Hope Bay Mining Limited

Doris North Gold Mine Project: Aquatic Effects Monitoring Plan

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DORIS NORTH GOLD MINE PROJECT:
Aquatic Effects Monitoring Plan

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Prepared for:

NEWMONT NORTH AMERICA

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DORIS NORTH GOLD MINE PROJECT:

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1. Introduction

1. Introduction

The following requirements are outlined in the Doris North Project Type "A" Water Licence (Water Licence # 2AM-DOH0713) issued by the Nunavut Water Board (NWB; September 19, 2007):

- Part K, Item 7. The Licensee shall submit to the Board for approval…, a proposal for the development of an Aquatic Effects Monitoring Plan (AEMP) in consultation with Environment Canada. The proposal for an AEMP shall consider modifications and advances in schedule which are consistent with the objectives and requirements of the Metal Mining Effluent Regulations (MMER);
- Part K, Item 8. The Licensee and Environment Canada shall coordinate with the NWB to ensure that the advanced submission of the AEMP meets the requirements of MMER;
- Part K, Item 9. The Licensee shall continue to collect baseline data consist[ent] with previously collected baseline data until such time as an AEMP is approved and implemented.

In compliance with Part K, item 7, a proposal to develop an AEMP was submitted to the NWB on March 31, 2008. This proposal was also distributed to Environment Canada (EC). However, given the plans to delay the Doris North Project at that time, a final AEMP plan was never developed.

Hope Bay Mining Ltd. (HBML), a fully owned subsidiary of Newmont Mining Corporation (Newmont), has changed its development plans, and is now going to proceed with the development of the Doris North Project as permitted.

In compliance with the Doris North Project Type "A" Water Licence (Part K, Item 9), HBML, along with Rescan Environmental Services Ltd. (Rescan), continued to collect baseline data in 2009 as an approved AEMP is not yet in place.

This report presents the plan for the Aquatic Effects Monitoring Program (AEMP) to be carried out during the construction, operation, and closure of the Doris North Project. As outlined in Part K, items 7 and 8, this plan has been developed in consultation with EC during the period of December, 2009 to February, 2010. EC and HBML agreed to this plan on February 17, 2010. The intent is to implement the AEMP starting in April of 2010 (winter water quality sampling).

As specified in the Type "A" Water Licence, this plan has incorporated requirements of the Metal Mining Effluent Regulations (MMER) pertaining to Environmental Effects Monitoring (EEM) in the receiving environment. MMER monitoring requirements pertaining to effluent characterization have already been incorporated into the Doris North Project Type "A" Water Licence, and are therefore not discussed in this plan.

2. Objectives of AEMP

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2.1 IDENTIFYING AEMP OBJECTIVES

The Doris North Project Type "A" Water Licence includes the following definition of an Aquatic Effects Monitoring Plan:

> *A monitoring program designed to determine the short and long-term effects in the aquatic environment resulting from the Project, to evaluate the accuracy of impact predictions, to assess the effectiveness of planned impact mitigation measures and to identify additional impact mitigation measures to avert or reduce environmental effects.*

As this definition would have been reviewed by all interested parties and regulators during the Doris North Project water licence process, it is assumed that this is an agreed-upon definition for all interested parties. As such, the following objectives can be extracted from the definition:

1. To determine the short and long-term effects in the aquatic environment resulting from the Doris North Project;

2. To evaluate the accuracy of impact predictions;

3. To assess the effectiveness of planned impact mitigation measures; and

4. To identify additional impact mitigation measures to avert or reduce environmental effects.

In addition to the above four objectives, the primary stated objective of the mining EEM program is as follows:

1. To evaluate the effects of mining effluents on fish, fish habitat, and the use of fisheries resources.

Hence, the above five objectives are the proposed objectives of the Doris North Project Aquatic Effects Monitoring Program.

2.2 MEETING AEMP OBJECTIVES

The AEMP plan described in the document was designed to address objectives 1, 3, 4, and 5 above. Item 2 above is addressed in the requirements of the Doris North Gold Mine Project Certificate issued by the Nunavut Impact Review Board (NIRB; issued September 15, 2007) as part of the Post-Environmental Assessment Monitoring Program (PEAMP; as outlined in Appendix D). One of the purposes of the PEAMP is to assess the accuracy of predictions contained in the project impact statement.

This plan meets objective 1 by measuring the receiving environment in the short-term (on an annual basis) and the long-term (during construction, operation, and closure of the Project). It is proposed to re-evaluate the AEMP plan upon closure, to determine the sampling frequency required at that point.

This plan meets objective 3 by documenting the conditions of the receiving environment prior to and during operations. Reference areas are also included in the sampling design. The proposed sampling design will allow for changes in the receiving environment to be detected, which will determine whether mitigation measures are being effective. Results of the program will be presented in the program reports.

Objective 4 will be met by identifying changes in the receiving environment, and communicating those changes to HBML management. Results of the program will be presented in the program reports. If adverse changes are detected, HBML through adaptive management can identify and implement additional mitigation measures.

Objective 5 will be met by monitoring components of fish, fish habitat, and fisheries resources as outlined in the EEM guidance documents. These environmental components will be evaluated for effects by the methods outlined in this plan, and results of the evaluation will be presented in the program reports.

3. AEMP Study Design

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This AEMP plan is designed to fulfil the objectives outlined in Chapter 2 of this document. By meeting these objectives, this plan incorporates expectations outlined in the Doris North Project Type "A" Water Licence, as well as the MMER's EEM program.

This Chapter describes the proposed spatial and temporal sampling plan, monitoring schedule, and the methods proposed for monitoring environmental components. Reporting of the program results is described in Chapter 4.

3.1 INCORPORATION OF MMER INTO AEMP STUDY DESIGN

This AEMP plan is designed to be consistent with the objectives and requirements of the MMER, which stipulate that mines are required to conduct Environmental Effects Monitoring (EEM) if effluent discharge rates exceed 50 m^3 per day and/or deleterious substances are discharged into any water body as per subsection 36(3) of the *Fisheries Act*.

As stated in Chapter 2, the primary objective of the mining EEM program is to:

- Evaluate the effects of mining effluents on fish, fish habitat, and the use of fisheries resources.

To meet this objective, there are two key components to the EEM program:

- Effluent Characterization and Water Quality Monitoring Studies that are designed to aid the interpretation of biological data; and
- Biological Monitoring Studies that include surveys for fish populations and health, fish prey resources (benthic invertebrate surveys), and fish usability (mercury/metal tissue content).

The effluent characterization and water quality monitoring studies consist of three components: effluent characterization (deleterious substances and other contaminants), water quality monitoring, and sublethal toxicity testing. These facets are required under MMER and EEM; however, the study details for these components are outlined in Part J of the Doris North Type "A" Water Licence and are therefore not discussed further.

This AEMP plan is designed to include the biological and water quality monitoring (including sediment quality) specified in the EEM guidance documents. The monitoring program will include the following components: water quality, phytoplankton and periphyton biomass, sediment quality, benthic invertebrates, fish population and condition, and fish metal concentrations (including mercury). The proposed sampling frequency is more frequent than outlined under the MMER given the short mine life of the Doris North Project. The methods used will be consistent with the EEM guidance documents.

3.2 STUDY AREA AND SAMPLING LOCATIONS

3.2.1 Study Area

The AEMP study area is comprised of those areas anticipated to be potentially influenced by mining-related activity (exposure areas) and those areas beyond any mining influence (reference areas).

In Schedule 5, Section 1 of the MMER, exposure areas are defined as "all fish habitat and waters frequented by fish that are exposed to effluent", and a reference area is defined as "water frequented by fish that is not exposed to effluent and that has fish habitat that, as far as practicable, is most similar to that of the exposed area".

The exposure areas to be monitored as part of the AEMP have been expanded to encompass other mining-related activities in addition to exposure to effluent. The main mining-related activities that could influence the aquatic environment and were considered for the AEMP sampling locations include the following:

- Constructions of roads and infrastructure (potential generation of dust and/or sediment);
- Operation of the Tailings Impoundment Facility (formerly Tail Lake) (changes to water quantity, potential changes to water quality);
- Runoff from site infrastructure, roads, waste rock, explosives facility (potential changes to water quality);
- Dust-generating activities such as air strip and road usage (potential dust generation); and
- Accidental spills (potential changes to water quality).

3.2.2 Sampling Locations (Exposure and Reference Sites)

3.2.2.1 Exposure Sites

The principal exposure sites in the AEMP study area are those water bodies that will be downstream of the discharge effluent from the Tailings Impoundment Facility. From upstream to downstream, these locations include Doris Outflow, Little Roberts Lake, Little Roberts Outflow, and Roberts Bay East (Figure 3.2-1). The Doris Outflow sampling station will be situated within 100 m of the projected discharge location to best measure the potential effects of the effluent. Little Roberts Lake, a small, shallow lake (<0.1 km^2, <4 m depth) receiving outflow from Doris Lake and Roberts Lake, is the only lake along the projected effluent path. Because there is historic mining in the immediate area (an abandoned silver mine), a sampling station has been included between Little Roberts Lake and Roberts Lake (Roberts Lake Outflow). This will gauge any potential confounding influence of the mine as well as inflowing water from Roberts Lake. A final station along the effluent path is located in eastern Roberts Bay where Little Roberts Outflow enters the marine habitat (Roberts Bay East).

In addition to the effluent-influenced sampling stations, other exposure sites have been considered to address potential effects from other mining activity. These include two sampling locations in Doris Lake (adjacent to site infrastructure and roads), and a single site in western Roberts Bay near the jetty (roads, site infrastructure, marine loading/unloading activities). In all, there are three stream exposure sites, three lake exposure sites, and two marine exposure sites.

