Section 2B

Habitat Compensation Monitoring Plan – Western Channel Temporary Crossing

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Meadowbank Gold Project

Western Channel Crossing – Habitat Compensation Monitoring Plan

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- Gary Mann (Azimuth) – Gary was project manager and primary author on this report.
- Randy Baker (Azimuth) –Randy also reviewed this monitoring plan and provided valuable input.

PROFESSIONAL LIABILITY STATEMENT

This report has been prepared by Azimuth Consulting Group Inc. (Azimuth), for the use of Agnico-Eagle Mines Ltd. (AEM), who has been party to the development of the scope of work for this project and understands its limitations. The extent to which previous investigations were relied on is detailed in the report.

This report provides details regarding specific monitoring components (i.e., NNLP habitat compensation structures) identified in the NNLP. The monitoring scope and design was developed in consideration of a specific project development plan. It is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the proposed development may necessitate modification of this monitoring plan.

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The recommendations in this report reflect our best professional judgment and have been developed in consultation with relevant regulatory authorities. This monitoring plan, and its associated commitments, was prepared by Azimuth on behalf of AEM. Implementation of the plan and its commitments is the sole responsibility of AEM.

ACRONYMS

AEM – Agnico Eagle Mines

AEMP – Aquatic Effects Management Program

ANOVA – Analysis of Variance

AWPAR – All Weather Private Access Road

DFO – Department of Fisheries and Oceans

DQO – Data Quality Objective

EEM – Environmental Effects Monitoring

GPS – Global Positioning System

HADD – Harmful Alteration, Disturbance or Destruction of fish habitat

HCF – Habitat Compensation Features

HCFMP – Habitat Compensation Features Monitoring Plan

IF – Iron Formation rock type

IM – Intermediate Volcanic rock type

INUG – Inuggugayualik Lake

ISQG – Interim Sediment Quality Guidelines

MDL – Method Detection Limit

MMER – Metal Mining Effluent Regulations

NNLP – No Net Loss Plan

PEL – Probable Effect Level

QA/QC – Quality Assurance / Quality Control

RPD – Relative Percent Difference

SOP – Standard Operating Procedure

SQG – Sediment Quality Guidelines

SP – Second Portage Lake

TE – Tehek Lake

TPE – Third Portage Lake – East Basin

TPN – Third Portage Lake – North Basin

TPS – Third Portage Lake – South Basin

UM – Ultramafic Rock type

UTM – Universal Transverse Mercator

WAL – Wally Lake

1. INTRODUCTION

1.1. Background

Agnico-Eagle Mines Ltd. (AEM; formerly Cumberland Resources Ltd.) is currently working towards completion of the regulatory permitting process for its Meadowbank Gold Project near Baker Lake, Nunavut[2]. To this end, AEM has been working closely with Fisheries and Oceans Canada (DFO) on aspects of the project related to the harmful alteration, disruption or destruction (HADD) of fish habitat.

The Western Channel Crossing No-Net-Loss Plan (WCC NNLP, 2008) was prepared to quantify project-related HADDs and present a habitat compensation strategy to comply with DFO's No-Net-Loss of Habitat policy. Azimuth Consulting Group Inc. (Azimuth) was commissioned by AEM to develop this habitat compensation feature monitoring plan (HCFMP).

Adaptive management is a core concept embedded within the AEMP strategy (AEMP, 2005). Simply stated, it allows new knowledge, learned from experience (e.g., monitoring), to be incorporated into future decision making. As more information about the relationship between mining activities and their potential effects on the receiving environment become understood, monitoring strategies (i.e. parameters, frequency, tools, triggers, and spatial intensity) can be altered to ensure that the aquatic environment is well protected over the life of the mine. Increased construction and monitoring of HCFs in the north will lead to a better understanding of their relative and absolute performance regarding fish productivity. Similarly, site-specific monitoring results will also provide new knowledge regarding how these structures are functioning. As new information becomes available in the future, the program will be reviewed and the monitoring commitments described herein may be revised.

1.2. Environmental Setting

The Meadowbank project lakes, where the proposed HCF will be constructed, are situated in the barren-ground central Arctic region of Nunavut within an area of continuous permafrost. These are headwater ultra-oligotrophic/oligotrophic (nutrient poor and unproductive) lakes, situated on the watershed boundary that separates two main drainages—the Arctic and Hudson Bay drainages. Only a few hundred meters to the north of Second and Third Portage lakes is the divide between water that flows north to

[2] No-Net-Loss Plans have been submitted to DFO for the Mine Site (NNLP, 2006) and the All-Weather Private Access Road (AWPAR; appendix to NNLP, 2006). The AWPAR, which joins the Mine Site to the Hamlet of Baker Lake and was completed in early 2008, was constructed under *Fisheries Act* Authorization **NU-03-0190(2)**; monitoring requirements are summarized elsewhere (Azimuth, 2007a).

the Arctic Ocean (via the Meadowbank and Back River system) or to Chesterfield Inlet and Hudson Bay (via the Quoich River system).

