M E M O R A N D U M

TO:	Jenny Ferone, Environment Canada	**DATE:**	November 28, 2003
FROM:	Malcolm Stephenson, (JWEL)	**FILE:**	JWEL NBF15058
CC:	Bob Carreau, Breakwater Resources		
RE:	Outline of EEM Study Design for the Nanisivik Mine, Nunavut		

1.0 Introduction

This memorandum is intended to be a discussion document only. The purpose is to outline the requirements for an Environmental Effects Monitoring (EEM) Study at Nanisivik Mine, as required by the *Metal Mining Effluent Regulation* (*MMER*). The specific constraints on study design imposed by the environment at Nanisivik are also outlined, and a preliminary proposal is advanced to describe the scope of EEM studies that appear to be practical, and potentially in compliance with the *MMER*.

This memorandum, and the two supporting letters from JWEL referenced herein (JWEL 2003a, b) have been forwarded to the Environment Canada Authorization Officer and Technical Advisory Panel (TAP), in order that the general acceptability of this preliminary proposal can be informally considered. At this time, we would also like to request a conference call with the TAP, preferably during the first week of December, so that the general acceptability, or deficiencies, of the study design outlined herein can be discussed and resolved. It is our intent to submit a study design that will be acceptable to the TAP before the end of December 2003. We believe that the proposed dialogue will be constructive, and will simplify the regulatory review process when EEM Study Design document is formally submitted.

2.0 Background

All mines regulated under the *MMER*, as part of the *Fisheries Act*, are required to conduct periodic Environmental Effects Monitoring (EEM) studies as part of their authority to deposit effluent. Section 7 of the *MMER* obliges the mine to conduct EEM studies, submit reports within prescribed timelines, and use standards of good scientific practice to conduct studies and interpret results. Specifically, Section 7 states:

(1) The owner or operator of a mine shall conduct environmental effects monitoring studies of the potential effects of effluent on the fish population, on fish tissue and on the benthic invertebrate community in accordance with the requirements and within the periods set out in Schedule 5.
(2) The owner or operator shall record the results of the studies and submit the reports and required information to the authorization officer as set out in Schedule 5.
(3) The studies shall be performed and their results interpreted and reported on in accordance with generally accepted standards of good scientific practice at the time that the studies are performed.

A key assumption of Section 7 (1) is that there is a fish population in the area where effluent is deposited that can be affected by the effluent. In addition, Section 7 (3) requires that the studies shall be performed and interpreted in accordance with good scientific practice. That means that the studies should be carried out in the expectation of being able to establish a cause and effect relationship. If it is not possible to design a study that can scientifically evaluate potential effects on a fish population that is exposed to the effluent, then a fish study should not be required.

Nanisivik Mine provided notification of their intent to achieve recognized closed mine status to the Regional Director, Prairie and Northern Region, Environment Canada, on July 03, 2003. This notification results in the mine becoming subject to Part 4 of the *MMER*, dealing with Recognized Closed Mines. As described in Part 4 of the *MMER*, the mine is required to conduct a biological study during a three year period following the receipt of this notification by Environment Canada, in accordance with Division 3 of Part 2 of Schedule 5 of the *MMER*.

For Nanisivik Mine, there are potentially two effluent discharge points that would be subject to the *MMER*. These are:

- mine effluent discharge from the West Twin Lake tailings area into Twin Lakes Creek, also known as station 159-4; and
- the East Adit Treatment Facility.

Due to the shut-down of Nanisivik Mine, and mine closure activities that are ongoing, there was no discharge of mine effluent from the East Adit during 2002 or 2003, and it is not expected that there will be any discharge of mine effluent from this location in the future. Therefore, the EEM program will focus on the effluent discharged from the West Twin Lake tailings area. This would change if there was a plan to resume discharge of effluent from the East Adit Treatment Facility at some future time, in which case it is understood that monitoring of effluent quality and water quality would be required at this location, and at a suitable reference area.

