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Core Receiving Environment Monitoring Program (CREMP): 2015 Plan Update

Prepared for:

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ACRONYMS

AEM Agnico Eagle Mines Ltd.

AEMP Aquatic Effects Monitoring Program

ANOVA Analysis of Variance

AWPAR All weather private access road

BACI Before/After Control/Impact

BACIP Before/After Control/Impact Paired

BAER Baseline Aquatic Ecosystem Report

BAP, BBD, BES, BPJ Baker Lake – Akilahaarjuk Point, Barge Dock, East Shore, Proposed Jetty

CCME Canadian Council of Ministers of the Environment

CREMP Core Receiving Environment Monitoring Program

CRM Certified Reference Material

DQO Data Quality Objective

EAS Effects assessment study

EEM Environmental effects monitoring

EIA Environmental Impact Assessment

FF Far Field

GPS Global Positioning System

INUG Inuggugayualik Lake

KIA Kivalliq Inuit Association

MDL Method detection limit

MF Mid-Field

MMER Metal mining effluent regulations

NF Near Field

NWB Nunavut Water Board

PAH Polycyclic aromatic hydrocarbon

PDL Pipedream Lake

QA/QC Quality Assurance / Quality Control

REF Reference

RPD Relative percent difference

RSF Rock storage facility

SOP Standard Operating Procedure

SP Second Portage Lake

TE Tehek Lake

TEFF Tehek Lake Farfield

TIA Tailings impoundment area

TSF Tailings storage facility

TSS Total Suspended Solids

TPE, TPN, TPS Third Portage Lake – East, North, and South Basins

UTM Universal Transverse Mercator

WAL Wally Lake

1. INTRODUCTION

1.1. Overview

In accordance with the terms of the renewed Nunavut Water Board (NWB) Type A Water Licence (2AM-MEA1525), Azimuth Consulting Group Partnership (Azimuth) was retained by Agnico Eagle Mines Ltd. (AEM) to complete an update of the core receiving environment monitoring program (CREMP) plan. This document reflects a broad scope that includes: re-tooling the general CREMP plan to match AEM's upcoming activities at the Meadowbank site and Baker Lake, and developing a CREMP component for monitoring pit flooding. This document also integrates a number of changes from the previous CREMP plan update (Azimuth, 2010a) stemming from comments and recommendations from the Kivalliq Inuit Association (KIA) that came out of the NWB Type A Water Licence renewal process. Finally, this plan update includes a new strategy, based on the existing gradient approach, to improve program efficiency by allowing reduced sampling effort when warranted.

1.2. Approach

The following components are addressed herein:

1. ***Meadowbank CREMP Routine Monitoring*** – the general CREMP monitoring strategy was initially conceived during the permitting process (AEMP, 2005) and has been modified over the years (e.g., Azimuth, 2010a, 2012a) to better support environmental management and decision-making at the Meadowbank Mine. These refinements reflect the adaptive nature of the CREMP, which has been an integral part of the program from its onset (AEMP, 2005). A substantial amount of data has been generated since the start of the program in 2006, leading to a good understanding of the nature of mine-related changes associated with the construction and operation of the Meadowbank Mine. Based on the available data, our understanding of the site construction and operations for the last decade, and future activities within the scope of the renewed NWB Type A Licence, we believe that there are opportunities to simplify the current design while maintaining the protection goals for the aquatic receiving environment.
2. ***Meadowbank Pit Flooding Monitoring*** – As discussed in **Section 2.2**, mining-related activities under the renewed NWB Type A Licence will include flooding the pits, eventually breaching the dikes and repatriating the pit lakes with the adjacent lake ecosystems. Those activities will require specific monitoring and an associated decision framework to guide the repatriation process (i.e., for determining when water quality in the flooded pit areas is acceptable to rejoin to the surrounding receiving environment). As per licence requirements, AEM will continue to implement a detailed program of water quality monitoring (key source areas and the flooding pits) and modelling to track progress and forecast pit lake water quality to support management decisions regarding this activity. Given the CREMP focus on receiving environments, this plan includes a general risk-based framework to ensure that water quality in flooded areas will not pose unacceptable risks to lake ecosystems when the dikes are eventually breached.

1.3. Report Organization

The remainder of this document is organized as follows:

- **Section 2** – Meadowbank CREMP routine monitoring
- **Section 3** – Meadowbank pit flooding monitoring
- **Section 4** – References

2. MEADOWBANK CREMP ROUTINE MONITORING

2.1. Introduction

AEM's Meadowbank Mine is situated approximately 75 km north of the hamlet of Baker Lake, Nunavut. The Aquatic Effects Management Program (AEMP, 2005) was developed to address issues identified during the Environmental Impact Assessment (EIA) process that could potentially impact the aquatic receiving environments surrounding the development. Building from earlier baseline monitoring (BAER, 2005), the 2005 AEMP described the general monitoring strategy designed to detect impacts to the aquatic environment. This strategy relied on two primary components: the core monitoring program[1] and targeted studies. Monitoring following the 2005 AEMP strategy has been implemented as follows:

- 2006 and 2007 – The core monitoring program was implemented over two complete cycles (Azimuth, 2008a, 2008b) prior to construction of the mine (i.e., baseline conditions).
- 2008 – 2014 – Mine construction started in 2008, with dike construction activities occurring directly in the receiving environment. Core receiving environment monitoring (Azimuth, 2009c, 2010b, 2011b, 2012b, 2013, 2014, 2015) was complemented by targeted studies directed towards effects of dike construction (Azimuth, 2009a, 2010c; AEM, 2011) and associated effects related to the effects of total suspended solids (TSS) on water quality and benthic community in affected waterbodies (Azimuth, 2009b, 2010d, 2011a, 2012c).

2.2. Meadowbank Site Activities and Potential Impacts

The site components include the Meadowbank mine site, the Vault Pit area to the north, marshalling and fuel storage facilities in Baker Lake, and the 110-km All Weather Private Access Road (AWPAR) between Baker Lake and the Meadowbank site. The Meadowbank Mine consists of several gold-bearing deposits; mining has targeted three open pits (Portage Pit, Goose Pit, and Vault Pit). Much of the pit development is located in close proximity to the mill, office and lodging infrastructure, with the exception of the Vault Pit which is approximately 8 km northeast of the main mine site. The operations phase of the project began in February 2010 with commercial production from Portage Pit, followed by the Goose Pit in the first quarter of 2012, and finally Vault Pit in the first quarter of 2014. Mining at the Goose Pit has been completed, leaving commercial production to Portage and Vault Pits until the end of the mine life in 2018.

2.2.1. Historical Site Activities

The CREMP study design was tailored to target the identification of effects related to AEM's activities, particularly to those which have the potential to affect the aquatic receiving environment. Key mining activities and their general effects on the aquatic environment are typically described in the routine monitoring reports and used to interpret the CREMP results each year. These activities include:

- Dike construction
- Dewatering
- Effluent Discharge
- Dust from general site-related activities (e.g., rock crushing, road building, pit blasting, ore and waste hauling, ground preparation, vehicle (truck and aircraft) traffic, infrastructure construction)
- Barge traffic (Baker Lake)

[1] Note that this program was designed as a complement to Environmental Effects Monitoring (EEM) requirements under the Metal Mining Effluent Regulations (MMER). EEM activities at Meadowbank have been conducted in 2011 (Cycle 1) and in 2014 (Cycle 2).

