a) the mine may not produce compounds capable of causing those effects,
b) the dilution at the site may be sufficient that the effects are not manifested,
c) there may be insufficient critical habitat in the exposure area, such that fish do not spend sufficient time in the effluent to demonstrate impacts (if any were possible).

To this we would add a fourth possible reason, that fish in the exposure area may not be significantly exposed to the effluent, as may be the case when a freshwater plume enters the marine environment is carried on the surface while slowly being diffused and dispersed, and the fish study examines a bottom-dwelling species.

The statistical analysis of the Fish Study data will mainly rely upon Analysis of Covariance (ANCOVA), although Analysis of Variance (ANOVA), regression, and simple "t" or χ^2 tests may be applied, where appropriate. Analysis will be carried out separately for male and female fish. The following parameters will be derived and analyzed:

- growth, as size-at-age;
- reproductive investment, as gonad weight relative to body weight or length;
- fecundity, as number of eggs per female relative to body weight, length, or age;
- egg size, as mean egg weight against body weight, or age;
- survival, from age structure and length frequency analysis;
- energy storage, from condition factors (body weight relative to length), liver weight relative to body weight, and liver weight relative to body length; and
- frequency of physical abnormalities such as tumors, lesions, or parasites.

3.5 Quality Assurance and Quality Control

All work will be performed by suitably qualified and trained staff (biologists and technicians), under the direction of Dr. Malcolm Stephenson, Senior Aquatic Scientist for JWEL in Fredericton, New Brunswick. Where subcontractors are used (such as for analysis of otoliths to determine age, or for chemical analysis) they will be selected for their specialist expertise. Labs that are used for chemical analysis will be chosen on the basis of their being accredited by the Canadian Association of Environmental Analytical Laboratories (CAEAL) to perform the required analyses, where such accreditation exists.

All field work will be carried out following Standard Operating Procedures, to ensure overall consistency and that appropriate procedures are followed. All field measurements will be made using appropriately calibrated instruments (for example, field balances will be calibrated before and after use with standard calibration weights). All field data will be recorded using standard forms, to ensure that all of the required data are collected, in a reproducible and standardized format.

To the extent practical, all field sampling bottles and containers will be pre-labelled and packaged in an orderly fashion, to minimize the potential for labelling errors.

Where appropriate, replicate samples will be collected for duplicate analysis, and/or replicate analysis of subsamples will be requested, in order to verify the accuracy and reproducibility of both field measurements and laboratory analyses. These replicate analyses will be performed at a frequency of approximately 10% of the overall sample stream.

In data analysis, the first step will be the screening of the data for outliers. A rapid way to screen for outliers is to create scatterplots of pairs of variables, with 95% confidence ellipses superimposed. Potential outlier data points can then be identified as those that lie outside the confidence ellipses. Outliers can result from a number of causes, including data entry or transcription errors. Where outliers are detected, the data records will be reviewed in order to attempt to isolate and if possible correct the source of a potential error. Where no such identification is possible the analysis will be performed both with and without the outlier, in order to evaluate the influence that the outlier exerts on the results of the data analysis.

Statistical data will be examined to evaluate the degree to which the data conform to the underlying assumptions of the analysis (such as normality and homogeneity of variance, or equality of slopes in ANCOVA). Where appropriate, transformations may be applied in order to reduce the magnitude of violations of the underlying assumptions.

4.0 BENTHIC INVERTEBRATE COMMUNITY SURVEY

According to *MMER*, the objective of the EEM program is to evaluate the effects of effluent on the aquatic environment. The benthic invertebrate community survey component of the EEM program is intended to evaluate whether the mine effluent has effects on the benthic invertebrate community (considered to be a component of fish habitat) within the aquatic environment most proximate to the effluent discharge. At mines where the EEM study will be periodically repeated (*i.e.*, at mines that have not applied for recognized closed mine status), it is expected that follow-up rounds of EEM will evaluate trends over time, and determine the magnitude and geographic extent of effects that are related to mine effluent. The Nanisivik Mine has applied for recognized closed mine status, therefore the benthic invertebrate component of the Final EEM Study described in this document will not include follow up rounds of EEM.