The landscape consists of rolling hills and relief with low growing vegetative cover and poor soil development. Numerous lakes are interspersed among boulder fields, eskers and bedrock outcrops, with indistinct and complex drainages. The main lakes in the Meadowbank project area include: Third Portage Lake (TP), Second Portage Lake (SP), Tehek Lake (TE), and the Vault Lake system – Vault, Wally (WAL) and Drilltrail lakes. As is common of headwater lakes, all of the project lakes have small drainage areas relative to the surface area of the lakes themselves. Local inflow from surrounding terrain is the predominant influence on water movement within the system. Small channels connect the project area lakes, although there is little flow between lakes during most of the year. The ice-free season on these lakes is very short, with ice break-up in late-June to mid-July and ice-up beginning in late September or early October. Maximum ice thickness is at least 2 m by March/April.

Overall, the Meadowbank project lakes support healthy communities of plankton, benthos and fish that are typical of oligotrophic Arctic lakes (BAER, 2005). Biological productivity of the lakes is limited by nutrient availability, cold water and a short growing season.

1.3. Objectives and Approach

The purpose of this HCFMP is to provide details regarding monitoring components needed to evaluate the effectiveness of the HCF. The habitat compensation feature monitoring covered in this plan is considered a targeted program under the AEMP (2005); details are provided elsewhere for the core AEMP program (Azimuth, 2008a; 2008b) and other targeted studies (e.g., dike construction and dewatering monitoring; AEM, 2008). This HCFMP follows the same principles and details laid out in the monitoring plan for the main Meadowbank Gold Project (Azimuth, 2008c).

The WCC NNLP (2008) and design technical memorandum (Golder, 2008) describe the habitat mount that will be created to offset project-related habitat losses.

HCF effectiveness will be judged based on the following success measures (n.b., specific criteria will be discussed in **Sections 3 and 4**):

- *Physical Attributes* – in the short-term, this component is essentially quality control monitoring (i.e., establishing that HCFs were constructed to design specifications); in the long-term, this refers to stability and integrity of these features.

- *Ecological Attributes* – the HCFs have been designed to function as productive fish habitat. The goal of this component is to document whether the HCFs are achieving this goal.

This monitoring plan is presented in the following sections:

- *HCF Overview* – key aspects related to the structure and intended function of the HCF are discussed (**Section 2**).
- *Physical Monitoring Components* – this section describes the process (including success criteria) by which the design engineer will evaluate the as-built HCF to determine whether it meets design intent and will describe long-term monitoring of physical stability (**Section 3**).
- *Ecological Monitoring Components* – this section presents the monitoring strategy for ecological attributes, including success criteria and supporting rationale (**Section 4**).
- *Adaptive Management and Program Reassessment* – this section discusses how the monitoring program will be reassessed based on new knowledge to ensure scientific defensibility and cost effectiveness (**Section 5**).

2. HABITAT COMPENSATION FEATURE OVERVIEW

The HCF has been designed (WC NNLP, 2008; Golder, 2008) to serve as productive fish habitat. Development of a successful monitoring plan requires understanding of the basic structure of the HCFs and their expected function.

Construction of the HCF will rely on the use of waste rock from mining activity. While there are three main rock types making up local geology, only iron formation (IF) will be used for the construction of this HCF. IF rock is potentially acid generating in oxygen-rich environments (e.g., in air), but has the lowest metals leaching characteristics of all three rock types in low or high-oxygen environments (including underwater).

Modeling conducted during the environmental impact assessment stage (summarized in Golder, 2007) predicted that post-construction interstitial water quality would generally meet CCME water quality guidelines for the protection of aquatic life (CCME, 2006). The only exception for IF rock is fluoride, which may exceed the CCME guidelines. Thus, in addition to meeting physical design specifications for fish, acceptable water quality is essential if HCFs are to function as intended.

