, this AEMP focuses on comparisons between exposure and reference areas	• although comparable benthos baseline data are lacking, the 2000 to 2005 data should be evaluated against newly collected data to assess temporal trends
Fish Health	• no previous fish health AEMP component.	• rather than AEMP comparisons to baseline data, this AEMP focuses on comparisons between exposure and reference sites	• consistent with MMEEM approach

Table 2-1 Continued.

Reference Sites			
AEMP Components	**2001-2005 AEMP**	**2006 AEMP**	**2006 AEMP Evaluation**
Water Quality	• no reference lake (this was approved by the MVLWB and the DTC) • instead relies on comparisons to baseline information to measure effects, and far-field monitoring to determine regional (actually cumulative) changes that may be due to sources other than DDMI Specific Comments: • the far-field sites can potentially be affected cumulatively by DDMI and EKATI operations, which limit the capability of these sites to act as reference sites	• no reference lake is proposed; • 2006 program establishes a reference site, Reference A (northeast end of Lac de Gras at the inlet from Lac du Sauvage) for the annual routine water sampling • Reference locations A, B (West side of Lac de Gras), and C (Coppermine River) were established for the water sampling program in support of the Benthos and Fish Health surveys	• reference sites should be located upstream and/or outside of the area potentially affected by DDMI and/or EKATI • it has not been established that Reference A is completely outside of the mine effluent plume (need better plume modeling) • Reference B and C could be potentially affected by DDMI and/or Ekati • plumes in lakes are very transient in nature and vary with wind strength and direction. The statement in the 2006 AEMP that - as the inflow is from Lac du Sauvage in the Northeast, the mine effluent is therefore unlikely to travel north to the narrows (p. 49) - is unsubstantiated. The plume delineation should have been done under a variety of wind conditions (See MMEEM 2002; Page 3-18) in order to determine the maximum extent of the plume. The manual also recommends concurrent tracking of lake currents with drogues • the inclusion of a reference lake is standard practice for environmental effects monitoring programs (MMEEM 2002). “Where no suitable reference area on the same water body is available, then the reference area should be located in an adjacent water body with similar characteristics” (MMEEM 2002) • without an appropriate reference lake, it may not be possible to determine if changes observed in the study area are the result of project operations or the result of changes attributable to other factors (e.g., regional changes, climate effects). The inclusion of a reference lake could be in the best interest of an AEMP Proponent as it could avoid reaching false conclusions that a project was responsible for observed effects when external factors are really the cause
Sediment Quality		• reference zones for the sediment program in support of the Benthos and Fish Health surveys include Reference zones A and B	
Benthic Invertebrate Community (Benthos)		• reference zones for the benthic invertebrate program include Reference zone A; northeast end of Lac de Gras and Reference B; west end of Lac de Gras	
Fish Health	• no previous fish health AEMP component.	• no reference lake is proposed • involves sampling at Reference A; northeast end of Lac de Gras (inlet from Lac du Sauvage) • consistent with Metal Mining EEM guidance for study design	

Table 2-1 Continued.

Study Design			
AEMP Components	**2001-2005 AEMP**	**2006 AEMP**	**2006 AEMP Evaluation**
Water Quality			
General Design	• potential project-related effects determined by the comparison of current results from the near, mid-field and far-field data to baseline conditions in the same areas.	• 2006 AEMP proposes adoption of the EEM approach where effects are determined by comparing water chemistry in exposed areas relative to a reference area	• DDMI is commended for adapting the EEM approach • for historical continuity it is recommended that DDMI retain a number of its long-term monitoring stations that were abandoned in adapting the EEM study design
Effluent Characterization	•	• effluent concentrations for parameters regulated in the DDMI Water License are summarized in Table 2.6-1 for 2005	• while DDMI is commended for characterizing its effluent, the MMER also recommends that mines calculate monthly mass loadings of the monitored parameters • loadings can be used to examine mass effects on lake chemistry
Plume Delineation	•	• plume delineation was conducted in 2005 to assess the three dimensional shape and extent of the effluent plume in Lac de Gras under ice-covered and ice-free conditions	• DDMI is commended for characterizing its effluent dispersion in Lac de Gras. However, the full methodology and results of the plume study were not available. From the two figures provided, it appears that only 22 sites were sampled for conductivity over an area 3.5 km by 2.5 km. The full extent of the plume under various wind conditions was not reported here (see comments above)
Sampling Sites/Sample No.	• water quality sites located in near-, mid-, and far-field areas, in relation to distance from East Island (a total of 3, 6, and 3 sites per area, respectively) • near-field stations are part of the "Surveillance Network Program" • water quality monitoring data collected by BHP Billiton also incorporated (3 sites)	• three routine water quality stations each in Exposure A (edge of mixing zone), Exposure B (within 1 % effluent zone of plume) and in Reference Area A (inlet from Lac du Sauvage) • supporting water quality information for Benthos and Fish Health surveys will be collected at Exposure A, B, and C (beyond the 1% effluent zone) and at Reference A, B, and C stations	• sample numbers may be too low to detect subtle effects • it is recommended that the power analysis to determine sample numbers be reviewed and continually updated • the effect size for conductivity was taken as twice the median of the annual means. This means that the number of samples was set to detect a concentration double that of the median concentration with a given level of confidence. In a dilute lake like Lac de Gras, setting the sample number to detect, in effect, a doubling of conductivity may already represent a significant change in lake chemistry. Sample numbers should be set to detect much smaller changes • the threshold values used in the power analysis for setting the effect sizes and sample numbers for aluminum, barium and nickel should also be re-evaluated
Parameters	• total and dissolved metals, nutrients, and routine parameters in water	• total and dissolved metals, nutrients, routine parameters in water, and chlorophyll *a* • in situ water profiles of DO, specific conductivity, temp, and pH	• these parameters should be adequate to study change in the lake unless there are chemicals in the effluent that have not been reported in the effluent characterization

Table 2-1 Continued.

Study Design (continued)			
AEMP Components	**2001-2005 AEMP**	**2006 AEMP**	**2006 AEMP Evaluation**
Water Quality (continued)			

Timing/ Frequency	• monitoring occurs once in the open-water season (August) and the ice-cover season (April) at mid- and far-field sites
	• monitoring at near-field water quality sites is monthly
		• annual routine sampling conducted four times a year:
		  • April (late ice-cover)
		  • early July (early ice-free)
		  • late August (ice-free)
		  • December/January (early ice-cover)
		• Benthos and Fish Health supportive water quality sampling conducted once (in late August) every three years (Part 2 of Program)
			• Diavik is commended for adapting the guidelines set by the MMEEM

Methodologies	• water samples (post-project) are collected at mid-depth at each station, with depth profiles of *in situ* variables also collected at each site • analytical detection limits changed over the course of the monitoring and baseline studies Specific Comments: • samples collected at mid-depth post-project but during baseline studies, samples were collected at various depths • sampling at mid-depth may not be adequate to describe water quality conditions, as conditions may vary across depth • the inconsistency of the sampling methodologies employed by DDMI over the course of the baseline and post-project studies may limit the validity of the program and temporal comparisons	• water samples are collected at three depths across the water column: 2 m from the bottom, mid-depth, and 2 m below the water surface • depth integrated samples for total phosphorus and chlorophyll a will be collected over the top 10 m of water • vertical profiles (1 m intervals ?) will be taken of field parameters (oxygen, pH, temperature, conductivity, turbidity)	• Diavik is commended for standardizing the method of sample collection and incorporating vertically integrated sampling of total phosphorus and chlorophyll. However, the water quality monitoring program should incorporate discrete depth sampling (or integrated sampling techniques) for all parameters when vertical gradients are observed

Table 2-1 Continued.