The Nanisivik Mine discharges effluent from the West Twin Lake tailings area, via a weir, to Twin Lakes Creek. A secondary effluent discharge point, at the East Adit Treatment Facility, did not discharge effluent in 2002 or 2003, and is not expected to discharge effluent in future, due to mine closure and reclamation. Therefore, the benthic invertebrate community study design will focus on the effluent discharged from the West Twin Lake tailings area.

4.1 Goals and Objectives of the Benthic Invertebrate Community Survey

The objective of the benthic invertebrate community survey is to evaluate the effects of effluent on the aquatic environment in the immediate vicinity of the effluent discharge by sampling, identifying, and statistically analyzing the benthic community that is highly exposed to the effluent. The reach of Twin Lakes Creek that is located immediately downstream from the West Twin Lake tailings area discharge point provides suitable conditions for this study.

The Metal Mining EEM Guidance Document describes the expectations for the benthic invertebrate community survey, as summarized below. The study design for the First EEM Study should include:

- one ecologically relevant season;
- sampling in reference and high exposure areas (proximate to the effluent discharge);
- sampling in ecologically relevant habitat;
- one of five site-specific sampling design;
- collection of data for site-specific supporting variables; and
- use of standard field and laboratory methods.

The benthic invertebrate community descriptors which are required to be calculated and reported include:

- total invertebrate numerical density;
- taxonomic richness;
- Simpson's diversity index; and
- Bray-Curtis index.

The above list does not exclude the use of other (additional) benthic invertebrate community descriptors or analyses.

4.2 Past Monitoring Results and Conclusions

Twin Lakes Creek has been sampled to investigate the benthic invertebrate community on at least two occasions in the past. The first was prior to the mine development (1974), and is reported by BC Research (1975a). The most recent was during the summer of 2003, and is reported in JWEL (2003b). The latter document is included as Appendix C with this EEM Study Design document.

4.2.1 The Benthic Community Prior to Mine Development

BC Research (1975a) reported collecting a number of benthic invertebrate samples from Twin Lakes Creek, and other creeks in the area, using a Surber sampler. Although mesh size was not reported, it is reasonable to suppose that it would have been nominally 0.5 mm. It was reported that "invertebrate samplings revealed the presence of a few individuals of only three types of organisms ... indicating low stream productivity and low community stability. Stations sampled by BC Research included one station (WS-17) a short distance downstream from the outlet to West Twin Lake, and a second station (WS25) near the mouth of Twin Lakes Creek at Strathcona Sound. Five replicate samples were collected at each station. The collected invertebrate community was represented by 1 annelid and 3 Tipulidae at Station WS-17, and 1 annelid and 1 Tendipedidae (Chironomidae) at station WS-25.

4.2.2 The Benthic Community in 2003

The full report from which the following information is an extract is reproduced as Appendix C to this document.

Benthic samples were collected in July 2003 using a U-frame kick net, having a mesh size of 0.25 mm. This gear encloses a section of creek bed having an area of one square foot (0.093 m^2). In operation, the net is similar to a Surber sampler, in that the net encloses an area of substrate that is disturbed (by kicking). Invertebrates that are dislodged are collected in the net. Five replicate benthic samples were collected at stations located on the stream flowing out of East Twin Lake (ETL-1 to ETL-5), below the effluent discharge from West Twin Lake (WTL-1 to WTL-5) and in Twin Lakes Creek (TLC-1 to TLC-5) below the confluence of these two flows. The samples were sieved in the field using a 0.25 mm mesh, and were preserved using 10% formalin solution. After being sorted from the associated debris, the benthic invertebrates were identified to the Order/Family level, by an experienced benthic invertebrate taxonomist. Quality assurance checks included re-sorting two samples (TLC-2 and ETL-4) to verify sorting efficiency, which met the requirements of the *MMER*.

The benthic invertebrate community was dominated by Chironomidae, although a few Tipulidae and one other unidentified dipteran larva (Tabanidae?) were collected. Some Cladocerans (*Daphnia*?) were also collected, but these were presumably drifting down from the zooplankton population present in East Twin Lake, and do not represent true benthic fauna.