The HCF is intended to enhance long-term habitat quality and abundance by providing spawning, nursery and foraging habitat for all important species including lake trout, arctic char and round whitefish. Spawning by lake trout, round whitefish, and char in the project lakes occurs in relatively shallow water, between 2 and 6 m depth. This is the depth range below the ice scour depth and above the depth where there is a transition to very fine grain sediment (BAER, 2005). This is consistent with the generalized spawning habitat preferences for lake trout as Scott and Crossman (1979) stated that, "spawning occurs over large boulder or rubble bottom in inland lakes at depths of less than 40 ft [12 m]." Note that the spawning habitat requirements of the other dominant species, round whitefish and Arctic char, are similar to those for lake trout. Arctic char spawn over gravel and rocky shoals at depths to 4.5 m, while round whitefish seek "gravely shallows of lakes," or a "gravel and rock bottom," in reasonably shallow depths (Scott and Crossman, 1979). A complete discussion of habitat requirements by resident fish species is provided in the NNLP (2006).

Other authors who have documented spawning habitat features for lake trout in the Great Lakes (Thibodeau and Kelso, 1990; Fitzsimons, 1996), northeastern USA and Ontario (Sly and Evans, 1996), and in Northwest Territories and Nunavut lakes (Richardson et al., 2001) and at other mine sites found similar preferences. In Lac de Gras for example, lake trout selected spawning characterized by either open water shoals or shorelines bordered by deep water with large substrates (boulders >256 mm in diameter), with many interstitial spaces, shallow water (2.5 to 7 m), steep slope, and wind exposed areas to prevent accumulation of fine materials (Diavik EIA, 1999). Similarly, preferred spawning habitat by lake trout in Snap Lake occurred over exposed, rocky shoals of 2 to 6 m depth with a boulder/bedrock substrate (Snap Lake EIA, 2002).

Thus, design of the HCF (WCC NNLP, 2008; Golder, 2008) will incorporate features optimal for spawning, egg incubation, and nursery habitat by lake trout, round whitefish, and Arctic char. Recent research has shown that replacing lost habitat with artificially created spawning habitat has been successful for lake trout in most of the Great Lakes (Fitzsimons, 1996). Furthermore, when lake trout have been deprived of traditional spawning sites, trout responded by seeking out alternative spawning locations within the lake, or utilizing other traditional spawning sites to a greater degree than before (McAughey and Gunn, 1995). The authors observed that there was no change in the timing of spawning, and that trout adapted very quickly to the altered conditions and appeared to readily and quickly use alternate sites. McAughey and Gunn (1995) stated that theirs was the first study to quantitatively demonstrate this behaviour in lake trout.

It is important to emphasize that the Project Lakes are not habitat limited. Rather, productivity in these ultra-oligotrophic lakes is constrained by lack of nutrients. Habitat mapping of these lakes (BFH, 2005) did not identify any obvious deficiencies in high-value habitat that would limit biomass. Whether fish use, or do not use natural or engineered habitat does not necessarily demonstrate functionality of the habitat, given the abundance of habitat available. Consequently, the intent of improving habitat quality is to replace HADD-related habitat losses and to ensure that fish productivity is optimized for the prevailing nutrient regime. Evaluation of the intended HCF function, therefore, will be focused primarily on *capability* rather than on actual use.

3. PHYSICAL MONITORING COMPONENTS

Golder (2008) has prepared preliminary design drawings for the Meadowbank Gold Project HCFs based on conceptual designs presented in the WCC NNLP (2008). This section describes the processes for short-term (i.e., as-built assessment) and long-term (i.e., structural/stability assessments) physical monitoring.

3.1. Monitoring Elements

Success may be measured differently for various types of construction projects. Assessment endpoints are defined here as the key design aspects inherent in the success of the HCFs. The following assessment endpoints were identified based on the HCF design (Golder, 2008):

- *Material Sizing* – ensure that the appropriate design rock size range is being used.
- *Rock Segregation* – ensure that appropriate rock types are used to minimize metals leaching potential.
- *Structure* – ensure overall structural stability. Video surveys will be used to assess underwater construction.
- *Depth Characteristics* – ensure that sufficient materials were placed to reach target depth characteristics. Bathymetric survey information will be used to support this assessment.
- *HCF Size* – ensure that sufficient materials were placed to create target habitat units. A combination of construction records (e.g., m^3 materials placed), bathymetric survey results and underwater video will be used to develop as-built drawings of the HCF. These will be used to calculate habitat units created, which will be compared to the WCC NNLP (2008c).

Success criteria for each assessment endpoint are presented in the next section.

3.2. Quality Assurance/Quality Control and Success Criteria

Quality assurance and quality control (QA/QC) are essential to the successful construction of the HCF. Much thought has gone into designing a feature to improve fish habitat, so it is important that these elements are not lost during the construction process. QA encompasses a wide range of management and technical practices implemented to ensure known quality commensurate with design intentions. QC is an internal aspect of QA that involves direct measurements of data quality.

While sound execution of project design plans involves a range of QA-related practices, planning, communication, and oversight are particularly important. It should be noted that the monitoring process does not start once construction is completed. Rather, the process starts during construction as one of the QA practices.