Study Design (continued)			
AEMP Components	**2001-2005 AEMP**	**2006 AEMP**	**2006 AEMP Evaluation**
Sediment Quality			
Sampling Sites	• sediment quality is monitored at one site in each of the near-, mid-, and far-field areas	• five stations each in Exposure B and C and Reference A and B areas	• two of the old AEMP sites (there were only three) overlap with the 2006 AEMP sites, thereby allowing temporal comparisons
Parameters	• total metals, total organic carbon, TN, TP, and particle size	• total metals, total organic carbon, TP, and particle size Specific Comments: • not clearly stipulated what metals will be analyzed; the reader is led to believe that analyses is limited to elements listed in Table 7.1-1 (MDLs), which omits arsenic, bismuth, boron, nitrogen, selenium and uranium compared to the old AEMP	• specify the metals to be analyzed in the sediments and which have national or provincial sediment quality guidelines • consider adding TKN and soluble nitrates to the parameter list. Sediment nitrogen may increase during eutrophication.
Timing/ Frequency	• sediment samples are collected once per year in the open-water season (i.e., August sampling)	• late August sampling concurrent with benthos surveys • sampled once every three years	• the recommendation for benthos (below) was to establish three years of annual sampling prior the triennial cycle to establish a database for temporal comparisons and evaluate the monitoring methodologies sooner than later. It was also recommended to sample during ice-cover (during a period when the benthos is more stable); if this were to be adopted into the AEMP, then concurrent sediment sampling should be altered similarly
Methodologies	• triplicate samples of upper (top 5 cm) sediments are collected using a gravity-feed corer • samples are submitted to an analytical laboratory for analysis Specific Comments: • triplicate cores characterize small-scale variability at their respective sites, but are not adequate to characterize larger-scale variability within near-, mid-, and far-field areas • this requires more sampling sites per area	• composites samples of the top 3-5 cm of sediment from three Ekman grabs collected for TOC and particle size analysis • a composite of the top 5 cm of sediment from three cores at each station will be collected with a gravity-feed corer for metals analysis • Particle size determinations and TOC are used in interpreting the results of the benthic invertebrate study • Comparisons will be made between exposure and reference areas to identify potential differences	• although analysis of the upper 5 cm of sediment is standard practice (e.g., is consistent with application of CCME sediment quality guidelines), the sensitivity of this method in lakes with very low rates of sediment accumulation is questionable. The first 5 cm of sediment may represent decades of sediment accumulation. Differences between sites will be very difficult to detect. Finer sediment sections near the sediment-water interface, representing more recent sediments, should be sampled. • despite the efforts expended on power analyses for water quality parameters, there has been no attempt to determine the variability and sample numbers required to detect changes in sediment parameters. In fact, sediments at a single station exhibit a higher degree of horizontal and vertical variability in chemical parameters than in water samples taken at the same station. If detection of differences between exposed and reference stations is a goal, a power analysis should be applied to determine the variability in sediment chemical parameters and the sample number required to detect changes

Table 2-1 Continued.

Study Design (continued)			
AEMP Components	**2001-2005 AEMP**	**2006 AEMP**	**2006 AEMP Evaluation**
Benthic Invertebrate Community (Benthos)			
Sampling Sites	• three sampling sites: near-field (~1 km east of the mine-water discharge); mid-field (~4 km east of the mine-water discharge); and, far-field (near outlet of Lac de Gras to Coppermine River) Specific Comments: • this AEMP requires more sampling locations that are standardized according to habitat characteristics • recommend implementing a gradient study design approach with a minimum of three gradients in the near- and mid-field areas • do power analysis to determine adequate number of sampling sites	• five stations each in Exposure B and C and Reference A and B areas • distance between stations was stipulated as 20+ metres	• the number of stations in each area follow MMEEM recommendations • two of the old AEMP sites overlap with the 2006 AEMP sites, which provides overlap for some temporal comparisons • as stated previously, the addition of a reference lake would aid in the evaluation of regional impacts on Lac de Gras and effects due to natural phenomena
Parameters	• benthic invertebrate community descriptors used to determine effects include: total invertebrate density (number of organisms/m^2); taxon richness; and composition of major taxonomic groups • concurrent sediment sampling (substrate type and particle size) Specific Comments: • biomass measurements were not taken as outlined in the AEMP design • in situ water quality measurements were not taken at benthic sampling sites • this AEMP would be improved by including a similarity index (e.g., Bray-Curtis index) to summarize the overall difference in community structure once reference and effect areas are established	• benthic invertebrate community descriptors used to determine effects include: total invertebrate density; taxon richness; relative abundance; presence/absence; evenness; Simpson's Diversity index, and the Bray-Curtis index • field water quality parameters (profiles of DO, water temperature, pH, and conductivity) • substrate type and particle size	• the 2006 AEMP follows standard MMEEM recommendations
Timing/ Frequency	• once per year, during the open-water season; ranging from early August to early September Specific Comments: • within-year sampling was spread over long periods (up to weeks) and annual sampling periods were not consistent • some sampling occurred in late summer at a time when benthos were not likely stable due to potential adult emergence • this is inappropriate for spatial and temporal comparisons	• once every three years during late August or early September	• based on the difficulty obtaining samples over similar periods within and between years during the ice-free season (as observed in the former AEMP), it may be more ideal to sample during ice-cover • this ensures sampling the benthic community during a consistently stable period that would reduce temporal variability between sites and between years

Table 2-1 Continued.

Study Design (continued)			
AEMP Components	**2001-2005 AEMP**	**2006 AEMP**	**2006 AEMP Evaluation**
Benthic Invertebrate Community (continued)			

Methodologies	• the study design is a scaled-down version of the standard EEM control/impact study design, intended to spatially compare sampling areas (reference and impact) to determine effects of point-source discharges on Lac de Gras benthic invertebrate communities
	• at each benthic sampling site: three replicate samples, each consisting of a composite of six Ekman grabs; 250 µm mesh sieve
	Specific Comments:
	• methodologies outlined in the AEMP annual reports are too brief and at times incomplete
	• DDMI needs to improve their study design to allow both spatial and temporal assessments of benthic communities in Lac de Gras
	• DDMI did not provide a rationale for the exclusion of invertebrate biomass measurements
		• one composite of six Ekman grabs per station (stations not less than 20 m apart)
		• 250 µm mesh sieve
		• supporting environmental data include DO, specific conductivity, temperature, and pH
		• substrate characteristics and chemistry will be measured concurrently as described above in the Sediment Quality section
		• tiered approach based on MMEEM
		• this assesses the combined results of fish, fish tissue, and benthic invertebrate monitoring in one year compared to previous sampling results
		• this AEMP proposes a three year cycle that are based on the following stipulations:
		  • no effects have been found in fish, fish tissue and the benthos;
		  • an effect has been found in one or two of these three in one year; or
		  • the magnitude, geographic extent and cause of the effects are known
		• monitoring may be shortened to two years if:
		  • an effect has been found in fish, fish tissue, and the benthos (has to be all three);
		  • two consecutive studies find the same effect on fish, fish tissue, or benthos; and
		  • if there are changes in the mine operations or environmental conditions that result in an increased potential to have an effect on the aquatic environment
			• the 2006 AEMP follows standard MMEEM recommendations
			• however, to implement a three year monitoring cycle requires previous biological monitoring information that can determine if there are effects on fish, fish tissue or the benthic invertebrate community
			• based on the previous AEMP's limitations in results (e.g., low number of sampling sites, fluctuating sampling periods, and the resulting high among and within area, and within year variability in benthos) it is recommended that an annual database be initially established for the new benthic invertebrate sites and areas prior to implementing a three year monitoring cycle

Table 2-1 Continued.