The assemblages present at the ETL site were qualitatively and quantitatively similar to the assemblages present at the TLC site (see Table 4.1). However, no benthic invertebrates were recovered from the WTL site, immediately below the effluent discharge weir. The effluent is not acutely lethal to fish, however, it appears to be toxic to *Daphnia magna*, at least at some times of the year (Nanisivik Mine monitoring data). Therefore, it is possible that the absence of benthic invertebrates immediately below the effluent discharge point (where the exposure to effluent is essentially 100%) may be an effect of the mine effluent.

Table 4.1 Benthic Invertebrates Collected in Twin Lakes Creek July 11, 2003

Taxa	Chironomidae	Tipulidae	Other Diptera	Cladocera
TLC1	3			1
TLC2	12			
TLC3	5			
TLC4	7	2		1
TLC5	7			
WTL1				
WTL2				
WTL3				
WTL4				
WTL5				
ETL1	9			
ETL2	9			
ETL3	14			
ETL4	3		1	
ETL5	23			

4.3 Benthic Invertebrate Community Survey Design for EEM

This section provides the proposed benthic invertebrate community survey design for the Nanisivik Mine EEM program.

4.3.1 Rationale

A benthic invertebrate community survey is possible in Twin Lakes Creek, as has been demonstrated by the 2003 field investigation. It is proposed to carry out the survey in a portion of the creek proximal to the point of effluent discharge.

4.3.2 Hypotheses

The null hypothesis to be evaluated is:

- benthic invertebrate community metrics (total invertebrate numerical density, taxonomic richness, Simpson's diversity index and Bray-Curtis index) are not significantly different in areas exposed to the effluent than in an upstream reference area.

If this null hypothesis is rejected ($p<0.05$) for any of the biological measurements, it will be concluded that there is a statistically significant difference present.

4.3.3 Confounding Factors

If carried out in the upper reach of Twin Lakes Creek, proximal to the point of effluent discharge, then there are no known confounding factors present.

4.3.4 Field Study and Statistical Design

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. In order to obtain larger numbers of invertebrates for analysis, and to reduce the inter-replicate variability, it is proposed to collect and combine in the field three individual benthic invertebrate sub-samples at each replicate station. There will be five replicate stations for each sampling area. Four sampling areas will be defined as follows.

- A Reference Area (Twin Lakes Creek upstream of the effluent discharge point).
- A High Exposure Area in the effluent mixing zone of Twin Lakes Creek, at nominally 80% effluent concentration, at locations between 50 and 200 m downstream from the point of effluent discharge. Effluent concentration will be determined in the field using specific conductance. The five replicate stations will each be spaced approximately 30 m apart.
- A Low Exposure Area in the effluent mixing zone of Twin Lakes Creek, at nominally 10% effluent concentration, at locations between 50 and 200 m downstream from the point of discharge. The five replicate stations for this Exposure Area will correspond with the stations for the High Exposure

Area, but will be located near the opposite bank of the creek, with low exposure to the effluent. Exposure will be assessed in the field using specific conductance.

- A Terminal Exposure Area, located below a waterfall approximately 600 m downstream from the point of effluent discharge, where the effluent is fully mixed across the stream width. It is anticipated that when the study is carried out in August 2004, the terminal dilution for the effluent in Twin Lakes Creek may be approximately 30%.

Although it is not strictly required to sample more than a single exposure area in the Initial Monitoring study, the Metal Mining EEM Guidance Document notes that there may be situations where questions regarding the magnitude and extent of effects can be addressed by additional sampling during the same field trip. The present study design recognizes the benefits of doing so.

The appropriate ecologically relevant habitat type for sampling is cobble in riffles, since this is the predominant habitat type in the stream. The benthic invertebrate samples will be collected in late July or early August, 2004. This timing is driven in part by a need to coordinate sampling with the timing of the fish study and because effluent is discharged only during the months of June, July, and August. The summer season at Nanisivik is short, and the creek is fully frozen during the winter. In the early summer, flows in the creek can be very large due to spring runoff, and this would introduce a working hazard.