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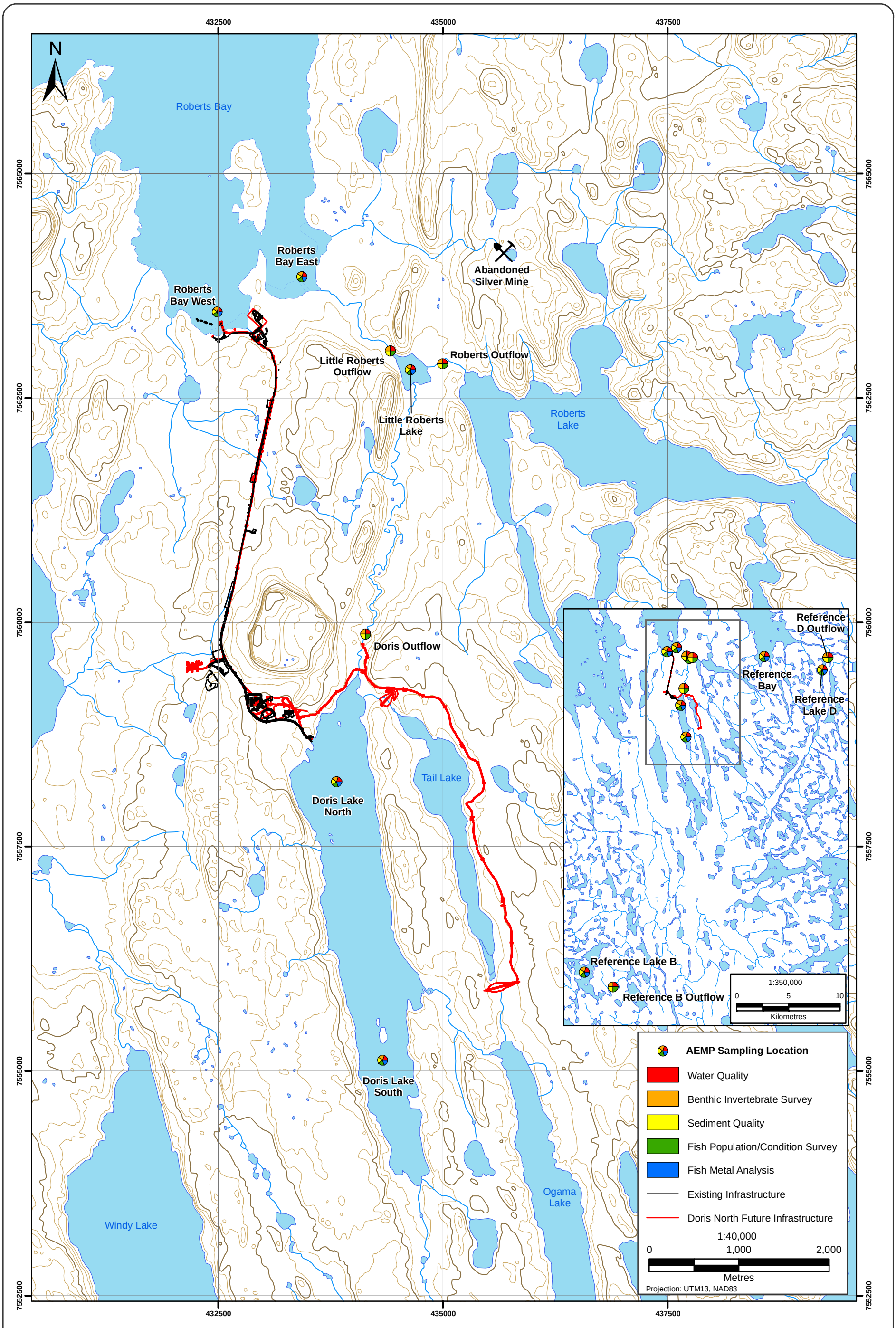

Figure 3.2-1

NEWMONT The Gold Company

AEMP Sampling Locations, Doris North Project

Figure 3.2-1

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3.2.2.2 Reference Sites

Three reference areas have been selected for the AEMP; two lake/outflow systems (Reference B and D) and one marine site (Reference Bay; Figure 3.2-1). These reference areas have been chosen with two features in mind: 1) the reference areas are located sufficiently far away from the influence of mining activity, and 2) the reference areas resemble, as much as possible, the hydrological and habitat features of the exposure areas.

Ideally, reference areas should be located in the same or adjacent watershed as the potential exposure area so environmental differences cannot be attributed to habitat differences. However, the long-term development of the Doris North Project area cannot be discounted, which hampers the long-term potential of reference sites that would be located directly in this region. In addition, wind-driven particulates from mining infrastructure (e.g., road dust, blasting agents, rock crushing) can project contaminants over large areas that surround mine sites. At the EKATI diamond mine, an open-pit mining facility in the Northwest Territories, elevated levels of wind-driven particulates were found within 5–10 km of the mine site, but were effectively dispersed 15 km from the mine. Since the Hope Bay habitat is similar to the EKATI region (i.e., low-lying tundra habitat, similar wind fields), reference sites for this AEMP have been situated at least 10 km from any mining infrastructure to negate any dust-related impacts as well as far beyond the area where any effluent will be discharged. This is seen as a conservative distance since no open-pit mining will be practiced in the Doris North area. Reference Lake D is located 15 km from any Doris North infrastructure, Reference Lake B is located 25 km away, and the reference site in Reference Bay is located 10 km away. Notably, wind trajectories flow from the Doris North region towards Reference Lake B and Reference Bay (northwest and west) only ca. 20% of the time.

Another consideration is the large size difference between the two exposure lakes, Little Roberts Lake (<0.1 km^2) and Doris Lake (3.4 km^2). The large size and depth difference between these lakes suggest different hydrodynamics and biological interactions. Thus, choosing similarly sized reference sites could favour inference for one exposure system over the other. Consequently, two different sized reference systems, one small (Reference D lake/outflow; 0.6 km^2) and one large (Reference B lake/outflow; 8.6 km^2), have been selected as reference analogues for Little Roberts Lake and Doris Lake, respectively. The final important selection criterion is related to habitat similarity between the reference and exposure systems, primarily regarding Little Roberts Lake and Reference Lake/Outflow D. Little Roberts Lake is the key exposure lake along the effluent conduit. It is a small lake that links its upper watershed (including Doris Lake) to the marine habitat. Accordingly, the small reference lake (Reference D) was selected to resemble Little Roberts Lake as it links a larger upper watershed to the downstream marine region (Reference Bay).

Finally, a marine reference area has also been included (Reference Bay) to provide a reference area for the two marine exposure sites (Roberts Bay East, Roberts Bay West (Jetty)). The MMER/EEM guideline document recommends that marine reference sites be located in the same water body as the exposure site; however, the western section of Roberts Bay receives vastly different water from the Glenn watershed than the eastern section, which receives freshwater from Little Roberts Outflow. As well, there are few areas in eastern Roberts Bay that resemble where Little Roberts Outflow meets Roberts Bay (as it is lined with steep cliffs and rapid drop-offs), and the one area that does (ca. 800 m upstream), is undoubtedly within the zone of influence of Reference Bay East station. As a result, the Reference Bay site has been selected as a location that provides the best long-term reference comparison for the two exposure marine stations. Table 3.3-1 presents a summary of proposed sampling locations.

3.3 SAMPLING DESIGN

The sampling design for the AEMP will be a Multiple Paired Before-After/Control-Impact (BACI) design with water quality, sediment quality, and biological sampling taking place within lakes, streams, and the near-shore marine habitat. Exposure sampling locations will occur downstream of the Tailings Impoundment Facility discharge: Doris Outflow (stream), Little Roberts Lake, Little Roberts Outflow (stream), and Roberts Bay East (marine; Figure 3.2-1). A single site located at Roberts Lake Outflow will be used to gauge any potential influence from an abandoned silver mine flowing into Little Roberts Lake and will provide evidence for any confounding effects between inflowing and outflowing water from Little Roberts Lake. Other exposed sampling stations will occur in western Roberts Bay and Doris Lake to account for any jetty activity and infrastructure construction and usage, respectively.

Table 3.3-1. AEMP Sampling Locations, Descriptions, and Purpose

Sampling Location	Description	Purpose
Doris Outflow	Immediately downstream of discharge point from the Tailings Impoundment Facility	First exposure site downstream of effluent discharge location
Little Roberts Lake	Small lake downstream of Doris Outflow	First and only lake exposed to upstream effluent discharge
Little Roberts Outflow	Stream downstream of Little Roberts Lake	Second exposure stream downstream of effluent discharge location
Roberts Bay East	Marine bay where Little Roberts Lake drains in to	Marine receiving environment for freshwater system downstream of effluent discharge location
Roberts Outflow	Stream upstream of Little Roberts Lake, which drains the much larger Roberts Lake	To characterize any influence of the abandoned silver mine on Little Roberts Outflow, to be able to differentiate this from potential effects of effluent discharge upstream
Doris Lake North	Large lake located south of main project site. North part of lake is adjacent to project infrastructure.	Potential exposure lake due to close proximity of project infrastructure and explosives storage
Doris Lake South	Large lake located south of main project site. South part of lake is 4 km away from project infrastructure.	South site can be used to characterize any potential changes to the lake (whether local or lake-wide)
Roberts Bay West (Jetty)	Small marine bay where jetty is located.	Potential exposure marine area due to marine activities and infrastructure
Reference Lake D	Small reference lake located west of the project	Reference lake meant to closely resemble the morphology, habitat, and fish community of Little Roberts Lake
Reference Outflow D	reference outflow located west of the project	Reference stream meant to closely resemble the morphology, habitat, and fish community of Little Roberts Outflow
Reference Lake B	Large reference lake located southwest of the project	Reference lake meant to closely resemble the morphology, habitat, and fish community of Doris Lake
Reference Outflow B	reference outflow located southwest of the project	Reference stream meant to closely resemble the morphology, habitat, and fish community of Doris Outflow
Marine Reference Bay	Marine bay located west of the project	Marine reference area meant to provide a reference for the 2 potential marine exposure sites (Roberts Bay East, Roberts Bay West-Jetty)

Three reference areas will be used for comparison to the exposed areas. Two lake/stream outflow areas (Reference Lake B/Reference B Outflow and Reference Lake D/Reference D Outflow) will be used as reference sites for comparability between exposure and reference freshwater habitats (Figure 3.2-1). A single marine reference site will be located in south Reference Bay for comparability with the two exposure sites in Roberts Bay.

To determine potential impacts, all monitored parameters (as per MMER/EEM requirements) will be analyzed using a Multiple Paired Before-After/Control-Impact (BACI) design. Multiple exposure sites and control sites in the lake, stream, and marine habitat will be sampled annually during the construction period (2010; 'before' component of BACI given minimal construction plans; 2011; may be 'before' or 'after' component of BACI, depending on construction activities), the operation period (2012 and 2013; 'after' component of BACI), and into the closure phase of the Project (2014 onwards; 'after' component of BACI). Each of the parameters will be collected at the same time (paired) over the course of the AEMP and will be analyzed using a two-factor Analysis of Variance design (exposure/control system × before/after). All analyzed data will be tested for normality and equal variances, thereby conforming to ANOVA assumptions. The following assumptions will be made in the BACI statistical analysis:

- Potential exposure sites will be Doris Outflow, Little Roberts Lake, Little Roberts Outflow, Roberts Bay East, Doris Lake North, Roberts Bay West;
- Control sites will be Reference Lake B, Reference B Outflow, Reference Lake D, Reference D Outflow, Marine Reference Bay;
- Additional characterization sites will be Roberts Outflow and Doris Lake South;
- 'Before' date will be in 2010, as the construction activities planned are minimal and not expected to influence exposure sites; historical information will also be used for the 'before' period; 2011 may be considered a 'before' date or an 'after' date, depending on the construction activities;
- 'After' dates will be during the operation (2012 and 2013) and closure (2014 onwards) phases; and
- All statistical assumptions will be met to ensure proper inference.

