Appendix F

Lake Sedimentation Monitoring Program

Mary River Project

June 2014

Aquatic Effects Monitoring Program:

Lake Sedimentation Monitoring Program

North/South Consultants Inc.
Aquatic Environment Specialists

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Prepared by

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For

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LIST OF ABBREVIATIONS

AEMP	Aquatic Effects Monitoring Program
BIM	Baffinland Iron Mines Corporation
BMI	Benthic macroinvertebrate(s)
DFO	Department of Fisheries and Oceans
ERP	Early Revenue Phase
FEIS	Final Environmental Impact Statements
NSC	North/South Consultants Inc.
QA/QC	Quality assurance/quality control
TSS	Total suspended solids
UTM	Universal Transverse Mercator

1.0 INTRODUCTION AND BACKGROUND

The Mary River Project is expected to result in increased sediment deposition in Mine Area waterbodies, including lakes, due to dust deposition and potentially due to introduction of suspended solids from various activities (e.g., wastewater discharges). Dust will be directly deposited on watercourses during the open-water season and on snow and ice during the winter. Dust will be indirectly introduced from runoff within the watersheds which will likely be greatest during the snowmelt/freshet period.

Potential effects of dust on aquatic ecosystems include effects on water quality (i.e., total suspended solids [TSS], metals, nutrients, water clarity) when suspended in the water column and effects once deposited on the lake bottom or streambed. Sedimentation of dust in lakes and streams may affect aquatic biota through changes in sediment quality (e., metals, nutrients, particle size, organic matter), through changes in habitat quality (i.e., changes in substrate composition), direct effects on benthic macroinvertebrates (BMI; i.e., smothering), and direct effects on fish eggs (i.e., smothering of eggs).

Baffinland Iron Mines Corporation (BIM) proposed a targeted study, which was subsequently recommended by the Department of Fisheries and Oceans (DFO), to measure rates of sediment deposition in Mine Area lakes. The following describes the general background, approach, and methods for this targeted study to monitor sediment deposition in Mine Area lakes during Project operation as part of the Aquatic Effects Monitoring Program (AEMP).

2.0 PATHWAYS OF EFFECT AND KEY QUESTIONS

The Project may affect sediment deposition in Mine Area lakes through airborne dust deposition and through introduction of suspended materials (i.e., TSS) to lakes via tributary streams and/or aqueous point or non-point sources. Potential pathways of effect on freshwater biota in lakes include:

- Increased sediment deposition in lakes may adversely affect BMI communities which may in turn affect Arctic Char populations;
- Increased sediment deposition in lakes may alter Arctic Char (*Salvelinus alpinus*) habitat, notably Arctic Char spawning habitat, through changes in substrate composition; and
- Increased sediment deposition in lakes during the Arctic Char egg incubation period (i.e., over winter) may adversely affect egg survival and hatching success.

The key question related to the pathways of effect is:

- What are the combined effects of point and non-point sources of suspended materials on sedimentation rates in Mine Area lakes?

The primary issue of concern in relation to Mine Area lakes is the potential effect of the Project on sediment deposition on Arctic Char eggs.

3.0 PARAMETERS

The key parameter that will be monitored under this special study is total sediment deposition, measured as total dry weight of sediment deposited in a known area over a known duration (i.e., $mg/cm^2/day$). Measurements will also allow for determination of the total mass of sediment deposited over the sampling period. Results of a baseline sampling program conducted over the open-water season of 2013 in Sheardown Lake NW indicate that sufficient volumes of sediment for laboratory analysis of total dry weight of sediment can be obtained during this period (North/South Consultants Inc. [NSC] 2014). Sediment deposition monitoring over the ice-cover season is ongoing and it is unknown whether sufficient volumes of sediments can be obtained from the lake over this period for reliable laboratory analysis. Results of the winter sedimentation program will be reviewed when available and details of this study may be modified in accordance.

If sufficient sample was collected in future lake sedimentation monitoring, bulk density would also be measured to facilitate estimates of total depth of sediment deposition in lakes (i.e., mm of sediment). However required volumes for these measurements were not realized in the open-water season of 2013 due to low rates of sedimentation (even with deployment of multiple traps and sample compositing) in the Mine Area. Therefore, it is anticipated that due to logistical restrictions, samples will only be analysed for total dry weight of sediment in the lake sedimentation monitoring program.

4.0 MONITORING AREA AND SAMPLING SITES

In the Mine Area, Arctic Char spawning habitat is restricted to lakes, as rivers and streams freeze solid in winter, and lakes provide the sole overwintering habitat for Arctic Char. The results of air quality modeling presented in the Final Environmental Impact Statement (FEIS) and the Addendum to the FEIS for the Early Revenue Phase (ERP), indicate that Sheardown Lake will experience the largest increases in sediment deposition of the Mine Area lakes. The lake sediment deposition special study is therefore focused on monitoring in Sheardown Lake NW. However, monitoring at additional Mine Area lakes may be undertaken in the future upon review of initial monitoring results collected during the ERP and/or during full production if increased effects (e.g., greater rates of dust deposition) are measured.