It is proposed to use a U-frame kick net having a mesh size of 0.25 mm for sampling. This is finer mesh size than is standard for metal mining EEM (0.5 mm). However, given the low numbers of invertebrates present in Twin Lakes Creek, and the fact that many of the chironomids collected during 2003 were extremely small, the selection of 0.25 mm mesh size will be critical to a successful survey. As recommended by the Metal Mining EEM Guidance Document, the samples will be sorted and reported in two stages. The first stage will recover those organisms that are retained on a mesh size of 0.5 mm, so that overall comparisons to other mines can be entertained by Environment Canada. The second stage will recover those organisms that are retained on a 0.25 mm mesh. The statistical analysis will be carried out only once, and will include all recovered organisms. Based upon our experience in 2003, it is highly unlikely that any of the benthic invertebrate samples will require subsampling.

The samples will be processed in accordance with the guidance provided in the Metal Mining EEM Guidance Document. The selection of five replicate stations per sampling area is consistent with generic guidance for EEM studies, and provides statistical power of $\alpha = \beta = 0.05$ and Effect Size = 2 standard deviations.

Due to the dimensions of the stream, it will not be possible to separate replicate stations in Twin Lakes Creek at a distance that corresponds to the riffle-pool sequence. Twin Lakes Creek has a width of approximately 20 m. Assuming that the riffle-pool sequence is approximately 6 times the stream bankfull width, the replicate stations would have to be separated by a distance of 120 m to follow the guidance. This distance is too large for optimal study design. It is proposed here to separate replicate stations by a distance of 30 m in order to optimally locate stations at exposure levels that will provide meaningful information about effluent effects within the stream.

4.3.5 Benthic Invertebrate Taxonomy

Benthic invertebrates will be identified by an experienced taxonomist, to the Family level, using appropriate taxonomic keys. A reference collection will be prepared, and will be held by the mine for a period of six years following submission of the Interpretive Report. Although initially fixed and preserved in 10% formalin, the invertebrate specimens will be transferred at the first opportunity to 70% ethanol for long-term storage. Dilute formalin is preferred for initial fixation because the samples will be shipped by air, and 70% ethanol is highly flammable.

4.3.6 Supporting Environmental Measurements

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 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.

The following variables will be measured at each replicate station, at the time of benthic sampling:

- stream width, and replicate station distance from the left bank;
- water depth (m) and velocity (m/s);
- substrate types (e.g., % cobble, gravel, sand, etc.), dominant size range (cm) and embeddedness (%);
- water temperature (°C), specific conductance (µS/cm), dissolved oxygen (mg/L) and pH; and
- water chemistry (samples to be collected for subsequent analysis of general chemistry, including alkalinity, turbidity, nutrients, and zinc).

In addition, a single set of water samples will be collected within each sampling area at the time of the benthic invertebrate community survey. These samples will be submitted for analysis of a suite of chemicals as described for Water Quality Monitoring in Section 5 of this document.

4.4 Benthic Invertebrate Community Survey Data Analysis and Interpretation

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. Differences between reference and exposure areas will be evaluated using ANOVA. Data will evaluated to see whether transformations would improve their normality, or the homogeneity of variances, and transformations will be applied if so justified. Following ANOVA, multiple comparison tests, such as Tukey's HSD test, will be used to determine which Exposure Area or Areas differ significantly from the others.

This analysis will allow the following questions to be answered:

- is there an effect?
- is the effect mine related?
- is the magnitude and extent of the effect known?

4.5 Quality Assurance and Quality Control

All work will be performed by suitably qualified and trained staff (biologists and technicians), under the direction of Dr. Malcolm Stephenson, Senior Aquatic Scientist for JWEL in Fredericton, New Brunswick. Where subcontractors are used (such as for benthic invertebrate taxonomy) they will be selected for their specialist expertise. Labs that are used for chemical analysis will be chosen on the basis of their being accredited by the Canadian Association of Environmental Analytical Laboratories (CAEAL) to perform the required analyses, where such accreditation exists.

