Section 2C

Tier 2 and 3 Habitat Compensation Monitoring Plan v1 March 2009

Technical Memorandum

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To: **Amy Liu, Department of Fisheries and Oceans, Iqaluit**

Cc: **Rachel Gould, Agnico-Eagle Mines Ltd.**

From: **Randy Baker and Gary Mann Azimuth Consulting Group**

RE: **Detailed Plans for Tier 2 and Tier 3 Habitat Features Compensation Monitoring for the Meadowbank Gold Project**

Background

The objective of this Technical Memo is to provide additional details for Tier 2 and Tier 3 monitoring plans as per Section 5.3 of the Department of Fisheries and Oceans (DFO) Authorization NU-03-0191 for Works or Undertakings Affecting Fish Habitat for the Meadowbank Gold Project.

A critical component of the No-Net-Loss Plan (NNLP, 2006) for the Meadowbank Mine project was to design a habitat compensation strategy that complied with DFO's No-Net-Loss of Habitat policy. The general strategy for monitoring the effectiveness of Habitat Compensation Features (HCFs) is described as a Targeted Monitoring Study within the Aquatic Effects Management Program (AEMP, 2005). In support of the issuance of a *Fisheries Act* Authorization for the Mine Site, Azimuth Consulting Group Inc. (Azimuth) produced a document for Agnico-Eagle Mines (AEM) entitled A*quatic Effects Management Plan Targeted Monitoring – Habitat Compensation Monitoring Plan* that was published in May 2008 (Azimuth, 2008). This plan described a tiered strategy for monitoring the effectiveness of the main habitat features including:

- *Dike Faces* – in addition to their primary purposes supporting mining activities, all dikes have been designed to serve as productive fish habitat.
- *Finger Dikes* – these features are extensions built off the dikes; their only purpose is to serve as fish habitat.
- *Habitat Mounts* – while similar to finger dikes in purpose (i.e., fish habitat only), these are isolated features located away from dike structures.
- *Shoals, Reefs and Boulder Gardens* – these features are targeted to improve habitat quality in the open basin areas immediately adjacent to the open pits (i.e., the un-mined areas impounded by the dikes) and will become functional at the end of mine life, after re-flooding of the impoundments.

Overview of Tiered Monitoring Strategy of HCFs

The tiered program involves a combination of qualitative and quantitative measures to assess the capability of the habitat to replace HADD related habitat loss (Figure 1). Qualitative tools include visual/functional components including angling, visual surveys, minnow trapping and measuring periphyton growth. Quantitative measures start with simple tools such as interstitial water quality/chemistry, and lead to complex

tools such as toxicity testing and/or *in situ* studies, should Tier 1 or Tier 2 studies fail respectively. Tiering provides a scientifically-defensible, yet cost-effective means of quantitatively assessing potential limitations to HCF productivity.

In addition to meeting physical design specifications for fish, acceptable water quality is essential if HCFs are to function as intended, by providing spawning, nursery and foraging habitat for lake trout, Arctic char and round whitefish. Spawning requirements of each of these species in the project lakes is similar and occurs in relatively shallow water, between 2 and 6 m depth, below the ice scour depth and above the depth where there is a transition to very fine grain sediment (BAER, 2005).

Quantitative Tier 1 studies involve testing HCF interstitial pore water chemistry for conventional parameters (pH, conductivity, hardness etc.), nutrients (ammonia, alkalinity, nitrate, nitrite, total Kjeldahl nitrogen, phosphates etc.), total and dissolved organic carbon, and metals. Where available, HCF chemistry will be compared to CCME (2006) water quality guidelines for the protection of aquatic life and to reference area chemistry. In the event that weight-of-evidence of Tier 1 qualitative and water chemistry/quality fails to meet CCME guidelines, Tier 2 studies will be enacted.

Tier 2 Detailed Studies

Study Design

Water samples for toxicity testing will be collected from HCFs where water chemistry fails CCME water quality guidelines for the protection of life as per Tier 1 success criteria as soon after Tier 1 failure as possible. This is important as substrate type (i.e., rock type consisting of iron formation rock that is stable under water) and depth may influence dike pore water quality depending on mixing depth due to wind speed and direction, porosity of the dike at the particular location of water sampling and rock size. The same procedures will be followed at each sampling location to ensure consistency. At least one reference station will be sampled for the full suite of toxicity tests and compared to exposure areas.