All favourable historical information will be used to strengthen the baseline data set. Historical information is available for most of the exposed locations, but not for all of the reference locations.

3.4 MONITORING SCHEDULE

The proposed monitoring schedule for the Doris North AEMP is presented in Table 3.4-1. The overall plan is to conduct AEMP sampling on a yearly basis, given the short mine life of the project. The proposed seasonal sampling (within year sampling) is also provided in Table 3.4-1.

Baseline information will be collected in 2010 ('Before' period) as the planned construction activities are minimal and will likely not affect the exposure sites. Depending on the construction activities, 2011 may be considered an 'After' period.

The AEMP will be conducted during both years of operation (2012 and 2013). 2012 is the first year that there could be effluent discharge from the Tailings Impoundment Facility.

Table 3.4-1. AEMP Monitoring Schedule, Doris North Project

Mine Phase:	Construction		Operation		Closure	
Year:	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
EEM Cycle:				**EEM First Study Design Report**	**EEM Cycle 1 Interpretive Report**	
Monitoring Component						
Lakes					Re-Evaluate AEMP Monitoring Schedule and EEM Cycles	
Water Quality	4 times/yr	4 times/yr	4 times/yr	4 times/yr		
Phytoplankton Biomass	4 times/yr	4 times/yr	4 times/yr	4 times/yr		
Sediment Quality	1 time/yr	1 time/yr	1 time/yr	1 time/yr		
Benthic Invertebrates	1 time/yr	1 time/yr	1 time/yr	1 time/yr		
Fish Population/Condition	1 time/yr	-	-	1 time/yr		
Fish Hg/Metal	1 time/yr	-	-	1 time/yr*		
Streams						
Water Quality	4 times/yr	4 times/yr	4 times/yr	4 times/yr		
Periphyton Biomass	4 times/yr	4 times/yr	4 times/yr	4 times/yr		
Sediment Quality	1 time/yr	1 time/yr	1 time/yr	1 time/yr		
Benthic Invertebrates	1 time/yr	1 time/yr	1 time/yr	1 time/yr		
Fish Population/Condition	1 time/yr	-	-	1 time/yr		
Fish Hg/Metal	-	-	-	-		
Marine						
Water Quality	4 times/yr	4 times/yr	4 times/yr	4 times/yr		
Phytoplankton Biomass	4 times/yr	4 times/yr	4 times/yr	4 times/yr		
Sediment Quality	1 time/yr	1 time/yr	1 time/yr	1 time/yr		
Benthic Invertebrates	1 time/yr	1 time/yr	1 time/yr	1 time/yr		
Fish Population/Condition	1 time/yr	-	-	1 time/yr		
Fish Hg/Metal	1 time/yr	-	-	1 time/yr*		

**A full suite of fish tissue metal samples will be collected. This will include mercury concentration, which is required under the MMER when the mining effluent (determined during effluent characterization) equals or exceeds 0.10 µg/L (Schedule 5, s. 9(c) of MMER)*

Effluent discharge will facilitate two reports for the EEM/MMER. A First Study Design report must be completed no more than 12 months after the mine becomes subject to MMER (Schedule 5, s. 14(a)), and six months before biological monitoring is initiated (Schedule 5, s. 15). Based on a 2012 effluent discharge date, the First Study Design report would be submitted in 2013. This report will describe how fish population monitoring, fish tissue, and benthic invertebrate community studies will be conducted as well as presenting a full site characterization of the Project area (Section 3.10). The first interpretive EEM cycle 1 report that presents the biological monitoring findings is due within 30 months of effluent discharge. Hence, given that the first chance of effluent discharge is in 2012, and the mine life is over in 2013, it is proposed to complete the EEM Cycle 1 report in 2014.

It is proposed that after the operation phase of the Doris North Project, the AEMP be re-evaluated to determine what the future monitoring schedule should be. If there are additional plans for development in the belt at this time, the AEMP can be modified to accommodate new development plans as well.

For seasonal sampling, Table 3.4-1 presents the proposed sampling frequency outlined in the EEM guidance documents.

3.5 SUMMARY OF AEMP SAMPLING DETAILS

Table 3.5-1 presents the details of the AEMP sampling plan, including the proposed intra-year sampling frequency, replication, timing, and the sampling devices. All proposed field sampling devices and methods comply with the EEM guidance documents.

3.6 WATER QUALITY

Water quality monitoring is a component of the Effluent and Water Quality Monitoring Studies required by EEM studies (Schedule 5, s. 7) and is included in detail in the Doris North Type "A" Water Licence (Schedule J). As mentioned previously, effluent characterization and the site-specific Surveillance Network Program are covered in detail in the Type "A" Water Licence and are not addressed in the AEMP.

Water quality samples collected as part of the AEMP will focus on the receiving environment and reference areas, with the intent of meeting the objectives outlined in Chapter 2 of this document. Water quality results will be analyzed for changes, and will also provide supporting information for the assessment and interpretation of the results of biological monitoring.

3.6.1 Lakes and Marine Areas

To comply with Schedule 5, s.7 (1-2) of the MMER, water quality samples from lakes and the marine environment will be collected four times annually, no less than one month apart (Schedule 5, s. 2(a)), from sampling stations used for the biological and sediment monitoring as well as at the same time as the mine effluent characterization and biological samples are collected (Schedule 5, s. 2(b)). The compulsory parameters identified in Schedules 4 and 5 of the MMER will be analyzed as will other important water quality parameters (Table 3.6-1).

Samples will be collected one time during the winter (late April, when under-ice water quality can be considered 'worst case scenario', and oxygen concentrations will be at their minimums), and one time during the months of July, August, and September.

To assess effects of potential eutrophication, phytoplankton biomass (as determined by chlorophyll *a* concentration) and Secchi depths will also be collected. Dissolved oxygen, temperature, and conductivity (salinity at marine stations) measurements will also be collected at all lake and marine sampling stations.

3.6.2 Streams

Depending on the duration of ice-free conditions, the aim will be to conduct stream water quality surveys four times between June and September.

Samples will be collected 1-2 weeks after freshet (likely late June), and one time during the months of July, August, and September.

The same water quality parameters will be analyzed for streams as for lakes (Table 3.6-1). In addition, periphyton biomass (as determined by chlorophyll *a* concentration) will be measured at the stream locations. Dissolved oxygen and temperature measurements will also be collected.

Table 3.5-1. AEMP Sampling Details, Doris North Project

Monitoring Parameter	Sampling Frequency	Sample Replication and Depths	Sampling Dates/Timing	Sampling Device
Lake and Marine Water Quality				
Physical, nutrients, total metals, dissolved oxygen/temperature profile, Secchi depth	4 x	Lakes: n=1/site @ 1 m below the surface and 2 m above water-sediment interface + 20% replication; Marine: n=2/site	April, July, August, September	GoFlo sampling bottle; Conductivity-Temperature-Depth (CTD) probe; DO meter
Lake and Marine Phytoplankton				
Biomass (chlorophyll *a*)	4 x	n=3/site @ 1 m below the surface	April, July, August, September; coincident with lake and marine water quality	GoFlo sampling bottle
Lake and Marine Benthos				
Abundance and taxonomy	1 x	n=5/site (3 replicate subsamples)	August; coincident with August lake and marine survey	Ekman grab (lake); Ponar grab (marine); 500 µm sieve
Lake and Marine Sediment Quality				
Physical, particle size, nutrients, metals, TOC	1 x	n=3/site	August; coincident with August lake and marine survey	Ekman grab (lake); Ponar Grab (marine)
Stream Water Quality				
Physical, nutrients, total metals, dissolved oxygen, temperature	4 x	n=2/site	June, July, August, September	Clean water sampling bottles; DO/Temperature meter
Stream Periphyton				
Biomass (chlorophyll *a*)	4 x	n=3/site	June, July, August, September; coincident with stream water quality	Artificial Samplers (Plexiglas plates)
Stream Benthos				
Abundance and taxonomy	1 x	n=5/site (3 replicate subsamples)	August; coincident with August stream survey	Hess sampler
Stream Sediment Quality				
Physical, particle size, nutrients, metals	1 x	n=3/site	August; coincident with August stream survey	Ekman grab; 500 µm sieve
Lake Fish Survey				
Condition and reproduction (length, weight, age, DELT, liver weight, gonad weight, egg counts); tissue metals	1 x	n=60 fish/lake (20 male/20 female/20 immature); 8 fish/site for tissue metals	August; coincident with lake and marine August water quality survey	Electrofishing
Marine Fish Survey (Shellfish)				
Condition (whole animal wet weight, soft tissue wet weight, shell length); tissue metals	1 x	n=20 shellfish/site (condition); n=8 shellfish/site (tissue metals)	August; coincident with lake fish survey	Ponar; sieving

Table 3.6-1. AEMP Water Quality Parameters, Doris North Project

Physical Tests and Other	Total Metals
Conductivity[a]	Aluminum (Al)[c]
Salinity[b]	Antimony (Sb)
Total Hardness[f]	Arsenic (As)[d]
pH[f]	Barium (Ba)
Total Alkalinity[f]	Beryllium (Be)
Total Suspended Solids[d]	Bismuth (Bi)
Total Dissolved Solids	Boron (B)
Turbidity	Cadmium (Cd)[c]
Temperature[e]	Calcium (Ca)
Dissolved Oxygen[e]	Chromium (Cr)
Secchi Depth	Cobalt (Co)
Water Depth	Copper (Cu)[d]
Radium 226[d]	Iron (Fe)[c]
Anions	Lead (Pb)[d]
Bromide (Br)	Lithium (Li)
Chloride (Cl)	Magnesium (Mg)
Fluoride (F)	Manganese (Mn)
Sulfate (SO4)	Mercury (Hg)[c]
Total Cyanide (CN)[d]	Molybdenum (Mo)[c]
Nutrients	Nickel (Ni)[d]
Ammonia[c]	Phosphorus (P)
Nitrate[c]	Potassium (K)
Nitrite	Selenium (Se)
Total Kjeldahl Nitrogen (TKN)	Silicon (Si)
Ortho-Phosphate	Silver (Ag)
Total Phosphate	Sodium (Na)
Phytoplankton & Periphyton Biomass and Organic Carbon	Strontium (Sr)
	Thallium (Tl)
Chlorophyll *a*	Tin (Sn)
Total Organic Carbon	Titanium (Ti)
Dissolved Organic Carbon	Uranium (U)
	Vanadium (V)
	Zinc (Zn)[d]

[a] *fresh water samples*

[b] *marine samples*

[c] *subject to EEM Effluent Characterization Study (Schedule 5 s.4(1a-g))*

[d] *MMER deleterious effluent substance (Schedule 4 - Column 1)*

[e] *subject to EEM Water Quality Monitoring Study (Schedule 5 s. 7(b))*

[f] *subject to EEM Water Quality Monitoring Study (Schedule 5 s. 7(c))*

3.6.3 Quality Assurance/Quality Control (QA/QC)

QA/QC principles will follow those outlined in the Metal Mining Guidance Document throughout the field collection and laboratory operation phases. All water quality samples will be collected by qualified personnel using suitable sampling gear (e.g., acid-rinsed Go-Flo sampling bottles). Samples will be properly preserved (where applicable) in appropriate containers and shipped and stored following accepted procedures. Chain-of-Custody forms will be used to track the samples.