A chronological overview of these activities is presented by year in **Table 2-1** alongside related changes observed in the receiving environment.

As outlined in **Table 2-1**, the most significant changes observed in the receiving environment were largely attributable to East Dike and Bay-Goose Dike construction. Specifically, elevated turbidity and TSS concentrations were observed in SP, TPE and TE during active dike construction years (2008-2010), and an increasing trend in sediment chromium concentrations was observed at TPE in recent years (2013-2014), likely attributable to the use of ultramafic rock in the construction of the Bay-Goose Dike. In addition, the program has identified a number of minor water quality changes relative to baseline/reference conditions (e.g., conductivity, hardness, calcium, potassium, magnesium, sodium, and total dissolved solids) at near-field monitoring areas (e.g., the north basin of Third Portage Lake, the east basin of Third Portage Lake and Second Portage Lake); while these changes provide confidence in the CREMP's statistical power to detect mine-related changes in the receiving environment, the magnitude of change in all these cases was considered unlikely to adversely affect aquatic life (Azimuth, 2014). Overall, no apparent mine-related changes to the receiving environment in Baker Lake have been identified, despite the increase in barge traffic observed from 2008-2010.

2.2.2. Ongoing/Future Site Activities

Mining activity at Meadowbank is progressing from the south (Goose and Portage Pits) from early in the mine life (2010-2016), northward (Vault Pit) towards the end of mine life (2014-2018). The staged mine development results in the southern pits being completely mined out and undergoing closure during the operational phase of the Vault Pit, while the mill and tailings storage facility operate throughout the mine life (AEM, 2015).

The mine is now entering the late operational phase and AEM has recently renewed their NWB Type A Licence (NWB 2AM-MEA1525) until July 2025. This licence would take Meadowbank mine through late operations and into closure phase.

The current understanding of planned activities from late operations through closure and post-closure is as follows (AEM, 2015):

- Mining in the Goose Pit was completed in the second quarter of 2015
    - The Goose Pit will be flooded on a controlled basis from Third Portage Lake through until the end of September 2023. Water quality of all water sources to the pit (e.g., seepage water, groundwater, TSF reclaim water, and lake water) will be monitored carefully prior to, during and after flooding; the results will be compared to modelled predictions and managed accordingly (see **Section 3**).
- Mining in the Portage Pit will be completed in 2016
    - There is no planned effluent discharge to Third Portage Lake or Second Portage Lake in the next 10 years
    - Ultramafic waste rock will be used to progressively cap the Portage Rock Storage Facility (RSF) by end of 2016
    - Ultramafic waste rock will be used to progressively cap the Portage Tailings Storage Facility (TSF) for closure after September 2018
    - The Portage Pit will be flooded on a controlled basis from Third Portage Lake through until the end of September 2023. Water quality of all water sources to the pits (e.g., seepage water, groundwater, TSF reclaim water, and lake water) will be monitored

carefully prior to, during and after flooding; the results will be compared to modelled predictions and managed accordingly (see **Section 3**).

- Mining in the Vault Pit, Phaser Pit and BB Phaser Pit will continue through until approximately September 2018
    - Waste rock from the Vault Pit will continue to be delivered to the Vault RSF
    - Ore from the Vault Pit area will continue to be transported to and milled at the Meadowbank Mill
    - Tailings from the Vault Pit area will be transported and deposited in the Portage TSF
    - Runoff and infiltration drainage from the Vault RSF, dike seepage and Vault area contact water will be collected in the Vault Attenuation Pond prior to discharge to Wally Lake (treated as necessary)
    - The Vault RSF will not be capped as it is not expected to generate acid rock drainage
    - The Vault Pit will be flooded on a controlled basis from Wally Lake through until the end of 2023; by this time, the Vault Attenuation Pond and the pit lake will have merged. Water quality of all water sources to the pits (e.g., seepage water, groundwater, and lake water) will be monitored carefully prior to, during, and after flooding; the results will be compared to modelled predictions and managed accordingly (see **Section 3**).
- Flooded pit lakes and the reclaimed Portage TSF will continue to be monitored during the closure and post-closure phases. The Bay-Goose and Vault Dikes will be breached once water quality within the pit lakes meets discharge criteria, including CCME freshwater aquatic life guidelines where available, ambient lake concentrations and/or other risk-based assessment criteria (see **Section 3**).

As outlined above, mining-related activity over the next decade is decreasing in the Goose and Portage areas and remaining the same in the Vault area. Generally, there is a shift in location, but not necessarily in overall mining intensity, until mining at the currently targeted deposits is predicted to be completed in late 2018. After that, mine-related activities in all areas will cease as the mine moves into closure phase. It should be noted that progressive reclamation will be started as early as possible, so while the site as a whole may be in the operations phase, specific site components might already be in closure (e.g., TSF capping and Goose Pit flooding have already begun).

In terms of potential impacts to the aquatic receiving environment, based on historical activity-impact relationships, we would not expect to see any significant[2] impacts from the ongoing/future activities around the Meadowbank Mill, Goose Pit, Portage Pit, Vault Pit and Phaser Pits, described above through the end of 2018:

- *Dewatering* – significant impacts to the aquatic receiving environment at Wally Lake are unlikely given that no significant effects related to dewatering were observed historically in the north basin of Third Portage Lake or into Wally Lake. Furthermore, water treatment will be used if necessary to remove suspended sediments (and sediment-associated metals).

[2] Similar to the subtle changes detected by the CREMP at near-field monitoring areas over the last few years, continued low-magnitude mine-related changes to water quality at near-field areas adjacent to on-going activities would be expected moving forward; based on past results, none of these changes would be of sufficient magnitude to adversely affect aquatic life.

- *Effluent Discharge* – similar to dewatering, significant impacts to Wally Lake (from Vault Attenuation Pond) and to Second Portage Lake (from East Dike seepage) are not expected given that no significant effects were observed from effluent discharge to the north basin of Third Portage Lake historically. Discharge to Third Portage Lake has ceased; site contact water will be directed to the reclaim pond or will contribute to pit flooding.
- *Dust* – as mining and related activities are ongoing and will continue for the next few years, a number of activities could contribute to dust inputs into the aquatic receiving environment such as, blasting in the Vault Pit, waste rock hauling in the Vault area, ore hauling from the Vault area to the Portage area mill, and general mine site vehicle traffic. However, given that these activities are essentially a continuation of historical site activities, we would not expect any significant impacts as these were considered negligible relative to natural variability in the past.
- *Barge Traffic* – barge traffic is expected to remain the same or decrease as the mine approaches closure phase. Impacts are not expected particularly since no mine-related changes to the receiving environment in Baker Lake were identified even in years when barge traffic increased.

The planned cessation of mining Portage Pit, Vault Pit and Phaser Pits at Meadowbank in late 2018 will substantially change the nature of activities conducted on site, likely further reducing the potential for significant changes to the aquatic receiving environment. Accordingly, AEM commits to revisiting the CREMP plan in advance of the completion of mining prior to the closure phase.

Table 2-1. Chronology of mine operational activities and associated receiving environment overview from 2008-2014.