QC observations or measurements provide a direct means to assess construction quality. This process is most effective when success criteria are defined in advance (i.e., *a priori*). **Table 3-1** presents the post-construction monitoring success criteria for the Western Channel Crossing HCF. We have proposed quantitative success criteria where possible. However, this was not practical for certain assessment endpoints.

Table 3-1. Post-construction success criteria for Western Channel Crossing habitat compensation feature, Meadowbank Gold Project.

HCF Type	Material Sizing	Rock Segregation	Structure	Depth Characteristics	HCF Size
Habitat Mount	• Material viewed in place on ice; size distribution recorded; photographic records.	• Ensure proper material segregation and use (i.e., to meet design intent). • Construction logs reviewed.	• Post-construction video to be used to verify adequate face uniformity and slope characteristics (i.e., to meet design intent).	• Post-construction bathymetric survey used to confirm all top depths to be deeper than 3m; mean top depth between 3 to 6m.	• Habitat units created to meet or exceed NNLP.

Notes: HCF = habitat compensation feature.
Technical specifications for HCF construction are provided in Golder (2008)

3.3. Monitoring Frequency and Reporting

The intent of physical monitoring is to verify that design intent is met with the HCF. A schedule for conducting physical monitoring is presented in **Table 3-2**. An as-built report, including all assessment endpoints, will be completed by an engineer during the first open water season following construction (i.e., year C). This habitat mount will likely be constructed on the ice above the planned location[3]. While it is anticipated that construction will be completed in one year, the process may be iterative to ensure that design intent is met.

Once the as-built assessment process has verified that the HCF meets the intent of the design, subsequent physical monitoring events (i.e., long-term monitoring) will focus entirely on the structural integrity of the HCFs. The monitoring duration recommended herein should be sufficient to verify the long-term integrity of the HCFs. All reporting will be integrated into the annual AEMP report to streamline the process.

Table 3-2. Schedule for physical monitoring of Western Channel Crossing habitat compensation feature, Meadowbank Gold Project.

HCF Type	Material Sizing	Rock Segregation	Structure	Depth Characteristics	HCF Size
Habitat Mount	C	C	C, C+1, +3, +5, +10[1]	C	C

Notes: HCF = habitat compensation feature.
Technical specifications for HCF construction are provided in Golder (2008).
"C" refers to the year of construction; +1 refers to years after to construction.
1. Approximate timing for long-term monitoring; actual timing may vary in order to include more HCFs.

[3] Note that other construction methods (e.g., end dumping during the open water season) may be used if access alternatives (e.g., dikes and/or dike extensions) are successfully permitted.

