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Technical Memorandum

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Project: Environmental Consulting Services to
Environmental Monitoring Advisory
Board (for the Diavik mine)

Subject: Review of DDMI's Proposed 2011
Aquatic Environment Monitoring
Program (AEMP)

REVIEW OF DDMI'S PROPOSED 2011 AEMP

1.0 APPROACH TO THE REVIEW

To aid in the review of the Diavik Diamond Mines Inc. (DDMI) letter proposal for 2011 monitoring (DDMI 2011), North/South Consultants Inc. (North/South) referred to the following documents:

- Territorial Water Licence W2007L2-003, Part K;
- DDMI 2007 AEMP Design Document (DDMI 2008);
- DDMI 2010 AEMP Annual Report, non-technical summary (DDMI 2011); and,
- Federal Environmental Effects Monitoring (EEM) program documents, specifically technical guidance for Metal Mining EEM (Environment Canada 2002).

The following excerpts are taken from the 2007 AEMP Design Document (DDMI 2008) and used as a reference for subsequent review comments.

p. 445 – *"After the initial three years of monitoring, the data for each component will be evaluated to determine whether early warning/low effect levels have been reached. Frequency and intensity of subsequent monitoring will depend on this assessment. If early warning/low (or higher) effect levels are reached, then intensive monitoring will continue at an annual frequency*



until there are sufficient data to indicate that those effects are no longer apparent for a given AEMP component. If three years of monitoring does not indicate the presence of early warning/low effects, monitoring frequency will be reduced to once every three years for biological components (except chlorophyll a) and intensity will be reduced to that of basic monitoring (Table 4.4-1). However, even if no early warning/low effects are found, water quality monitoring will continue at an annual frequency at the mixing zone boundary and in the NF and FF/Ref areas (number of stations to be determined after the initial three years of monitoring) to retain the ability of detecting early warning/low level effects by the component that has the greatest early warning potential. Under basic monitoring, biological components will be monitored at the frequency of once every three years.

Figure 4.3-11 (p. 431) – After the initial yearly monitoring (first three years), moderate or high level effects (mine-related) trigger Intensive Monitoring; early warning change/low level effects that are mine-related also trigger Intensive Monitoring.

Table 4.4-1 (p. 443-444) – During the initial three years, all components were monitored annually, with the exception of fish palatability-large bodied fish tissue chemistry, fish tissue chemistry-small bodied fish, and fish health (all to be done one year of the three). Under Intensive Monitoring, all components are to be monitored annually, with the exception of sediment quality (once every two years), fish palatability-large bodied fish tissue chemistry (once every two years), fish tissue chemistry-small bodied fish (once every two years), and fish health (once every three years [lethal]; once every two years [non-lethal]).

Note: The DDMI letter proposal refers to completing the initial four years of intensive monitoring following the approved 2007 AEMP Design Document. However, the Wek'èezhìi Land and Water Board (WLWB) concluded that 2007 could not be considered as the first of the initial three years of intensive monitoring, as defined in Section 4 of the approved AEMP Design Document, due to incomplete sampling in the 2007 open-water field season (WLWB 2008). Although 2007 data may be used in the overall synthesis of monitoring information, 2008 was to be considered as year 1 in all references to the initial three years of monitoring in the current AEMP Design Document.



2.0 REVIEW OF DDMI'S PROPOSAL FOR 2011 MONITORING

2.1 ICE COVER PROGRAM

2.1.1 Proposed 2011 Program

- No change from current program.

2.1.1.1 Comments

- 'Ice Cover Program' does not detail specific components.

2.1.1.2 Recommendations

- Specify ice cover program components. Will the 2011 program include snow core, snow quality, and dust gauge (conducted throughout the year) sampling?
- 2007 AEMP Design Document (DDMI 2008) stipulates annual monitoring after initial three years (for Basic and Intensive frequencies); therefore, the snow and dust gauge monitoring should be continued in 2011 (regardless of 2010 AEMP results).

2.2 OPEN WATER PROGRAM

2.2.1 Eutrophication Indicators

- No change from current program proposed for 2011:

"... three open water season measures of nutrients, chlorophyll a and zooplankton biomass – unchanged from current program. The upcoming design review will determine if this monitoring can be optimized to fewer sampling periods, but given that enrichment is the primary aquatic effect that has been measured and that these indicators are good early warning measures, it seems prudent to continue in the interim at this intensity."