Field Methods

Details of water sample collections for toxicity testing are as follows:

- Depending on depth, water collection will be from shore or from a boat at a precise GPS location. The boat will be anchored at a sufficient distance away from the dike face so as not disturb fine sediments on the bottom or on habitat surfaces.
- Weather conditions (air temperature, wind speed, direction etc.) and vertical temperature, conductivity, oxygen profiles will be measured from surface to bottom.
- An electric diaphragm pump with food-grade silicon tubing will be attached to a long plastic guiding pole to assist in placement of the tubing between interstitial spaces within the rocks. This will take place at the location and depth of the Tier 1 water quality failure. A clear plexi-glass viewer box hung over the side of the boat will be used to assist in guidance of the pole and water collection device.
- The pump will be turned on and the tubing allowed to flush for approximately 1 minute. Water will be extracted slowly from the interstitial areas between rocks within a spatially small area to ensure that surface water is not being preferentially withdrawn and that a representative sample of pore water within the discrete area/depth is acquired.
- Water will be pumped slowly into the required number of 20-L plastic carboy containers, appropriately labeled and place on ice.

- Water samples for chemical analysis (conventional parameters, nutrients and metals) will be collected at the same time and placed into the required containers as supplied by the analytical laboratory.
- Containers will be shipped to the toxicity testing laboratory as quickly as possible to ensure that holding times are not missed.

Laboratory Analyses

Quantitative Tier 2 Success Criteria involves toxicity testing of dike pore waters and is based on the full suite of Metal Mining Effluent Regulation (MMER) program requirements for sublethal toxicity testing including:

- 7-d rainbow trout (*Oncorhynchus mykiss*) embryo development test (Reference Method EPS 1/RM/28).
- 7-d invertebrate (*Ceriodaphnia dubia*) reproduction and survival test (Reference Method EPS 1/RM/21).
- 7-d macrophyte (*Lemna minor*) growth test (Reference Method EPS 1/RM/37).
- 72-h or 96-h green algae (*Selenastrum capricornutum*) growth test (Reference Method EPS 1/RM/25).

Data Analysis and Decision Criteria

Toxicity testing results for each HCF sample will be statistically compared to the laboratory control and any reference sample(s). Chemistry of representative water samples for chemical analysis will be compared to CCME standards to determine what metal(s) or other parameters (e.g., fluoride) exceed guideline concentrations. In the event that HCF samples exceed a 20% effect level (e.g., EC20 or IC20) relative to reference performance, water quality results will be examined to determine if there is a potential cause/effect relationship that might explain test failure. Failure of a test will automatically trigger an immediate second round of toxicity testing from the same location as caused the first failure(s). At this time a Toxicity Identification Evaluation (TIE) will be conducted to determine the cause of toxicity, whether metals, pH, or some other factor, to assist in results interpretation and weight-of-evidence evaluation of cause – effect. Failure of EC_{20} effects level a second time, with confirmation of the cause of toxicity will trigger Tier 3 testing. Escalation to Tier 3 testing will only be conducted after consultation with DFO to determine the most appropriate course of action and its timing. Given the very short open water season, it may not be possible to complete two rounds of toxicity testing or initiate Tier 3 studies in the same calendar year.

QA/QC

A full suite of QA/QC procedures will be followed as a routine part of Tier 2 monitoring including use of standard field water quality QA (field blanks, travel blanks, blind duplicate samples) and laboratory QA (use of standard reference materials and laboratory duplicates). Toxicity testing will also follow standard methods and be conducted by a certified laboratory.

Tier 3 Detailed Studies

Study Design

In the event of consistent failure of one or more toxicity tests at one or more areas within HCF areas, quantitative Tier 3 studies will be enacted as soon as is practicable after completion and analysis of Tier 2 studies. Two such studies were identified in the AEMP (2005) as possible Tier 3 target studies: 1) Incubation of fish eggs harvested from native fish during fall and placement in egg baskets situated at the site of toxicity testing failures; and 2) colonization of periphyton on native rock structures to determine if periphyton growth in

being inhibited. Tier 3 studies are designed to determine the suitability of HCFs to ultimately act as healthy substrates for periphyton to support benthic invertebrate communities and provide spawning and rearing habitat for fall spawning fish species. Because eggs are incubated over the course of the fall and winter, this is a long exposure period at the most sensitive life history stage. Depending on which toxicity tests fail Tier 2, one or both of the following may be undertaken (e.g., failure of trout embryo test would trigger field-based egg development test).