4. ECOLOGICAL MONITORING COMPONENTS

4.1. Monitoring Strategy

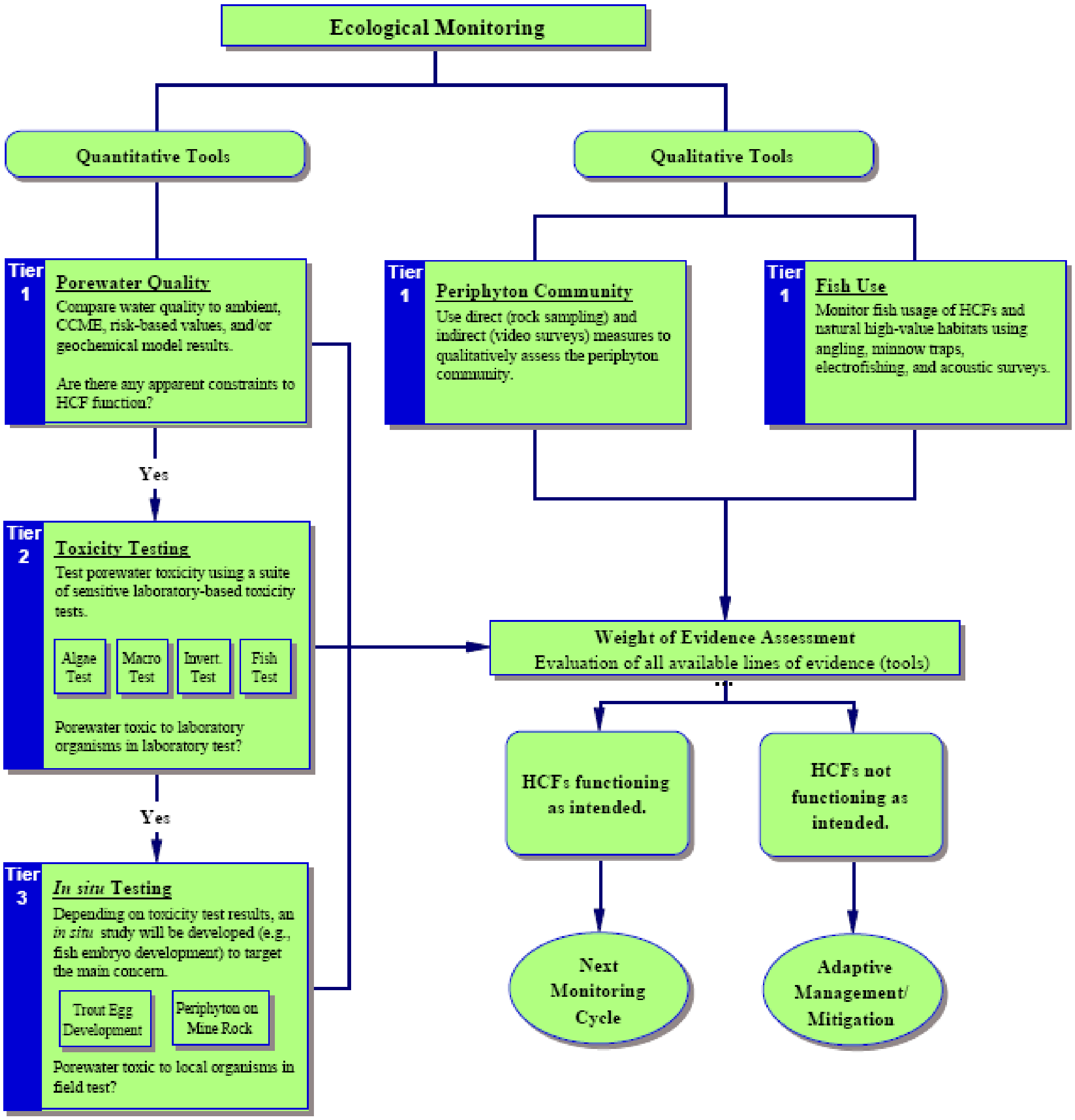
Based on the HCF overview provided in **Section 2**, there are a number of considerations related to developing a monitoring strategy to verify the intended functionality of the HCF:

- *Physical* – The HCF is designed based on our understanding of the habitat requirements of the main fish species in the Project Lakes area: lake trout (*Salvelinus namaycush*), arctic char (*Salvelinus alpinus*) and round whitefish (*Prosopium cylindraceum*). The NNLP (2006) provides a detailed review of these requirements for each life history stage of these species. Thus, successful implementation of the HCF design (WCC NNLP, 2008; Golder, 2008) should result in the increased availability of high-value physical habitat for fish use.
- *Chemical* – The potential for metals leaching from quarried rock (i.e., blasted during the mining process) used to build the dikes (and by extension the HCF) was identified during the EIA process (PEIA, 2005; AEFHIA, 2005). The AEFHIA concluded that this aspect of the project posed no significant effects to fish or fish habitat based on geochemical modeling results. However, as prudent when relying on modeling, the AEMP (2005) identified target monitoring programs to follow up on this issue.
- *Biological* – Productivity of the Project Lakes is limited by nutrients rather than habitat. Consequently, the provision of high-value habitat may not necessarily result in an increase in fish productivity or biomass, particularly in the short term. Consequently, success criteria for monitoring will focus on the capability of the HCF to function as fish habitat rather than on actual fish use or performance.

The monitoring strategy for the HCF is provided in **Figure 4-1**. Two categories of monitoring tools are proposed based on the above considerations:

- *Quantitative* – these tools are geared towards identifying any ecological constraints to HCF function; they are considered sufficiently accurate and precise to be used in decision making (i.e., by comparison to success criteria). A tiered monitoring framework is recommended for their use, starting with simple tools (interstitial water quality/chemistry) and leading to complex tools (toxicity testing and/or *in situ* studies) should the need arise (i.e., not meeting success criteria). Tiering provides a scientifically-defensible, yet cost-effective means of quantitatively assessing potential limitations to HCF productivity. Details for each tool are provided in **Section 4.2**. Success criteria for each tool are discussed in **Section 4.3**.

Figure 4.1. Ecological monitoring strategy for habitat compensation feature, Meadowbank Gold Project.



Qualitative – these tools will be used to complement the quantitative tools, but will not be used on their own for decision making; they include periphyton community and fish usage. The results of these studies will be considered in the weight-of-evidence assessment.

As discussed above, all lines of evidence are integrated to make the final determination regarding HCF functionality.