Year	Major Mine-Related Activities	Receiving Environment Overview
2008	●Major in-water construction activities included the East Dike (located in Second Portage Lake) and the Western Channel Dike (located between Third Portage Lake and Second Portage Lake); the closest CREMP sampling area to these activities was the Second Portage Lake area (SP). ●Other site-related activities included rock crushing, road building, pit blasting, ground preparation, and infrastructure construction. ●Barge traffic increases in Baker Lake to support construction.	●As described in detail elsewhere (Azimuth, 2009a; 2009b), East Dike construction led to a sedimentation event that extended through Second Portage Lake (SP) to Tehek Lake (TE). The potential impact of construction-related sediment releases to the aquatic environment was the focus of the four-year EAS study (Azimuth, 2009b, 2010d, 2011a, 2012c).
2009	●Dewatering discharges (i.e., impounded Second Portage Lake water with TSS) were directed primarily into the north basin of Third Portage Lake (TPN), but also into Second Portage Lake (March to July and Oct to Dec, 2009). ●Bay-Goose Dike construction started in late July 2009. ●Most of the site preparation and road infrastructure was completed in 2009. ●North Portage Pit was the primary focus of blasting and mine operations. ●Barge traffic increases in Baker Lake.	●Despite a number of precautions, storm winds broke the Bay-Goose Dike turbidity barrier containment system, leading to another sedimentation event in late August. ●Elevated TSS (and other parameters) was primarily restricted to east basin of Third Portage Lake (TPE) and to a minor extent into SP and TE. The implications of the release were assessed in the EAS study (see above).
2010	●Bay-Goose Dike construction completed using additional mitigation measures. ●Mine officially opened on 27 Feb 2010, marking the started of the operations period. ●Pit development focused on North Portage and South Portage pits. ●Waste rock to rock storage facility (RSF). Tailings to impoundment area (TIA). Contact water from operations not discharged to receiving environment. ●Dewatering of SP impoundment to TPN continued, with discharge now subject to MMER. ●Barge traffic increases in Baker Lake.	●Bay-Goose Dike construction leads to less-pronounced sedimentation event in TPE and extends through SP to TE; EAS studies continue. ●TPN (dewatering) TSS concentrations generally consistent with baseline conditions.
2011	●Mining operations focus on North Portage and South Portage pits. ●Waste rock to rock storage facility (RSF). Tailings to impoundment area (TIA). ●Construction activities limited to mine footprint. ●Dewatering of SP and TPE to TPN continued, with treatment added to reduce fine sediment and turbidity. ●Barge traffic stabilizes in Baker Lake.	●TPN focus of routine EEM study - no mine-related effects detected (Azimuth, 2012e). ●TPN TSS concentrations consistent with baseline. ●The TSS EAS targeting dike construction sedimentation events completed.
2012	●SP and TPE dewatering discharges to TPN finished by spring. Diffuser installed and effluent (mix of residual Bay-Goose water, contact water, East Dike seepage and run-off) discharge to TPN commences; treatment (for fine sediment, turbidity) continues. ●North cell non-contact water diversion completed in August (intercepting run-off prior to the tailings and waste rock areas and diverting to NP2 and Dogleg ponds). ●Vault access road constructed and site preparation activities for the Vault Pit and Vault Dike commence. ●Barge traffic remains stable in Baker Lake; 200-L diesel spill occurs, but cleaned up successfully.	●TPN TSS concentrations generally consistent with baseline. ●Minor mine-related trends identified for a number of water chemistry parameters at near-field areas: conductivity, sulphate and total dissolved solids. ●Spill-related monitoring show no traces of hydrocarbons in Baker Lake.
2013	●Effluent discharge to TPN continued. ●Fishout activity in Vault lake was completed. ●Vault lake was dewatered into WAL (ongoing) and did not require TSS treatment. ●Minor construction modifications to north cell diversion ditch completed. ●Completion of the Airstrip extension (18m) into Third Portage Lake in March. ●Seepage from Rock Storage Facility (ST-16) through the road into NP2 identified (additional monitoring in NP2 to evaluate near-shore water quality) (Golder, 2014).	●TPN TSS concentrations consistent with baseline. ●Minor mine-related trends identified for a number of water chemistry parameters at near-field areas: alkalinity, conductivity, calcium and total dissolved solids. ●TPE sediment chromium concentrations were elevated above trigger value; better spatial coverage needed to reduce uncertainty in 2014.
2014	•Effluent discharge to TPN from the Portage Attenuation Pond occurred only from June 10 to July 5. Discharge to TPN is now complete. The former Portage Attenuation Pond has now become the South Cell for tailings deposition. •EEM Cycle 2 Study Design was conducted at the end of August through the beginning of September (no TPN discharge at this time). •Vault Dewatering into Wally Lake from June 20 to 29 (now complete); discharge from Vault Attenuation Pond into Wally Lake from July 24 to August 14. No TSS treatment for Vault Discharge. •New discharge into Second Portage Lake during all of 2014 (except from May 3 to July 28): two seepage collection points (North and South) are situated on west side of the East Dike to collect seepage through dike from SP. Water is pumped from both collection points, which are connected together before discharging back into Second Portage Lake through a diffuser. No TSS treatment for East Dike Discharge. •No more seepage water from Rock Storage Facility (ST-16) reaching the NP2 Lake in 2014. •Commercial mining in Vault Pit started at the beginning of 2014. No major construction or modifications in 2014.	●Minor mine-related trends identified for a number of water chemistry parameters at near-field areas: conductivity, hardness, Ca/Mg/K/Na and total dissolved solids. ●Temporal trend in TPE sediment chromium confirmed in coring study; targeted study recommended for 2015.

2.3. Study Design

The study design is based on a before-after-control-impact (BACI) approach, but has also incorporated the concept of gradients in exposure. Tracking spatial and temporal differences related to mining activities relied on categorizing areas using two factors:

- *Area Type* – this concept relates to an area's spatial proximity to the planned mine development (i.e., whether built or not); categories include near-field, mid-field, far-field, and reference (see **Section 2.3.2**).
- *Area Status* – this concept is temporal and has two levels: control (not exposed to mine-related activity) or impact (exposed to mine-related activity). The term "impact" is taken from the BACI statistical study design approach and does not mean that an actual impact has taken place; rather, it designates a time period when potential mine-related impacts may occur for an area (i.e., that an area has been exposed to one or more mining activities).

Together, area categorization by type and status provide a logical framework to facilitate the identification of real mining-related changes to the aquatic receiving environment (as opposed to natural regional changes due to climate or other factors).

The onset of construction activities in proximity to a CREMP monitoring area formally ends the baseline phase and changes the status of that area from "control" to "impact". Status changes are also important for any statistical analyses, as they dictate how data are grouped when assessing potential trends. Note that the end of the baseline phase is specific to each area. The status of all CREMP areas since monitoring started is provided in **Table 2-2**.