Study Design (continued)			
AEMP Components	**2001-2005 AEMP**	**2006 AEMP**	**2006 AEMP Evaluation**
Fish Health			
Sampling Sites	•	• Exposure B (exposed to at least 1% effluent) and Reference A areas • specific sites will be determined based on habitat characteristics	• assumes Reference A is unaffected by effluent; clearer effluent plume delineation would improve confidence
Parameters	•	• catch-per-unit-effort • length, weight, age, physical abnormalities, and liver weight will be summarized by sample size, mean, median, min, max, standard deviation, and standard error • condition factor and liver somatic indices • fish tissue mercury concentrations	• the 2006 AEMP follows standard MMEEM recommendations
Timing/ Frequency	• Fisheries Authorization requires sampling once every five years	• once every three years with the potential to change to once every six years • sampling to be concurrent with other AEMP physical and biological components in late August to early September	• no detailed protocol for determining mercury concentration in fish tissue studies are provided in the AEMP; more detail would be beneficial
Methodologies	•	• adult and juvenile slimy sculpin chosen as the sentinel fish species to be monitored • sculpin to be collected by backpack electrofishing • for the internal fish health assessment, 20 each of adult males, adult females, and juveniles will be sacrificed • non-lethal sampling of 100 sculpin in each sampling area will be conducted for age distribution, growth and condition information Specific Comments: • DDMI concur that the survey timing may make accurate gonad weight measurements difficult in slimy sculpin as gonad development may be limited at this time • it was determined in the 2006 AEMP that large-bodied fish species would not be appropriate for assessing mine-related activities because of their potential movements throughout the lake (in and out of mine-related exposure areas) and that no reference lake was chosen (state that a suitable reference lake could not be established as determined by the EA survey)	• selection of slimy sculpin as sentinel species is appropriate and in line with EEM guidance • however, use of slimy sculpin to monitor fish usability (i.e., tissue mercury) is questionable because they are small omnivorous species (i.e., less likely to bioaccumulate mercury). • also, the usability monitoring would be more relevant if it was conducted on a species that is consumed by resource users • calculation of condition for non-sacrificed slimy sculpin may be confounded by occurrence of *Ligula intestinalis*, an internal parasite that can represent a significant portion of a fish's weight. This parasite can also affect reproductive health. Occurrence of this parasite has been reported and may be common, but this potential issue should be better delineated

Table 2-1 Continued.

Quality Assurance/Quality Control			
AEMP Components	**DDMI AEMP**	**2006 AEMP**	**2006 AEMP Evaluation**
Water Quality	• the QA/QC program for water quality included analysis of blanks and replicate samples; • QA/QC for sediment quality sampling and data analysis includes the collection of a triplicate sample for calculation of variability and routine laboratory QA/QC Specific Comments: • there appeared to be some issues regarding water quality data management (e.g., poor agreement between sample replicates, transcription errors, treatment of replicate samples both as independent data points as well as sample duplicates)	• each field trip to include a field blank, travel blank, equipment blank, and a duplicate sample (represents 10% of the total number of water quality samples) • field and travel blank parameter concentrations would be considered significant if they are greater than five times the corresponding method detection limit (MDL) • duplicate sample parameter concentrations to be considered significant if the difference is greater than 20%, and overall intra-site variability in sample analyses results will be assessed • ultra-low metals analysis are to be used only for low turbidity samples from Exposure C and References A and B	• the 1985 EPA blank acceptance criterion of 5 times the MDL should be reviewed and reduced • the current method of determining the MDL is to use low level spikes and determine the concentration equivalent to two standard deviations at this spiking level. This ensures a 95% probability that a value at the MDL is real and not just noise. Five times the MDL corresponds to 10 standard deviations. This would be a highly significant concentration (relative to noise levels) and significantly different from the MDL. The blank concentration should be much less than 5 times the MDL • there should be a protocol established for corrective actions to deal with any issues of contamination indicated by the quality control samples. Flagging the samples does nothing to correct the problem • use an ultra-low metals analysis for all samples. This analysis, presumably using a mass spec detector, can be used for any sample, especially if the sample is filtered and digested in aqua regia. It makes no sense to use it when metals levels are high. However, even then, the sample is simply diluted and run on-scale
Sediment Quality	• triplicate core samples taken at each of the three sampling sites provides an estimate of the precision of sampling Specific Comments: • QA/QC section (methods, evaluation criteria and results) should be expanded	• none stipulated	• introduce replicate analysis, trip blanks and equipment rinsates to sediment program
Benthic Invertebrate Community (Benthos)	• only provided QA/QC results of invertebrate sorting efficiency Specific Comments: • Diavik's AEMP requires more complete QA/QC criteria that incorporate all study design components, namely: field operations; laboratory operations; data input and verification; and report preparation	• laboratory analysis of benthic invertebrate samples to incorporate invertebrate removal efficiency in 10% of the samples collected (90% removal efficiency) • establishment and use of taxonomic references	• the 2006 AEMP follows standard MMEEM recommendations
Fish Health	•	• fish ageing structures will be read independently at least three times and a confidence level will be assigned to each age estimate • 10% of all fecundity samples will be re-counted by a second independent reader	• QA/QC is adequate

Table 2-1 Continued.

Data Analysis and the Ability to Detect Change			
AEMP Components	**DDMI AEMP**	**2006 AEMP**	**2006 AEMP Evaluation**

Water Quality	• a four step process is adopted to assess effects relative to baseline conditions, and to determine if additional mitigation measures are necessary
	• Step 1: determine if there had been a change in a measured variable from baseline, governed by two decision rules:
	  ◦ if three consecutive results are greater than the 75th percentile of the baseline population set (or lower than the 25th, where appropriate), then a change or an effect is determined to have occurred.
	  ◦ if analysis of the data indicates there has been a significant positive trend which when extrapolated forward intersects the 75th baseline percentile within three years (n=4; p=0.05), then a change or an effect is determined to have occurred
	• Step 2: determine if DDMI activities were the source of the measured change.
	• Step 3: determine if measured results exceed the predictions made during the Environmental Assessment with respect to spatial and temporal extent and magnitude
	• Step 4: determine if the measured change is likely to cause a significant adverse environmental impact
	• Step 1 would be implemented on an annual basis, but steps 2 through 4 would only be triggered by a positive result in the preceding step
	<u>Specific Comments:</u>
	• due to problems associated with variability in the timing and methods of baseline water quality data collection, comparisons between pre- and post-project data are questionable. Additionally, pooling of seasons may not be valid
	• Zajdlik & Associates (2005) suggested in a recent review of the DDMI baseline data set, that acceptance of the first rule of Step 1 in the approved two–step analysis procedure (i.e., there were not three consecutive results greater than the 75th percentile of the baseline population set) as a trigger value would likely result in periodic exceedences in parameters above the 75th percentile being left unaddressed. These periodic exceedences could have ecological relevance and need to be addressed individually
		• no formal (statistical) analysis will be conducted on the annual water quality monitoring program (Part 1). Analysis will include:
		  ◦ qualitative comparisons between exposure and reference areas to determine those parameters having differences in exposure of a factor of 2 or more.
		  ◦ comparison of parameters regulated by the DDMI water license to ambient thresholds established in the original EIA
		• statistical analyses will be conducted on water quality parameters collected during the triennial benthic/fish monitoring program. Analyses will include analysis of variance to detect spatial differences (exposed vs. reference) and regressions to detect temporal changes. Parameters at least twice the concentration the exposed area vs. the reference area will be noted
			• it is recommended to include the annual water quality samples in the formal statistical analysis. The samples are being taken anyway and the data should be used appropriately. Why do the power analysis to determine the sample numbers required to detect differences only to decide not to conduct the analyses? Analyses of these data would help establish seasonal variability in key parameters, a better estimate of year-to-year variability and an earlier indication of potential changes/differences between the exposed and reference areas.
			• the factor of 2 effects criterion should be re-examined for its relevance. For example, a two-fold increase in total phosphorus or conductivity may be highly significant in a dilute lake like Lac du Gras.
			• regression analysis may be a rather poor way of detecting temporal trends. One or two years of no change in a parameter or a reverse change could render a regression statistically insignificant. Formal trend analysis may be more appropriate.

Sediment Quality		• sediment quality and chemistry data to be summarized 'as appropriate' for use in interpretation of the benthos results • comparisons to be made between exposure and reference areas to identify sediment chemistry and quality differences	• does not stipulate any statistical analyses to be conducted on sediment quality parameters (spatial and temporal analysis) • recommend similar statistical analyses that are proposed for the triennial water quality parameters
Benthic Invertebrate Community (Benthos)		• a Spearman correlation matrix will be generated to determine correlations between the benthos and environmental variables (e.g., water depth, particle size, TOC) • ANOVA to be used to determine significant differences between Exposure B and C compared to Reference A and B; and between the Reference A and Reference B • if ANOVA results are statistically significant, planned comparison will be conducted for reference and exposure areas • statistical power = 0.90 • sensitivity of statistical comparison will be examined by computing percentage differences between reference and exposure area means	• does not stipulate an integrated interpretation and discussion of sediment chemistry with benthic invertebrate data

Table 2-1 Continued.