Replicate samples will be collected at 10-20% of the total sample number to quantify environmental variability and analytical consistency. Travel, equipment, and field blanks will be collected to verify potential sources of contamination.

3.7 FISH MONITORING

Fish monitoring will include the following two components, which is similar to that outlined in the EEM guidance documents:

1. **Fish Populations and Health** - This component is designed to determine if the mine effluent has an effect on fish health, and

2. **Fish Tissue** - This component is designed to determine if effluent has an effect on fish usability as measured by tissue metal content, with particular attention paid to tissue mercury concentrations.

3.7.1 Fish Population and Health

The EEM program requires fish population monitoring to be undertaken if the effluent in the exposure area is greater than 1% in the area located within 250 m of a final discharge point (*Schedule 5, s. 9(b)*). This trigger is taken into account in the AEMP as fish surveys will be conducted every three years (Table 3.4-1) to determine if there have been changes to fish populations and health irrespective of the effluent discharge regime.

In 2009, comprehensive fish population inventories were conducted in Doris Lake, Little Roberts Lake, and Reference Lake B and their outflows. Fish population inventories were also conducted in the marine habitat (Roberts Bay East and West, Reference Bay). A full fish population survey will be completed in Reference Lake D and Reference D Outflow in 2010 similar to that conducted in 2009. This will give complete fish inventories for two reference lakes (B and D) and their outflows in addition to the two exposure lakes, Doris and Little Roberts lakes, and the marine area.

In addition to the full Reference D lake/outflow survey, two fish species will be collected in all exposure and reference lakes in 2010. Specific survival, energy use, and energy storage parameters will be collected from the fish and compared between sites and over time to properly assess changes in fish populations and health over the life of the mine. This sampling will continue every three years and complies with MMER/EEM guidelines.

There are several important issues to be considered in the fish population and health study design. For example, fish density and richness is low in many Doris North Project lakes and some fish species are present in particular lakes while not present in others. This complicates the study design as it makes inter-lake comparisons difficult if an incorrect sentinel species is selected or insufficient fish are caught to meet statistical considerations. Also, sampling small fish populations can lead to dramatic sampling-induced population losses, which can lead to altered population dynamics and water body trophodynamics, particularly if the fish is an apex consumer such as lake trout or Arctic char. Thus, to meet the fish population and health objective of the proposed AEMP, and to avoid potential sampling pitfalls, particularly in the small Little Roberts Lake, the nine-spined stickleback (*Pungitius pungitius*) will be the primary fish species chosen to estimate potential Project effects. The nine-spined stickleback is a small-bodied fish that is found in all proposed AEMP waterways, is not harvested by Northern residents, and is not an apex consumer thereby making it a suitable sentinel species.

A second fish species will be determined based on 2010 sampling in the Reference D Lake since it is the analogue for Little Roberts Lake. Lake trout will be avoided to lessen potential impacts to the small populations that likely exist in Little Roberts Lake, and Arctic char is not suitable because of its anadromous nature. It is possible that the nine-spined stickleback may be the only fish candidate to be considered.

The study design will focus on the effects that affect fish survival, energy use (growth and reproductive investment), and energy storage (condition). Sampling will commence in 2010 (Before component of BACI design) with a second sampling period being completed in 2013 (After component of BACI design). Following MMER/EEM guidelines, 60 fish (20 male, 20 female, 20 immature) will be caught at each lake from the exposure (Doris and Little Roberts lakes) and reference areas (B and D). The following biological variables will be sampled from each fish to address potential effects:

- Age;
- Size (length and weight);
- Gonad weight;
- Liver weight;
- Fecundity (egg number and weight); and
- DELT (deformities, eroded fins, lesions, and tumours).

From these variables, the following effects endpoints will be assessed:

- Age;
- Size-at-age (body weight against age);
- Relative gonad size (gonad weight against body weight);
- Condition (body weight against length);
- Relative liver size (liver weight against body weight);
- Relative fecundity (# of eggs/female against body weight); and
- Relative egg size (mean egg weight against body weight [or age]).

Internal variables (e.g., liver, gonads) will only be collected from parasite-free fish since internal parasites can make up a large portion of the internal cavity making accurate dissection improbable. Since fish abundance is low in the Project area streams (Appendix 1), and the streams are completely frozen into May and are often not ice-free until early July (the freshet has occurred in mid-July in some years), these waterways will not be sampled for the aforementioned variables.

For the marine areas, previous EEM studies have shown that finfish surveys often perform poorly in the marine environment because of insufficient fish catches or inadequate quantification of effluent exposure. This is likely the result of the high mobility of fish in this environment. According to Section 2(b) of the *Fisheries Act*, 'shellfish, crustaceans, marine animals…' are considered 'fish'. Therefore, we are proposing to sample a bivalve which is present in the marine sampling areas, to include in the AEMP analysis of effects.

The bivalve, Pointed Macoma (*Macoma inquinata*), will be collected for the marine fish survey. This mollusc is present in Hope Bay sediments and is sufficiently large (>5 cm) for tissue collection. Parameters to be measured will include those required to address bivalve condition (whole animal wet weight, soft tissue wet weight, shell length, width, and height) as well as tissue metal and polycyclic aromatic hydrocarbon (PAH) concentrations.

3.7.2 Fish Tissue – Use of Fisheries Resources

Effects on fish usability are monitored by comparing contaminants in edible fish tissue. For the MMER/EEM program, the mercury concentration in fish tissue is used to determine if fish are safe for human consumption, and monitoring is triggered when the mercury concentration in the mining effluent (determined during effluent characterization) equals or exceeds 0.10 µg/L (Schedule 5, s. 9(c)).

As part of the AEMP, fish tissue surveys will be conducted on the nine-spined stickleback in each of the exposure and reference lakes every three years. Whole-fish samples will be tested for a full suite of metals (including mercury). While it is ideal to test the usability criterion on a consumable species such as the lake trout, this species is susceptible to sampling-related mortality, and sampling this species is considered a last resort. Arctic char, another consumable species, frequents Little Roberts Lake, but has not been found in Doris Lake, and is therefore not a sentinel species throughout the entire Doris North Project area. It is also an anadromous species, which is not ideal for monitoring because exposure to an effluent is minimal or transient. Thus, it is proposed to test for metal concentrations in the nine-spined stickleback, and if significant statistical differences are found between exposure and reference lakes during the sampling periods of 2010 and 2013, then a small sample of lake trout (n=8) could be collected from the same lakes and analyzed for metal content. The results would then be compared to lake trout caught in 2009 (n=10) in the exposure and reference lakes allowing for potential effects to be determined. There is a strong possibility that the metal content in lake trout will be sampled non-lethally by 2013 as technological advances may allow much smaller amounts of tissues to be analyzed. If this is the case, the fish will be sampled using biopsy needles where a small plug of tissue is removed, frozen in liquid nitrogen, and subsequently analyzed.

In the marine habitat, the Pointed Macoma will be used to monitor metals in a consumable species. If the Pointed Macoma is not present in sufficient numbers, attempts will be made to collect the Blunt Gaper (*Mya truncata*), a bivalve that has a known Arctic distribution and is eaten by human populations.

3.7.3 Power and Statistical Tests

Because the nine-spined stickleback is a small-bodied fish, and will be sampled lethally, 20 fish of each sex and 20 immatures will be collected at each site since gathering more does little to change the 95% confidence limits. Effect sizes will be considered statistically different between reference and exposure sites at α=0.1. For fish tissue, an effect on fish usability is defined as measurements of total mercury that exceed 0.45 mg/kg wet weight of fish tissue taken from an exposure area that are statistically different from fish tissue measured in a reference area (Schedule 5, s. 1). While most sample sizes in this study will be associated with a power of 0.9 (β=0.1), fish (freshwater) and shellfish (marine) tissue metal analyses will be conducted using a power of 0.95 (eight samples from each site). Statistical power and adequate sample sizes for the 2013 sampling season will be determined based on the information collected from 2010 data collection.

Descriptive summary statistics will be reported for all collected biological parameters. Potential effects to fish size (length and weight) and age will be determined using Analysis of Variance (ANOVA). All ANOVA assumptions will be met prior to analysis and includes normally distributed populations,

equal variances between populations, and sample independence. If populations or variances are unequal, the appropriate transformation will be applied before ANOVA is carried forth.

The remaining effects endpoints (see above) will be analyzed for statistical differences and interactions between the exposure and reference sites using Analysis of Covariance (ANCOVA). The following assumptions will be met before an ANCOVA is applied: equal regression slopes among areas, the independent variable (covariate) is fixed and measured without error, and normally and independently distributed residuals with zero mean and a common variance.

Potential differences in DELT characteristics between exposure and reference sites will be compared using the Chi Square (X^2) test.

3.7.4 Quality Assurance/Quality Control (QA/QC)

QA/QC measures will be followed throughout the data, field, and laboratory phases. Data quality will be screened for entry errors and will be checked for outliers using scatterplots. It will be determined whether outliers are due to data entry or occur through biological means (e.g., sick or damaged fish, parasitized fish). Data entry errors will be corrected while outliers from sick/injured fish will be removed. If there is no clear reason for the outlier, analysis will be conducted in the presence and in the absence of the outlier(s) to determine the magnitude of influence it has on the conclusions.