All field work will be carried out following Standard Operating Procedures, to ensure overall consistency and that appropriate procedures are followed. All field measurements will be made using appropriately calibrated instruments (for example, pH meters will be calibrated at pH 4.0 and 7.0 using certified buffer solutions). All field data will be recorded using standard forms, to ensure that all of the required data are collected, in a reproducible and standardized format.

To the extent practical, all field sampling bottles and containers will be pre-labelled and packaged in an orderly fashion, to minimize the potential for labelling errors.

Where appropriate, replicate samples will be collected for duplicate analysis, and/or replicate analysis of subsamples will be requested, in order to verify the accuracy and reproducibility of both field measurements and laboratory analyses. These replicate analyses will be performed at a frequency of approximately 10% of the overall sample stream. While the benthic invertebrate samples are being sorted, 10% of samples will be subject to re-sorting to verify that the sorting efficiency is at least 95%. If less than 95% recovery of benthic invertebrates is achieved, all of the samples will be re-sorted until a minimum 95% recovery is documented.

In data analysis, the first step will be the screening of the data for outliers. A rapid way to screen for outliers is to create scatterplots of pairs of variables, with 95% confidence ellipses superimposed.

Potential outlier data points can then be identified as those that lie outside the confidence ellipses. Outliers can result from a number of causes, including data entry or transcription errors. Where outliers are detected, the data records will be reviewed in order to attempt to isolate and if possible correct the source of a potential error. Where no such identification is possible the analysis will be performed both with and without the outlier, in order to evaluate the influence that the outlier exerts on the results of the data analysis.

Statistical data will be examined to evaluate the degree to which the data conform to the underlying assumptions of the analysis (such as normality and homogeneity of variance, or equality of slopes in ANCOVA). Where appropriate, transformations may be applied in order to reduce the magnitude of violations of the underlying assumptions.

5.0 EFFLUENT AND WATER QUALITY MONITORING

Effluent quality monitoring is the regular sampling and analysis of mine effluent to determine concentrations of a set of chemical and physical parameters. In addition to the regulated deleterious substances and pH described in Schedule 3 of the *MMER*, samples for effluent quality monitoring are also analyzed for other potential contaminants and supporting parameters. This sampling is normally carried out four times per calendar year.

Water quality monitoring is the regular sampling and analysis of water from the receiving stream to compare the concentrations of contaminants related to mine activities in the exposure area and the reference area. These samples are analyzed for the same suite of parameters as the effluent, as well as dissolved oxygen and temperature. In addition, a single set of samples of water will be collected from each sampling area (including exposure and reference areas) in receiving environments where biological monitoring is completed, at the same time that biological monitoring is conducted.

5.1 Goals and Objectives of Effluent and Water Quality Monitoring

The goals and objectives of effluent and water quality monitoring are to provide the following information:

- to monitor changes in environmental conditions in the receiving environment, that might be caused by mining operations;
- to provide an indication of variability or seasonal trends in effluent quality; and
- to provide supporting environmental information to help interpret the results of biological monitoring and sublethal toxicity testing.

5.2 Past Effluent and Water Quality Monitoring Results

The Nanisivik mine has collected and reported effluent and water quality data from a set of sampling stations on Twin Lakes Creek, and at the East Adit, for many years. Data relating to operations since 2000 were summarized as part of the baseline data provided in Section 2 of this report (see Table 2.3 and Figures 2.4, 2.5, and 2.6). The mine has been shut down since September, 2002.

5.3 Effluent and Water Quality Monitoring Design for EEM

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.

5.3.1 Primary Monitoring Plan for the WTDA and Twin Lakes Creek

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. The *MMER* normally requires that a minimum of four samples are collected each year, separated by at least one month. This is not possible at Nanisivik, therefore, the EEM study will be designed taking into account the fact that there are fewer than four months each year 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. Following this schedule and based on past experience, 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.

Monitoring as required by the new *MMER* was initiated at Nanisivik in 2003 (see Appendix D). For a Recognized Closed Mine, this effluent characterization program would continue for three years following the date of notification. Therefore, this program is expected to continue in 2004, 2005 and 2006.