Field Methods for Lake Trout Egg Development

Field-installed egg incubation chambers will be used to measure developmental success of lake trout (*Salvelinus namaycush*), or secondarily, Arctic char (*S. alpinus*) eggs *in situ*. While this approach has been used to assess the potential impacts of various stressors on lake trout hatching success (e.g., Gunn and Keller, 1984; Fitzsimons, 1994; Casselman, 1995; Eshenroder et al., 1995; Manny et al., 1995; Faulkner et al., 2006), it is logistically and technically challenging and should only be used if Tier 1 and 2 results identify contaminant-related adverse effects to fish reproductive success. Adaptive management principals would be brought in at this stage as a considerable amount of information may have been learned about artificial incubation of native eggs along HCFs between now and whenever Tier 3 monitoring may be enacted. Detailed discussions with DFO will be required to ensure that the most recent science is brought to bear on Tier 3 monitoring.

Artificial egg incubation steps are as follows:

- During late fall, prior to spawning, fine mesh gill nets would be set for short durations (~0.5 – 1.0 h) adjacent to high value spawning habitats to capture sexually mature lake trout.
- Eggs and milt will be milked from running fish. Milt from two males per female will be mixed together and eggs allowed to fertilize and water harden.
- Water-hardened fertilized eggs would be placed in specially designed, labeled egg incubation chambers containing a set number of eggs.
- Egg baskets will be set using SCUBA at depths greater than 2.5 m (i.e., below the freeze layer) and above the fine sediment bottom in protected areas within pore spaces of HCF substrate so that eggs are exposed to dike pore waters for development over the winter.
- Egg traps will be set within HCFs where Tier 2 toxicity testing failed and at non-HCF reference high-value spawning habitat areas in the same lake. Differential GPS will be used to mark the exact location of incubation trap sets.
- One half of the incubation chambers will be retrieved from HCF and reference habitats just prior to ice formation to determine egg survivorship during critical early developmental stages of newly fertilized eggs.

The remaining egg incubation chambers will be retrieved either in the following May, after hatching of eggs, during alevin development and prior to swim-up or after ice-out in early July. This approach was used by Faulkner et al. (2006) during a study of the effects of blasting on egg survival of lake trout at Diavik Mine. If eggs are collected under ice this will ensure that larvae are sampled prior to typical swim-up and exogenous feeding, to avoid potential mortality unrelated to HCF. However, retrieving eggs incubation chambers under the ice presents logistical difficulties as well as risks to human life. Several large holes would have to be made through the ice to accommodate SCUBA divers. Other issues such as freezing of equipment and winter weather conditions make this a challenging and potentially dangerous undertaking. If incubation chambers are recovered in July, there is the potential that eggs or alevins that died over the winter might have been consumed by invertebrates, potentially leading to the assumption that absent larvae survived and assumed to have swam

away. However, according to Faulkner et al. (2006), microscopic examination of empty cells can reveal whether there are organic remains that would suggest predation as opposed to survival and escape by larvae.

Alternatively, consideration might be given to raising lake trout eggs in a hatchery or artificial situation by emulating field conditions using HCF materials. Given the inherent logistical difficulties in installing and retrieving egg traps over 9 – 10 months duration and the risk of failure for reasons unrelated to dike pore water chemistry (i.e., fungus, predation) better control over the test is desirable. Furthermore, given the safety considerations using SCUBA under the ice or in remote areas in extreme conditions, this also might warrant an alternative approach. However, the alternative (i.e., *ex situ*) also poses challenges because it will be difficult to emulate field conditions in a laboratory, i.e., no water renewal, maintaining oxygenation, preventing disease, risk of control failure, etc. Because of the logistical considerations of either method, DFO will be consulted prior to initiation of this Tier 3 study to determine the most effective means of conducting egg incubation studies at Meadowbank.