In the field, all personnel will have suitable expertise to conduct surveys and perform dissections. All safety measures and standard operations protocols (SOPs) will be followed. Proper sampling gear (e.g., dissecting equipment) and methods (e.g., electrofishing) will be employed by personnel while in the field. All sampling information will be appropriately documented, preserved (as necessary), stored, and shipped. Chain of Custody forms will used to track all sample shipments.

Fish samples will be analyzed by accredited laboratories with trained staff. Analyses will be conducted by recognised protocols and methods with properly calibrated and maintained instrumentation. Records of samples, analyses, method detection limits, and laboratory staff conducting analyses must be kept and be readily available. Analyses will be conducted by as few as technicians as possible to maintain consistency and reduce measurement error. If sub-sampling is required (e.g., fecundity, egg size), efficiency and accuracy results of the technique must be documented and the information used to calculate appropriate correction or scaling factors to minimise potential differences in methods and efficiency. All records of lesions, parasites, and other deformities will be noted.

3.8 BENTHIC INVERTEBRATE COMMUNITY

Benthic invertebrate surveys will be conducted annually to determine if the Doris North effluent and infrastructure is having an effect on fish habitat. This will be done by collecting benthic invertebrates from exposure and reference areas in all three aquatic habitats: lakes, streams, and marine.

Final endpoints to be compared will include:

- Total Invertebrate Density;
- Taxon richness;
- Simpson's diversity index and evenness; and
- Bray-Curtis Index.

Samples will be collected from the most "ecologically-relevant" area (i.e., considering habitat type with the highest density and the dominant habitat in exposure area) during the most "ecologically-relevant" season (i.e., the time of year when the benthic invertebrate diversity is highest and benthic invertebrates are most exposed to effluent). For the Doris North Project site, this will be August. Sampling will coincide with the water quality, primary producer biomass, and sediment surveys.

3.8.1 Power and Statistical Tests

Statistical considerations will include the determination of the magnitude of an environmental impact, or effect size, which is deemed ecologically important. Adequate sample sizes will be determined via power analysis by selecting the appropriate α and β values to control for Type I and II errors. With an effect size estimate for any effect endpoint set *a priori* at ±2SD (calculated from the reference area), and α and β values both equal and set at 0.1, five replicate benthic samples (with three subsamples per replicate station) will have sufficient power (1-β=0.9) to determine statistically significant differences for specific endpoints between the exposure and reference sites. The level of power and adequate sample sizes will be assessed at each study phase through the course of the AEMP and EEM/MMER.

Descriptive summary statistics will be reported for all collected biological parameters. Analysis of Variance (ANOVA) will be used to determine statistically significant differences for the four effect endpoints (density, taxon richness, the Simpson's Evenness Index, and the Bray-Curtis Index) between reference and exposure areas. All statistical assumptions will be met before analysis is attempted. These include normally and independently distributed data with equal variances observed between the exposed and reference areas. Non-normal data will be suitably transformed to meet the requirements for parametric tests.

3.8.2 Quality Assurance/Quality Control (QA/QC)

QA/QC principles will be follow those outlined in the Metal Mining Guidance Document throughout the field collection and laboratory operation phases. Briefly, benthic invertebrate samples will be collected by qualified personnel using suitable sampling gear (e.g., Ekman grab (lakes); Hess sampler (streams); Ponar grab (marine); sieved through 500 µm mesh). Samples will be properly preserved (buffered formalin) in appropriate containers and shipped and stored following accepted procedures.

In the laboratory, all sample processing and identifications will be conducted by expert taxonomists and appropriate sub-sampling and random re-sorting techniques will be followed. Data quality will be verified by screening potential data entry errors. All samples will be stored for six years following analysis and a reference collection will be compiled.

3.9 SEDIMENT QUALITY

Sediment quality samples will be collected annually in conjunction with the benthic invertebrate surveys to determine if mining activity is having an effect on the sediment layer, and by extension, the benthic invertebrate community and fish habitat. The total organic carbon content and particle size distribution of the sediments at each benthic invertebrate station will be collected thereby following EEM guidelines. Other important sediment parameters to be collected will include the total metal and nutrient content of the sediment (Table 3.9-1).

3.9.1 Quality Assurance/Quality Control (QA/QC)

QA/QC principles will follow those outlined in the Metal Mining Guidance Document throughout the field collection and laboratory operation phases. All sediment quality samples will be collected by qualified personnel using suitable sampling gear (e.g., Ekman grab [lakes and streams]; Ponar grab [marine]). Samples will be deposited into appropriate containers and shipped and stored following accepted procedures. Chain-of-Custody forms will be used to track the samples.

Table 3.9-1. AEMP Sediment Quality Parameters, Doris North Project

Physical Tests	**Metals**	Manganese (Mn)
% Moisture	Aluminum (Al)	Mercury (Hg)
pH	Antimony (Sb)	Molybdenum (Mo)
Particle Size[a]	Arsenic (As)	Nickel (Ni)
% Gravel (>2 mm)	Barium (Ba)	Phosphorus (P)
% Sand (2.0 mm - 0.063 mm)	Beryllium (Be)	Potassium (K)
% Silt (0.063 mm - 4 µm)	Bismuth (Bi)	Selenium (Se)
% Clay (<4 µm)	Cadmium (Cd)	Silver (Ag)
Nutrients	Calcium (Ca)	Sodium (Na)
Total Nitrogen	Chromium (Cr)	Strontium (Sr)
Ammonium	Cobalt (Co)	Sulfur (S)-Total
Nitrate	Copper (Cu)	Thallium (Tl)
Nitrite	Iron (Fe)	Tin (Sn)
Phosphate	Lead (Pb)	Titanium (Ti)
Organic/Inorganic Carbon	Lithium (Li)	Vanadium (V)
Total Organic Carbon[a]	Magnesium (Mg)	Zinc (Zn)

[a] mandatory for EEM benthic invertebrate survey

3.10 SITE CHARACTERIZATION

Site characterization information is required as a subset of the biological monitoring studies (Schedule 5, s. 9) when mines become subject to MMER. This information will be included in the First Study Design submission that is required within 12 months of initial effluent discharge and six months before any biological sampling can proceed. The following information will be included as part of the EEM/MMER First Study Design submission (2013 – see Section 5.2.1):

- a description how the effluent mixes within the exposure area, with an estimate of the effluent concentration in water 250 m from the discharge point;
- a description of the reference and exposure areas where the biological monitoring studies will be conducted. Information will include the geology, hydrology, oceanography, limnology, and the chemical and biological features of these areas;
- the type of production process used by the mine, and environmental protection practices used at the mine;
- a description of any anthropogenic, natural or other factors that are unrelated to the effluent that may contribute to an observed effect; and
- any additional information relevant to the site characterization.

4. Reporting

5. Adaptive Management

4. Reporting

4.1 ANNUAL AEMP REPORTS

Following each AEMP monitoring season, an annual report will be prepared and submitted to the Nunavut Water Board. The annual report will include the following:

- All of the raw monitoring data obtained during that year of monitoring;
- Description of the methods used for data collection;
- A detailed evaluation of effects on the designed monitored parameters;
- Results from the evaluation of effects, in text and figures;
- Conclusions from the evaluation of effects;
- Description of mitigation measures in place, and a discussion of effectiveness; and
- Identification if additional mitigation measures could be employed.

4.2 FIRST STUDY DESIGN AND CYCLE 1 EEM REPORT

4.2.1 First Study Design Report

MMER requires that an initial study design be submitted to an authorization officer within 12 months of the mine becoming subject to MMER (Schedule 5, s. 14(a)) and six months before biological monitoring is initiated (Schedule 5, s. 15). Since the earliest date of effluent discharge is 2012, the First Study Design report would be submitted to the required authorities no later than 2013. This report will contain:

- a site characterization;
- a description of how the study respecting the fish population will be conducted;
- a description of how the study respecting the fish tissue will be conducted;
- a description of how the study respecting the benthic invertebrate community will be conducted;
- the dates and times that the samples will be collected for the biological monitoring; and
- a description of the quality assurance and quality control measures that will be implemented to ensure the validity of the data collected.

4.2.2 Cycle 1 Interpretative EEM Report

Pursuant to Schedule 5, s. 18(a) of the MMER, the first interpretative report must be submitted within 30 months after the mine becomes subject to MMER. Thus, the first Cycle 1 interpretative report is planned to be submitted in late 2014 since the earliest date effluent would be released is 2012. This report will contain the following information:

- documentation of latitude and longitude of sampling areas and a sufficient description of sampling areas to allow proper identification;
- dates and times of sample collection;

- sample sizes;
- the results of data assessment with appropriate statistical analyses and all supporting raw data;
- the identification of any biological effects;
- the comparison of any effects with results from sublethal toxicity testing (from effluent characterization, as will be carried out as per the Doris North Type "A" Water Licence);
- the conclusions of biological monitoring and water quality studies, taking into account any other potential factors not related to the effluent (anthropogenic or natural), and a description of quality assurance and control measures that were implemented;
- a description of how future study design for monitoring will be affected by the results; and
- the date when next biological EEM cycle will commence.

It is likely that the requirements of the Cycle 1 EEM report can be included in the annual AEMP report, so that two separate reports do not need to be produced. Hence, for the year that the Cycle 1 report must be prepared, that year's AEMP will be submitted to comply with the EEM requirements if appropriate.

5. Adaptive Management

The AEMP is a key component of adaptive management because it provides the annual monitoring data and analytic assessments required to determine if mining activity or natural variability are affecting the aquatic and marine ecosystems. Each year, the data collected as part of the AEMP will be screened, reviewed, and analyzed to determine if any changes have occurred in the aquatic environment. Results of that evaluation will be described in an annual report. The significance of change, and whether it is a mine effect or natural variation, will be determined using a combination of statistical analyses, graphical analyses, and the use of professional judgement.

During and after the analysis of each year's AEMP data, mining activities that may be responsible for environmental changes will be evaluated and potential mitigation measures will be determined on the basis of present and future risk to the aquatic environment. If there is insufficient data available to justify changing mining practices, then additional effects studies could be implemented to collect data to better assess ecological risk. If mitigation measures are commissioned, then follow-up monitoring should be conducted to assess the effectiveness of those measures.

Appendix 1

Existing Data

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APPENDIX 1 - Existing Data

The collection of environmental data has been ongoing in the Doris North Project area, with periodic exceptions, since 1995. This section presents an overview of the parameters and methods relevant to the proposed AEMP and EEM program.

