Environment

MMG Resources Inc

Lupin Gold Mine Site Characterization and Cycle 3 Environmental Effects Monitoring Investigation of Cause Study Design Report

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Project Number:

60147160

Date:

February, 2010

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February 10, 2010

Erik Allen
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Dear Mr. Allen:

Project No: **60147160-4.2.1.1**

Regarding: Lupin Gold Mine Site Characterization and Cycle 3 Environmental Effects Monitoring Investigation of Cause Study Design Report

On behalf of MMG Resources Inc (MMG), AECOM is pleased to submit the Site Characterization and Cycle 3 Environmental Effects Monitoring (EEM) Investigation of Cause (IOC) Study Design Report for the Lupin Gold Mine.

This study design report summarizes the general physical environment, hydrology, anthropogenic influences, aquatic resources and previous EEM study results associated with the Lupin Gold Mine site. This report also includes two proposed hypotheses to investigate the cause for the observed differences in Arctic grayling endpoints detected in both Cycle 1 and 2.

If you have any questions, or require further information on the report, please do not hesitate to contact Colleen via email or phone at 780-486-7041.

Sincerely,
AECOM Canada Ltd.

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1. Introduction

AECOM Canada Ltd. (AECOM) was retained by MMG Resources Inc (MMG) to update the current Site Characterization Report and complete the Cycle 3 Environmental Effects Monitoring (EEM) Investigation of Cause (IOC) Study Design Report for their Lupin Gold Mine. Under the Metal Mining Effluent Regulations (MMER), Schedule 5, Section 9, mines are required to submit a Site Characterization Report along with the Study Design for the current EEM study. The Site Characterization Report summarizes the general physical environment, hydrology, anthropogenic influences, aquatic resources, environmental protection measures employed along with any existing federal and/or provincial regulations in respect to the mine's effluent discharge. This Cycle 3 EEM IOC Study Design Report presents three proposed hypotheses to resolve the cause(s) of different length and weight measurements observed in Arctic grayling (*Thymallus arcticus*) young-of-year, between the Exposure and Reference Areas, in the Cycle 1 and 2 studies. This study design is consistent with the Metal Mining Technical Guidance Document (TGD) and other insights from Environment Canada (EC 2002).

2. Site Characterization

Site characterization has been provided for the Lupin mine site in the Cycle 1 study design (Golder 2004) and in the Cycle 1 (Golder 2006a,b) and Cycle 2 (AECOM 2009) Interpretative Reports. This report contains an update of information on site activity and details since the Cycle 2 Interpretative Report.

2.1 Mine History

2.1.1 Mine Setting - Andrew

The Lupin Mine is located on the west shore of Contwoyto Lake, Nunavut, approximately 300 km south-east of Kugluktuk and 80 km south of the Arctic Circle (65°46' N, 111°15' W) (Figure 1).

Mine construction started in August 1980 and was completed in March 1982. The mine was operated continuously from 1982 to 1998 when operations were suspended and the mine went into care and maintenance status. Production resumed in April 2000 but in 2003 the mine went back into care and maintenance following a merger between Echo Bay Mine and Kinross. Operations were started again in 2004 but the mine once again went into care and maintenance in February 2005. In February of 2007, the Lupin Mine was sold to Wolfden Resources Inc. of Thunder Bay, Ontario. A holding company, Lupin Mines Inc. was created as a wholly owned subsidiary of Wolfden Resources Inc. to receive the Lupin assets and it is that company that is the legal owner of the property. In May 2007, Wolfden was acquired by Zinifex Limited of Melbourne Australia and ownership of Lupin Mines Inc. was transferred to Zinifex. In 2008, Zinifex Ltd. and Oxiana Ltd., both of Melbourne Australia merged to form OZ Minerals Ltd. with headquarters in Melbourne. Again, the ownership of Lupin Mines Inc. was transferred to the merged company. In 2009 the Canadian assets of Oz Minerals were sold to China Minmetals Inc. of Bejing, China. Minerals and Metals Group Ltd. was set up in Australia to receive the OZ Minerals assets. Minerals and Metals Group Ltd. is a wholly owned, privately held subsidiary of China Minmetals Inc. In Canada, the operating company for Minerals and Metals Group Ltd. is MMG Resources Canada Inc., which is the sole shareholder of Lupin Mines Inc., which in turn remains the legal owner of the Lupin Mine.

Lupin Mine included underground mining and production systems and an ore handling system. Mining and processing equipment was designed to manage up to 2,300 tonnes per day. Materials and supplies were brought into Lupin by air transport and winter road transport while labour was brought in by air transport. Lupin is a self-contained facility with power generation and sewage facilities. The tailings containment area (TCA) is located approximately 7 km south of the mine (Figure 2).

2.1.2 Tailings

As reported by Golder (2006a), effluent discharge began in September 1985. Discharge from the TCA was scheduled to occur between July and September. Effluent is discharged from the TCA into Dam Lake and eventually reaches Contwoyto Lake via Seep Creek, Seep Creek Lake, unnamed creek, unnamed lake and Inner Sun Bay of Contwoyto Lake (Figure 1).

2.1.3 Activities since Cycle 2 Interpretative Report

An overview of mine operations, including management of mine water and tailings was provided in the Cycle 1 report (Golder 2006a,b). Some changes to the site have occurred since 2006.

Reclamation activities in the TCA during 2005 saw a major portion of Cell 5 and another portion of Cell 3 covered by a minimum of 1.0 m of esker gravel. The work was carried out between June 23 and September 28, 2005, with a total area covered of approximately 383,001 m^2.

Approximately 250,000 m^2 of exposed tailings remain to be covered. This work was scheduled to be completed during the summer of 2006; however, due to the premature shutdown of the 2006 winter road, Lupin did not receive enough fuel to carry out the program as scheduled.

In 2008, as part of the preparation for discharge from the TCA, 76,000 kg of lime was spread on Pond 2. The lime was dispersed over the ice surface and then covered with snow to prevent wind from blowing it around. Effluent was not released in 2008.

In 2009, approximately 3 million cubic litres of effluent was released from tailings pond 2 after effluent was tested for toxicity and passed (A. Mitchell, Lupin Mine, pers. comm.). In spring 2010, ponds 1 and 2 will be treated with lime, treated effluent will be transferred to pond 2 and a small volume will be released after July 15, 2010. After 2010, small releases will be scheduled either every year or every second year.

No further activities have been carried out to date and the mine site remains in care and maintenance.

2.2 Climate

Climate in this region is semi-arid subarctic with a mean daily temperature of -11.1°C and average annual precipitation of 299 mm (Canadian Climate Normals 1961-2000). Average temperature in May through September is 4.6°C and the heaviest precipitation occurs in June through September (Canadian Climate Normals 1961-2000). Snowfall can occur in any month but the heaviest snowfalls generally occur in October with an average annual snowfall of 138.1 cm (Canadian Climate Normals 1961-2000). The study area is subject to frequent strong winds from the northwest (Beak Consultants Ltd. and Mary Collins Consultants Ltd. 1980; Geocon Ltd. 1980).