2.3.1. Approach

The 2012 AEMP (Azimuth, 2012d) described a two-tiered approach for decision criteria at Meadowbank based on 'trigger' and 'threshold' level concentrations. These are defined as:

- Triggers are early warning criteria that may lead to action. Exceedence of a trigger value does not necessarily imply that an adverse effect may be expected. The triggers may be based on absolute numbers (e.g., an increases half-way from baseline to an identified effects-based threshold) or statistical criteria (e.g., statistically significant difference from baseline-reference conditions; these are used in the absence of an effects-based threshold for a substance and may be very conservative).
- Thresholds are legal requirements, regulatory guidelines (e.g., CCME), or other discrete benchmarks, below which unacceptable adverse effects are not expected and above which adverse effects may occur. If effects-based thresholds do not exist or are not warranted for a particular variable, then early warning triggers (based on statistical criteria) will be developed without thresholds. In such cases, if triggers are exceeded then the implications of such exceedences can only be understood through the integration of results from other AEMP monitoring programs, or, if important information gaps still exist, through prescribed EEM studies or targeted studies.

Thus, comparison of the data to the early warning trigger values is the initial analytical focus; only if trigger values are exceeded are data then compared to the applicable thresholds (if available). Details regarding the derivation of trigger and threshold values for the CREMP are presented in the CREMP Design Document 2012 (Azimuth, 2012a).

2.3.2. Sampling Areas

The program consists of 13 sampling areas, each categorized into one of the four main types of areas described below. Sampling areas are shown in **Figure 2-1** (Meadowbank) and **Figure 2-2** (Baker Lake).

- Near-field (NF) areas – Areas are situated in close proximity to the development, in particular near dikes, dewatering discharge, and proposed effluent sources. These areas provide the first line of early-warning for introductions of stressors into the receiving environment. In the Meadowbank study lakes, these areas include: Third Portage Lake North (TPN), Third Portage Lake East (TPE), Second Portage Lake (SP), and Wally Lake (WAL). For Baker Lake, there are two NF areas, one targeting the hamlet's barge landing area (Baker Barge Dock [BBD]) and the other AEM's fuel storage facility (Baker Proposed Jetty [BPJ]).
- Mid-field (MF) area – This area designation was added in 2011 to be consistent with the area categorizations used in the CREMP Design Document 2012 (Azimuth, 2012a) and includes Tehek Lake (TE) and Third Portage Lake South (TPS). TE is adjacent to the inlet from Second Portage Lake and was exposed to elevated TSS during construction of the East Dike in 2008, prompting the addition of a new far-field area (TEFF [Tehek Farfield]) in 2009; consequently, MF designation is more accurate for TE. TPS was an internal reference area in the 2005 AEMP. However, given the connectivity to TPN, it is more appropriately considered a MF area. Given that discharges to TPN are finished, TPS should still be appropriate as a reference area for EEM monitoring.
- Far-field (FF) area – The intent of this area is to monitor water and sediment quality downstream of project infrastructure to provide insights into the spatial extent of any effects observed at the near-field areas. The Tehek Farfield (TEFF) area is a key location that will ultimately determine whether or not contaminants are detectable downstream of the entire mine development. Lake waters from Second and Third Portage Lakes and the Vault Lakes (Vault, Wally, Drilltrail) meet at the southern end of Second Portage Lake and discharge via a single channel into Tehek Lake. Monitoring the water and sediment quality and the health of the benthic invertebrate community in the basin adjoining the discharge point from Second Portage Lake will help determine if any effects identified at SP are extending into TE and beyond into TEFF.
- Reference (Ref) areas – By definition, reference areas are sufficiently removed from mine activities that they are presumed to be unaffected by any infrastructure and point sources (e.g. aerial deposition and effluent) associated with mine development and activities. Inuggugayualik Lake (INUG) and Pipedream Lake (PDL) are external reference areas chosen for the purposes of making comparisons with the project lakes (EVS, 1999; BAER, 2005). Monitoring of reference areas is important in order to distinguish between possible mine-related changes in water quality or ecological parameters and natural changes, unrelated to the mine. The reference areas are situated about 16 km west at INUG and 12 km northwest at PDL of the mine site. They are both headwater lakes and flow north into the Arctic Ocean. Despite the different drainage basin, both these lakes satisfy the requirements of an external reference lake from a physical/chemical perspective because they are at similar in latitude, have similar geology, relief and climate, do not have any significant inflows and has generally similar limnological features, water chemistry and aquatic biological community structure to the project lakes (BAER, 2005). Pipedream Lake, added to the CREMP in 2009, was originally investigated as a candidate reference area in 1998 (EVS, 1999) from a fisheries perspective; it provides a second context for assessing regional changes due to climatic factors. For Baker Lake, the internal reference area is located several kilometers to the east of the hamlet along the north shore of the lake (Baker Akilahaarjuk Point

[BAP]) and a second reference area, primarily for interpretation of benthic invertebrate data, was added in 2011 based on a recommendation from additional analysis and interpretation of the historical Baker Lake data, which is located on the same shoreline, east of BPJ and west of BAP (Baker East Shore [BES]).

Thus, the core monitoring program is intended to detect changes at a basin or lake scale of inference and to help define the extent (both spatially and temporally) of any adverse effects identified.

2.3.3. Sampling Strategy

As prescribed in Schedule I Table 2 of the Type A water licence (NWB, 2015), the intensity of CREMP monitoring currently varies by component and location. For example, winter sampling is limited to limnological sampling at NF areas (SP, TPE, TPN, and WAL) only and benthic invertebrate sampling is conducted once per year during the August open water period. These component- and location-specific differences are intended to optimize the efficiency of the CREMP to detect changes in the aquatic receiving environment and to address safety concerns (e.g., avoiding on-ice work during dangerous conditions). That said, apart from winter sampling, the program was largely carried out with the same frequency at all locations (i.e., NF, MF, FF and Ref). The variable frequencies and locations of sampling were reviewed beginning in 2012 and approved during the NWB Type A renewal process.

The past decade of CREMP implementation has shown that the design is effective in identifying changes in the aquatic receiving environment (e.g., the low magnitude changes in conductivity, TDS and other parameters are detected at low levels). The results have also shown that the pattern of results is consistent with the conceptual model that mining-related changes will be seen first and most intensely at NF areas. While the significant changes in water quality associated with dike construction were also detected in Tehek Lake (i.e., at MF area TE), the more recent low magnitude changes in water quality have not extended to this area. These results support the introduction of further efficiencies into the CREMP sampling program without sacrificing protection of the aquatic receiving environment.

To that end, we propose a results-driven strategy that reduces sampling frequency at MF and FF sampling areas provided that the decision is supported by previous NF results and MF results for FF. The annual decision framework is presented in **Figure 2-3**. The framework applies to MF area TE (which is paired with upstream NF areas TPE, SP, and WAL), MF area TPS (which is paired with NF area TPN), and to FF area TEFF (paired with upstream MF area TE); this framework does not apply to the Baker Lake areas as there are no MF or FF areas in Baker Lake. As per the normal CREMP data analysis process (see **Section 2.6**), NF results are evaluated on an annual basis (i.e., with CREMP reporting due at the end of March following each monitoring year), with the NF results (i.e., for "Year") dictating the monitoring requirements for the MF area in the subsequent year (i.e., "Year +1"). The Year +1 NF and MF results are used as the basis to determine the MF and FF monitoring requirements for Year +2, and so on. While the full CREMP program will be conducted at each NF area each year, the specific monitoring requirements for the MF and FF areas vary based on the NF and MF results, respectively, as follows (see **Figure 2-3**):

- *No changes identified* – no statistical changes above any trigger values. No further sampling required.
- *Minor changes identified* – statistically significant changes exceeding the early warning trigger values for parameters without effects-based threshold values (i.e., trigger values are based on the 95th percentile of the baseline distribution). Spot sampling through-ice is required to determine if changes extend to MF area (or to FF if such changes are seen at an MF area).