4.2. Monitoring Components

An overview of the ecological monitoring components and their application (or not) for shallow and mid depth zones is presented in **Table 4-1**. Sampling details for each component are provided below:

Interstitial Water Quality (Tier 1) – Quantitative Tool

- *Sampling methods* – The intent is to collect a representative sample of water quality in the bioactive zone. Either a stainless-steel push-point sampler or an electric diaphragm pump with food-grade silicon tubing will be used to collect water from the interstitial areas between rocks. The latter, with a long, weighted guiding pole, will likely be most effective for sampling the interstitial spaces between rocks at 2 to 6 m depth.
- *Sampling locations* – due to the relatively small size of the HCF, a single sampling station will be monitored.
- *Parameters measured* – samples will be analyzed for conventional parameters (pH, conductivity, hardness, total dissolved and suspended solids), dissolved anions and nutrients (ammonia, bicarbonate, carbonate, hydroxide, alkalinity, chloride, silicate, sulfate, nitrate, nitrite, total Kjeldahl nitrogen, orthophosphate and total phosphate), organics (total and dissolved organic carbon), and metals (total and dissolved).
- *Timing of collections* – water samples will be collected during the fall to coincide with the fish use surveys.

Table 4-1. Overview of ecological components for monitoring of Western Channel Crossing habitat compensation feature, Meadowbank Gold Project.

HCF Depth Zones		Quantitative Tools			Qualitative Tools	
		Interstitial Water Quality ● Anions/Nutrients ● Total/dissolved metals	**Toxicity Testing** ● *Lemna* macrophyte test ● *Selenastrum* algae test ● *Ceriodaphnia* invertebrate test ● Trout embryo development test	***In situ* Biological Studies** ● Trout egg development ● Periphyton substrate	**Periphyton Community** ● Video/photo surveys	**Fish Use** ● Angling surveys ● Acoustic surveys
Mid[1]	3 - 6 m	Tier 1[2]	Tier 2[3]	Tier 3[4]	Tier 1[5]	Tier 1[6]

Notes: 1. Sampling will target the top of the HCF, which should be situated between 3 to 6 m deep.
2. Interstitial water samples will be collected from between the IF rocks used to build the HCF.
3. Toxicity testing conducted only if Tier 1 fails; trout toxicity test only done in mid zone.
4. *In situ* studies only conducted as warranted based on Tier 2 results (see text for more details).
5. Direct sampling to be conducted in shallow zone; video/photo surveys to be used for mid zone.
6. Minnow traps, electrofishing and visual observations in shallow zone; angling and acoustic surveys in mid zone.

Toxicity Testing (Tier 2) – Quantitative Tool

- *Sampling methods* – Samples will be collected as per interstitial water quality.
- *Sampling locations* – Samples will be collected only from stations failing success criteria (see **Section 4.3**); ambient samples from reference areas will also be collected to provide a local control.
- *Timing of sampling* – Water samples will be collected from all stations failing success criteria as soon as is practical after results of interstitial water chemistry are received by Azimuth. Additional water chemistry samples will be taken to verify the initial Tier 1 results.
- *Toxicity test information* – Test selection is based on the current MMER program requirements for sublethal testing:
    - 7-d rainbow trout (*Oncorhynchus mykiss*) embryo development test (Reference Method EPS 1/RM/28).
    - 7-d invertbrate (*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).

***In Situ* Biological Studies (Tier 3) – Quantitative Tool**

Depending on the outcome of Tier 2 testing, there is a range of possible field studies that could be conducted to address any outstanding concerns. Two such studies were identified in the AEMP (2005) as possible target studies:

- *Trout Egg Development* – Incubators would be used to measure developmental success of lake trout (or other species) eggs *in situ*. This would involve collecting eggs and sperm from native fish, fertilizing and hardening the eggs, seeding the incubators, and placing them at exposure and reference locations. The incubators would be retrieved in the spring and counts made of developmental success. 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.

- *Periphyton on Modified Natural Substrate* – See below for some general information regarding periphyton. This component would be implemented only if Tier 2 testing showed potential reductions in plant growth associated with exposure to elevated contaminants and the Tier 1 periphyton community sampling showed adverse effects (see below for details). Instead of directly sampling the HCF construction material (which, as discussed below, yields results with considerable variability), the same rock types used in HCF construction (i.e., UM and IF) would be cut into plates to provide a better surface to allow quantitative community analysis. A two-way ANOVA design would be used, with substrate type (i.e., UM plate, IF plate and control plate) and site (i.e., HCF or reference location) being the factors. The exact design layout would be determined from the results of the Tier 1/2 sampling. Total biomass would be the main decision point, but major taxa composition would also be evaluated.

As stated previously, these studies would not be conducted unless triggered by Tier 1 and 2 results. In that circumstance, discussions with DFO would take place regarding the specific details of Tier 3 studies in advance of their implementation.