Schedule 5 of the *MMER* provides definitions, and further interpretation of the requirements for EEM. In Schedule 5, an "effect on the fish population" is defined as a statistical difference between fish population measurements taken in an exposure area and a reference area. The "exposure area" is subsequently defined as all fish habitat and waters frequented by fish that are exposed to effluent. Since the area of Twin Lakes Creek downstream of the effluent discharge point from West Twin Lake is naturally fishless, no exposure area exists for fish at this location, although there is an exposure area for the benthic invertebrate community. The nearest place where there might be an exposure area for fish would be in the marine waters of Strathcona Sound, some 7.3 km downstream from the point of effluent discharge. However, as will be discussed below, it is not clear that a suitable scientific study can be designed at that location, due to confounding factors, and the physical behaviour of the freshwater plume in the marine environment.

Schedule 5 also describes the required studies that make up an EEM program under the *MMER*. These include:

- Effluent Characterization;
- Sublethal Toxicity Testing;

- Water Quality Monitoring; and
- Biological Studies.

The requirements of each of these components of the EEM study, as well as reporting requirements, are outlined in more detail below.

2.1 Effluent Characterization

Effluent characterization is conducted by analyzing samples of the effluent, four times per calendar year and not less than one month apart, with analysis for the following parameters (as a minimum):

- hardness and alkalinity
- aluminum;
- cadmium;
- iron;
- mercury (which may be discontinued if the concentration is less than 0.1 μg/L in 12 consecutive samples);
- molybdenum;
- ammonia; and
- nitrate.

At Nanisivik Mine, the Arctic environmental conditions dictate that it may not be possible to collect four effluent samples at monthly intervals. As a result, it is likely that three effluent samples will be collected each year, representing the months of July, August and September. For a Recognized Closed Mine, this effluent characterization program would continue for three years following the date of notification.

2.2 Sublethal Toxicity Testing

Sublethal toxicity testing can include either freshwater or marine tests, depending upon the nature of the effluent discharge zone. For Nanisivik Mine, where the effluent is discharged to a freshwater environment (Twin Lakes Creek), the appropriate tests include:

- fathead minnows (using method 1/RM/22);
- *Ceriodaphnia dubia* (using method 1/RM/21);
- duckweed (using method 1/RM/37); and
- freshwater algae (using method 1/RM/25).

Sublethal toxicity testing is to be carried out using a sample from the mine's final discharge point that has potentially the most adverse environmental impact, taking into account the mass loading of deleterious substances. For Nanisivik Mine, this would be the effluent discharge from the West Twin Lake tailings area. Sublethal toxicity testing is required to be conducted two times each calendar year for three years. Additional testing beyond that period would not be required in the case of a Recognized Closed Mine.

At Nanisivik Mine, it is anticipated that these samples would be collected in conjunction with water samples for acute toxicity testing. In 2003, the samples for acute toxicity testing were collected in August and September.

2.3 Water Quality Monitoring

Water quality monitoring involves collecting samples from the exposure area surrounding the point of entry of effluent into water from each final discharge point, and from suitable reference areas. Water quality monitoring is required four times per calendar year, and not less than one month apart. This monitoring requires the collection of the following data from exposure and reference areas:

- temperature and dissolved oxygen;
- pH, hardness and alkalinity;
- aluminum, cadmium, iron, mercury, molybdenum, ammonia and nitrate (from paragraph 4 of Schedule 5);
- arsenic, copper, cyanide, lead, nickel, zinc, total suspended solids, and radium 226 (from Column 1 of Schedule 4);

The schedule for this sampling must include the time periods when biological monitoring studies are carried out. In the event that fish population or benthic invertebrate studies are carried out at locations that are not in the same exposure area as that identified above, then water quality monitoring is also required at those locations, on the same schedule (four times each year, not less than one month apart). This monitoring would be required for a period of three years following notification that the mine intends to achieve recognized closed mine status.

2.4 Effluent and Water Quality Monitoring Report

A report on the effluent and water quality monitoring studies carried out during each calendar year must be submitted to the authorization office not later than March 31 of the following year. Since Nanisivik Mine has given notification (July 03, 2003) of its intention to achieve recognized closed mine status, this monitoring will be required during the 2003, 2004 and 2005 calendar years, with the last report to be submitted not later than March 31, 2006.

2.5 Biological Monitoring Studies

Three divisions of biological monitoring studies are identified in Schedule 5. These include:

- First biological monitoring studies;
- Subsequent biological monitoring studies; and
- Final biological monitoring study prior to closing mine.