1.1 WATER QUALITY

1.1.1 Lakes

Water quality data has been collected on a near annual basis for lakes in the Doris North Project area since 1995 (Appendix Table 1-1). Samples were collected using Go-Flo or Kemmerer water sampling devices and single samples were usually collected at each depth. Periodic duplicate samples were collected following a 10–20% replication procedure. Surface samples were always collected and deep depths were usually collected. Total metal concentrations were analyzed during each period agreeing with MMER/EEM standards. Travel, equipment, and field blanks were a consistent part of the QA/QC program and split samples were occasionally performed.

Seasonally, lake water quality samples were collected four times per year in 1995, 2004, and 2006–9 (three open-water; one under-ice). Three months of data were gathered in 1997, 2003, and 2005, respectively. Little Roberts Lake (11×) and Doris North (8×) were the most frequently sampled lakes, while Doris South (2×) and Reference Lake B (1×) were seldom sampled. Hence, high quality continuous data has been collected between 2003 and 2009, particularly in the proposed exposure lakes (Doris and Little Roberts).

1.1.2 Streams

Streams in the Doris North region were sampled during 11 of the 15 years between 1995 and 2009. In general, the sampling quality was high and meets a majority of the MMER/EEM guidelines and the sampling design proposed in this AEMP. Single samples were typically gathered with some replication based on a 10–20% replication procedure. Total metals were always analyzed. Water quality samples were collected the preferred four months per year consecutively from 2004 to 2008, and only twice were sampled less than three months per year. Each stream in the proposed AEMP (Doris, Little Roberts, and Roberts Outflows) was sampled four months per year from 2004 to 2008 and three times annually in 2009 (which also included Reference B Outflow). Doris Outflow has been sampled consistently throughout the sampling program.

A major sampling feature in streams is the timing of the spring thaw. A majority of the stream network in the Doris North Project area is frozen solid into May (no collectable water) and the annual freshet can be as late as mid-July. Consequently, the spring thaw and the ability to safely sample free-flowing water will dictate the timing of the first seasonal samples collected in streams.

Appendix Table 1-1. Historical Water Quality Baseline Data Summary for Doris North Project

Year	1995	1996	1997	1998
Lakes				
Sampling month(s):	May*, June*, July, Aug	Apr*, Aug	Apr*, July, Aug	Apr*
Sampling Depths:	Surface and shoreline surface grab at all sites. Vertical profiles at Doris N and S in August.	Metered depths throughout length of column.	Shallow depth at all sites. Deep depth sampled at Doris S	Shallow depth
Analytical Results for Metals:	Total (all sites) and dissolved (1 sample at Doris N)	Total and dissolved	Total and dissolved	Total
Replication:	n = 1 at each sampling event/depth	n = 1 at each sampling event/depth	n = 1 + ca. 20% replication at each sampling event/depth	n = 3 at each sampling event (2 Replicates, 1 split sample)
QA/QC:	Split samples, Travel/Field Blanks, Inter Lab Sample	Split samples, Travel/Field Blanks	Split samples, Replicates, Travel Blanks	Split samples, Replicates, Travel Blanks
Field Methodology:	Grab samples at surface. 2 L Aquatic Research Instruments sampler for depth sampling.	2 L GO-FLO Bottle	5 L GO-FLO Bottle	5 L GO-FLO Bottle
Sampled sites:	Doris N Doris S Little Roberts	Little Roberts	Little Roberts	Little Roberts
Streams				
Sampling month(s):		June, Aug	June, July, Aug	June, July, Aug
Analytical Results for Metals:		Total and dissolved	Total and dissolved	Total
Replication:		n = 1 at each sampling location/event + variable % of replicates	n = 1 at each sampling location/event + variable % of replicates	n = 1 at each sampling location/event + variable % of replicates
Sampled Sites:		Doris OF	Doris OF	
Marine				
Sampling Month(s):		August	August	July
Sampling Depths:		not provided	Shallow depth at RBE and RBW; Deep depth at RBW	Shallow depth at RBE and RBW; Deep depth at RBW
Physical:		none	Secchi Depth, DO and Temperature profiles; no salinity	Secchi Depth, DO and Temperature profiles; no salinity
Analytical Results for Metals:		Total and Dissolved	Dissolved	Dissolved
Replication:		n=1 at RBE; n=2 at RBW	n=1	n=1 surface; n=2 RBE deep depth
QA/QC:		Split samples, Replicates, Travel/Field Blanks	Split samples, Travel Blanks	Split samples, Replicates, Travel Blanks
Field Methodology:		2 L G-FLO Bottle	5 L GO-FLO Bottle	5 L GO-FLO Bottle
Sampled Sites:		Roberts Bay East Roberts Bay West	Roberts Bay East Roberts Bay West	Roberts Bay East Roberts Bay West

(continued)

Appendix Table 1-1. Historical Water Quality Baseline Data Summary for Doris North Project

Year	1999	2000	2003	2004
Lakes				
Sampling Month(s):	July	July, Aug	July, Aug, Sept	June*, July, Aug, Sept
Sampling Depths:	Shallow depth and Shoreline surface grab	Shallow depth and Mid Depth	Shallow depth	Shallow and deep depths
Analytical Results for Metals:	Total	Total	Total and dissolved	Total and dissolved
Replication:	n = 2 at each sampling event/depth	n = 2 at each sampling event/depth	n = 1 at each sampling event/depth	n = 1 at each sampling event/depth
QA/QC:	Replicates	Replicates, Travel/Field Blanks	Split samples, Travel Blank (due to laboratory error, blank was contaminated)	Replicates, Travel/Field/Equipment Blanks
Field Methodology:	Grab samples at surface. 5 L Go-Flo at depth	5 L GO-FLO Bottle	Van Dorn Water Sampler	Shallow samples - geopump and Tygon tubing; Deep samples - Kemmerer water sampler.
Sampled Sites:			Doris N Little Roberts	Doris N Little Roberts
Streams				
Sampling Month(s):		June, Sept	July, Aug, Sept	June, July, Aug, Sept
Analytical Results for Metals:		Total	Total	Total and dissolved
Replication:		n = 2 at each sampling event/location	n = 1 at each sampling event/location	n = 1 at each sampling event/location
Sampled Sites:		Doris OF	Doris OF Little Roberts OF	Doris OF Little Roberts OF Roberts OF
Marine				
Sampling Month(s):				July, August, September
Sampling Depths:				mid-column
Physical:				Secchi Depth, DO and Temperature profiles; no salinity
Analytical Results for Metals:				Total; Dissolved (August only)
Replication:				n=1
QA/QC:				Travel/Field/Equipment Blanks
Field Methodology:				Kemmerer Bottle Sampler
Sampled Sites:				Roberts Bay East

(continued)

Appendix Table 1-1. Historical Water Quality Baseline Data Summary for Doris North Project (completed)

Year	2005	2006	2007	2008	2009
Lakes					
Sampling Month(s):	July, Aug, Sept	May/June*, July, Aug, Sept	May*, July, Aug, Sept	May*, July, Aug, Sept	April/May*, Aug
Sampling Depths:	Shallow and deep depths	Shallow and deep depths	Shallow and deep depths	Shallow and deep depths	Shallow and deep depths
Analytical Results for Metals:	Total and dissolved	Total and dissolved	Total and dissolved	Total and dissolved	Total and dissolved
Replication:	n = 1 at each sampling event/depth	n = 1 at each sampling event/depth	n = 1 at each sampling event/depth	n = 1 at each sampling event/depth	n = 1 + 20% replication at each sampling event/depth
QA/QC:	Field/Equipment Blanks	Replicates, Field Blanks	Replicates, Field Blanks	Replicates, Field/Equipment Blanks	Replicates, Field/Equipment Blanks
Field Methodology:	Kemmerer Bottle Sampler	Kemmerer Bottle Sampler	Kemmerer Bottle Sampler	Kemmerer Bottle Sampler	5 L GO-FLO Bottle
Sampled Sites:	Doris N Little Roberts	Doris N Little Roberts	Doris N Little Roberts	Doris N Little Roberts	Doris N Doris S Little Roberts Ref Lk B
Streams					
Sampling Month(s):	June, July, Aug, Sept	June, July, Aug, Sept	June, July, Aug, Sept	June, July, Aug, Sept	June, Aug, Sept
Analytical Results for Metals:	Total and dissolved	Total and dissolved	Total and dissolved	Total and dissolved	Total and dissolved
Replication:	n = 1 at each sampling event/location	n = 1 at each sampling event/location	n = 1 at each sampling event/location	n = 1 at each sampling event/location	n = 2 at each sampling event/location
Sampled Sites:	Doris OF Little Roberts OF Roberts OF	Doris OF Little Roberts OF Roberts OF	Doris OF Little Roberts OF Roberts OF	Doris OF Little Roberts OF Roberts OF	Doris OF Little Roberts OF Roberts OF Ref B OF
Marine					
Sampling Month(s):	July, August, September	May*, July, Aug, Sept	May*, July, Aug, Sept	July, August, September	April*, August
Sampling Depths:	mid-column	mid-column (May); surface and deep (July, Aug, Sept)	surface and deep	surface and deep	Surface at RBE and RBW; deep at RBW (August only)
Physical:	Secchi Depth, DO and Temperature profiles	Secchi Depth, DO and Temperature profiles	Secchi Depth, DO and Temperature profiles	Secchi Depth, DO and Temperature profiles	Secchi Depth (August only), DO and Salinity/Temperature profiles
Analytical Results for Metals:	Total and Dissolved	Total and Dissolved	Total and Dissolved; limited data for May samples	Total and Dissolved	Total and Dissolved
Replication:	n=1	n=1	n=1	n=1	n=1 RBE, n=2 RBW (April); n=2 RBE, n=1 each depth RBW (August)
QA/QC:	Field/Equipment Blanks	Field Blanks	Field Blanks	Field/Equipment Blanks	Replicates, Field/Travel/Equipment Blanks
Field Methodology:	Kemmerer Bottle Sampler	Kemmerer Bottle Sampler	Kemmerer Bottle Sampler	Kemmerer Bottle Sampler	5 L Niskin (April); 5 L GO-FLO (August)
Sampled Sites:	Roberts Bay East	Roberts Bay East	Roberts Bay East	Roberts Bay East	Roberts Bay East Roberts Bay West

** denotes under-ice sampling*
RBE - Roberts Bay East
RBW - Roberts Bay West

1.1.3 Marine

The marine water quality sampling for the AEMP is designed to measure potential effects from the effluent that flows from Little Roberts Outflow into Roberts Bay (Roberts Bay East) and the marine traffic/off-loading near the jetty site (Roberts Bay West). Limited marine water quality samples were collected in Roberts Bay East (RBE) and West (RBW) during one summer month between 1996 and 1998. Water was collected using acid-rinsed Go-Flo bottles. Dissolved metals were collected each year and total metal concentrations were analyzed in 1996. Physical parameters (temperature, dissolved oxygen, and Secchi depth) were measured during 1997 and 1998.