2.3 Geology and Topography

The bedrock in the vicinity of the Lupin Mine is archean in age including supracrustal rocks of the Yellowknife supergroup of the Slave province of the Canadian shield. Rock types occurring in the vicinity of the mine include ultramafic, mafic, intermediate and felsic volcanic rocks, intrusive rocks and siliciclastic rocks and ironstones. The gold mineralization at the mine is hosted primarily by the ironstones. This region contains intrusive igneous material such as granite (Natural Resources Canada 2003). In the vicinity of the mine, terrain is low and undulating ranging between 450 and 530 m elevation. There are numerous shallow lakes and streams throughout the area (Gartner Lee Limited 2008a, b).

2.4 Vegetation

Lupin Mine is located in the subarctic tundra vegetation zone. This is an area characterized by continuous permafrost and “barren ground” vegetation including moss, lichens, heather and dwarf shrub communities in the well-drained areas, and grasses and sedges in the wet areas adjacent to waterbodies. Dwarf shrubs, up to 1 m high, occur adjacent to some waterbodies (RCPL and RL&L 1985).

2.5 Hydrology

Contwoyto Lake is the major waterbody in the study area with a surface area of approximately 959 km^2 and a drainage area of approximately 8,000 km^2 (Roberge *et al.* 1986). Contwoyto Lake has two outflows. The main outflow to the north, drains to the Burnside River and ultimately to Bathurst Inlet; the smaller outflow to the south, drains to the Contwoyto River and into Back River (Rescan 2002). The main basin of Contwoyto Lake is to the east and south of the mine (Figure 1). To the north of the mine, West Arm extends to the west terminating in a narrow bay (Outer and Inner Sun Bay). This area is west of the mine and ultimately receives mine waste after it has travelled through small lakes and streams.

Seep Creek, a small stream approximately 6.5 km in length, flows westerly from the mine area into Inner Sun Bay (Figure 1). Seep Creek watershed contains three lakes (Dam 2 Lake, Dam 1A Lake and Unnamed Lake), three headwater streams, two ponds (Seep Creek Ponds 1 and 2) and two embayment areas (Inner and Outer Sun Bay).

- Dam 2 Lake is a small lake, 7 m maximum depth, bordered to the north by a gravel pit and on the east by the TCA
- Dam 1A Lake is a shallow lake (< 1 m) south of Dam 2 Lake; water from the TCA discharges into this lake
- Dam 2 Lake and Dam 1A Lake are drained by tributaries that join to form Seep Creek
- Unnamed Lake is south of Dam 1A Lake

A tributary from Unnamed Lake joins Seep Creek approximately 400 m downstream of the Dam 2 Lake and Dam 1A Lake tributary confluence

2.6 Aquatic Resources

2.6.1 Water Quality

One final effluent discharge monitoring point was identified by Kinross to Environment Canada. This station is identified as Surveillance Network Point (SNP) 925-10. In the Cycle 1 report, water quality results collected from this location were summarized (Golder 2006a). There were no samples collected from this location as part of the Cycle 2 EEM program. Routine parameters including pH, conductivity, total suspended solids (TSS) and metals, including arsenic, remained at consistent concentrations from 2000 to 2005 and less than the maximum concentrations of identified MMER deleterious substances.

Conductivity has historically been measured at various sampling points in the Exposure Area. Field conductivity at the mouth of Seep Creek was recorded at 519 µS/cm (SNP 925-20) while at the mouth of Concession Creek (creek that drains Concession Lake before it enters Seep Creek watershed), conductivity was recorded at 11 µS/cm.

For Cycle 2 program, only one water quality sample was collected from SNP 925-20. Conductivity, hardness and pH were lower in 2008 as compared to 2000 to 2005 monitoring period. In addition, TSS and alkalinity, total cyanide, ammonia-nitrogen and total lead were non-detectable in the 2008 sample and total arsenic, cadmium, nickel and zinc were lower in 2008 than other years (Table 1). Concentration of total copper in 2008 was similar to previous years even though there was no effluent discharge in 2008.

File:60147160_C1_Fig1_StudyArea_03Feb10.mxd

Legend

Sampling Areas
- Exposure
- Reference Area 1
- Reference Area 2
- Reference Area 3

Mining Properties
- MMG Minerals Property

All-Season Roads
- Existing Road Alignment

Hydrological Features
- Watercourse
- Waterbody

Map Sources/Notes:
National Topographic Database (NTDB) provided by the Government of Canada, Natural Resources Canada at 1:250,000 scale.
Exposure and Reference areas delineated by AECOM.