Periphyton Community (Tier 1) – Qualitative Tool

Periphyton are unicellular and colonial aquatic algae species attached to and coating rocks and other hard substrates beneath the water surface. Periphyton provide an important food source for certain benthic invertebrate species and form the base of the food web, together with phytoplankton and benthic algae. 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, reflecting nutrient concentrations in the lake, 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.

The HCF is expected to provide good substrate for periphyton to colonize. This community serves as the base of the hard-bottom benthic food chain, which ultimately includes fish. The core AEMP program will have produced two years (2007 and 2008) of baseline periphyton community data on natural substrates at 7 stations throughout the Project Lakes area prior to starting HCF monitoring. The 2007 data showed high variability in biomass and to a lesser extent community composition, which is why this tool is recommended to qualitative use (see Azimuth, 2008b for more discussion of the limitations of this tool for quantitative use).

Video/photo surveys will be used to assess periphyton growth as direct sampling of the community is not practical in deeper waters. Five to ten rocks will be photographed or videoed at representative locations. The results will be compared to reference areas (i.e., high-value habitats such as shoals and reefs) and qualitatively assessed for differences in cover thickness.

Fish Use (Tier 1) – Qualitative Tool

As discussed previously, the construction of high-value habitat features may not necessarily result in use by fish, particularly in the short term. That being said, the increased presence of high-value habitat will give fish more options and help to optimize productivity of these nutrient-limited lakes.

Fish usage data will be used as a complementary qualitative tool to support the assessment of HCF functionality. A comparative approach will be used, examining usage patterns between the HCF and existing natural habitats. Mid-September is likely the best time to conduct these studies. Two main types of tools will be used for these mid-water features:

- *Angling surveys* – angling, conducted by trained biologists, will be used instead of short-set gillnetting to minimize stress and/or injury to fish. Catch-per-unit-effort records and GPS locations will be kept along with basic biological information (species, length, weight, external examination [DELT – deformities, erosions, lesions, tumours], and sex [physical features and/or abdominal palpation]); all fish will be released to the environment after processing.
- *Acoustic surveys* – Fish counts will be conducted along variable length transects. Count-per-meter-surveyed records will be kept along with start and end GPS position and depth profiling.

4.3. Quality Assurance/Quality Control and Success Criteria

4.3.1. QA/QC

The objective of quality assurance and quality control (QA/QC) is to assure that the chemical and biological data collected are representative of the material or populations being sampled, are of known quality, are properly documented, and are scientifically defensible. Data quality will be assured throughout the collection and analysis of samples using specified standardized procedures, by documenting pertinent information directly onto field datasheets or field notebooks, by the employment of laboratories that have been certified for all applicable methods, and by staffing the program with experienced technicians.

Laboratory QA/QC: Water Quality – Data Quality Objectives (DQOs) are numerically definable measures of analytical precision and completeness. Analytical precision is a measurement of the variability associated with duplicate analyses of the same sample in the laboratory. Completeness for this study is defined as the percentage of valid analytical results. Results that were made uncertain due to missed hold times, improper calibration, contamination of analytical blanks, or poor calibration verification results will be deemed questionable or invalid.

Duplicate results will be assessed using the relative percent difference (RPD) between measurements. The equation used to calculate a RPD is:

$$RPD = \frac{(A - B)}{((A + B)/2)} \times 100$$

where: A = analytical result; B = duplicate result.

The laboratory DQOs for this project are:

- Analytical Precision = 25% RPD or less for concentrations that exceed 10x the method detection limit (MDL).
- Completeness = 95% valid data obtained.

RPD values may be either positive or negative, and ideally should provide a mix of the two, clustered around zero. Consistently positive or negative values may indicate a bias. Large variations in RPD values are often observed between duplicate samples when the concentrations of analytes are very low and approaching the detection limit. The reason for this is apparent if one considers duplicate samples with concentrations of an analyte of 0.0005 and 0.0007 mg/L. In absolute terms, the concentration difference between the two is only 0.0002 mg/L, a very tiny amount; however, the RPD value is 33.3%. This may sometimes lead to a belief that the level of precision is less than it actually is.

Field QA/QC: Water Sampling – Field QA/QC standards during water sampling will be maintained for every sample. The standard QA/QC procedures included thoroughly flushing the flexible tubing and pump to prevent cross-contamination between stations and thoroughly rinsing the sample containers with site water prior to sample collection.

Trip blanks and field duplicates will be collected (approximately 1 per 10 samples). Field duplicates assess sample variability and sample homogeneity; a RPD of 50% or less for concentrations that exceed 10x the MDL is considered acceptable.