- *Moderate changes identified* – statistically significant changes exceeding the early warning trigger values for parameters with effects-based thresholds (e.g., CCME water quality guidelines for water chemistry parameters). Full CREMP water sampling (all events) is required to determine if changes extend to MF area (or to FF if such changes are seen at an MF area).
- *Major changes identified* – statistically significant changes exceeding the effects-based threshold values. Full CREMP program (i.e., including sediment and biological components) is required to determine if changes extend to MF area (or to FF if such changes are seen at an MF area).

This strategy improves the efficiency of the CREMP without compromising the high level of protection for the receiving environment. Furthermore, based on a decade of monitoring at Meadowbank and the nature of activities planned over the next few years, it would be unexpected to see bigger changes in the NF areas relative to what has been observed to date (i.e., minor changes only with the exception of during dike construction). As the site transitions from late operations to closure, it is anticipated that a greater emphasis of the CREMP will be placed on monitoring pit flooding and supporting environmental management decisions regarding breaching the dikes (see **Section 3**).

To help clarify how this strategy would be used, we provide a worked example in **Figure 2-4** which is supported in the text below:

Worked example

- The **2015** ("Year") CREMP data for all areas and components undergo analysis as per the normal annual data analysis process. Results of this analysis show that the yearly mean of the water chemistry parameter TSS significantly exceeds its trigger at WAL. TSS is a parameter with an effects-based threshold so this change constitutes a "Moderate change identified" in the above rule set.
- WAL is a NF area that is paired with MF area TE. In **2016** ("Year +1"), sampling at TE would be conducted in all 5 events but for water chemistry (and limnology) components only. No sampling would be required at TEFF in 2016 unless a change was identified at TE in the 2015 dataset.
- The TE water chemistry results from 2016 sampling undergo analysis as per the normal annual data analysis process. Results of this analysis show no exceedences of trigger values by the yearly means at TE; "No changes identified". Therefore, no sampling is required at both TE and TEFF in **2017** ("Year +2").
- Note that all 2016 NF data would be assessed separately to determine if sampling is required at MF areas in 2017 (i.e., the assessment of NF results occurs on an annual basis).

2.3.4. Sampling Components

CREMP monitoring has included the following components in one or more years since 2006: limnology, water chemistry, sediment chemistry, phytoplankton, periphyton, benthic invertebrates, and zooplankton. Fish are included in the EEM and MMER program as a component in the AEMP. Limnology, water chemistry, sediment chemistry, phytoplankton, and benthic invertebrates have been conducted each year and are the core of the program. Periphyton was included in the first few years of monitoring to characterize natural communities in the Meadowbank lakes to help interpret habitat-related monitoring of the dike faces; while it is still included in habitat monitoring, it has not been included in CREMP monitoring since 2008. Zooplankton was initially excluded from the CREMP due to the influences of high variability (AEMP, 2005).

As part of a two-year consultative process to ensure that the program was meeting its intended goal of protecting the aquatic receiving environment, the study design of the CREMP was formally reviewed, culminating in the preparation of the CREMP Design Document 2012 (Azimuth, 2012a). In the interest of transparency, this review included zooplankton (based on data collected in 2010 and 2011) and periphyton to formally assess their suitability as monitoring components in the CREMP.

The CREMP Design Document 2012 (Azimuth, 2012a) included recommendations on each component with regards to sample timing, frequency, and number of samples required (sampling effort). These recommendations (which were subsequently approved) were derived from statistical testing (using the BACI or BA framework) and used power analysis to determine the adequacy of statistical power to detect a change in a particular variable from baseline levels to the relevant trigger value. The review supported the initial decisions regarding zooplankton and periphyton, as both had low statistical power to detect effects for these components. Note that both these tools may have a role in more targeted studies, if warranted for specific issues.

2.3.5. Sampling Effort and Frequency

As mentioned above in **Section 2.3.4**, the CREMP Design Document 2012 (Azimuth, 2012a) also made recommendations on sampling effort (i.e., number of replicates per event) and frequency (i.e., number of events per year). The following details for each component were approved by regulators:

- *Water chemistry* – data should be collected for up to 6 months (events) per year, recognizing that in any given year there may be logistical constraints (e.g., snow and ice conditions). Sampling should be limited to open-water months only for PDL and for the Baker Lake areas. It is recommended that two randomly located samples be collected at each area in each month (event). In addition to the core water chemistry program, basic limnology data should be collected at key near-field areas (TPN, TPE, SP, and WAL) at least once mid-winter to reduce uncertainty regarding the potential occurrence of changes over winter.
- *Sediment chemistry* – grab samples should be collected once per year, synoptically with benthic invertebrates, to ensure collection of basic physical variables (e.g., particle size and organic carbon) which may affect benthic invertebrates. Coring samples should be collected at sampling frequency of approximately every three years. Core samples should be collected during open-water at all potentially impacted areas as well as INUG and BAP (reference areas). Ten independent samples per impact area should be collected, but only 5 should be submitted for analysis as a first cut. Collecting 5 independent replicate samples at the reference areas is sufficient as changes are assessed using a BA (before-after) design (i.e., as temporal changes in sediment chemistry are not expected to occur naturally in these low sedimentation environments).
- *Phytoplankton* – data should be collected whenever the water chemistry data are collected, but only the open-water samples need to be analyzed while it is recommended that the other samples be archived. As per water chemistry, it is recommended that two randomly located samples be collected at each area in each month (event).
- *Benthic Invertebrates* – data should be collected once per year in August at all areas, with 5 samples per area.

After 2012, these recommendations were approved and put into place and continue to be part of the routine CREMP. However, as time progresses towards the end of mine life, and mining activities change or decrease through late operations, closure and post-closure phases, there is a rationale for a

corresponding decrease in sampling effort and frequency as monitoring will put greater emphasis on pit flooding (as discussed in **Section 2.3.3**).

Table 2-2. Status of all CREMP areas since the beginning of monitoring.

	Meadowbank Areas									Baker Lake Areas			
	REF	REF	NF	NF	NF	NF	MF	MF	FF	REF	REF	NF	NF
Year	INUG	PDL	TPN	SP	TPE	WAL	TPS	TE	TEFF	BAP	BES	BBD	BPJ
2006	C		C	C	C	C	C	C					
2007	C		C	C	C	C	C	C					
2008	C		C	I (Aug)	C	C	C	I (Aug)		C		I	I
2009	C	C	I (Mar)	I	I (Aug)	C	C	I	C	C		I	I
2010	C	C	I	I	I	C	C	I	C	C		I	I
2011	C	C	I	I	I	C	C	I	C	C	C	I	I
2012	C	C	I	I	I	C	C	I	C	C	C	I	I
2013	C	C	I	I	I	I (Jul)	C	I	C	C	C	I	I
2014	C	C	I	I	I	I	C	I	C	C	C	I	I
2015	C	C	I	I	I	I	C	I	C	C	C	I	I

Notes: Area designations: C=Control; I=Impact; REF=reference (in grey shading); NF=near-field (in blue shading); MF=mid-field (in pink shading); FF=far-field (in teal shading); Blank denotes that the area was not part of the monitoring program that year. Area IDs: INUG=Inuggugayualik Lake; PDL=Pipedream Lake; TPN, TPE, TPS=Third Portage Lake - North, East, South basins; SP=Second Portage Lake; WAL=Wally Lake; TE, TEFF=Tehek Lake – Mid-field and Far-field; BAP, BES, BBD, BPJ=Baker Lake - Akilahaarjuk Point, East Shore, Barge Dock, Proposed Jetty.