N W E S

1 0.5 0 1 2 3 4 Km

1:200,000

UTM Zone 12N, NAD 83

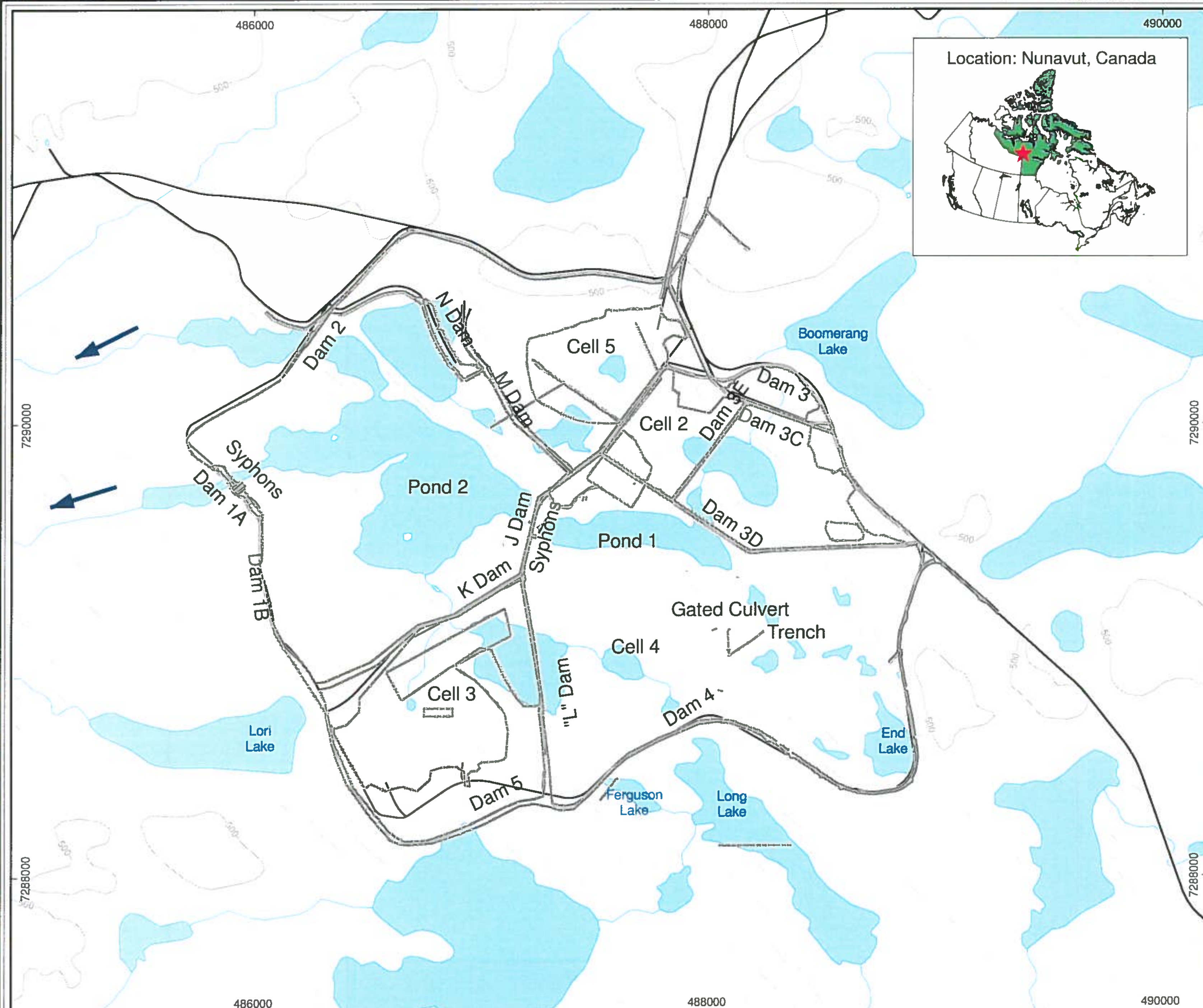
MMG
Lupin EEM

Exposure and Reference Study Areas for the Lupin Cycle 3 IOC EEM Program

05 February 2010

AECOM

Figure 1
Version 1



Map Sources/Notes:
National Topographic Database (NTDB) provided by the Government of Canada, Natural Resources Canada at 1:50,000 scale.
Tailings area provided by OZ Minerals.

1:24,000
UTM Zone 12N, NAD 83

MMG
Lupin EEM

Lupin Mine Tailings Containment Area

03 Feb 2010

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Figure 2
Version 1

Table 1. Summary of Water Quality Monitoring Downstream of Lupin Mine Effluent Discharge Location (SNP 925-20)

			2000	2002	2005	2008
Parameter	Units	CCME Aquatic Life[a]	Mean *SD*[b]	Mean *SD*[b]	Mean *SD*[b]	Sept
pH (units)	pH unit	6.5-9.0	6.03	6.48	5.7	*5.6*
			0.25	*0.15*	*0.45*	
Conductivity (µS/cm)	uS/cm		887	748	519	65.8
			37	*114*	*279*	
Hardness (as CaCO3)	mg/L		231	199	135	24
			9.1	*34.3*	*75.4*	
Total Suspended Solids	mg/L		0.53	0.93	<2	<3
			0.17	*0.73*	*0*	
Total Alkalinity (as $CaCO_3$)	mg/L		<5	7.4	<5	<5
			0	*9.2*	*0*	
Total Cyanide	mg/L	0.005	0.007	0.015	0.016	<0.002
			0.004	*0.014*	*0.008*	
Ammonia-Nitrogen	mg/L	0.019	2.72	0.72	0.64	<0.005
			0.48	*0.31*	*0.47*	
Total Arsenic	mg/L	0.005	0.0024	0.0036	0.0032	0.00186
			0.0006	*0.0006*	*0.0013*	
Total Cadmium	mg/L	0.000017	<0.0006	0.00017	0.00017	*0.00006*
			0	*0.00003*	*0.00010*	
Total Copper	mg/L	0.002-0.004	0.005	0.004	0.005	*0.0052*
			0.002	*0.002*	*0.002*	
Total Lead	mg/L	0.001-0.00[d]	<0.002	0.0002	0.0001	<0.00005
			0	*0.0002*	*0.0001*	
Total Nickel	mg/L	0.025-0.15	0.115	0.0755	0.0762	*0.0426*
			0.009	*0.0084*	*0.0411*	
Total Zinc	mg/L	0.03	0.228	0.146	0.159	0.0392
			0.026	*0.017*	*0.091*	

Note: a – Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007; b – Golder, 2006a

2.6.2 Exposure Area

Seep Creek, Seep Creek Ponds, and Sun Bay were designated as the Exposure Area (Golder 2006a). Best attempts were made to use the same sampling stations in the Exposure Area in the Cycle 2 study, consistent with the Cycle 1 study design and other data provided in the Cycle 1 report. The aquatic habitat in the Exposure Area, downstream of the TCA, is referenced as the Seep Creek watershed. Lakes Dam 2, Dam 1A and unnamed are west of the TCA. Dam 1A Lake receives effluent from the final discharge point (FDP). Dam 1A Lake is drained by Seep Creek. Seep Creek joins with the creek that drains Dam 2 Lake. At this point, Seep Creek flows for approximately 2.5 km before it enters two ponds (Seep Creek Pond 2 and Seep Creek Pond 1). Seep Creek is a well defined channel, 1 to 4 m wide with substrate dominated by boulders (RCPL and RL&L 1985). Seep Creek Ponds 1 and 2 are shallow (less than 1.5 m).

Historically, Lake trout (*Salvelinus namaycush*), Arctic grayling (*Thymallus arcticus*), Arctic cisco (*Coregonus autumnalis*), round whitefish (*Prosopium cylindraceum*), ninespine stickleback (*Pungitius pungitius*) and slimy sculpin (*Cottus cognatus*) have been documented in Seep Creek (RCPL and RL&L 1985). Fish use this stream for spawning, feeding and juvenile rearing in the early part of the open water season (RL&L and DFO 1991).

2.6.3 Reference Area

Fingers Lake and Fingers Creek was designated as the Reference Area. The Fingers Lake watershed is located east of the mine. Like the Seep Creek watershed, the Fingers Lake watershed also has a connection to Contwoyto Lake. Fingers Creek flows for approximately 3 km between Fingers Lake and Contwoyto Lake. Fingers Creek is between 1 to 3 m wide with substrate dominated by silt, boulders and cobble in the upper reaches, cobble gravel and silt in the middle reaches and cobble and boulders in the lower reaches. Habitat varied between shallow flat in the upper reaches and shallow run in the lower reaches.

Fingers Lake has a maximum depth of 6 m and a surface area of 3.7 km^2. Lake trout and Arctic char (*Salvelinus alpinus*) have been captured in Fingers Lake (Moore 1978) and prior to the Cycle 1 EEM study, fish capture data for Fingers Creek had not been previously collected.

2.7 Previous EEM Studies

2.7.1 Cycle 1 EEM

The Cycle 1 EEM study was conducted in August 2005 and the report was submitted to EC in 2006 (Golder 2006a, b). The Exposure and Reference Areas were determined through a literature and study design submitted to EC (Golder 2004). The study design was based on a control/impact study design. The Cycle 1 study investigated the defined Exposure and Reference Areas and completed a plume delineation model. Plume delineation modelling indicated that, under worst-case scenarios, 1% plume concentrations can extend for approximately 1,600 m into Outer Sun Bay. Based on the Benthic Invertebrate Community (BIC) survey data, mine effluent significantly affected patterns of benthic community diversity and evenness within the aquatic receiving environment. Mine effluent did not significantly affect invertebrate density, family richness or the Bray-Curtis Index (BCI). The fish study focused on juvenile (age 1) Arctic grayling as the target species. Arctic grayling are common to both the Exposure and Reference Areas of the Lupin Mine EEM biological monitoring studies. This species is also commonly fished and consumed by local residents and mine personnel. The state of general health of Arctic grayling was similar between the Reference and the Exposure Areas. However, in the Reference Area, Arctic grayling were heavier, longer and in better condition than in the Exposure Area. Laboratory assessments determined that mine effluent did not have sublethal or acute effects on various test species. The results of the Cycle 1 EEM monitoring program indicated invertebrates and fish were impacted by mine effluent, based on the BIC and reference fish population attributes.