Since 2004, marine water quality sampling in Roberts Bay East has largely followed MMER/EEM guidelines and the goals of this AEMP. Sampling has been undertaken with the proper sampling gear, total and dissolved metal concentrations have been analyzed each year, and several physical traits have been consistently measured (e.g., temperature, secchi depth, dissolved oxygen). Water quality sampling in Roberts Bay West was initiated in 2009. Collecting salinity profiles was also initiated in 2009.

Seasonally, marine water quality samples were collected twice in 2009, three times in 2004–5 and 2008, and four times per annum in 2006 and 2007. Notably, seawater analyses are significantly more expensive than freshwater, and the expected marine activities associated with the project have been minimal.

1.2 FISH

1.2.1 Lakes

Fish surveys in the proposed AEMP lakes have been conducted since 1995. Doris Lake has been surveyed seven times between 1995 and 2009, Little Roberts Lake four times, and Reference Lake B was first sampled in 2009 (Appendix Table 1-2). Length, weight, and age endpoints have been consistently collected in all lakes, and tissue metals have been collected in Doris Lake since 1995. Metal samples were drawn from the muscle, liver, and kidney of lake trout, lake whitefish, and lake cisco. Tissue metals were also collected in Little Roberts Lake and Reference Lake B in 2009. Stomach contents were collected in Little Roberts Lake fish from 2000 to 2003, Doris Lake in 2003, and in all proposed AEMP lakes in 2009.

Of the proposed AEMP lakes, the most fish were caught in Doris Lake, although catch-per-unit-effort (CPUE) data suggest this could occasionally be due to increased sampling effort (Appendix Table 1-3). Dominant species varied from year to year, but lake whitefish, lake trout, lake cisco, and nine-spined stickleback were the most abundant. Overall, fewer fish were caught in Little Roberts Lake. Arctic char appears to be the most abundant fish in this small lake, with small numbers of lake trout, lake whitefish, lake cisco, and nine-spined stickleback being observed. In Reference Lake B, nine-spined stickleback were the most frequently encountered fish, followed by lake trout, Arctic char, and the slimy sculpin. Most of the fishing effort between 1995 and 2009 was through gill-netting.

Appendix Table 1-2. Historical Lake Fisheries Baseline Data Summary for Doris North Project

Lake	Doris Lake								
Year	1995	1996	1997	2000	2002	2003	2005	2007	2009
Sampling month(s)	Aug	Aug	Aug			Jul, Aug, Sep	Sep	Aug	Aug
Fish Community	1 LT, 7 LW, 3 CS, unknown number of NS	18 CS, 4 LT, 20 LW	338 CS, 56 LT, 126 LW			5 LT, 5 LW, 1 LC, 1 CS, 16 NS	95 NS, 43 LT, 1 LW, 6 CS	9 LT, 18 LW, 143 CS	50 LT, 222 LW, 499 CS, 5 NS
Length, weight, age	√	√	√			√	√	√	√
Tissue Metals	1 LT (MLK), 3 LW (MLK)	1 LT (M*), 2 LW (ML*), 1 CS (M)	22 LT (ML), 29 LW (ML)			-	-	-	10 LT (ML)
Diet	-	-	-			√	-	-	√
Lake	**Little Roberts Lake**								
Year	1995	1996	1997	2000	2002	2003	2005	2007	2009
Sampling month(s)				Aug	Sep	Aug, Sep			Aug
Fish Community				29 AC, 1 BW, 6 LC, 7 LW, 21 LT	6 AC, 2 LT, 1 LC	7 AC, 6 LT, 1 CS, 3 LC, 20 NS			12 AC, 10 LT, 1 LW, 2 NS
Length, weight, age				√	√	√			√
Tissue Metals				-	-	-			9 LT (ML)
Diet				√	√	√			√
Lake	**Reference Lake B**								
Year	1995	1996	1997	2000	2002	2003	2005	2007	2009
Sampling month(s)									Aug
Fish Community									5 AC, 26 LT, 73 NS, 2 SS
Length, weight, age									√
Tissue Metals									10 LT (ML)
Diet									√

Fish Species Codes:

AC - Arctic Char
AF - Arctic Flounder
BW - Broad Whitefish
CS - Cisco
LC - Least Cisco
LT - Lake Trout
LW - Lake Whitefish
NS - Nine-spined Stickleback
SS - Slimy Sculpin
UC - Char spp.

Tissue Metal Codes:

M - Muscle
L - Liver
K - Kidney
** - Composite sample*

Appendix Table 1-3. Historical Fish Catch-per-Unit-Effort (CPUE) in Lakes for Doris North Project

Lake	Doris Lake															
Year	1995[a]	1996[b]	1997[c]	2000	2002	2003[d]				2005[e]			2007[f]	2009[i]		
Method	GN	GN	GN			GN	FN	EF	BS	EF	MT	AG	GN	GN	MT	EF
Arctic Char																
Arctic Flounder																
Broad Whitefish																
Cisco									0.19	0.09			233.8			
Fourhorn Sculpin																
Least Cisco	1.7	2.72 (s), 0.15 (l)	148.2			0.8								5.07		0.01
Lake Trout	0.6	0.48 (s), 0.15 (l)	23.4			0.51	0.08	0.03		0.06		4.24	14.7	0.51		
Lake Whitefish	4.0	3.04 (s), 0.15 (l)	51.7			1.04	0.04		0.19	0.01			29.4	2.27		0.05
Nine-spined Stickleback							0.2	0.34		0.62	7.27				0.04	
Slimy Sculpin																
Starry Flounder																
Unidentified Fish																

Lake	Little Roberts Lake									
Year	1995	1996	1997	2000[g]	2002[h]	2003[d]		2005	2007	2009[i]	
Method				GN	GN	GN	FN			GN	MT
Arctic Char				23.2	27.2	0.82	0.49			1.12	
Arctic Flounder											
Broad Whitefish				1.4							
Cisco						0.26					
Fourhorn Sculpin											
Least Cisco				3.6	4.5	0.87					
Lake Trout				15.3	9.1	1.05	0.25			0.93	
Lake Whitefish				4.6						0.10	
Nine-spined Stickleback							2.47				0.34
Slimy Sculpin											
Starry Flounder											
Unidentified Fish											

Lake	Reference B Lake									
Year	1995	1996	1997	2000	2002	2003	2005	2007	2009[i]	
Method									GN	MT
Arctic Char									0.51	0.09
Arctic Flounder										
Broad Whitefish										
Cisco										
Fourhorn Sculpin										
Least Cisco										
Lake Trout									2.22	
Lake Whitefish										
Nine-spined Stickleback										6.94
Slimy Sculpin										0.19
Starry Flounder										
Unidentified Fish										

GN = Gillnetting

[s] - small mesh gillnets

[l] - large mesh gillnets

FN = Fyke Net

EF = Backpack Electrofisher

BS = Beach Seine

MT = Minnow Trap

AG = Angling

[a] - CPUE = #fish/100 m^2 per 12 h period

[b] - small mesh size (s) CPUE - #fish/61 m/hr, large mesh size (l) CPUE fish/45.7 m/hr

[c] - CPUE = # of fish in gang x [(100/total gang area) x (24/set time)]

[d] - CPUE units: gill net = #fish/100 m^2 /24 hr; fyke net = fish/24 hr; electrofishing = fish/100 s; beach seine = fish/100 m^2

[e] - CPUE units: angling=#fish/ hr; electrofishing=#fish/100 s; minnow traps=#fish/24 hr

[f] - CPUE units: #gill net = fish/100 m^2 /24 hr

[g] - CPUE = # fish caught per gang X (100/total gang area) X (24/set time)

[h] - CPUE = # fish/100 m^2 of each mesh size panel/24 hr

[i] - CPUE units: gill net = # fish caught per net x (100 / total net area) x (1 / set time); Minnow Trap = # fish x [set time (h)/24 h(day)]; Electrofishing = # fish caught / 100 s

1.2.2 Streams

Fish surveys have been conducted in streams of the Doris North Project area since 1995 (Appendix Tables 1-4 and 1-5). Length, weight, condition, and age have commonly been measured in the proposed AEMP streams. Tissue metals were collected in Roberts Outflow during the 2002 sampling season, and stomach contents were collected in the same outflow during 2002 and 2003.

Arctic char, lake trout, lake cisco, and nine-spined stickleback were most common in the Doris Outflow. Arctic char and lake trout had high numbers in Little Roberts Outflow and nine-spined stickleback were occasionally recorded. This was also the case in Roberts Outflow. There were few fish recorded in Reference B Outflow in 2009 (first year of sampling). Three Arctic grayling were recorded in August, and a single lake trout was also observed.

1.3 BENTHIC INVERTEBRATE COMMUNITIES

Surveys of benthic invertebrate communities are a requirement of the MMER/EEM program and a major feature of any aquatic sampling program. Lake, stream, and marine benthic invertebrate communities have been quantitatively sampled since 1996. The MMER/EEM program has specific requirements for sample sizes based on effect size and α and β levels (0.1). These sampling considerations will be implemented beginning in 2010.

1.3.1 Lakes

Benthos samples were collected in lakes of the Doris North Region five times between 1996 and 2009 (Appendix Table 1-6). Samples were always collected during mid-summer using Ekman grabs, and except in 2007, were sieved through a 500 μm mesh size. The 243 μm mesh size used in 2007 precludes it from comparisons to other years. Benthic samples were collected from multiple depths (shallow, mid-depth, deep) in Doris Lake North and South and a single depth in Little Roberts Lake. Replication was typically three samples per station, which is lower than recommended by MMER/EEM guidelines.

1.3.2 Streams

Initial stream benthos sampling was conducted in 1996–7 and 2000 using Hester Dendy plates. When stream sampling resumed in 2009, a Hess sampler was used at each site in Doris, Little Roberts, and Reference B Outflows. Three replicates were collected at each site in 2009. This sample size can be used for statistical tests (e.g., ANOVA), although it does not meet the level of power desired under MMER/EEM guidelines (five replicates).

1.3.3 Marine

Single benthos samples were collected at both marine stations in 1997 and 1998. In 2009, benthos samples (n=3) were collected in Roberts Bay West (jetty station) and in Reference Bay.