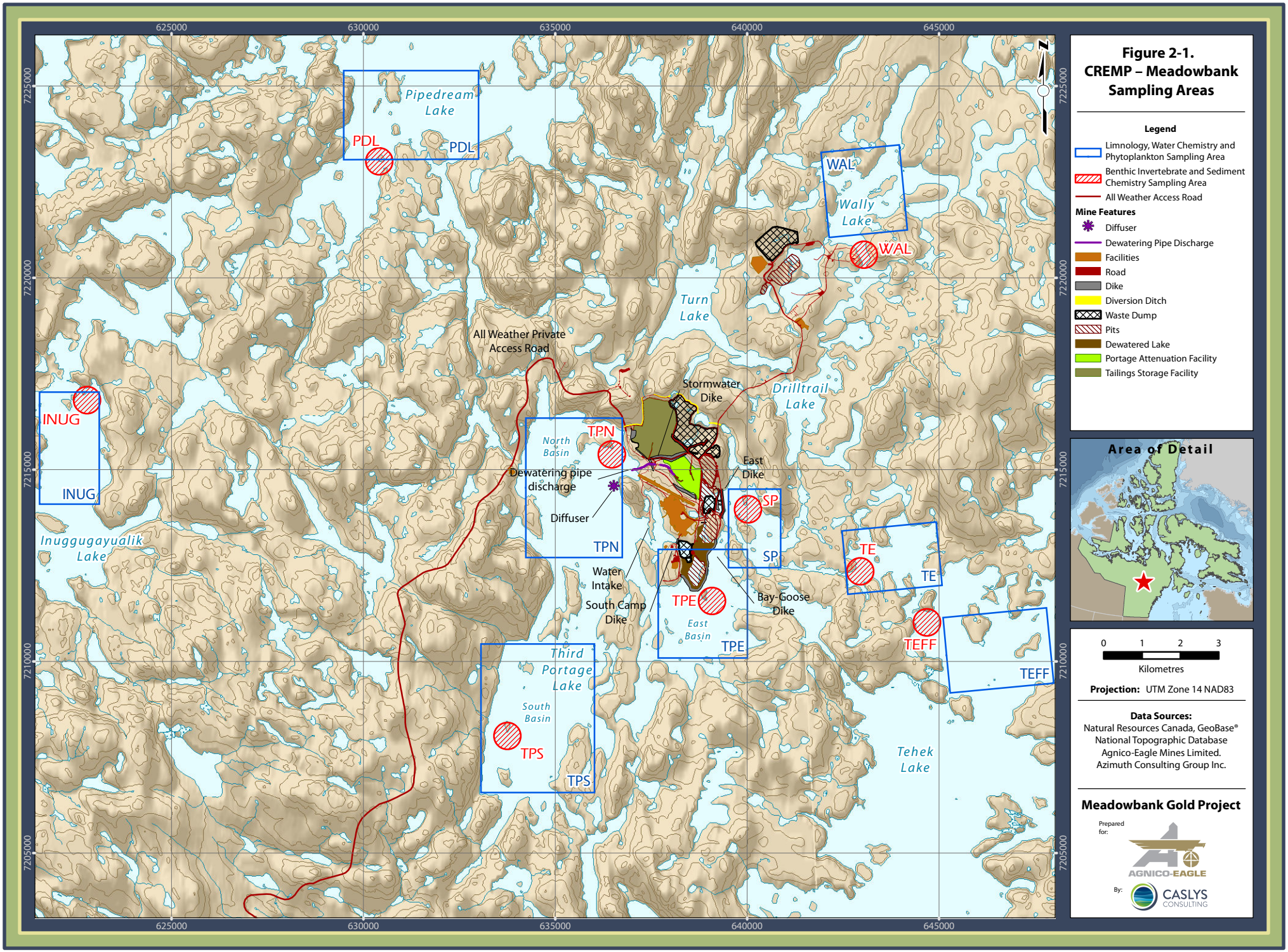


Figure 2-1. CREMP – Meadowbank Sampling Areas

Legend

- Limnology, Water Chemistry and Phytoplankton Sampling Area
- Benthic Invertebrate and Sediment Chemistry Sampling Area
- All Weather Access Road

Mine Features

- Diffuser
- Dewatering Pipe Discharge
- Facilities
- Road
- Dike
- Diversion Ditch
- Waste Dump
- Pits
- Dewatered Lake
- Portage Attenuation Facility
- Tailings Storage Facility

Area of Detail

0 1 2 3

Kilometres

Projection: UTM Zone 14 NAD83

Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.

Meadowbank Gold Project

Prepared for: AGNICO-EAGLE

By: CASLYS CONSULTING

Legend

- Limnology, Water Chemistry and Phytoplankton Sampling Area
- Benthic Invertebrate and Sediment Chemistry Sampling Area
- All Weather Access Road

0 5 10 15
Kilometres

Projection: UTM Zone 14 NAD83

Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.

Figure 2-2.
CREMP – Baker Lake Sampling Areas

Meadowbank Gold Project

Prepared for: AGNICO-EAGLE

By: CASLYS CONSULTING

Figure 2-3. Annual results-based sampling strategy rules for mid-field and far-field sampling areas.