2.7.2 Cycle 2 EEM

The Cycle 2 EEM study was conducted in August and September 208 and the report was submitted to EC in 2009 (AECOM 2009). The field program was designed to collect samples for water quality, sediment quality, fish (non-lethal and lethal sampling), and invertebrates during discharge of mine effluent. Effluent was scheduled to be released but due to malfunctioning equipment at the outfall and low pH of the effluent, it was not released in 2008. In any event, the completion of the field study was still required and was conducted, as proposed.

Field and lab water quality differed between the Exposure and Reference Areas: pH was lower and conductivity, hardness, magnesium, sodium, TOC, DOC, aluminum, boron, cadmium, chromium, cobalt, copper, iron, manganese and zinc were higher in the Exposure Area as compared to the Reference Area. Sediment grain size was similar between areas except for clay; there was more clay in exposure sediments as compared to reference sediments (3% and 1.8%, respectively). Sediment quality was significantly different for some parameters including arsenic, cobalt, copper, nickel and zinc which were higher in exposure as compared to reference sediments.

Mean invertebrate density was higher in the Exposure Area as compared to the Reference Area but the difference was not statistically significant.

Young-of-the-year (Age-0) Arctic grayling were lighter and shorter within the Exposure Area as compared to the Reference Area. The ratio of liver weight to fork length differed significantly by area (for a given fork length, livers were lighter in the Exposure Area as compared to the Reference Area). Body weight and length of ninespine stickleback in the Exposure Area were significantly heavier and longer, respectively, than Reference Area individuals. The ratio of liver weight to total length was statistically significantly different by area (for a given length, livers were heavier from Exposure Area versus individuals from the Reference Area).

2.7.3 Comparison of Cycle 1 and Cycle 2 EEM Studies

From Cycle 1 to Cycle 2 there was no consistency in Exposure versus Reference Area water quality. Sediment quality differences were similar for Cycle 1 and 2. Since there was no effluent release between Cycle 1 and 2, these variations in sediment and water quality parameters of the receiving environment suggest that the environment could be recovering but historical impacts may influence ecological recovery for some time.

In Cycle 1, there were more benthic invertebrates within the Reference Area as compared to the Exposure Area while in Cycle 2 there were more invertebrates in the Exposure Area as compared to the Reference Area. The average density of benthic invertebrates in the Reference Area was similar in both Cycle 1 and 2 but the average density of invertebrates in the Exposure Area was higher in Cycle 2 as compared to Cycle 1. There is some evidence that the benthic invertebrate community within the Exposure Area is recovering as a result of no effluent discharge, but without existing data on pre-disturbance conditions in the Exposure Area, interpretations remain uncertain.

Arctic grayling in the Exposure Area were shorter and lighter than in the Reference Area in both cycles while ninespine stickleback (Cycle 2 only), were heavier and longer in the Exposure Area than in the Reference Area.

4. Cycle 3 EEM IOC Study Design

4.1 EEM IOC Study Design

For the Lupin Mine Cycle 3 EEM IOC study, a biological monitoring program is required to assess the difference in growth that has been observed between Age-0 Arctic Grayling in one exposure stream and one reference stream. A review of the primary literature identified that Arctic grayling populations are most sensitive to perturbations that influence juvenile survival. Specifically, if juvenile survival of Arctic grayling decreases, it can jeopardize the viability of populations (Buzby and Deegan, 2004; Vélez-Espino et al. 2006). Other studies have demonstrated that age-0 Arctic grayling growth and survival are strongly dependent on temperature and availability of benthic invertebrates. For example, growth of juvenile Arctic grayling increases with mean water temperature (Deegan et al. 1999; Dion and Hughes, 2004; Luecke and MacKinnon, 2006) and a similar pattern of temperature-dependent growth was observed in the closely related European grayling (*T. thymallus*), particularly for the age-0 cohort in streams (e.g., Mallet et al. 1999). In addition, growth of age-0 Arctic grayling was positively correlated with greater proportions of invertebrates such as Chironomidae (i.e., chironimids) and Simulidae (i.e., black flies) in the diet (e.g., Jones et al. 2003). It has also been observed that the selection of spawning areas by adult Arctic grayling can lead to the exposure of eggs to cold or warm water, resulting in reduced or enhanced larval Arctic grayling growth rates, respectively (e.g., Luecke and Mackinnon, 2006). These observations identify the potential to test three discrete hypotheses to explain the growth rates of age-0 Arctic grayling between streams with and without ponds. Need to identify here the basic study design.

The proposed hypotheses to test for growth differences in Arctic grayling between Exposure and Reference Areas are:

1. Water temperature for streams with ponds will be higher through the growing season, and result in higher growth rates of age-0 Arctic grayling compared with streams with no ponds;
2. The landscape features of streams with ponds results in greater numbers of Chironomidae available to age-0 Arctic grayling resulting in higher growth rates compared with streams with no ponds; and
3. The spawning locations (i.e. water flow rates, available substrate, water depth, etc.) selected by adult Arctic grayling differ between streams with ponds and streams that lack ponds. This different selection by Arctic grayling in streams with ponds results in egg incubation times that are dependent on water temperature. Similarly, the water temperature experienced by early age-0 Arctic grayling will also differ between the streams with and without ponds. This hypothesis cannot be completed due to the time constraints resulting from the submission/approval dates required under the EEM.

4.2 Study Design Component

4.2.1 Hypothesis #1 Thermal Influences

4.2.1.1 Water Temperature

It is believed that Fingers Lake, in the Reference Area, provides thermal warming and thus better habitat for age-0 grayling growth. Since the Exposure Area lacks significant lake or ponded water, temperatures should be colder and thus influence age-0 growth. These habitat features, as represented by differing rates of warming and greater thermal holding capacity of ponded water compared with flowing water, indicate why Exposure Arctic grayling are smaller than the Reference Area age-0 fish. Due to the potential that the previously used Reference Area may not be the most appropriate for comparison to the Exposure Area due to differences in ponded water, an Alternative Reference Area will be selected based on the absence of ponded water and the presence of age-0 arctic grayling.