<table>
<tr><th colspan="4">Data Analysis and the Ability to Detect Change (continued)</th></tr>
<tr><th>AEMP Components</th><th>DDMI AEMP</th><th>2006 AEMP</th><th>2006 AEMP Evaluation</th></tr>
<tr><td>Fish Health</td><td>•</td><td>• based on statistical analysis of summary calculations (i.e., sample size, arithmetic mean, median, minimum, maximum, SD, and standard error) to detect differences between exposure and reference sites (differences in CPUE, survival, energy storage, energy use, reproduction)</td><td>• methodology described for determining survival seems inappropriate (i.e., comparison of mean age between impact and reference sites). Comparisons should be conducted on calculated mortality or survival rates, based on representative population age distribution analysis
• data analysis for tissue mercury needs clearer explanation</td></tr>
<tr><th colspan="4">Reporting</th></tr>
<tr><td>Water and Sediment Quality</td><td>• the major components of the water quality monitoring program (i.e., the non SNP monitoring data) are summarized, analysed, and presented in an annual report. Some discussion of SNP results are also included
• SNP water quality monitoring results are presented in separate monthly reports
<u>Specific Comments:</u>
• it would be useful to integrate all water quality monitoring data in one report to facilitate a comprehensive and integrated review of the data</td><td>• annual report including:
• site and sampling specifics
• analyses methods with detection limits
• results
• QA/QC
• qualitative comparisons of water chemistry data between exposure and reference areas</td><td>• as described above, quantitative comparisons between exposed and reference sites should be done annually. It makes no sense to collect seasonal data on an annual basis and not use these data to detect changes
• there is no cumulative effects section proposed for the 2006 AEMP</td></tr>
<tr><td>Sediment Quality</td><td>• sediment quality data are also presented in the annual AEMP report.</td><td rowspan="3">• triennial monitoring reports submitted in the year following sampling, including:
• site and sampling specifics
• methods used for analyses and any relevant detection limits
• results
• QA/QC
• statistical comparisons of data between exposure and reference areas
• recommendations for changes to the AEMP (if required)</td><td rowspan="2">• there is no cumulative effects section proposed for the 2006 AEMP</td></tr>
<tr><td>Benthos</td><td>• the major components of the benthic invertebrate monitoring program are summarized, analyzed, and presented in an annual report.
<u>Specific Comments:</u>
• methodologies need more detail
• results from benthic invertebrate monitoring and sediment sampling (concurrent sampling) have largely been discussed separately with limited integration</td></tr>
<tr><td>Fish Health</td><td>•</td><td></td></tr>
</table>

2.12 WATER LICENCE AND AEMP REGULATORY REQUIREMENTS

The existing Water Licence N7L2-1645 issued in August 2000, was amended in May 2004, to accommodate requirements regarding ammonia discharge limits. Part K of Water Licence N7L2-1645 refers to the conditions or requirements of the licence that apply to the Diavik AEMP (detailed in Appendix A.1). Clause 7 of the amended licence specifies what the AEMP should include as per Water Licence requirements. In July 2001, an AEMP plan for the Diavik Project was approved by the MVLWB in consultation with the DTC. This 2001-2004 AEMP design was developed in accordance with the Water Licence and *Fisheries Act* Authorizations issued for the Diavik project. The final 2001-2004 AEMP design was developed in consideration of the aquatic technical issues raised by regulators, first nations and other stakeholders, and also follow-up recommendations developed through the public Comprehensive Study Review. Ultimately the 2001-2004 AEMP was intended to become a component of DDMI's Environmental Management System (DDMI 2001).

Two water licence requirements related to the annual core monitoring program were excluded in the approved 2001-2004 AEMP, and these are given below with DDMI's rationale for their exclusion:

Exclusion 1

"*Clause 7l: the establishment of appropriate control sites in Lac de Gras or nearby lake systems to support an evaluation of project impacts. These control sites should be located outside the zone of influence of mining operations, mineral exploration or any other disturbance activities to provide the necessary information on natural background conditions that includes:*

> *a detailed rationale for site selection, including examination of alternative approaches for establishing the control site(s);*
>
> *an evaluation of the adequacy of baseline data for representing pre-development conditions at the control site(s); and*
>
> *an appraisal of the adequacy of each site"* (Water Licence N7L2-1645, May 2004)

DDMI Rationale for Exclusion 1: "*During baseline studies DDMI selected Lac du Sauvage as a control site due to it size and proximity to Lac de Gras. Results demonstrated that despite physical and geographical similarities, there were many differences in water quality, sediment quality, benthic invertebrates, primary productivity, fish tissue, etc. Furthermore changes to BHP's plans around Misery mean that Lac du Sauvage would no longer be a good control site. DDMI has not been able to establish a valid control site in close proximity to the mine site. Instead DDMI has developed a substantial baseline database that will be used as the basis from which to measure change coupled with far-field monitoring to determine regional changes that may be due to sources other than DDMI*" (DDMI 2001).

Exclusion 2

"Clause 7h: a process for measuring Project-related effects in periphyton" (Water Licence N7L2-1645, May 2004).

DDMI Rationale for Exclusion 2: "*The potential environmental issue in Lac de Gras identified in the Environmental Assessment (EA) was eutrophication. The indicators of eutrophication that were used in the EA and that are commonly used are total phosphorus and chlorophyll a. Phosphorus and chlorophyll were both collected as part of the baseline studies. Additionally, periphyton monitoring yield highly variable due to the nature of the growth and variability in substrate characteristics; particularly in comparison to phosphorus and chlorophyll.*" (DDMI 2001).

The final 2001-2004 AEMP design submitted by DDMI, with these two exclusions, was approved by the MVLWB and the DTC.

Article VII (Section 7.1) of the Environmental Agreement specifies that the AEMP should include activities designed to meet eight separate requirements, including: the consideration of traditional knowledge; the establishment or conformation of thresholds or early warning signs; and the trigger action by adaptive mitigation measures where appropriate. The remaining requirements are given in Appendix A.2 and relate to regulatory instruments, verification of the accuracy of the EIA, assessment of the effectiveness of mitigation measures, and involvement, training and participation of each of the Aboriginal Peoples. The Environmental Agreement also places emphasis on the principles of adaptive environmental management and the assessment of cumulative effects.

The proposed 2006 AEMP did not specifically address the existing Water License requirements (Appendix A.1), specifically Part K Clause 7 that stipulates aquatic effects monitoring requirements. The following Water License components are either not inherently covered by the 2006 AEMP or could be improved:

- Clause 7c: *a description of the sampling program that will be conducted…..including QA/QC procedures…* and 7e: *a description or procedures that will be used to analyze and interpret the data collected in reference to the results of the QA/QC program* are both lacking in the 2006 AEMP design of the sediment monitoring component and there is no protocol established for corrective actions to deal with contamination issues indicated by the water chemistry quality control samples.

- Clause 7f: *a description of the approaches to be used to annually evaluate and adjust the AEM program* could be strengthened by conducting formal statistical analysis on the annual water quality samples. This would help establish seasonal variability in key parameters, a better estimate of year-to-year variability and an earlier indication of potential changes/differences; and there no statistical methods or effects criteria have been established for sediment monitoring.

- Clause 7h-iii: *a process for measuring Project-related effects in…phytoplankton and zooplankton…*Although chlorophyll *a* will be monitored as an indicator of change in trophic status, phytoplankton and zooplankton will not specifically be monitored as part of the 2006 AEMP. The justification provided in the 2006 AEMP was that the plankton community structure is inherently variable, limiting its usefulness as a monitoring tool. Monitoring the plankton community composition would provide an early indicator of metal contaminants and strengthen indications of eutrophication; however, we concur that the variability in these community assemblages makes it difficult to discern Project-related effects and to properly monitoring these components would take an exorbitant amount of effort. The water quality monitoring program (including chlorophyll *a*, nutrients, and metals) should provide adequate early warning of potential eutrophication and metal contamination in Lac de Gras caused by DDMI. However, to satisfy this Water License requirement, plankton samples could be taken in conjunction with water sampling and be archived. If after assessing water chemistry, eutrophication or metals contamination is detected then community analysis of the archived phytoplankton and zooplankton samples can be used for further verification.