2.2.2 Sediment quality

- No monitoring proposed for 2011:

"Results to date have been consistent and it is possible that annual monitoring of sediment quality will not be necessary moving forward. Sediment quality changes are more likely to be trailing indicators of aquatic effects. The design review will consider the appropriate frequency for sediment quality monitoring. Additional 2011 results are not required."



2.2.2.1 2010 AEMP Results

- Calcium, potassium, and sodium = early warning/low level effect.
- There are no CCME sediment quality guidelines for these parameters.
- Lead = moderate level effect (however, lowest sediment quality guideline available [from Ontario = lowest effect level] is 31 mg/kg dw compared to a maximum 16.6 mg/kg dw measured in 2010 AEMP).
- Bismuth and uranium = high level effect (however, literature suggests a uranium no-effect level for freshwater benthos of 100 mg/kg dw compared to maximum of 21 mg/kg dw in NF measured in 2010; no available benchmarks for bismuth).
- Total organic carbon (TOC) = no effect.
- Sediment quality variables compared with effects guidelines (benchmarks) either remained below guidelines and/or were present at concentrations in the NF within the range found in reference areas.

2.2.2.2 Comments

- AEMP Design Document: Table 4.4-1 – Intensive Monitoring frequency once every two years for sediment quality.
- We agree with DDMI that the toxicity effects on benthic biota from the sediments of concern (above) are limited.

2.2.2.3 Recommendations

- Based on the 2007 AEMP Design Document it is not necessary to monitor sediments in 2011. If Intensive Monitoring frequency is determined for sediments in the modified monitoring program (through further evaluation of the toxicity potential of sediments of concern), then sediment monitoring must be conducted in 2012.

2.2.3 Water chemistry

- One open-water sampling program proposed for 2011:

“AEMP water quality results have consistently shown low level changes in water quality. With the exception of nutrients, which are addressed in eutrophication indicators, the water chemistry results do not indicate effects on the Lac de Gras aquatic ecosystem. SNP monitoring of the effluent (1645-18) and mixing zone boundary (1645-19) provide the best early warning indicator of changes to water chemistry and this monitoring continues at a fixed high frequency. The design review will consider the necessary



frequency of AEMP water chemistry monitoring. Additional open-water results for 2011 are not required.”

2.2.3.1 2010 AEMP Results

- A mine-related, low level effect was observed for water quality; specifically: TDS; ammonia; chloride; aluminum; arsenic; molybdenum; manganese; copper; uranium; calcium; magnesium; potassium; sulphate; strontium; alkalinity; and iron.

2.2.3.2 Comments

- After initial AEMP monitoring, water quality sampling outside mixing zone was to be reduced from three open-water and one ice-cover sampling periods to one open-water and one ice-cover sampling periods.
- AEMP Design Document: Table 4.4-1 – Intensive Monitoring frequency is annually for conventional, metals, and nutrients (NP, MF, FF/Ref).

2.2.3.3 Recommendations

- Based on the observed low level effects rating for water quality, Intensive Monitoring at NF, MF, and FF/Ref is recommended for 2011.
- Sampling should be conducted seasonally (three open-water and one ice-cover sampling periods), similar to eutrophication indicators sampling. Sampling should be conducted seasonally since the reduction to one open-water season has not yet been evaluated (e.g., in light of second diffuser to accommodate expanded NIWTP increasing the monthly discharge volume to Lac de Gras for some months).

2.2.4 Benthic invertebrates

- No monitoring proposed for 2011:

“Effects on benthic invertebrates have been well defined over the last four years and it is possible that the monitoring frequency can be reduced in the future. The design review will consider the frequency for confirmatory monitoring. Additional 2011 results are not required.”

2.2.4.1 2010 AEMP Results

- Reference areas versus exposure areas: early warning/low level effects were detected for richness, Bray-Curtis distance, and *Procladius* sp. density (= 3 of 12 variables measured); moderate level effects detected for total density, Pisidiidae density, *Heterotrissocladius* sp. density, and *Micropsectra* sp. density (= 4 of 12 variables).



- Gradient analysis: early-warning/low level effects were detected for total density, richness, evenness, Bray-Curtis distance, Pisidiidae density and *Heterotrissocladius* sp. density (= 6 of 12 variables); moderate level effects detected for *Procladius* sp. density (= 1 of 12 variables).
- The directions of these relationships were consistent with nutrient enrichment.