This may also provide insight into a regional variation that may exist in age-0 arctic grayling growth and survival rates (e.g., Deegan *et al.* 1999). To examine water temperature variations, digital logging thermometers (i.e., Hobo Tidbit loggers) will be placed strategically in the field in the Reference, Exposure, and Alternative Reference Areas. The three stream logging temperature locations for each area will include:

- Discharge into the main lake (Contwoyto Lake);
- Midway location between origin and the main lake;
- Origin; and/or,
- Pond stream interface (if present);

To capture freshet, temperature loggers will be placed in early July 2010 (Figure 3 and 4). It is recognized that this is earlier than the period equal to 6 months after the submission of the Study Design, as required by the MMER. However, this placement is required to fully capture and represent the seasonal variation in water temperature across habitats near Lupin Mine, and to test the thermal hypothesis. No samples other than temperature related to the EEM program will be collected at this time.

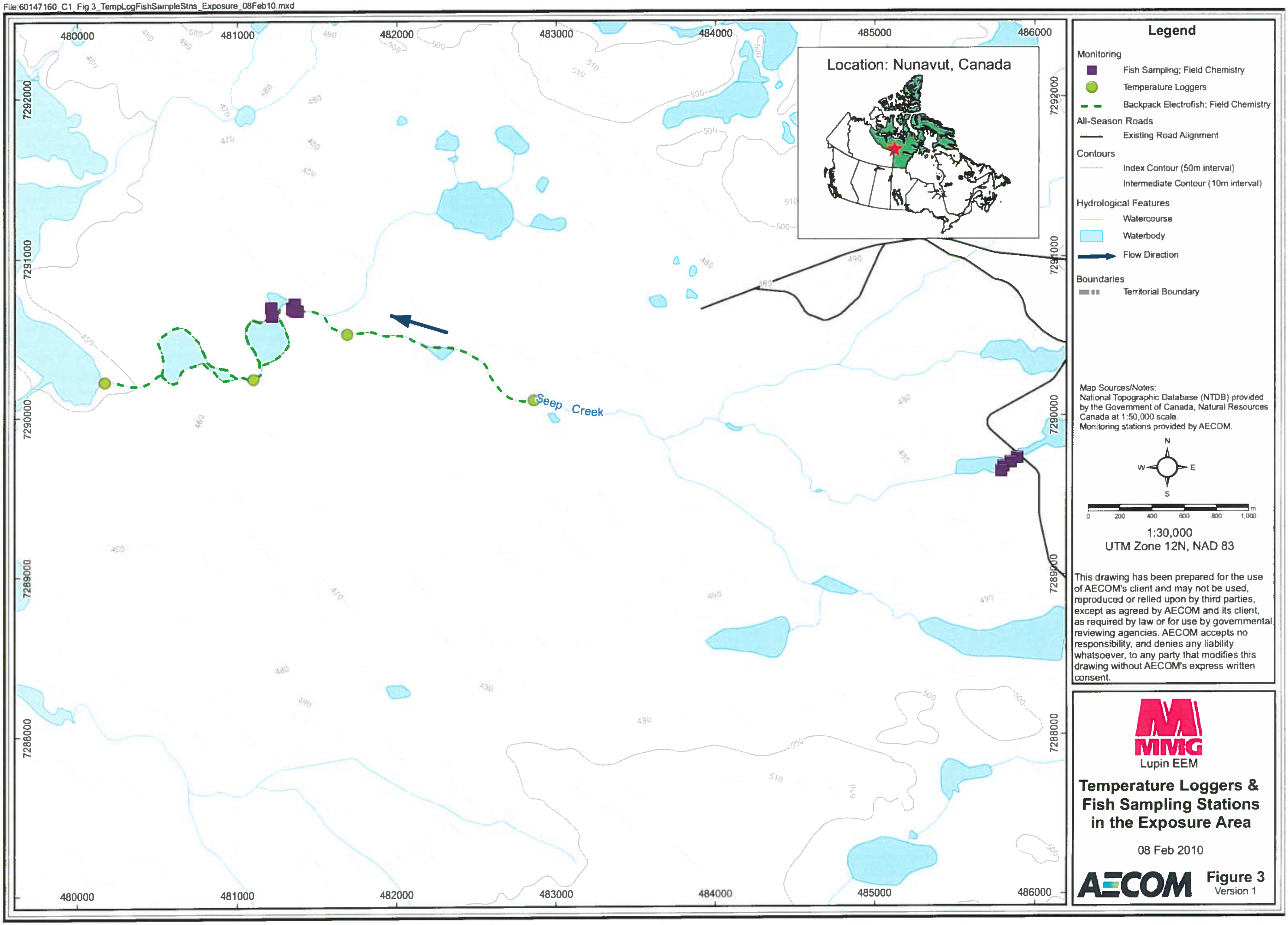
4.2.1.2 Fish Survey

Based on the previous EEM studies, it is proposed to conduct a non lethal fish survey to determine if the differences observed in the previous two cycles are still evident between the Reference and Exposure Areas (Figure 3 and 4). This strategy will allow for analyses to test for correlation between growth and temperature. Data from all three cycles will be used in the analyses. The survey will need to sample and collect no more than 100 age-0 Arctic grayling from the Reference and Exposure Areas used in the previous EEM studies. Since it is hypothesized that the Reference Area from the previous studies may not be the most appropriate system to use (based on the presence of large lake providing increased water temperatures and therefore possible higher temperature-dependent growth rates for age-0 arctic grayling), it is proposed to assess the potential of a more suitable reference stream (i.e. minimal surface area resulting from ponding waters). Reference Areas 2 and 3 (identified in Figure 1) will be surveyed for the presence of Arctic grayling and only one will be used for further investigation. Minnow traps (1.0 cm mesh size) and elector shocking (where safely feasible) will be used to capture fish. A target collection of 100 age-0 Arctic grayling will be needed from each of the Reference (existing), Exposure, and Alternative Reference (new) sampling areas to provide a non-lethal sampling program. Ideally, the sampling will occur in mid to late August. A catch per unit effort for each gear type will be recorded. Fish survey endpoint measurements for statistical analysis will include:

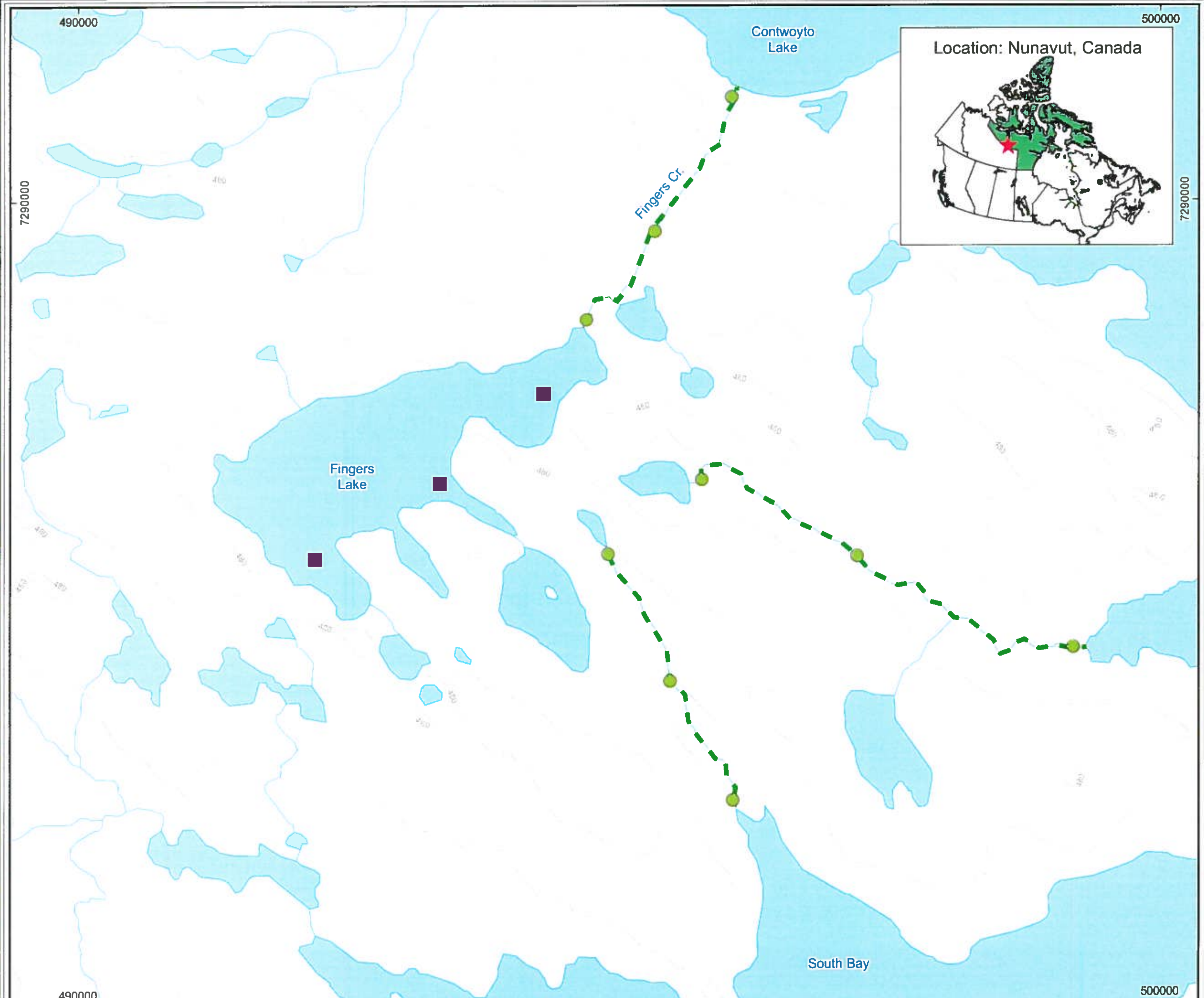
- Length (total, mm);
- Total body weight;

If, for any reason, deviations from the submitted Fish Survey need to be modified as a result of timing of sampling or environmental conditions, consultation with MMG Resources and Environment Canada (EC) will occur prior to any modifications, as directed by the MMER. If, for any reason, the fish survey cannot capture 100 fish from an area, the final number of fish captured will be recorded. The focus of this study is age-0 Arctic grayling. We will use the results of the previous EEM cycles to confirm the ages of the fish used in this study are actually within the age-0 cohort. Given results of the previous cycles, lethal sampling and collection of fish tissue for copper analysis is not recommended.

File:60147160_C1_Fig 3_TempLogFishSampleStns_Exposure_08Feb10.mxd



File:60147160_C1_Fig4_TempLogFishSampl_RefArea_03Feb10.mxd



Legend

Monitoring

- Fish Sampling
- Temperature Loggers
- Backpack Electrofish; Field Chemistry

Hydrological Features

- Watercourse
- Waterbody

Contours

- Intermediate Contours

Map Sources/Notes:
National Topographic Database (NTDB) provided by the Government of Canada, Natural Resources Canada at 1:250,000 scale.
Exposure and Reference areas delineated by AECOM.

0.3 0.15 0 0.3 0.6 0.9 1.2 Km

1:50,000

UTM Zone 12N, NAD 83

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MMG

Lupin EEM

Temperature Loggers & Fish Sampling Stations in the Reference Area and Alternate Reference Area

08 February 2010

AECOM

Figure 4
Version 1

Detailed habitat characteristics for Reference, Exposure and Alternative Reference Areas will be included in the Cycle 3 Interpretative Report.

QA/QC procedures for the fish survey will follow those outlined within the TGD (EC 2002).

Fish survey to be complete during August 2010.

4.2.2 Hypothesis #2 Benthic Community Structure

As indicated in Section 4.1, the density of Chironomidae and Simulidae may influence the growth of age-0 Arctic grayling, therefore a benthic community assessment at the Reference, Exposure, and Alternative Reference Areas will be completed and will focus on the densities of Chironomidae. We will focus only on Chironomidae density, as Simulidae was not identified as a significant benthic taxon in the past EEM studies.

A traditional benthic community survey will be completed. For each study area (Exposure, Reference and Alternate Reference), five sampling stations will be established (Figure 5 and 6). For the Exposure and Reference Areas, the same sampling stations used in the first two EEM programs will again be used. For the Alternate Reference, five new sampling stations will be determined while in the field. Water depth and water flow need to be consistent between sampling stations so these will be measured before the sample is collected. At each sampling station, five replicate samples will be collected (depth between 0.75 and 1.0 m) and combined into one composite sample for the site. Each replicate sample will be collected using a Petit Ponar dredge (6" x 6" x 6"). For each sampling station, the sampling areas will equal 0.116 m^2. Samples will be sieved (sieve size 243 µm), and preserved with buffered formalin. Samples will be stored in lab-grade glass jars, packed into coolers and shipped to Cordillera Consulting Inc in Summerland, British Columbia (same taxonomist used for Cycle 2).

Supporting environmental data including water depth, water flow, water temperature, field water chemistry (pH, conductivity, dissolved oxygen), lab water quality (Section 4.2.3) will be measured before samples are collected.

Varied analyses will be used to correlate benthic invertebrate densities with observed growth rates of Arctic grayling from the Reference, Exposure and Alternative Reference Areas. These analyses will also include separate consideration of the Chironomidae density in conjunction with growth rates. Any observed relationships with benthic invertebrate densities or Chironimidae density will be used to explain patterns with growth for the Exposure and both Reference Areas. We hypothesize that higher densities of Chironomidae will be correlated positively with growth (and body condition).