- Clause 7g: *a description of how the results of the AEMP program will be incorporated in the overall adaptive environmental management strategies employed by the Licensee, and how data will be used to identify the need for additional mitigation strategies to minimize the impacts of the project.* The 2006 AEMP incorporates recommendations for changes to the AEMP into the reporting for Part II Biological Monitoring that is to occur every three years. As previously stated in this review, DDMI is recommended to initially implement annual monitoring for three years to establish a database for the monitoring components (sediment, benthos, and fish). This would provide more data quicker to establish trends and to evaluate variability and ultimately strengthen the triennial assessments. This would also expedite assurances that the monitoring methods proposed are appropriate for long-term monitoring (field tested).

- Clause 7h-iv: *a process for measuring Project-related effects in…fish community status…*This is also stipulated as part of the *Fish Authorization* (Sec. 10.0) and is to occur every five years; however, the 2006 AEMP does not mention whether this will be conducted as part of the AEMP or another monitoring program.

- Clause 7i: *Special Effects Studies…*Although some studies were conducted under the *Fisheries Authorization* and some are described in the 2006 AEMP, there is no specific reference made to these Water License stipulations. For ease of review there should be a summary of what studies have been conducted to date with relevant discussion of results.

- Clause 7j: *an evaluation of the project-related cumulative effects of multiple stressors on the aquatic environment of Lac de Gras* has not been addressed in the 2006 AEMP.

- Clause 7k: *an evaluation of the contaminant loads associated with dust deposition and its effects on the aquatic environments* has not been addressed in the 2006 AEMP.

- Clause 7l: *the establishment of appropriate control sites in Lake de Gras…located outside the zone of influence of mining operations, mineral exploration or any other disturbance activities*…Reference B area and Reference C (site LDG 48) can potentially be affected cumulatively by DDMI and EKATI operations, which limit the capability of these sites to act as control sites. DDMI may want to consider another control site on the south the lake (e.g., in the bay south of LDG 50).

- Clause 7m: *the establishment of sufficient and appropriate monitoring sites within the predicted zones of influence which shall include*…As per this review, components under this clause are lacking in the 2006 AEMP design, for example:

  - There needs to be better delineation of the plume to establish appropriate monitoring sites.

  - To provide compliance with Clause 7m-iii: *monitoring… far field sites, including deeper basins* some of the previous AEMP monitoring stations could be monitored (e.g., LDG 50), which would also provide continuity with the 2006 AEMP and provide better evaluation of temporal trends.

It is recommended that all regulatory requirements relevant to an AEMP be stipulated in the AEMP design document and that subsequent annual AEMP reports evaluate compliance to these requirements.

3.0 REFERENCES

3.1 LITERATURE CITED

Diavik Diamond Mines Inc. (DDMI). 1998. Environmental Assessment Overview and Associated Baseline and Environmental Effects Reports. Yellowknife, NT.

DDMI. 2001. Aquatic effects monitoring program. July 2001.

DDMI. 2005. 2004 Aquatic effects monitoring program technical report. March 2005.

Golder (Golder Associates Ltd.). 2005. Summary of benthic invertebrate monitoring data collected in Lac de Gras – 1994 to 2004. Prepared for Diavik Diamond Mines Inc.

EC (Environment Canada). 2002. Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring. http://www.ec.gc.ca/eem.

Government of Canada. 1999. Comprehensive Study Report for the Diavik Diamonds Project.

North/South (North/South Consultants Inc.). 2005. Diavik Diamond Mine Aquatic Effects Monitoring Program Review. A report prepared for Environmental Monitoring Advisory Board (EMAB), Yellowknife, NT.

O'Brien, J.O., Barfield, M., Bettez, N, Hershey, A. E., Hobbie, J.E., Kipphut, G., Kling, G. and Miller , M.C. 2005. Long-term response and recovery to nutrient addition of a partitioned arctic lake. Freshwater Biology 50: 731-741.

Rosenberg, D.M., I.J. Davies, D.G. Cobb, and A.P. Wiens. 2001. Protocols for measuring biodiversity: benthic macroinvertebrates in fresh waters. Ecological Monitoring and Assessment Network (EMAN), Environment Canada. Available at: http://www.eman-rese.ca/eman/ecotools/protocols/freshwater/benthics/intro.html. Accessed 2006.

Schindler, D.W., Kalff, J., Welch, H.E., Brunskill, G.J., Kling, H. and Kritsch N. 1974. Eutrophication in the High Arctic- Meretta Lake, Cornwallis Island (75 ^{0} N Lat.). J. Fish. Res. Bd. Can. 31:647-662.

Welch, H. E., Legault, J.A., Kling, H. 1989. Phytoplanton, nutrients and primary production in fertilized and natural lakes at Saqvaqjuac, N.W.T. Can. J. Fish. Aquat. Sci. 46:90-107.

Zajdlik & Associates Inc. 2005. Review of DDMI baseline data set. Prepared for B. Blais and N. Richea, DIAND, by Zajdlik & Associates Inc., September 27, 2005.

APPENDIX A REGULATORY REQUIREMENTS

A.1 AMMENDED WATER LICENCE N7L2-1645, MAY 2004

The following are excerpts from the amended Water Licence N7L2-1645 issued in May 2004 that pertain to the AEMP.

PART K: CONDITIONS APPLYING TO THE AQUATIC EFFECTS MONITORING

1. The Licensee shall conduct sampling during the 2000 field season as proposed in the initial Aquatic Effect Monitoring (AEM) program as submitted in the Water License Application.

2. The Licensee shall provide to the Board, within sixty (60) days of issuance of this License, a compilation and evaluation of the adequacy of existing aquatic baseline information. The additional baseline information required to support an effective AEM program shall also be identified. This compilation shall be developed in accordance with Schedule 4, Item 1.

3. The Licensee shall address any deficiencies of the submissions made under Part K, Item 2 as directed by the Board.

4. The Licensee shall submit to the Board for approval, within ninety (90) days of the issuance of this License, a report that interprets the existing baseline information and provides a comprehensive, integrated description of the limnology and aquatic ecology of Lac de Gras. This compilation shall be developed in accordance with Schedule 4, Item 2.

5. The Licensee shall address any deficiencies in the submissions made under Part K, Item 4 as directed by the Board.

6. The Licensee shall submit to the Board for approval within six (6) months of issuance of this License, a Plan for conducting a revised AEM program designed to determine the short and long-term effects in the aquatic environment resulting from the Project, test impact predictions, measure the performance of operations and evaluate the effectiveness of impact mitigation.

7. The AEM program shall include, but not necessarily be limited to, the following:

   a) clear identifiable objectives of the program;

   b) a description of the area to be monitored that including maps depicting all sampling and control sites, as well as the overall predicted zones of influence of the Project;

   c) a description of the sampling program that will be conducted throughout the term of the License to achieve the objectives of the AEM program including: the variables, sample media, monitoring protocols and Quality Assurance/Quality Control (QA/QC) procedures. The QA/QC procedures must ensure that any future changes in monitoring protocols will be calibrated to initial monitoring protocols and data sets so that continuity, consistency, validity, and applicability of monitoring results will be maintained. This program shall also explicitly describe the measures that will be taken to identify and address any information deficiencies.