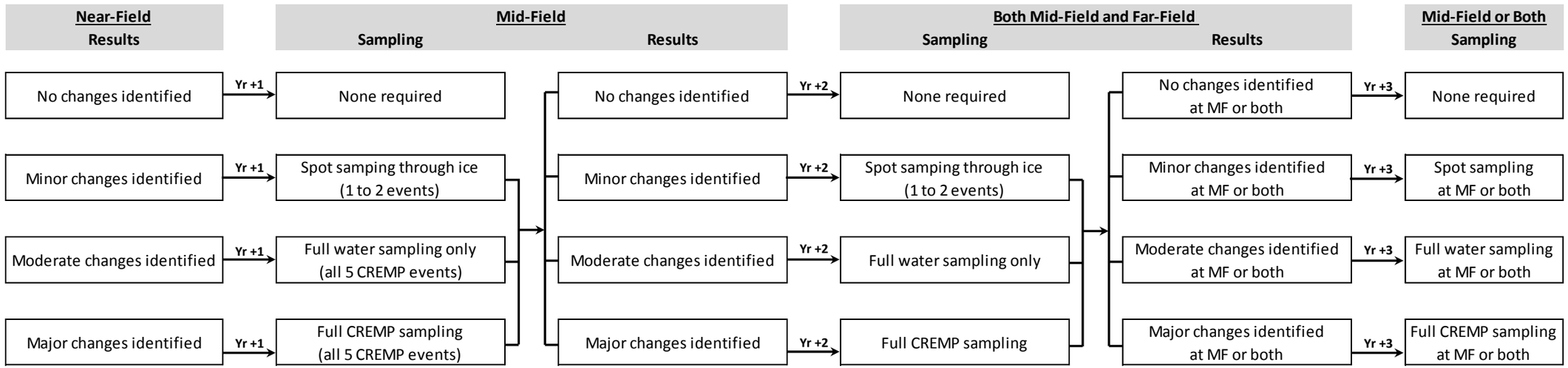
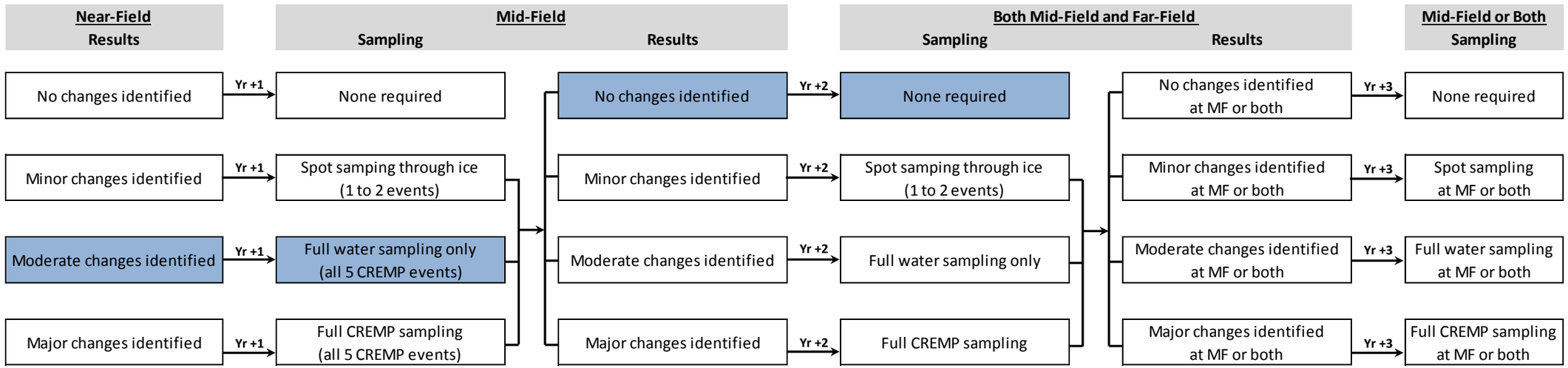


Figure 2-4. Worked example using the annual results-based sampling strategy rules for mid-field and far-field sampling areas.



Notes: The worked example follows a scenario which is highlighted in blue shading; each step and outcome is explained in text, see **Section 2.3.3**.

2.4. Sampling Methods

A summary of timing and frequency of sampling for each of the CREMP monitoring components is shown in **Table 2-3** by sampling season and month.

Sampling for the CREMP program is undertaken according to the Standard Operating Procedures (SOPs) for each of the monitoring components. The SOPs are appended herein and include general information on field collections, as well as detailed information on the location and timing of sampling, pre-trip planning, field collection materials, field quality assurance / quality control protocols, step-by-step instructions on sample collection, bottle requirements and list of parameters, sample preservation, and sample handling and transportation.

In accordance with the sampling strategy presented in **Section 2.3.3**, sampling frequency *may* be reduced or dropped altogether at MF and/or FF areas depending on the results of the paired NF areas.

2.4.1. Limnology, Water Chemistry and Phytoplankton

Sampling procedures for limnology, water chemistry, and phytoplankton are addressed together in one SOP (**Appendix A**). A brief overview is given below.

During each sampling event, limnology data, water chemistry samples, and phytoplankton samples are collected concurrently from two locations in each sampling area. These sampling locations are selected randomly for each sampling event from within the larger marked areas (blue rectangles) shown in **Figure 2-1** and **Figure 2-2**. This selection is done by bounding the sample areas and using a random number generator to select coordinates within those bounds. Coordinates are then recorded in MapSource and in the hand-held GPS units (NAD 83) before going out into the field. Selecting coordinates on a map does not ensure suitable locations in the field and occasionally field crew will move the sampling location away from shore to ensure a depth of at least 5 m is obtained.

Limnological parameters include a secchi depth measurement and vertical profiling for temperature (°C), dissolved oxygen (mg/L), specific conductivity (µS/cm), and pH at every meter from surface to 1 m off the bottom (or up to 20 m) using the YSI Professional Plus meter. If, during an open-water sampling month (July-September), a vertical profile shows abnormally low dissolved oxygen, or abnormally high conductivity or temperature for a particular depth, then a water chemistry sample is collected from that depth and analysed alongside the other water chemistry samples (see below). A description of the acceptable ranges for each of these limnological parameters for NF areas only is included in Table 3 of **Appendix A**.

Water chemistry samples are collected from approximately 3 m depth[3] by pumping lake water through a flexible (food-grade silicone) tube using a 12-V diaphragm pump. Water is pumped directly into sample bottles or first through a high-capacity 45-µm inline filter for dissolved parameters (all sample bottle and preservative requirements are listed in Table 1 of **Appendix A**). Water chemistry parameters include physical tests, anions and nutrients, organic and inorganic carbon, chlorophyll-a, cyanide, and total and dissolved metals. A full detailed list of parameters is shown in Table 2 of **Appendix A**.

Phytoplankton samples are collected from the same depth (3 m) and pump system used for water chemistry samples, prior to attaching a filter. Samples are preserved with a few drops of Lugol's solution and sent for taxonomic identification and biomass analyses.

[3] This depth was selected to provide a consistent depth at which to sample during any season, including during winter months when ice thickness can exceed 2 m.

2.4.2. Benthic Invertebrates and Sediment Grab Chemistry

Sampling procedures for benthic invertebrates and sediment grab chemistry are addressed together in one SOP (**Appendix B**). A brief overview is given below.

During the August sampling event only, benthic invertebrates and sediment chemistry grab samples are collected concurrently from five locations (replicates) in each sampling area. These sampling locations are selected in the field using a target depth range of 6.5-9.5 m each year from within the small marked areas (red hatched circles) shown in **Figure 2-1** and **Figure 2-2**. The depth zone is limited to this fairly narrow range to reduce the influence of depth-related variability on the analyses.

Benthic invertebrates are collected first in the sequence, using a Petite Ponar grab (0.023 m^2) and a 500-µm sieve. Two independent grabs per replicate are composited to form a single sample to reduce sampling variation within areas and to increase the surface area sampled. Samples are preserved in the field with a 10% buffered formalin solution and sent for taxonomic identification and analysis.

Sediment grab chemistry samples are collected second in the sequence, from the same depth and grab sampler used for benthic invertebrates. The top 3-5 cm of sediment from two independent grabs per replicate are homogenized in a bowl. Sediment is scooped into sample jars for the following chemistry parameters: physical tests, particle size, organic carbon, and metals. Another scoop of sediment is set aside from each of the 5 replicate locations, homogenized and placed into a sample jar for the following chemistry parameters: aggregate organics, hydrocarbons, and polycyclic aromatic hydrocarbons (PAHs). A full detailed list of parameters is shown in Table 1 of **Appendix B**.