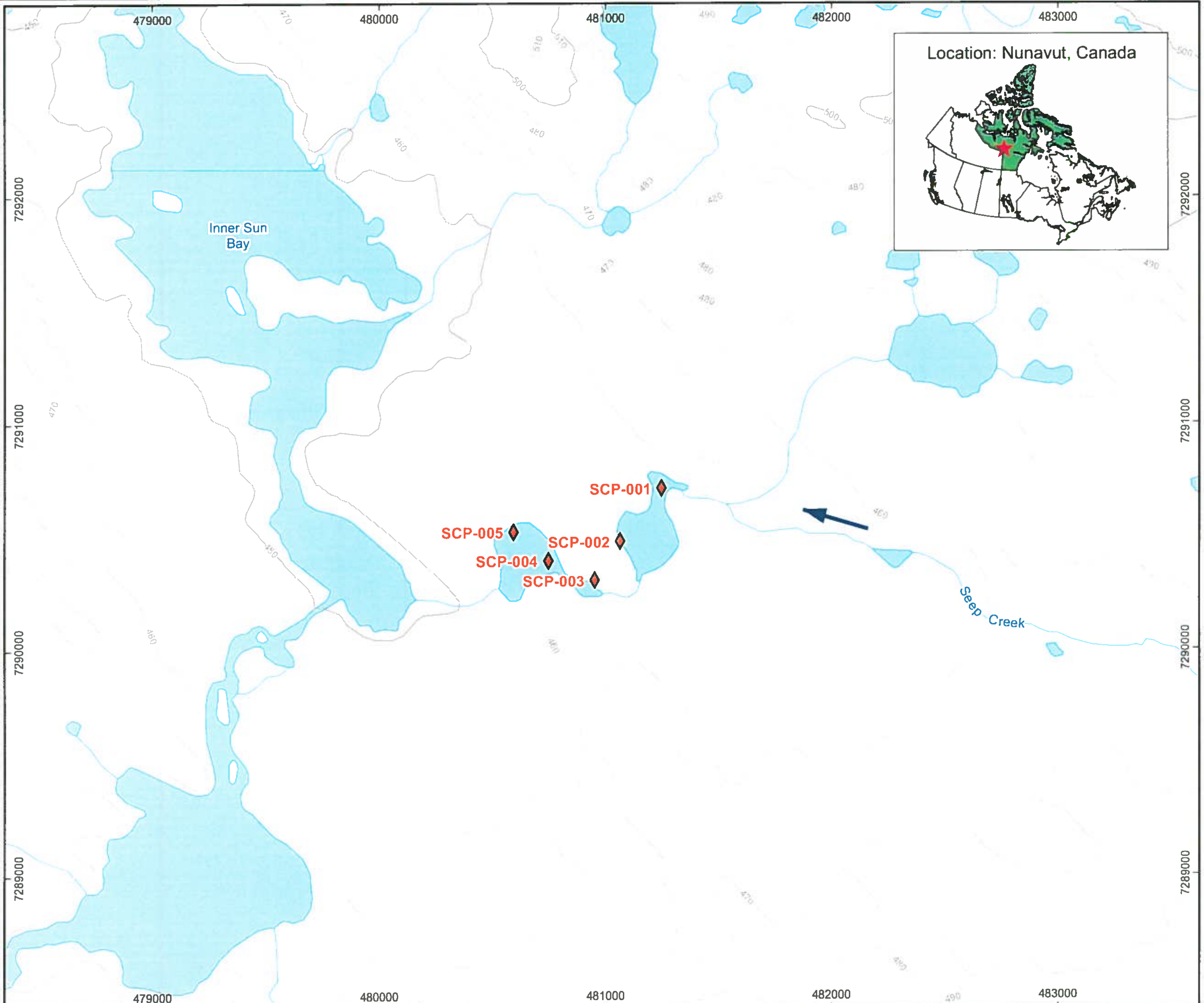
Detailed habitat characteristics for the Control Impact designs for the Reference, Exposure and Alternative Reference Areas are outlined in the Site Characterization Section, and will be supplemented with site-specific attributes described above. Proposed Cycle 3 Sampling locations are identified in Figures 5 and 6.

Final endpoints for statistical analysis from the benthic community analysis will include:

- Total invertebrate density*;
- Density of Chironomidae; and,
- Density of Simulidae (if observed in the 2010 benthic invertebrate surveys)

* used to statistically test for effluent effect on benthic community

File:60147160_C1_Fig5_BenthicSedimentQ_Exposure_08Feb10



Legend

Monitoring
- Benthic Invertebrate Community; Field Chemistry; Sediment Quality

Mining Properties
- MMG Minerals Property

All-Season Roads
- Existing Road Alignment

Contours
- Index Contour (50m interval)
- Intermediate Contour (10m interval)

Hydrological Features
- Watercourse
- Waterbody
- Flow Direction

Boundaries
- Territorial Boundary

Map Sources/Notes:
National Topographic Database (NTDB) provided by the Government of Canada, Natural Resources Canada at 1:50,000 scale.
Monitoring stations provided by AECOM.

N W E S

0 150 300 450 600 750 m

1:24,000

UTM Zone 12N, NAD 83

MMG

Lupin EEM

Benthic Invertebrate Community and Sediment Sampling Stations in the Exposure Area