Table 5.1 provides a list of analytical parameters to be measured for effluent characterization and water quality monitoring. Unless otherwise specified, analyses refer to "total" concentrations, not "dissolved" concentrations.

Table 5.1 Analytical Parameters Required and Recommended for Effluent and Water Quality Monitoring

Required Effluent and Water Quality Monitoring Parameters	Recommended Additional Parameters for Effluent and Water Quality Monitoring[1]	Required Additional Parameters for Water Quality Monitoring
Aluminum	Calcium	Dissolved Oxygen
Arsenic	Magnesium	Temperature
Cadmium	Manganese	
Copper	Potassium	
Iron	Selenium	
Lead	Sodium	
Mercury	Uranium	
Molybdenum	Chloride	
Nickel	Sulphate	
Zinc	Total Organic Carbon	
Ammonia		
Nitrate		
Total Cyanide		
Total Suspended Solids		
Total Hardness		
Alkalinity		
pH		
Radium-226		

[1] Note – the list of recommended parameters included here is abbreviated from the recommended parameters from Table 6.1 in the Metal Mining EEM Guidance Document. All required parameters are carried forward.

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. A summary of data collected by the Nanisivik Mine in 2003 is provided in Appendix D.

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

- a reference site in Twin Lakes Creek upstream of the effluent discharge point, at ¼ and ¾ of the stream width, with these two subsamples being combined to form a single composite sample;
- 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, with these two subsamples being combined to form a single composite sample;
- as a single grab sample 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
- as a single grab sample at the mouth of Twin Lakes Creek, before entering the marine environment, at a station known as 159-6.

Due to the shallow and turbulent (well mixed) nature of Twin Lakes Creek, all water samples will be collected as surface grab samples.

5.3.2 Water Sampling Concurrent with Biological Studies

Water samples will be collected at the same time as biological sampling is carried out in Twin Lakes Creek (Benthic Invertebrate Community Survey) and in the marine environment of Strathcona Sound (Fish Study). These water samples will be collected only at the time of the biological studies, and will be collected at one location within each Exposure Area and Reference Area sampling station. In the marine environment, it will be necessary to collect both "surface" and "bottom" water samples, due to the potential for stratification.

The water samples that are collected with the biological studies will be analyzed for the same suite of parameters that has been outlined for other water quality monitoring (Table 5.1).

5.3.3 Contingency Monitoring Plan for the East Adit Treatment Facility

In the event that there is a discharge of effluent from the East Adit Treatment Facility, collection of effluent and water samples from the receiving environment will be required at this discharge point. The polishing pond below the East Adit Treatment Facility discharges via a valved pipe. Effluent samples will be collected from this pipe on a monthly basis while effluent is being discharged. It is highly unlikely that effluent discharge from this location would continue for more than a few weeks each year, if at all. The effluent samples will be analyzed for the list of parameters indicated as being required or recommended for effluents, in Table 5.1.

Water samples will also be required from the receiving environment near the East Adit Treatment Facility. Flow at this location is frequently below ground, and there is no permanent flowing stream upstream of the East Adit Treatment Facility. Therefore, it will only be possible to collect downstream water samples. These samples will be taken from a pond down gradient of the East Adit Treatment Facility, to which the effluent from the facility presumably drains.

5.4 Effluent and Water Quality Monitoring Data Analysis, Interpretation and Reporting

The results of effluent and water quality monitoring are required to be submitted to the Authorization Officer as part of an Effluent and Water Quality Monitoring Report. This report must be submitted no later than March 31 of each year, and will include for the previous calendar year:

- the dates when samples were collected;
- the locations of the final effluent discharge points for which samples were collected for effluent characterization;
- the location of the effluent discharge point used for sublethal toxicity testing;
- the latitude and longitude of sampling areas for water quality monitoring (in degrees, minutes and seconds, with written descriptions that also identify the sampling areas;
- the results of effluent characterization;
- the results of sublethal toxicity testing;
- the results of water quality monitoring;
- a comparison of water quality data in the exposure and reference areas, and where the results for these two areas differ by more than a factor of two, an estimate should be made of the geographic extent for which this condition exists;
- the methods used to conduct effluent characterization and water quality monitoring, with the related method detection limits for analyses; and
- a description of the quality assurance and quality control measures that were implemented, and the identification of any results that may interfere with the reliability of the data reported.