Since Nanisivik Mine has provided to the authorization officer a notice its intent to achieve Recognized Closed Mine status under subsection 32(1) of the *MMER*, the mine is subject to the Final Biological Monitoring Study provisions of Division 3, Part 2 of Schedule 5.

The Final Study Design is required to include:

- site characterization information as outlined in Section 11 of Schedule 5;
- a description of how the fish population study will be conducted, if the effluent concentration in the exposure area is greater than 1% in the area located within 250 m of a final discharge point;
- a description of how the fish tissue study will be conducted, if the total mercury concentration in the final effluent is equal to or greater than 0.1 µg/L;
- a description of how the benthic invertebrate community study will be conducted;
- the dates and times that samples will be collected for the biological monitoring;
- a description of the quality assurance and quality control measures that will be implemented to ensure the validity of the data; and
- a summary of the results of any previous biological monitoring studies that were conducted after June 6, 2002 (the date of registration of the *MMER*) respecting the fish population, fish tissue, and the benthic invertebrate community.

3.0 Application of the *MMER* to Nanisivik Mine

3.1 Effluent and Water Quality Monitoring

The primary effluent discharge point for Nanisivik Mine is located at the outlet to the West Twin Lake tailings area. The only other effluent discharge point would be at the East Adit Treatment Facility, but there is no discharge anticipated at this location. Therefore, the study design will focus on the West Twin Lake effluent discharge point. However, it is recognized that in the event of discharge at the East Adit Treatment Facility, effluent quality and water quality monitoring would be required at this location.

Effluent from the West Twin Lake tailings area is discharged into Twin Lakes Creek. This discharge typically takes place during the months of June, July and August. In other months, there is no discharge, and during the winter, Twin Lakes Creek freezes completely. Therefore, the EEM study will be designed taking into account the fact that there are fewer than four months when discharge takes place. Effluent and water quality monitoring will begin in the same week that effluent discharge begins, and will continue on a monthly basis until effluent discharge ceases. Therefore, it is likely that there will be only three dates in any given calendar year when measurements of effluent quality and water quality are taken in accordance with the *MMER*. It is anticipated that these dates will be in mid-June, mid-July and mid-August each year.

Samples of the effluent will be collected at the effluent discharge weir (this location is also known as Station 159-4) and will be analyzed for the suite of substances required by the MMER, Schedule 5.

Samples of water from the receiving environment will be collected from:

- a reference site (Twin Lakes Creek upstream of the effluent discharge point);
- in the effluent mixing zone of Twin Lakes Creek, at ¼ and ¾ of the creek width, at a location 100 m downstream from the point of effluent discharge,
- at a downstream site on Twin Lakes Creek (also known as Station 159-9) where the creek waters and effluent are fully mixed but before the creek enters the mineralized zone; and

- at the mouth of Twin Lakes Creek, before entering the marine environment, at a station known as 159-6.

Quality assurance and quality control measures will include analysis of distilled water "travelling blank" samples, field duplicate samples, and laboratory duplicate analyses. All field measurements (such as pH and conductivity) will be made using instruments that are calibrated using appropriate standards, following the manufacturer's instructions. The calibrations will be documented.

3.2 Benthic Invertebrate Study

A benthic invertebrate study is practical and appropriate in Twin Lakes Creek. Samples collected by BC Research (1975) and by JWEL (2003) have documented the presence of a benthic invertebrate community in the creek. The community is of low diversity, abundance, and biomass, being composed mainly of small numbers of Chironomidae, and even smaller numbers of Tipulidae and other Diptera. The total number of invertebrates recovered from kick samples (0.25 mm mesh) having an area of 0.093 m^2, was typically less than 20 per sample.

It is proposed to collect benthic invertebrate samples (five replicates per station, each replicate being a composite of three subsamples) at the following stations:

- a reference site (Twin Lakes Creek 50 m upstream of the effluent discharge point, also known as Station 159-4B);
- in the effluent mixing zone of Twin Lakes Creek, at ¼ and ¾ of the creek width, at a location 50 m downstream from the point of effluent discharge (this station on the left bank of the creek is also known as Station 159-4A); and
- at a downstream site on Twin Lakes Creek (also known as Station 159-9) where the creek waters and effluent are fully mixed but before the creek enters the mineralized zone.