Increases in sedimentation rates may affect BMIs (through smothering and changes in substrate characteristics), Arctic Char habitat (notably spawning areas which are typically hard substrates), and/or Arctic Char eggs (through deposition on incubating eggs). Therefore the sampling sites will include a suspected Arctic Char spawning area, a shallow, soft substrate area, and a deep-water location. Collectively this information will provide information on sedimentation rates in

different habitat types in the lake. Sites sampled during baseline studies will be retained for operation monitoring. A brief description of these sites is provided below.

Specific spawning sites have not been identified within Sheardown Lake NW and the FEIS conservatively assumed that areas of hard substrate at water depths ranging from 2-12 m in the lakes could potentially provide spawning habitat. One area in Sheardown Lake NW best matched these criteria and was selected for sediment trap deployment in 2013 to represent potential Arctic Char spawning habitat (Figure 1). A second sampling site was selected at a similar depth range (2-12 m), but with a soft substrate for comparison. A third sampling site was selected near the deepest point in the lake as these areas are typically the ultimate depositional areas in lakes and because sampling the profundal zone (i.e., depth > 12 m) would provide a measure of a dominant aquatic habitat type.

5.0 SAMPLING FREQUENCY AND SCHEDULE

Sediment traps will be deployed year-round in Sheardown Lake NW but will be retrieved and emptied in late summer/fall prior to freeze up and again in spring following ice breakup on the lake. This will provide a means for quantifying annual deposition rates in the lake as well as rates associated with the open-water and ice-cover seasons.

Baseline studies are on-going and will continue into fall 2014. Monitoring during Project operation will commence this fall and will continue for three years, following which a review of the program and results will be undertaken to advise on monitoring during full production.

6.0 FIELD AND LABORATORY METHODS

Sedimentation rates will be measured through deployment of sediment traps with an aspect ratio of > 5:1 as recommended for cylindrical sediment traps (Mudroch and MacKnight 1994). Traps will be anchored such that the trap is suspended off the bottom and secured with a buoy.

Five replicate traps (i.e., subsamples) will be deployed within close proximity at each of the three sites. The number of replicates may be modified pending the results of the ongoing baseline studies and initial results of monitoring during operation. Total water depth, substrate, date, time, and universal transverse mercator units (UTMs) will be recorded at each site.

Traps will be retrieved and emptied in late summer/fall and in spring following breakup. Trap contents will be transferred to sample bottles, kept cool and in the dark and transported to an analytical laboratory for analysis.

Samples will be analysed by filtering samples, which includes sediments and water, through a pre-weighed 0.70 µm glass fibre filter, rinsing the filter apparatus and container three times, and drying the filter at 105 ^{o}C for two hours. Samples are then allowed to cool for one hour and weighed.

7.0 QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance/quality control (QA/QC) measures will include verifications that sediments are not disturbed (i.e., resuspended) during sediment deployment and retrieval and inclusion of sample replicates to measure variability.

8.0 STUDY DESIGN AND DATA ANALYSIS

As the objective of this study is to monitor rates of sediment deposition in Mine Area lakes as it may affect BMIs, habitat, and Arctic Char eggs, the study is designed to provide measures of sediment deposition on a seasonal (i.e., open-water vs. ice-cover season) basis. Rates will be measured through deployment of sediment traps in Sheardown Lake NW year-round, but with retrieval of samples at the end of the open-water and ice-cover seasons to provide measures for both periods. This will facilitate examination of sedimentation rates during the Arctic Char incubation period as well as during the growing season in Sheardown Lake NW.

Measured sedimentation rates will be compared to effects predictions presented in the FEIS and the Addendum to the FEIS for the ERP, as well as to the effects threshold applied in the impact assessment (i.e., 1 mm of deposition on fish eggs). Sedimentation rates exceeding 1 mm during the egg incubation period have been identified as exerting adverse effects on fish eggs (e.g., Fudge and Bodaly 1984). The FEIS and Addendum to the FEIS indicated that sedimentation is not expected to exceed this threshold in Mine Area lakes.

The study is designed to compare results directly to the threshold rather than to demonstrate statistically significant differences. Therefore, true replicates for each habitat type are not included in the design of the monitoring program. Rather, replicates will be included to provide a measure of variability at each site (i.e., subsamples) and to provide additional contingency in the event that traps cannot be located and/or quantities of sediments collected in the traps are so low that sample compositing is required. As previously indicated, results of open-water season sampling completed in 2013 indicate that sufficient sediment volumes will likely be obtainable in the open-water season, however, it is unknown whether this can be attained for winter.