Laboratory QA/QC: Toxicity Testing – Standard testing procedures (see **Section 4.2** for listing) will be followed by a CAEAL-certified laboratory. This includes running both positive and negative controls.

Field QA/QC: Toxicity Testing – Field methods for collection of water samples for toxicity testing will be identical to those used for water quality sampling. Care will be taken to avoid cross-contamination between sampling areas by rinsing the diaphragm pump prior to sample collection.

Field QA/QC: *In situ* Studies – Specific details would depend on which studies were implemented. These would be developed in consultation with DFO to ensure that the studies were conducted appropriately.

Field QA/QC: Periphyton Community – Video/photo survey data will be conducted carefully to provide representative images of target communities. All relevant spatial and depth information will be recorded and identified by the time stamp (or photo number) and tape number (or memory card number).

Field QA/QC: Fish Use – These study components will be conducted in accordance to the general practices listed previously. All relevant spatial and depth information will be recorded. Fish biological data will be recorded as will reference spatial information. Field notebooks will be used to compile notes and observations relevant to the studies. Fishing will be carried out by experienced biologists who are very familiar with this kind of work.

4.3.2. Success Criteria

The following success criteria will be used to evaluate HCF functionality from an ecological perspective:

- *Interstitial Water Quality (Tier 1)* – water chemistry results will be compared to reference locations (i.e., ambient levels), CCME water quality guidelines, risk-based toxicity reference values, and/or geochemistry model results[4]. Follow-up sampling will be conducted early the following year to verify success criteria failures. HCF locations with water quality still not meeting success criteria after two monitoring events will trigger Tier 2 testing.
- *Toxicity Testing (Tier 2)* – water sampling will be conducted as soon as practical after the second Tier 1water quality failure for a particular station. Toxicity testing results for each HCF sample will be statistically compared to the reference sample. HCF samples exceeding a 20% effect level (e.g., EC_{20} or IC_{20}) relative to reference performance will trigger Tier 3 testing.

[4] Geochemical modeling results are included to evaluate the validity of the modeling assumptions and results.

- *In situ Biological Studies (Tier 3) – in situ* studies will be conducted using a control-impact (also know as exposure-reference) design. HCF results will be statistically compared to the reference sites. The results (i.e., statistical significance, *a posteriori* power analysis, and observed effect magnitude) will be assessed for ecological relevance; the latter will vary depending on which studies are conducted.

The results of all components, including qualitative Tier 1 studies, will be assessed using a weight-of-evidence approach to make the final determination regarding HCF functionality.

4.4. Monitoring Frequency and Reporting

The intent of ecological monitoring is to verify that the HCF is functioning as intended. An approximate schedule for conducting ecological monitoring is presented in **Table 4-2** (n.b., "C" = year of construction); this schedule may be modified slightly over time to increase the efficiency of the program if more HCFs are constructed (e.g., monitoring for specific HCFs may be offset by a year to include more HCFs).

The general schedule has been set to decrease in frequency over time and end after 10 years. This assumes that monitoring results support HCF functionality and recognizes that these features are intended to function in perpetuity. As discussed in **Section 4.3.2**, success criteria failures will result in follow-up actions (e.g., repeat of Tier 1, then possibly Tiers 2 and 3). These follow-up actions will be conducted as soon as practical, but could be delayed until the next open water season.

HCFMP Reporting will be integrated into the annual AEMP report to streamline the process.

Table 4-2. Schedule for ecological monitoring of Western Channel Crossing habitat compensation feature, Meadowbank Gold Project.

HCF Types	Quantitative Tools			Qualitative Tools	
	Interstitial Water Quality (Tier 1)	Toxicity Testing (Tier 2)	*In situ* Biological Studies (Tier 3)	Periphyton Community (Tier 1)	Fish Use (Tier 1)
Habitat Mount	C,C+1,+3,+5,+10	*	*	C,C+1,+3,+5,+10	C,C+1,+3,+5,+10

Notes: * Tier 2 and 3 quantitative tools only conducted if warranted (see text).

C = construction

5. ADAPTIVE MANAGEMENT AND PROGRAM REASSESSMENT

Adaptive management (i.e., revising management strategy to account for new information) is an integral part of the AEMP for the Meadowbank Gold Project (AEMP, 2005). This facilitates making refinements of the HCFMP to account for new knowledge gained during the initial HCF monitoring events. For example, if monitoring results clearly indicate that the HCFs are functioning as intended, then the program could be adjusted to reduce monitoring intensity (spatial and temporal) to appropriate levels. Similarly, if results are questionable, then the frequency or spatial coverage of certain components may need to be increased.

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