Diavik Diamond Mines Inc. N7L2-1645, amended May 2004 Page 24 of 30

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

e) a description of procedures that will be used to analyze and interpret the data collected in reference to the results of the QA/QC program;

f) a description of the approaches to be used to annually evaluate and adjust the AEM program;

g) a description of how the results of the AEM program will be incorporated in the overall adaptive environmental management strategies employed by the Licensee, and how data will be used to identify the need for additional mitigation strategies to minimize the impacts of the project;

h) a process for measuring Project-related effects in:

   i) water quality;

   ii) sediment quality;

   iii) phytoplankton, periphyton, zooplankton and benthic invertebrate

   iv) communities;

   v) fish, including contaminant levels (e.g.: mercury) in fish tissues, indicators of fish health and fish community status; and

   vi) other ecosystem components as may be required by the Board.

i) Specific Effects Studies (SES's) that shall include but not necessarily be limited to the following:

   i) in-situ evaluation of metal leaching and releases of explosives residues from the Water Retention Dikes;

   ii) delineation study of any plume(s) from the main effluent discharge;

   iii) characterization of the toxicity of the effluent source waters;

   iv) validation of nutrient input predictions for Lac de Gras;

   v) evaluation of the effects of dredging, dike construction, and associated sediment plume(s) on water quality and biota;

   vi) evaluation of contaminant loading and the fate of contaminants in Lac de Gras;

   vii) an evaluation of various eutrophication monitoring tools that may be

   viii) used to evaluate the effects of nutrient releases to Lac de Gras;

   ix) an evaluation of the effects of nutrient releases on the algal, benthos, and zooplankton communities and trophic status of Lac de Gras; and

   x) a site-specific evaluation of the impacts of cadmium on the waters of Lac de Gras;

j) an evaluation of the project-related cumulative effects of multiple stressors on the aquatic environment of Lac de Gras;

Diavik Diamond Mines Inc. N7L2-1645, amended May 2004 Page 25 of 30

k) an evaluation of the contaminant loads associated with dust deposition and its effects on the aquatic environments;

l) the establishment of appropriate control sites in Lac de Gras or nearby lake systems to support an evaluation of project impacts. These control sites should be located outside the zone of influence of mining operations, mineral exploration or any other disturbance activities to provide the necessary information on natural background conditions that includes:

   i) a detailed rationale for site selection, including examination of alternative approaches for establishing the control site(s);

   ii) an evaluation of the adequacy of baseline data for representing pre-development conditions at the control site(s); and

   iii) an appraisal of the adequacy of each site.

m) the establishment of sufficient and appropriate monitoring sites within the predicted zones of influence which shall include, but not necessarily be limited to, the following:

   i) sites at appropriate intervals from the source of influence to a point one (1) kilometer from the source of influence;

   ii) sites along the perimeter of East Island, including the channel between the East and West Islands;

   iii) far field sites, including deeper basins;

   iv) Lac de Gras at or near the outflow to the Coppermine River;

   v) Lac de Gras at or near the Lac du Sauvage narrows; and

   vi) any additional sites necessary to evaluate the spatial extent of impacts associated with the Project, and/or as predicted in the environmental assessment.

8. The Licensee shall prepare a Status Report for each of the Special Effects Studies identified under Part K, Item 7(i). The Status Report will include schedules for completion of any studies not yet completed under Part K, Item 7(i). This status report shall be submitted to the Board for approval within one (1) month of amendment issuance.

9. The Licensee shall submit to the Board for approval within one (1) month of amendment issuance, reports for all studies completed under Part K, Item 7(i).

10. If the AEM program is not approved by the Board, the Licensee shall resubmit a revised plan within thirty (30) days of notification.

11. The Licensee shall implement the AEM program as and when approved by the Board.

12. The Licensee shall submit to the Board on a annual basis the following information:

    a) a summary of activities conducted under the AEM program;

Diavik Diamond Mines Inc. N7L2-1645, amended May 2004 Page 26 of 30

b) tabular summaries of all data and information generated under the AEM program in an electronic and printed format acceptable to the Board;

c) an interpretation of the results;

d) an evaluation of any identified environmental changes relative to baseline conditions that occurred as a result of the Project;

e) an evaluation of the overall effectiveness of the AEM program to date;

f) recommendations for refining the AEM program to improve its effectiveness as required; and

g) each AEM program annual report shall include, a summary of the significant results of the AEM program from the project inception, term effects of the Project, and of the actual effects of the Project to date, in comparison to the predicted impacts.

13. The Licensee shall review and update the AEM program of each year by March 31st.

Diavik Diamond Mines Inc. N7L2-1645, amended May 2004 Page 27 of 30

A.2 ENVIRONMENTAL AGREEMENT - ENVIRONMENTAL MONITORING PROGRAMS

ARTICLE VII

ENVIRONMENTAL MONITORING PROGRAMS

7.1 PROVISION OF ENVIRONMENTAL MONITORING PROGRAMS

DDMI shall undertake compliance and environmental effects monitoring of the Project through the Environmental Monitoring Programs. DDMI shall provide the Parties, the Government of Nunavut, and the Advisory Board (when established) with copies of its Environmental Monitoring Programs. The Environmental Monitoring Programs contemplated by this Article shall be reviewed in accordance with Article 7.5 of this Agreement. The Environmental Monitoring Programs shall be revised on an ongoing basis as necessary and where appropriate in response to changing circumstances and additional information.

The Environmental Monitoring Programs shall include activities designed to:

(a) meet the monitoring requirements of all Regulatory Instruments;
(b) verify the accuracy of the environmental assessment of the Project;
(c) determine the effectiveness of measures taken to mitigate any adverse environmental effects of the Project;
(d) consider traditional knowledge;
(e) establish or confirm thresholds or early warning signs;
(f) trigger action by adaptive mitigation measures where appropriate;
(g) provide opportunities for the involvement or active participation of each of the Aboriginal Peoples in the implementation of the monitoring programs; and
(h) provide training opportunities for each of the Aboriginal Peoples.

7.2 ENVIRONMENTAL MONITORING COMPONENTS

The Environmental Monitoring Programs shall include, but not necessarily be limited to, the following programs:

(a) An Environmental Air Quality Monitoring Program;
(b) A Wildlife/Vegetation Monitoring Program;
(c) An Aquatic Effects Monitoring Program;
(d) A Geotechnical Monitoring Program;
(e) An Operational Health and Safety Program (limited to effects on human health resulting from environmental changes); and
(f) Other specific environmental monitoring programs as required under territorial or federal legislation or as required in the CSR.

7.3 The Environmental Monitoring Programs will include the identification of monitoring objectives and the monitoring programs outlined in DDMI's Commitments and in the conclusions of the Responsible Authorities documented in the CSR. DDMI shall adapt or revise the Environmental Monitoring Programs in accordance with the principles of adaptive environmental management.

7.4 MONITORING DATA AND RESULTS

(a) DDMI shall deliver monitoring data and information to the Parties, the Government of Nunavut, and the Advisory Board in time-frames and in formats developed in Consultation with the Advisory Board.

(b) The formats for submission of monitoring program results and analysis shall not be inconsistent with reporting requirements established under legislation, regulations and Regulatory Instruments and the requirements of such legislation, regulations and Regulatory Instruments shall apply to the extent of any inconsistency.

(c) Reporting dates will be established to conform with the requirements of the appropriate Regulatory Instruments.

(d) DDMI shall carry out the monitoring in a manner which will provide data consistent with any cumulative effects monitoring programs and shall Consult and co-operate with the regulatory agencies undertaking such programs, as appropriate.

7.5 REVIEW OF ENVIRONMENTAL MONITORING PROGRAMS

(a) In the event that, at any time, the Minister, on his/her own initiative, or in response to a request of any Party or the Advisory Board, and after Consultation with DDMI, determines that an Environmental Monitoring Program is inadequate or incomplete, including with respect to a matter under Article 7.4, the Minister may provide DDMI with a Minister's Report and DDMI shall forthwith, but in any event within sixty (60) days of receipt of the Minister's Report, provide:

(i) the Minister with revisions to the Environmental Monitoring Program which address to the Minister's satisfaction the deficiencies described in the Minister's Report;

(ii) a replacement Environmental Monitoring Program which addresses to the Minister's satisfaction the deficiencies described in the Minister's Report; or

(iii) specific replies to the deficiencies described in the Minister's Report and DDMI's detailed explanation, to the Minister's satisfaction, as to why, in DDMI's view, the Environmental Monitoring Program need not be revised or replaced to deal with the deficiencies outlined in the Minister's Report.

(b) In relation to matters substantially within the jurisdiction of the GNWT, the Minister shall provide DDMI with a Minister's Report pursuant to Article 7.5(a) when the Minister receives a request from the GNWT pursuant to that Article and the GNWT's request shall be included in the Minister's Report.

(c) The Minister may provide DDMI with an extension of time where DDMI is bona fide delayed in complying with this section.