Results of the targeted study may also be compared to baseline data collected in 2013 and 2014 from Sheardown Lake NW to provide a means of identifying Project-related effects on this parameter.

This document was prepared, and the special study was designed, with baseline information available at the time of preparation of this report. It is noted that not all results of additional baseline sampling initiated in 2013 were available at the time of preparation of this report; upon receipt and analysis of these additional data, recommendations for modification to the special study may be made. Results of the baseline program completed in the open-water season of 2013 are presented in NSC (2014).

9.0 REFERENCES

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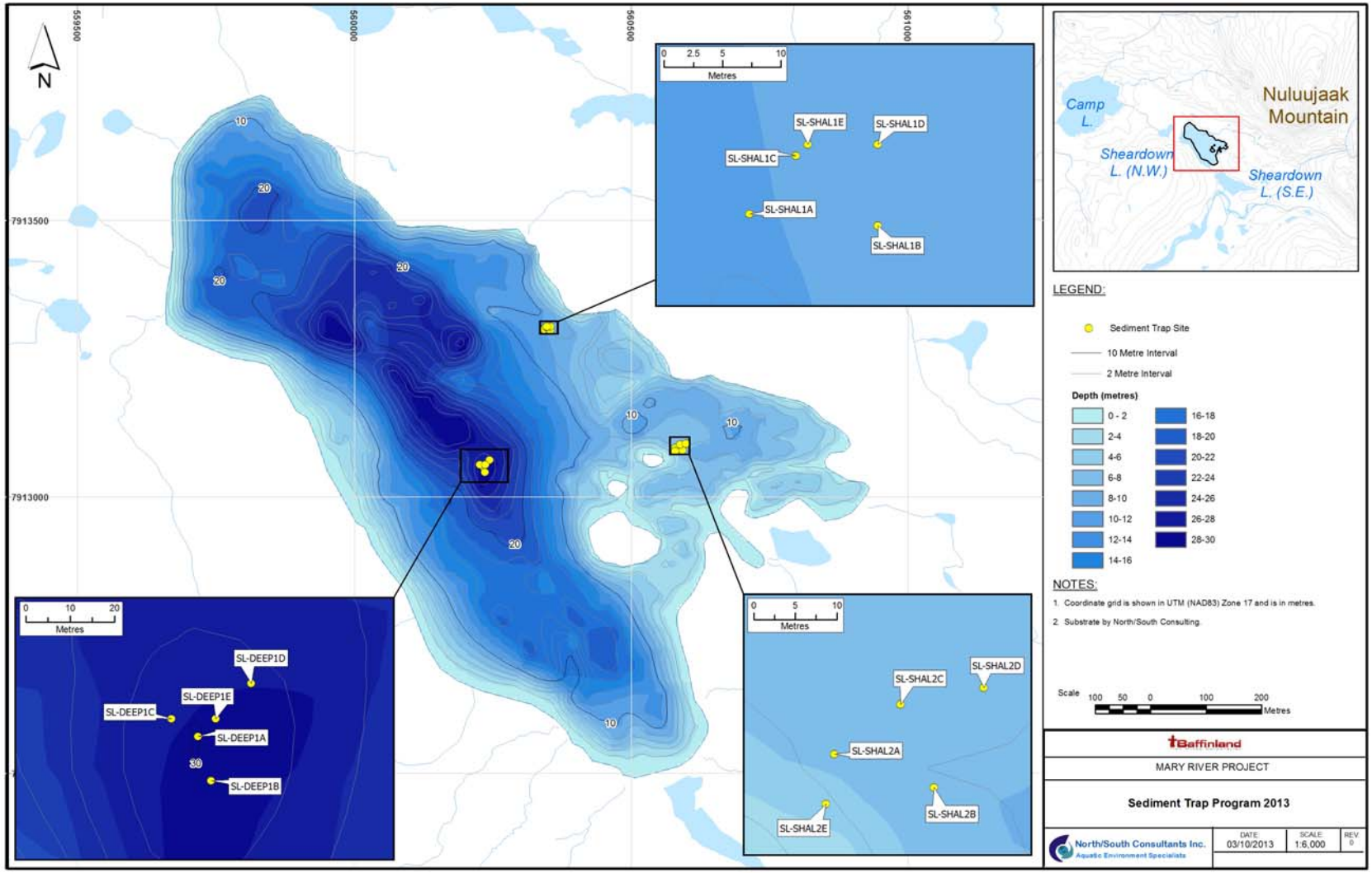

Figure 1. Sediment trap sampling sites in Sheardown Lake NW, 2013.