Data Analysis and Decision Criteria

One half of the traps will be retrieved shortly after fertilization and development and the other half after swim-up of larvae. ANOVA will be used to test for differences in survivorship/mortality at different areas along the HCF relative to reference area egg incubation traps. An assessment of developmental status and appearance to assess visible deformities will also be conducted to compare exposure area eggs to reference area eggs and alevins. Analysis of egg/alevin survival from incubation chambers will provide quantitative information on early survival of fertilized eggs and overall survivorship of eggs/alevins/fry.

Field Methods for Periphyton Growth on Modified Natural Substrate

Periphyton are unicellular and colonial aquatic algae species attached to and coating rocks and other hard substrates beneath the water surface and provide an important food source for benthic invertebrate species. Periphyton are most abundant between the surface and several meters water depth, and typically increase in biomass during the course of the open water season, reaching maximum abundance during late summer, and decline during late fall and winter, as the sun disappears.

Species composition and biomass of periphyton are indirect indicators of lake productivity and are sometimes indicators of the presence of contaminants. Because some periphyton species are sensitive to the presence of metals, reductions in periphyton communities over time can indicate the presence of dissolved metals in the water column, or dissolving from the surface of rocks.

The HCFs are expected to provide good substrate for periphyton to colonize. From core AEMP studies we have assembled a baseline periphyton community dataset on natural substrates throughout the Project Lakes area. Although periphyton biomass is highly variable, it is a useful indicator that may assist in determining if particular rock types used in HCF construction may be inhibiting plankton growth, or be responsible for toxicity.

Provided that Tier 1 periphyton community sampling showed adverse effects and Tier 2 testing showed declines in macrophyte and green algae growth associated with exposure to elevated contaminants, Tier 3 direct testing of periphyton growth using HCF rock is warranted. The proposed sampling program is as follows:

- Representative rock types used in HCF construction would be harvested from the field at the location of Tier 1 and Tier 2 failures and cut into plates using a rock saw. The plates will provide a flat, even

surface to allow quantitative community analysis. Control plates consisting of inert tiles will also be used.

- Plates will be marked and set below the water in similar depths, angle of exposure to the sun, and orientation to ensure that environmental factors are minimized as much as possible.
- Plates will be set about 1 m below the water surface in areas that failed Tier 1 and Tier 2 testing. A series of rock plates will be used along the shorelines to provide sufficient precision to detect differences in periphyton growth among locations.
- In addition to inert plates, consideration will be given to using native rock from reference areas to act as controls. Native rock will be ground or smoothed to remove existing periphyton colonies and prepared to act as 'new' surfaces for periphyton growth for comparison to periphyton growth on HCF substrates.
- Rock plates will be set in spring as soon after ice-off as possible and left until late summer at which time they will be picked up.
- At the end of summer plates will be collected from HCF and reference areas and thoroughly cleaned to wash off and collect all periphyton species growing on the plates.
- Periphyton scraped from a prescribed surface area on each rock surface will be preserved with Lugol's solution and sent to a laboratory for analysis of community composition, abundance and biomass on a per m^2 basis.

Data Analysis and Decision Criteria

A two-way ANOVA design would be used, with substrate type (i.e., ultramafic plate, iron formation plate and control plate) and site (i.e., HCF or reference location) being the factors. The exact design layout would be determined from results of the Tier 1/2 sampling results. Total biomass (mg per m^2) would be the main decision point, but major taxa composition would also be evaluated to determine if key periphyton groups are excluded or inhibited from growing.

Results of artificial egg incubation studies from HCF habitats, combined with periphyton community growth evaluation on HCF substrates will be used to determine if habitat features have the capability of functioning as intended. If it can be demonstrated that HCF structures are not functioning as intended and do not provide the capability of productive habitat features, further mitigation may have to be explored.

It is important to note the details presented herein may not be completely relevant in the future depending on the situation. As such, this document should be treated as guidance rather than a prescriptive study plan prior to implementation of Tier 2 and Tier 3 studies; DFO will be consulted to review study design, objectives, decision endpoints and overall objectives prior to implementation of Tier 2 and Tier 3 studies. Detailed Sampling and Analysis Plans (SAPs) will be prepared for each tiered study to ensure that success criterion of each component is achieved. In addition, quality assurance/quality control (QA/QC) measures will be implemented at all phases of the study to ensure that the highest data quality are collected.

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Figure 1. Ecological monitoring strategy for habitat compensation features (HCFs), Meadowbank Gold Project.