The data from effluent and water quality monitoring may be of use in interpreting the results of the Fish Study and Benthic Invertebrate Community Survey. Therefore, some or all of the monitoring data may be presented in the Interpretive Reports for the biological study components.

5.5 Quality Assurance and Quality Control

Collection and handling of samples for effluent and water quality analysis will follow procedures recommended in the "*Guidance document for the sampling and analysis of metal mining effluent*", EPS 2/MM/5, Environment Canada, 2001. Samples will be stored at 4°C and not frozen before analysis. Holding times will not exceed the holding times listed in Table 6-2 of the Metal Mining EEM Guidance Document, and every effort will be made to ship samples to the analytical laboratory at the earliest possible date. Samples will be shipped in coolers, with ice packs.

All field measurements (such as pH, specific conductance, and dissolved oxygen) will be made using instruments that are calibrated using appropriate standards, following the manufacturer's instructions. Field notes will be documented in notebook that is waterproof and bound, and these notes will be copied to a secure file following field work.

Sampling containers will be selected in consultation with the analytical laboratory, and will be of suitable materials, pre-cleaned, and labelled prior to filling. A chain of custody system will be implemented to ensure that there is a designated individual responsible for the samples at all times, and that the security of the samples from tampering is assured.

Quality assurance and quality control measures will include analysis of distilled water "travelling blank" samples, field duplicate samples, and laboratory duplicate analyses. These results will be reported, and any findings from these analyses that affect the reliability of the monitoring data will be identified and discussed.

6.0 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:

- rainbow trout (using method 1/RM/28);
- *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.

6.1 Goals and Objectives of Sublethal Toxicity Testing

The purpose of sublethal toxicity testing is to determine whether there is evidence that the mine effluent might affect fish, invertebrates or aquatic plants. Over time, it may also be possible to gather information on variability in effluent quality, and temporal or seasonal trends. Sublethal toxicity testing is normally performed twice each calendar year.

6.2 Past Sublethal Toxicity Testing Results and Conclusions

Sublethal toxicity testing was carried out on the WTDA final effluent during 2003, however, these data were not available at the time this report was submitted. These data will be forwarded to the TAP when they become available.

6.3 Sublethal Toxicity Testing Study Design for EEM

For the Nanisivik Mine, which has applied for Recognized Closed Mine status, sublethal toxicity testing will be required in 2004, 2005 and 2006. Based on the normal effluent discharge cycle for the mine, it is anticipated that effluent samples will be collected for sublethal toxicity testing during June and August each year, on the same dates that effluent and creek water samples are collected for chemical characterization.

The preferred sublethal toxicity tests for the Nanisivik Mine include:

- Fish Early Life Stage Development Test, using rainbow trout, since fathead minnows are not an indigenous species at Nanisivik, method reference 1/RM/28 Environment Canada (1998);
- Invertebrate Reproduction Test, using *Ceriodaphnia dubia*, method reference 1/RM/21 Environment Canada (1992a);
- Plant Toxicity Test, using *Lemna minor*, method reference 1/RM/37 Environment Canada (1999); and
- Algal Toxicity Test, using *Selenastrum capricornutum*, method reference 1/RM/25 Environment Canada (1992b)

These tests will be contracted to the Stantech (formerly Beak/ESG) aquatic toxicity testing laboratories in Ontario. The laboratory will be responsible for completing the tests in accordance with the required Environment Canada methodologies, as well as for implementing and reporting the appropriate QA/QC procedures during the tests.