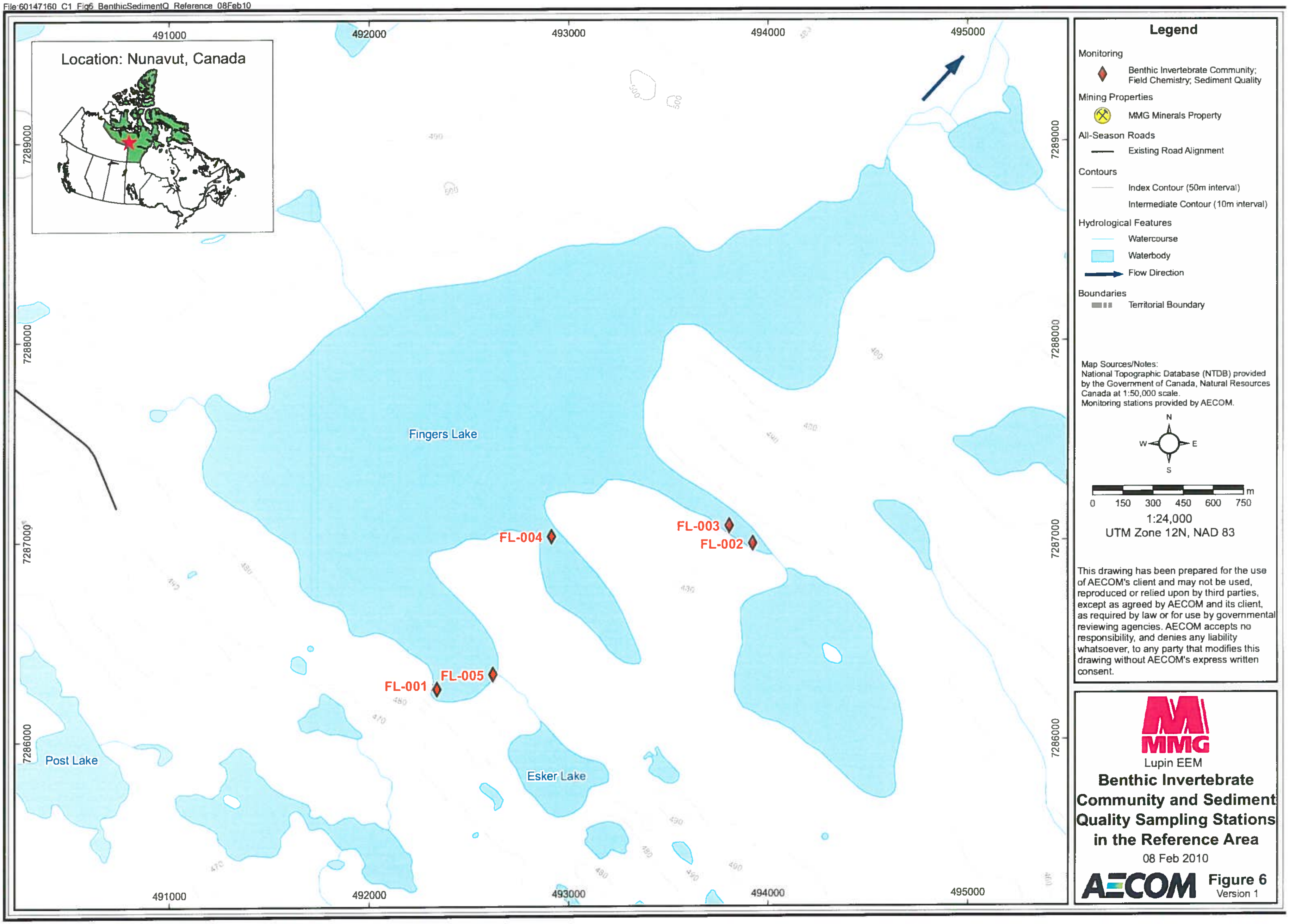
08 Feb 2010

AECOM

Figure 5

Version 1

File 60147160_C1_Fig6_BenthicSedimentQ_Reference_08Feb10



4.2.3 Water Quality

As outlined in the TGD (EC 2002), water quality sampling is to be completed in areas of biological sampling. Water quality sampling will take place at the same location of the benthic sampling, prior to the collection of the required sediment samples. Parameters to be measured at each area:

- Arsenic
- Lead
- Zinc
- Total cyanide
- pH
- Cadmium
- Mercury
- Ammonia
- Alkalinity
- Dissolved oxygen
- DOC/TOC
- Phosphorus
- Nitrite
- Copper
- Nickel
- Radium 226
- TSS
- Aluminum
- Iron
- Molybdenum
- Nitrate
- Total Hardness
- Temperature

4.2.4 Sediment Sampling

Sediments will be collected and analyzed for particle size and total organic carbon (TOC) from the Reference, Exposure, and Alternative Reference benthic stations, as recommended in the TGD. Sediment samples will be collected and classified according to the Wentworth Classification.

5. References

AECOM. 2009. Lupin Gold Mine Environmental Effects Monitoring Cycle 2 Interpretative Report. Prepared for OZ Minerals Canada Resources Inc. May 2009.

Beak Consultants Ltd. and Mary Collins Consultants Ltd. 1980. Initial environmental evaluation for the Lupin gold project, Contwoyto Lake, N.W.T. Prepared for Echo Bay Mines Ltd.

Buzby, K.M. and L.A. Deegan. 2004. Long-term survival of adult Arctic grayling (*Thymallus arcticus*) in the Kuparuk River, Alaska. Canadian Journal of Fisheries and Aquatic Sciences 61: 1954-1964.

Canadian Climate Normals – 1961 to 2000. Computer file provided by Atmospheric Environment Service, Ottawa, Ontario. Internet web site: http://www.climate.weatheroffice.ec.gc.ca/climate_normals/index_e.html

CCME. 2007. Canadian Council of Ministers of the Environment. Canadian Environmental Quality Guidelines. Update 7.1. Canadian Council of Ministers of the Environment. Winnipeg, Manitoba.

Dion, C.A., and N.F. Hughes. 2004. Testing the ability of a temperature dependent model to predict growth of age-0 Arctic grayling. Transactions of the American Fisheries Society 133:1047-1050.

Environment Canada (EC) June 2002. Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring (TGD).

Gartner Lee Limited (GLL). 2008a. Gap Analysis for Environmental and Socio-economic Baseline Studies, Izok Mine/Road to Lupin. Report prepared for Zinifex Canada Inc., May 2008.

Gartner Lee Limited (GLL). 2008b. Gap Analysis for Environmental and Socio-economic Baseline Studies, Lupin High Lake Road. Report prepared for Zinifex Canada Inc., May 2008.

Geocon (1975) Ltd. (Geocon) 1980. Geotechnical study of proposed tailings pond, Lupin project, Contwoyto Lake, N.W.T. Prepared for Echo Bay Mines Ltd., Project A1207.

Golder Associates Ltd. (Golder). 2004. Lupin Gold Mine environmental effects monitoring study design. Prepared for Kinross Gold Corporation, Edmonton, Alberta. Golder Report No. 04-1373-046. 75 p. + 4 app.

Golder Associates Ltd. (Golder). 2006a. Lupin Gold Mine environmental effects monitoring Cycle 1 interpretative report for Lupin mine. Prepared for Kinross Gold Corporation, Edmonton, Alberta. Golder Report No. 05-1373-019. 13 p.

Golder Associates Ltd. (Golder). 2006b. Addendum Report to the environmental effects monitoring Cycle 1 interpretative report. Prepared for Kinross Gold Corporation, Edmonton, Alberta. Golder Report No. 05-1373-019. 85 p. + 6 app.

Jones, N.E., W.M. Tonn, and G.J. Scrimgeour. 2003. Selective feeding of age-0 Arctic grayling in lake-outlet streams of the Northwest Territories, Canada. Environmental Biology of Fishes 67:169-178.

Luecke, C., and P. MacKinnon. 2006. Landscape effects of age-0 Arctic grayling in tundra streams. Transactions of the American Fisheries Society 137:236-243.

Mallet, J.P., S. Charles, H. Persat, and P. Auger. 1999. Growth modeling in accordance with daily water temperature in European grayling (*Thymallus thymallus* L.). Canadian Journal of Fisheries and Aquatic Sciences 56:994-1000.

Moore, J.W. 1978. Biological and water quality surveys at potential mines in the Northwest Territories. II Inco Gold Property, Contwoyto Lake. Environment Canada, Environmental Protection Services, Northwest Region. Manuscript Report NW – 7806. 39 p.

Natural Resources Canada. 2003. The atlas of Canada. Internet web site: http://atlas.gc.ca/site/english/maps/environment/geology/geologicalprovinces/1

RL&L Environmental Services Ltd. and Department of Fisheries and Oceans (RL&L and DFO). 1991. Fisheries investigations at the Lupin Gold Mine, Contwoyto Lake, NWT, 1990. Prepared for Echo Bay Mines Ltd., Edmonton, AB. RL&L Report No. 275: 59 p. + 2 app.

Reid Crowther & Partners Ltd. and RL&L Environmental Services Ltd. (RCPL and RL&L). 1985. Report on aquatic studies program. Prepared for Echo Bay Mines Ltd., Lupin Mine. 86 p. + 5 app.

Rescan Environmental Services Ltd. (Rescan). 2002. Bathurst Inlet Port and Road Project; Freshwater Environmental Studies, 2001.

Roberge, M.M., L. Dahlke, and J.B. Dunn. 1986. Biological investigation of Contwoyto Lake, Northwest Territories, 1981-82. Canadian Data Report of Fisheries and Aquatic Sciences 605: iv + 29 p.

Vélez-Espino, L.A., M.G. Fox, and R.L. McLaughlin. 2006. Characterization of elasticity patterns of North American freshwater fishes. Canadian Journal of Fisheries and Aquatic Sciences 63:2050-2066.