7.6 ABORIGINAL COMMUNITY INVOLVEMENT

In addition to the participation of Aboriginal Peoples in the review of Environmental Management Plans and Environmental Monitoring Programs through participation on the Advisory Board and its activities, and the resulting capacity building, DDMI shall use its best efforts to:

(a) provide for the involvement of members of each of the Aboriginal Peoples in Environmental Monitoring Program design and implementation;

APPENDIX B 2005 AEMP SAMPLING SITES

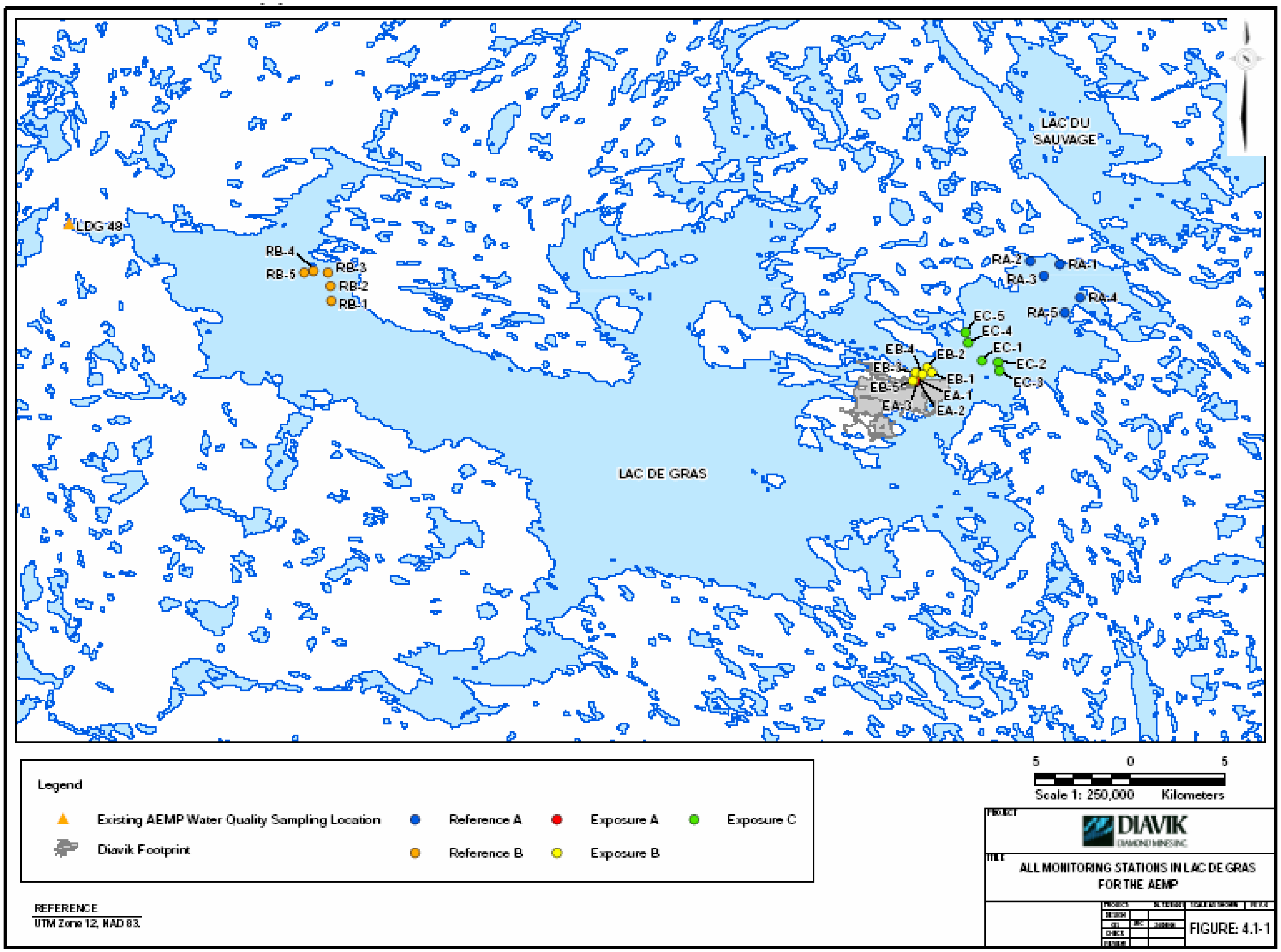


Figure B-1 DDMI 2006 AEMP sampling locations (from DDMI 2006).

APPENDIX C 2001-2004 AEMP SAMPLING SITES

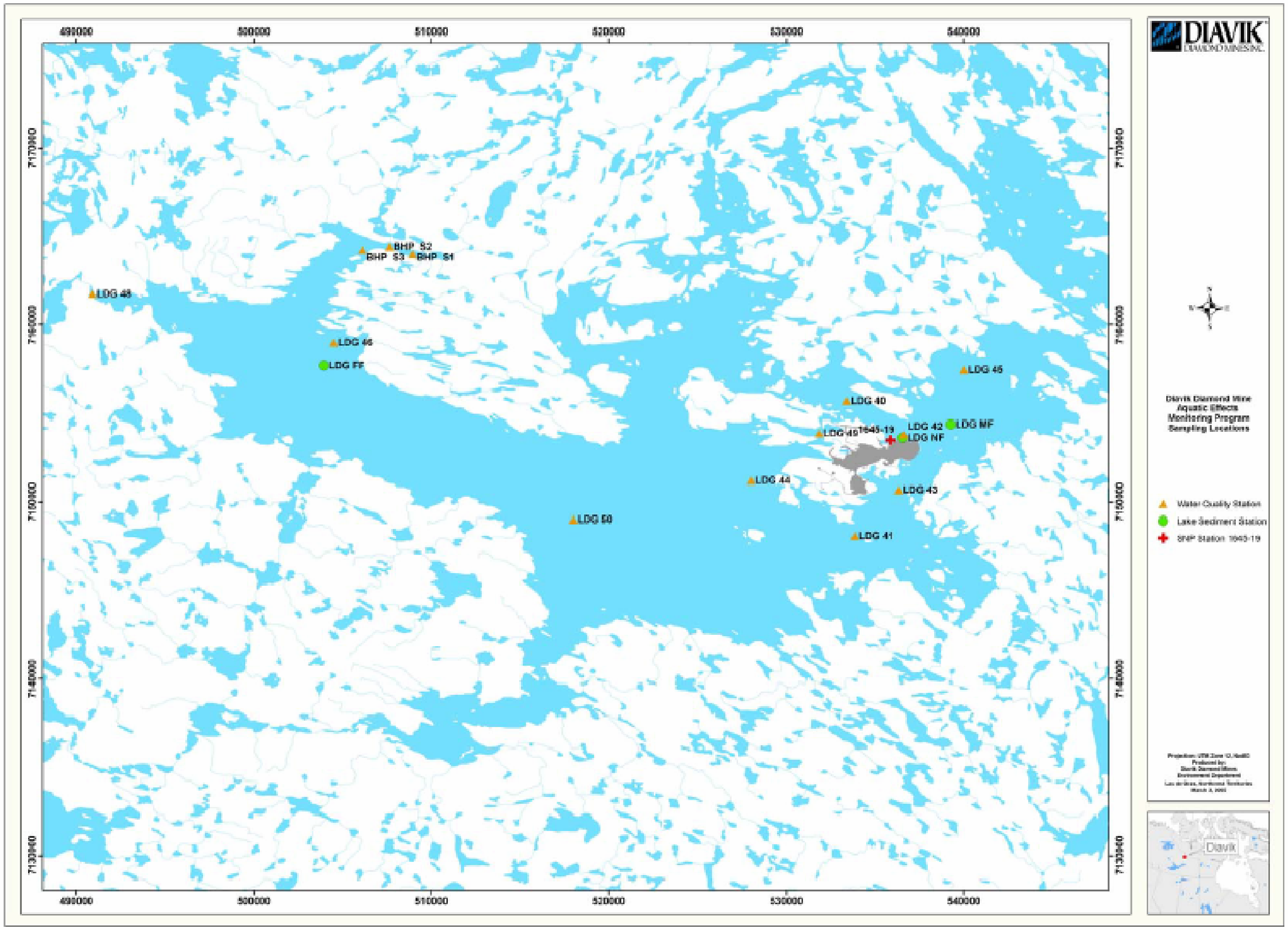


Figure C-1 DDMI AEMP water and sediment quality sampling locations and SNP monitoring stations (from DDMI 2005a).