The benthic invertebrate samples will be collected in mid July, 2004. It is proposed to use a U-frame kick net having a mesh size of 0.25 mm for sampling. The samples will be processed in accordance with the guidance provided in the Metal Mining EEM Guidance Document. The selection of five replicate samples per sampling area is consistent with generic guidance for EEM studies, and provides statistical power of $\alpha = \beta = 0.01$ and Effect Size = 2 standard deviations.

The benthic invertebrate community data will be analyzed to provide the arithmetic mean, median, standard deviation, standard error, minimum and maximum values for the total benthic invertebrate density, Simpson's Diversity Index, taxa richness, and the Bray-Curtis index.

Due to the characteristics of substrates in both the reference and exposure areas (*i.e.*, a predominance of boulder and cobble substrate, with essentially no fines present, no aquatic vegetation, and essentially no terrestrial vegetation) it is not practical to measure the trace element concentrations, total organic carbon content or particle size distribution of sediments. Therefore, these measures will not be reported or recorded, although the nominal dimensions of cobbles and boulders at each sampling location will be recorded.

3.3 Fish Population Study

Twin Lakes Creek was described as a naturally fishless system by BC Research (1975), prior to the development of Nanisivik Mine, and remains fishless today. The creek has a high gradient, with a number of natural waterfalls that act as a barrier to access by fish. Since there are no fish present in the primary effluent mixing zone downstream of the West Twin Lake tailings area, it is not possible to conduct a fish population or fish tissue study at this location.

Twin Lakes Creek cuts through a naturally occurring zone of metal sulfide mineralization about half way down its length. Episodes of rain periodically wash high loadings of zinc, lead and acidity from this mineralized zone into the creek. As a result of these high metal loadings, which are substantially larger than the metal loadings from the mine effluent, the concentration of zinc at the creek mouth is usually elevated. In addition, raw sewage from the townsite is deposited into the creek at a location close to the former Mill. These two factors (high natural metal loadings and nutrient addition due to raw sewage discharge) are considered to be confounding factors that will make it impractical to evaluate the effects of mine effluent discharge on fish in the marine environment.

Adding to the confounding factors, the behaviour of the creek waters upon entering the marine environment also merits consideration. When visited in July 2003, the combination of melting sea ice and fresh water inflows resulted in the formation of a layer of fresh water on top of the marine water. The predominant species of fish in this area appears to be shorthorn sculpin (*Myxocephalus scorpius*), a bottom-dwelling species. As a result, marine fish will not be exposed to creek water containing the effluent, except at very high dilution. The same phenomenon has been observed at a number of pulp and paper mills that discharge effluent to the marine environment, and in many cases fish surveys were not required at these mills in EEM Cycles 1 and 2.

The marine intertidal environment at the mouth of Twin Lakes Creek was described by BC Research (1975) as being “barren”, prior to the mine development. The same condition was observed by JWEL during 2003. The absence of marine fauna in the intertidal zone may be attributable to the severe weather conditions in winter (which will rapidly freeze biota in the intertidal zone at low tide), or the heavy ice scouring that occurs each year. Therefore, sampling of the marine intertidal environment does not appear to provide an alternative for the fish study.

Other alternatives to the fish study, including mesocosms or caged bivalves, do not appear to be practical or cost-effective for implementation at Nanisivik. There is no known source of suitable fish to populate a mesocosm study, and the logistics and cost of attempting such a study in such a remote location would appear to be unreasonable. The importation of non-native fish from southern locations to the high Arctic, even if certified as disease free, is unlikely to be allowed by the Department of Fisheries and Oceans. It can also be anticipated that the stress to fish and risks associated with irregular or uncertain flight schedules or freight handling delays could result in unacceptable testing conditions. Likewise, we are unaware of a source of bivalves that could be used to populate a caged bivalve study. Even if these limitations were overcome, the cost associated with travel (about $4,000), dedicating a biologist to the project for up to six weeks (about $20,000), providing food and accommodations at Nanisivik (about $11,000) are substantial, before the costs of project materials, supplies, and freight are even considered.

Therefore, considering the existing environmental conditions, the layout of the mine and tailings area, and the confounding factors that are present, we have serious concerns as to whether there is a practical, scientifically defensible and cost-feasible way to carry out this portion of the EEM program at Nanisivik.

We look forward to discussing this matter further with you, and are available to do so at a mutually agreeable time.

Best Regards,

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4.0 References

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