2.2.4.2 Comments

- Based on moderate level effects rating for benthic invertebrates, Intensive Monitoring is directed by the 2007 AEMP Design Document.
- AEMP Design Document: Table 4.4-1 – Intensive Monitoring frequency is annually for benthic invertebrates.
- AEMP Design Document: Table 4.4-1 – Intensive Monitoring frequency once every two years for sediment quality.
- Federal EEM technical guidance requires the integration of benthic invertebrate and sediment programs (Environment Canada 2002).

2.2.4.3 Recommendations

- An enrichment effect has been consistently evident in the benthic invertebrate community. Eutrophication indicators sampling and recommended water quality sampling will further delineate enrichment effects in 2011.
- 2007 AEMP Design Document (DDMI 2008) stipulates annual monitoring after initial three years (for Intensive frequency); therefore, benthic invertebrate monitoring should be continued in 2011 until a synthesis of the AEMP results and design review are presented for consideration.
- Although the 2007 Design Document stipulates annual benthic invertebrate monitoring under Intensive Monitoring, it is recommended that sampling the benthic invertebrate community concurrently with sediment quality be considered during the design review. This integration would allow for a more thorough evaluation of potential mine-related effects on the benthic invertebrate community. Sediment sampling would next occur in 2012 (if Intensive Monitoring is required for sediments) or 2013 (if Basic Monitoring is required), depending on the outcome of the AEMP design review scheduled to be completed by 30 September 2011.

2.2.5 Fish

- No monitoring proposed for 2011:



“Slimy sculpin were sampled in 2007 and 2010. No sampling was planned for 2011 due to potential effects of over sampling these fish populations. The next planned sampling is 2013, to be confirmed in the design review.”

2.2.5.1 2010 AEMP Results

- Early-warning/low level effects in slimy sculpin at both the NF and FF exposure areas for the fish population health study. Increased size, size-at-age and condition factor, suggests that there is nutrient enrichment occurring in these areas that increased the availability of food.
- Moderate-level effects seen in the slimy sculpin fish tissue chemistry for bismuth, strontium, titanium and uranium. DDMI concluded that there was no evidence that tissue metal concentrations were negatively impacting fish health.
- Mercury levels in slimy sculpin at the NF exposure site were lower than previously reported for slimy sculpin captured in 2007 and 2005. The reason for the differences between the previous AEMP results for mercury and the 2010 results is unknown; however, a different analytical laboratory employing slightly different methods was used in 2010.

2.2.5.2 Comments

- The frequency of fish tissue chemistry (slimy sculpin) sampling in the 2007 AEMP Design Document is once every two years for Intensive Monitoring.
- The frequency of fish health sampling is once every three years [lethal] and once every two years [non-lethal] for Intensive Monitoring.

2.2.5.3 Recommendations

- According to the 2007 AEMP Design Document, small-bodied fish sampling is not required in 2011; however, sampling should be considered for 2012 rather than 2013.

2.3 OTHER

2.3.1 Plankton Special Effects Study (SES)

- The Plankton SES report was not included in the 2010 AEMP summary document.
- The 2010 SES report consists of 2009 phytoplankton and 2010 zooplankton results. When will 2010 phytoplankton results be available?
- This was a three year feasibility study that will be evaluated in 2011. No sampling is required in 2011 (if three years of phytoplankton sampling was completed in 2010).



I will be glad to discuss this review and our recommendations with you; please let me know if any clarifications are needed.

Sincerely,

Leanne Zrum
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MSc, PBIol, RPBio



3.0 REFERENCES

- Diavik Diamond Mines Inc. (DDMI). 2008. Diavik Diamond Mine Aquatic Effects Monitoring Program. AEMP Design Document. February 2008 Version.
- DDMI. 2011. Diavik Diamond Mine Aquatic Effects Monitoring Program. 2010 AEMP Annual Report. March 2011.
- Environment Canada. 2002. Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring.
- Territorial Water Licence W2007L2-003, Part K, amended July 2008.
- Wek'èezhii Land and Water Board (WLWB). 2008. June 9, 2008 letter to DDMI Re: Request for Modification to AEMP – Part K Item 9 – W2007L2-0003.