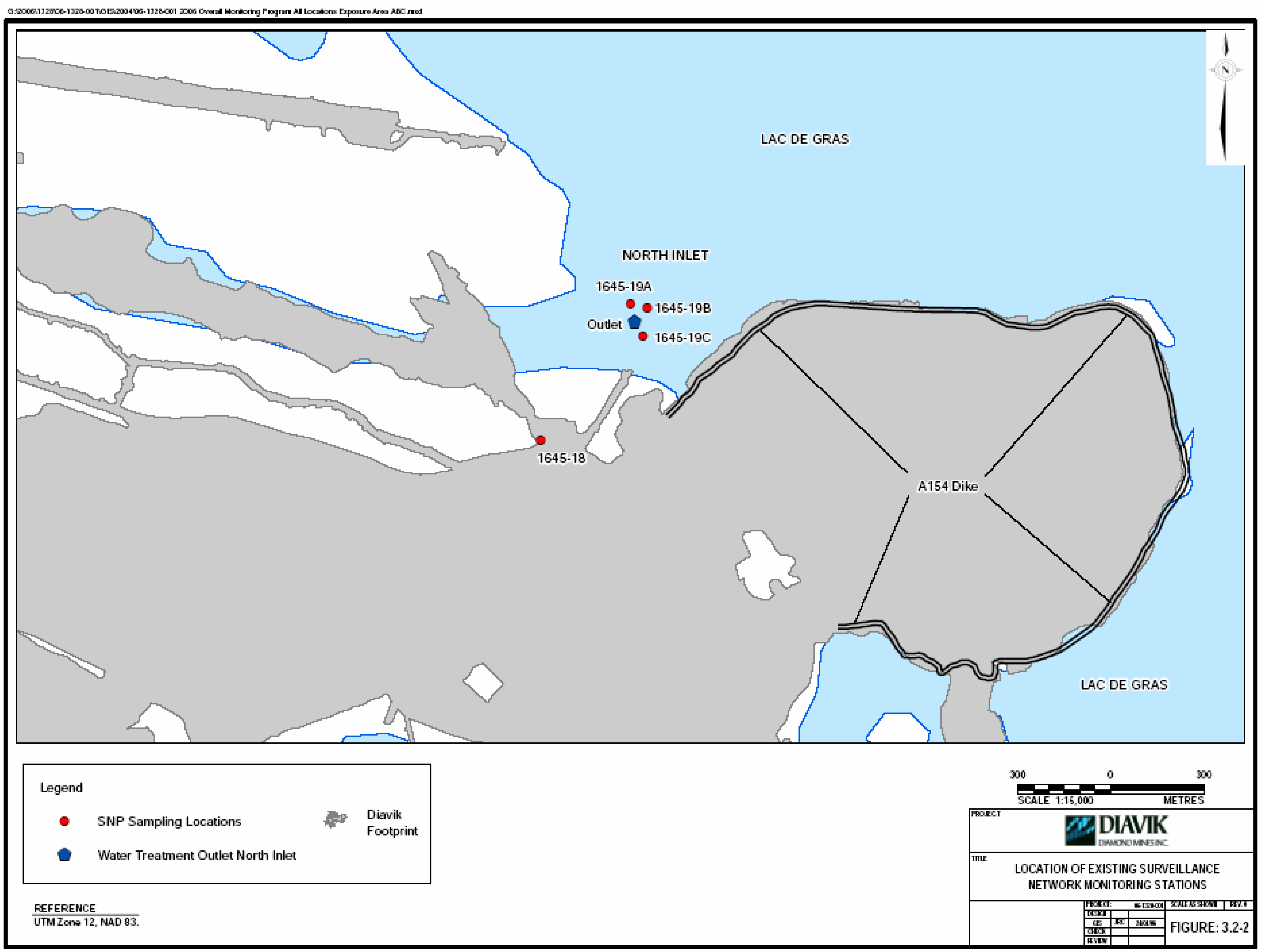
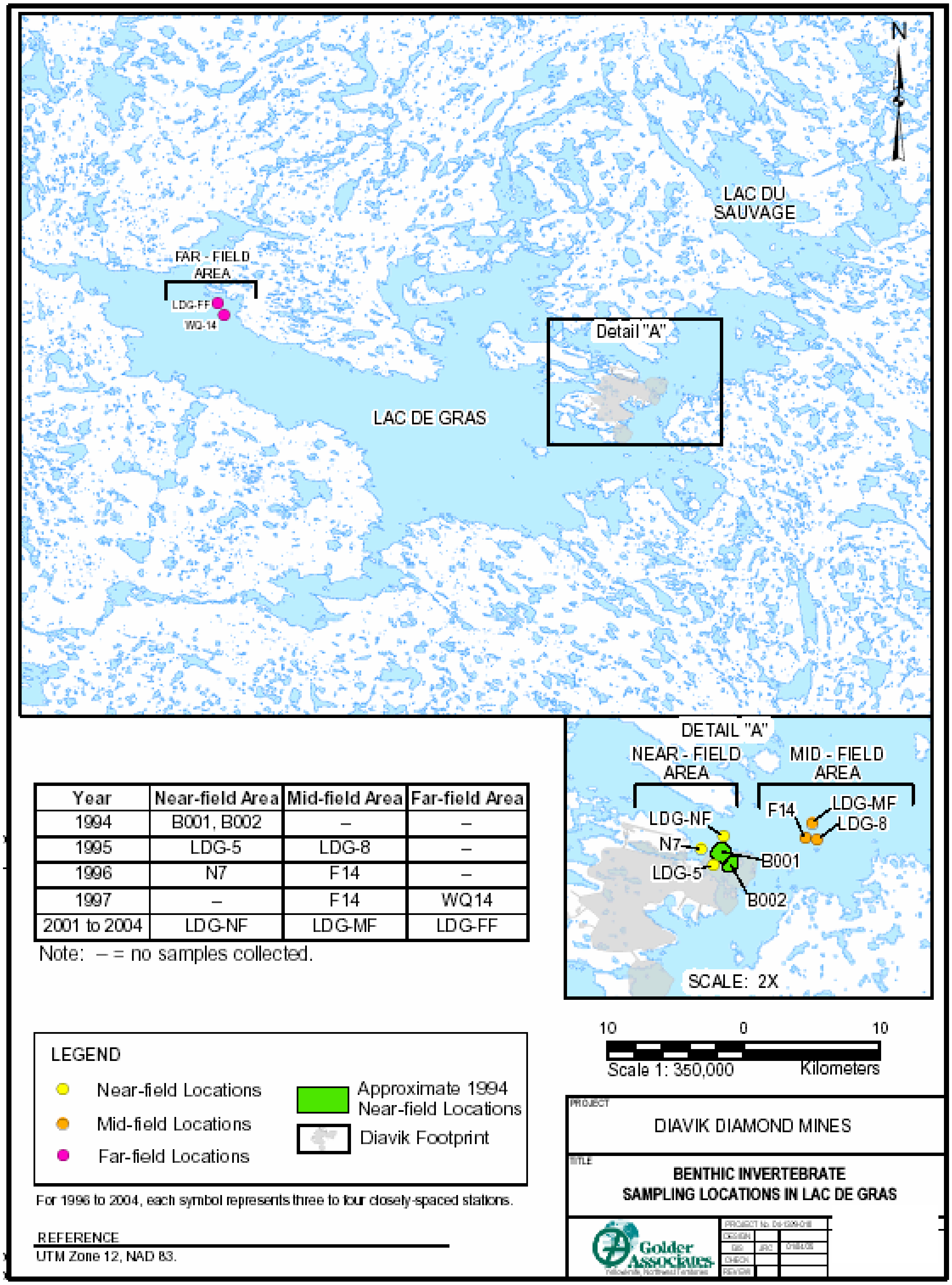


Figure C-2 DDMI SNP monitoring stations (from DDMI 2006).



Year	Near-field Area	Mid-field Area	Far-field Area
1994	B001, B002	–	–
1995	LDG-5	LDG-8	–
1996	N7	F14	–
1997	–	F14	WQ14
2001 to 2004	LDG-NF	LDG-MF	LDG-FF

Note: – = no samples collected.

Figure C-3 DDMI AEMP benthic Invertebrate sampling locations (from Golder 2005).