1.4 SEDIMENT QUALITY

Sediment quality surveys (particle size and total organic carbon) are used to compliment the benthic invertebrate surveys under the MMER/EEM. While only limited sediment quality parameters with no sample replication are required, a full suite of sediment parameters (e.g., total metals, nutrients, organics) with adequate replication will increase the interpretative capability of the sediment habitat as it relates to the biological monitoring components (i.e., benthic invertebrates and fish). This will be undertaken as part of the proposed AEMP.

Appendix Table 1-4. Historical Stream Fisheries Baseline Data Summary for Doris North Project

Stream	Doris Outflow											
Year	**1995**	**1996**	**1997**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2009**
Sampling month(s)	Aug	Jul	Aug	Jun, Aug			Aug		Sep			Aug
Fish Community	5 AC, 3 CS, unknown number of NS	5 LT, 1 LW, 2 unknown	7 AC, 7 CS, 6 LT, 1 LW, 7 NS, 1 LT	19 NS			5 AC, 12 LT, 11 NS		3 LT			8 NS, 1 LT
Length, weight, age	√	-	√	√			√		√			√
Tissue Metals	-	-	-	-			-		-			-
Diet	-	-	-	-			-		-			-

Stream	Little Roberts Outflow											
Year	**1995**	**1996**	**1997**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2009**
Sampling month(s)			Aug	Aug			Aug	Aug		Jun, Jul	Jun, Jul	Aug
Fish Community			10 juv. AC, 3 juv. LT, 11 NS	none caught			11 NS, 1 AC, 1 FS	12 AC, 6 LT, 23 NS, 1 AF		193 AC, 66 LT, 1 BW	375 AC, 119 LT, 2 LW, 2 BW, 1 LC	NS (observed)
Length, weight, age			√	-			√	√		√	√	
Tissue Metals			-	-			-	-		-	-	
Diet			-	-			-	-		-	-	

Stream	Roberts Outflow											
Year	**1995**	**1996**	**1997**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2009**
Sampling month(s)						Aug	Aug, Sep	Aug, Sep	Aug, Sep			
Fish Community						168 AC, 18 LT, 1 BW	479 AC, 43 LT, 2 BW, 3 CS, 8 LC, 8 NS	236 AC, 147 LT, 18 UC, 1 CS, 1 NS	279 AC, 96 LT, 1 LW, 5 NS			
Length, weight, age						√	√	√	√			
Tissue Metals						30 AC (MLK)	-	-	-			
Diet						√	√	-	-			

Stream	Reference B Outflow											
Year	**1995**	**1996**	**1997**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2009**
Sampling month(s)												Aug
Fish Community												1 AG, 1 LK
Length, weight, age												√
Tissue Metals												-
Diet												-

Fish Species Codes:

AC - Arctic Char
AF - Arctic Flounder
AG - Arctic Grayling
BW - Broad Whitefish
CS - Cisco
FS - Fourhorn Sculpin
LC - Least Cisco
LT - Lake Trout
LW - Lake Whitefish
NS - Nine-spined Stickleback
UC - Char spp.

Tissue Metal Codes:

M - Muscle
L - Liver
K - Kidney
** - Composite sample*

Appendix Table 1-5. Historical Fish Catch-per-Unit-Effort (CPUE) in Streams for Doris North Project

Stream	Doris Outflow												
Year	1995[a]	1996[b]	1997[c]	2000	2001	2002	2003[d]	2004	2005[e]		2006	2007	2009[d]
Method	EF	EF	EF	EF					EF	AG			EF
Arctic Char	0.08		1.2				0.24						
Arctic Flounder													
Broad Whitefish													
Cisco													
Fourhorn Sculpin													
Least Cisco	0.10		1.2										none caught
Lake Trout		18.9	1.1				0.56		0.31	2			
Lake Whitefish		5.52	0.2										
Nine-spined Stickleback	0.25		1.2	*			0.52						
Slimy Sculpin													
Starry Flounder													
Unidentified Fish		7.3											

Stream	Little Roberts Outflow											
Year	1995	1996	1997	2000	2001	2002	2003[d]	2004[d]	2005	2006[f]	2007[f]	2009
Method			EF	EF			EF	EF		FF	FF	
Arctic Char			0.9				0.06	0.46		5.24 (dt), 63.42 (ut)	3.01 (ut)	
Arctic Flounder								0.04				
Broad Whitefish										0.38 (ut)	0.08 (ut)	
Cisco												
Fourhorn Sculpin							0.06					
Least Cisco				none caught								
Lake Trout			0.3					0.23		0.44 (dt), 215.62 (ut)	3.8 (ut)	
Lake Whitefish											0.04 (ut)	
Nine-spined Stickleback			1				0.62	0.88				
Slimy Sculpin												
Starry Flounder												
Unidentified Fish												

Stream	Reference B Outflow											
Year	1995	1996	1997	2000	2001	2002	2003	2004	2005	2006	2007	2009[d]
Method												EF
Arctic Char												
Arctic Flounder												
Broad Whitefish												
Cisco												
Fourhorn Sculpin												
Least Cisco												
Lake Trout												
Lake Whitefish												
Nine-spined Stickleback												
Slimy Sculpin												
Starry Flounder												0.03
Unidentified Fish												

EF = Backpack Electrofisher

AG = Angling

FF = Fish Fence

ut - upstream trap catch

dt - downstream trap catch

NFC = No Fish Caught

** = CPUE not calculated*

[a] *- number of fish encountered per 100 m sampled*

[b] *- fish/300m/hr*

[c] *- fish/min*

[d] *- CPUE units = fish/100 s.*

[e] *- Angling CPUE = fish/hr, Electrofishing CPUE - fish/100s*

[f] *- Total CPUE = total (n) / total (h) *24*

Appendix Table 1-6. Historical Benthic Invertebrate Community Baseline Data Summary for Doris North Project

Year	1996	1997	2000	2007	2009
Lake					
Sampling month(s)	Aug	July	July	Aug	Aug
Sampling Equipment	Ekman; 493 µm sieve	Ekman; 493 µm sieve	Ekman; 500 µm sieve	Ekman; 243 µm sieve	Ekman; 500 µm sieve
Sampled Depth Zones	Deepest location	Shallow & Mid or Deep	Shallow, Mid, & Deep	Shallow & Mid or Deep	Shallow & Mid or Deep
Replicates/depth	3	3	3	3-5	3
Sampled sites	Doris S (1) Little Roberts (1)	Doris S (2) Doris N (2) Little Roberts (1)	Doris S (3)		Doris S (2) Doris N (2) Little Roberts (1) Reference Lake B
Note: numbers in parantheses indicate number of depth zones sampled					
Stream					
Sampling month(s)	Aug	Aug (& July at some sites)	Aug		July
Sampling Equipment	Hester Dendy	Hester Dendy	Hester Dendy		Hess Sampler
Replicates	2-5	1-3	3		3
Sampled sites	Doris OF (4) Little Roberts OF (2)	Doris OF (3,1) Little Roberts (3,3)	Doris OF (3)		Doris OF (3) Little Roberts (3) Reference B OF (3)
Note: numbers in parantheses indicate number of replicates per sampling month					
Marine					
Sampling month		August	July		August
Sampling Equipment		Ekman; 493 µm sieve	Ponar; 500 µm sieve		Ponar; 500 µm sieve
Sampled Depth		9.5 m (RBW); 0.75 m (RBE)	10.2 m (RBW); 1.2 m (RBE)		2 m (Site 1); 8 m (Site 2); 7 m (Site 3)
Replicates		1	1		3
Sampled sites		Roberts Bay East Roberts Bay West	Roberts Bay East Roberts Bay West		Roberts Bay West Reference Bay

RBW - Roberts Bay West

RBE - Roberts Bay East

1.4.1 Lakes

Sediment samples were collected in Doris and Little Roberts lakes in 1996, 1997, and 2009 (Appendix Table 1-7). Single samples were collected in 1996 and 1997 using Ekman grabs. Sampling in 2009 collected triplicate samples at shallow and deep depths in Doris North/South and Reference Lake B. Triplicate shallow samples were also collected in Little Roberts Lake. All samples between 1996 and 2009 were analyzed for sediment chemistry and particle size thereby conforming to MMER/EEM guidelines.

1.4.2 Streams

Sediment samples from proposed AEMP streams were collected in 2009. These samples were collected in triplicate in the depositional areas of Doris, Little Roberts, and the Reference B Outflows. Sediment chemistry and particle size was measured in each system.

1.4.3 Marine

Sediment sampling was conducted in Roberts Bay during the summer months of 1997, 2002, and 2009. Ekman grabs were used to gather sediment samples in 1997 and 2002 and a Ponar sampler was used in 2009. Samples were collected in Roberts Bay West during each year and samples were collected from Roberts Bay East during 1997. Sediment sampling in Reference Bay was initiated in 2009. Particle size, total organic carbon, and total metal concentrations were measured each year. Polycyclic aromatic hydrocarbons (PAH) were analyzed from Roberts Bay West and Reference Bay sediment samples as part of the 2009 marine sediment sampling program.

Appendix Table 1-7. Historical Sediment Quality Baseline Data Summary for Doris North Project

Year	1996	1997	1998	2002	2007	2009
Lake						
Sampling month(s)	August	July				August
Sampling methods	Ekman grab	Ekman grab				Ekman Grab
Data collected	Sediment Chemistry & particle size	Sediment Chemistry & particle size				Sediment Chemistry & particle size
Sampled Depth Zones	Deepest location	Deepest location				Shallow & Mid or Deep
Replicates	1	1				3
Sampled sites	Doris S Little Roberts	Doris S Little Roberts				Doris S Doris N Little Roberts Reference Lake B
Stream						
Sampling month(s)						July
Sampling methods						Ekman grab; depositional areas
Data collected						Sediment Chemistry & particle size
Replicates						3
Sampled sites						Doris OF Little Roberts OF Reference B OF
Marine						
Sampling month(s)		August		September		August
Sampling methods		Ekman Grab		Ekman Grab		Ponar Grab
Data collected		Moisture, TOC, Total Metals		TOC, pH, Total Metals, Particle Size, Hydrocarbons		TOC, pH, Nutrients, Total Metals, Particle Size, PAH/EPH
Sampled Depth Zones		10 m (RBW); 0.8 m (RBE)		8 m (Site 1); 5 m (Site 2)		2 m (Site 1); 8 m (Site 2); 7 m (Site 3)
Replicates		n=1		n=5		n=3
Sampled sites		Roberts Bay East Roberts Bay West		Roberts Bay West (near Jetty)		Roberts Bay West Reference Bay

RBW - Roberts Bay West

RBE - Roberts Bay East