6.4 Sublethal Toxicity Testing Data Analysis, Interpretation and Reporting

The results of sublethal toxicity testing are to be submitted to the Authorizing Officer as part of the Effluent and Water Quality Monitoring Report, no later than March 31 of each year, for the previous calendar year. This section of the Effluent and Water Quality Monitoring Report will contain:

- dates when samples were collected for sublethal toxicity testing;
- location of the final effluent discharge point from which samples were collected, with a justification to show that this location had the greatest potential to have an adverse effect on the environment (based on monthly mass loadings of deleterious substances and/or the manner in which the effluent mixes in the exposure area);
- the results of sublethal toxicity testing; and
- a description of the QA/QC measures that were implemented.

6.5 Sublethal Toxicity Testing Quality Assurance and Quality Control

Quality assurance and quality control measures related to the sublethal toxicity testing can be divided into two components:

- those that are under the control of Mine staff, associated with collecting and shipping the sample; and
- those that are under the control of the contracted toxicity laboratory, associated with performing and reporting the results of the test to the Mine.

Mine staff will ensure that the effluent samples for sublethal toxicity testing are collected at the point of effluent discharge from the WTDA, concurrently with samples for effluent quality monitoring, using appropriate sampling containers (to be supplied by the testing laboratory). Mine staff will also be responsible for proper holding of the samples prior to shipment, shipping promptly, and initiating the chain of custody documentation to ensure the integrity of the samples.

Staff at the toxicity testing laboratory will complete the chain of custody, and be responsible for performing the toxicity tests according to the prescribed methods. Quality assurance measures to be completed by the performing laboratory include:

- performance and reporting of reference toxicant tests and their results;
- test-specific validity criteria to be met and reported in all effluent sublethal toxicity testing;
- sublethal toxicity tests to be initiated within 3 days of sample collection;
- quantitative endpoints to be provided for all sublethal toxicity tests conducted on effluent; and
- test endpoints between 0.1% and 100% to be bracketed by at least one test concentration.

7.0 SUMMARY AND SCHEDULE

The proposed EEM study for the Nanisivik Mine, which notified Environment Canada of its intent to obtain recognized closed mine status effective July 30, 2003, is summarized below.

- **Fish Study** to be carried out in the marine waters of Strathcona Sound, with the Exposure Area at the mouth of Twin Lakes Creek and the Reference Area at the mouth of the Strathcona River. A single fish species, shorthorn sculpin to be collected, with 20 adult male and 20 adult females to be collected at both exposure and reference areas. This study to be carried out during the summer of 2004. The full rationale and study design for this component was provided in Section 3 of this document.

- **Benthic Invertebrate Community Survey** to be carried out in Twin Lakes Creek, proximal to the point of effluent discharge. The study will have an upstream Reference Area, and three downstream Exposure Areas, with differing levels of exposure to the effluent. Five replicate stations to be sampled within each Area. The sample from each replicate station to be a composite of three field subsamples. Effluent exposure will be determined in the field using specific conductance. Samples will be taken using a U-net with 0.25 mm mesh size. The full rationale and study design for this component was provided in Section 4 of this document.

- **Effluent Monitoring** to be carried out on a monthly basis while effluent is being discharged (likely only three months each year). Analysis for a suite of required and recommended parameters. The full rationale and study design for this component was provided in Section 5 of this document.

- **Water Quality Monitoring** to be carried out concurrently with effluent monitoring, at upstream and downstream stations in Twin Lakes Creek. Analysis for a suite of required and recommended parameters. Water sampling for the same suite of parameters will also be performed in the Exposure and Reference Areas for the Fish Study and the Benthic Invertebrate Community Survey, to provide supporting environmental information for those studies. The full rationale and study design for this component was provided in Section 5 of this document.

- **Sublethal Toxicity Testing** to be carried out twice each year (likely in June and August of each year, to correspond with the early and late periods of effluent discharge). The testing suite will include rainbow trout survival and early development test, *Ceriodaphnia dubia* reproduction and survival test, macrophyte growth inhibition test using *Lemna minor*, and algal growth inhibition test using *Selenastrum capricornutum*. Sampling dates for sublethal toxicity testing to correspond with effluent monitoring dates. The full rationale and study design for this component was provided in Section 6 of this document.