2.4.3. Sediment Coring Chemistry

Sampling procedures for sediment coring chemistry are presented in **Appendix C**. A brief overview is given below.

Sediment coring is only conducted every three years to match monitoring for EEM field studies. In a coring year, samples are collected during the August sampling event only, and collected concurrently with benthic invertebrates and sediment grab chemistry. Core sediment samples are collected prior to benthic invertebrate grab sampling and use the same general sampling area (and depths). However, an additional five locations (replicates) are sampled in each sampling area, for a total of 10 coring replicate samples. While 10 independent replicates are collected from each area, in some cases, only five cores are sent for analysis. This decision is based on whether acceptable statistical power can be achieved from only 5 samples (i.e., as predicted by the CREMP Design Document 2012 [Azimuth, 2012a]).

Sediment cores are collected using a hand-operated gravity corer (barrel diameter of 7 cm). The top 1.5 cm of sediment from one independent core per replicate is sampled. Sediment is transferred into a sample jar for the following chemistry parameters: pH, total organic carbon, and metals.

Table 2-3. CREMP monitoring component sampling summary for Meadowbank and Baker Lake.

Sampling Season	Sampling Month	Sampling Crew	Monitoring Conditions	Monitoring Components	Meadowbank Areas									Baker Areas			
					INUG	PDL	TPN	SP	TPE	WAL	TPS	TE	TEFF	BAP	BES	BBD	BPJ
					REF	REF	NF	NF	NF	NF	MF	MF	FF	REF	REF	NF	NF
Winter	January	AEM	Ice	L			✓	✓	✓	✓							
	February	AEM	Ice	L			✓	✓	✓	✓							
	March	AEM	Ice	L			✓	✓	✓	✓							
Spring	April or May	AEM	Ice	L,W,P	✓		✓	✓	✓	✓		?					
	June		***Ice not safe***														
Summer	July	AEM	Open-water	L,W,P	✓	✓	✓	✓	✓	✓	?	?	?	✓		✓	✓
	August	Azimuth	Open-water	L,W,P	✓	✓	✓	✓	✓	✓	?	?	?	✓		✓	✓
				B,S,C*	✓	✓	✓	✓	✓	✓	?	?	?	✓	✓	✓	✓
	September	AEM	Open-water	L,W,P	✓	✓	✓	✓	✓	✓	?	?	?	✓		✓	✓
Autumn	***October***		***Ice not safe***														
	November or December	AEM	Ice	L,W,P	✓		✓	✓	✓	✓		?					

Notes: Components: L=Limnology; W=Water chemistry; P=Phytoplankton; B=Benthic invertebrates; S=Sediment grab chemistry; C=Sediment coring chemistry. *Sediment coring is conducted to match the timing of EEM field studies program (i.e., in 2014, 2017, 2020…). Area IDs: TPN, TPE, TPS=Third Portage Lake - North, East, South basins; SP=Second Portage Lake; TE, TEFF=Tehek Lake – Mid-field and Far-field; WAL=Wally Lake; INUG=Inuggugayualik Lake; PDL=Pipedream Lake; BBD, BPJ, BAP, BES=Baker Lake - Barge Dock, Proposed Jetty, Akilahaarjuk Point, East Shore. Area types: REF=reference (in grey shading); NF=near-field (in blue shading); MF=mid-field (in pink shading); FF=far-field (in teal shading). ✓ indicates that monitoring components are conducted at the area/month given. ? indicates that sampling frequency *may* change from what is shown in this table for any mid-field and/or far-field areas if the sampling strategy is used to reduce sampling frequency for these areas.

2.5. Quality Assurance/Quality Control

The objective of quality assurance / 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, have sufficient laboratory precision to be highly repeatable, are properly documented, and are scientifically defensible. Data quality was assured throughout the collection and analysis of samples using specified standardized procedures, by the employment of laboratories that have been certified for all applicable methods, and by staffing the program with experienced technicians.

2.5.1. Water Chemistry

Laboratory QA/QC: 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. The laboratory duplicate is a new aliquot from the sample bottle/jar and is analyzed from the start in the same manner as the original aliquot taken from the bottle/jar. Also, Certified Reference Materials (CRM) are always included as part of routine laboratory QA/QC. The full list of laboratory DQOs for each parameter are presented in **Appendix A**.

Field QA/QC: The standard QA/QC procedures include thoroughly flushing the flexible tubing and pump to prevent cross-contamination between areas and thoroughly rinsing the sample containers with site water prior to sample collection. Field QA procedures include collection and/or analysis of the following:

- *Field Duplicates* – An independent collection of water samples at the same time and location as the original, as a measure of consistency in sampling methodology and heterogeneity of chemical parameters at discrete locations. The number of field duplicates taken is approximately 10% of original samples.
- *Travel Blanks* – Laboratory supplied bottles of distilled water that are transported to site, carried back and forth into the field and returned to the laboratory, unopened, to test for inadvertent contamination during the transport and field sampling process.
- *Equipment Blanks* – At the beginning or end of a field sampling episode, after routine rinsing of the pump and tubing, distilled water is run through the equipment and placed in sampling bottles for analysis of a wide suite of parameters (e.g., metals, nutrients, and conventionals). This sample tests for possible cross-contamination of samples from the water sampling equipment.

Results from both the equipment and travel blanks are examined for detectable concentrations of any of the parameters measured; no parameter in either blank should exceed laboratory method detection limits (MDLs).

Quality assurance results of the laboratory and field duplicates are assessed by measuring the relative percent difference (RPD) between original and duplicate measurements as measure of precision by the laboratory and the magnitude of variability between original and field duplicate samples respectively. The equation used to calculate a RPD is:

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

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

The DQOs for CREMP monitoring are:

- Laboratory Duplicate = 20% RPD (for most parameters; see Table 2 of **Appendix A** for a list of RPDs for all parameters) for concentrations that exceed 10 x MDL.

- Field Duplicate = 50% RPD for concentrations that exceed 10 x MDL.

RPD values may be either positive or negative, and ideally should provide a mix of the two, clustered around zero. RPDs are not calculated for cases where one of the samples (i.e., either A or B above) is below detection and the other is not.

2.5.2. Sediment Chemistry

Laboratory QA/QC: Laboratory duplicates are also conducted for sediment chemistry parameters, similar to water chemistry parameters. The DQO for laboratory duplicate samples is based on an RPD of 20-50% (see Table 1 of **Appendix B** for a list of RPDs for all parameters) for concentrations that are >10 x MDL. The full list of laboratory DQOs for each parameter are presented in **Appendix B**.

Field QA/QC: Field QA/QC standards during sediment sampling consisted of taking care between sampling areas, by rinsing and cleaning the sampling gear for sediment grabs (Petite Ponar grab, stainless steel compositing bowls and spoons) and sediment cores (corer and spatula) using site water and phosphate-free cleaning detergent, avoids the possibility of cross-contamination. Field QA procedures include collection and/or analysis of the following:

- *Field Duplicates* – Field duplicate samples are collected in the immediate vicinity of original samples from randomly selected locations as a test of consistency in field methodology and to characterize heterogeneity of sediment chemistry within discrete areas. The number of field duplicates taken is approximately 10% of original samples. The DQO for field duplicate samples is based on an RPD of 50% for concentrations that are >10 x MDL.
- *Filter Swipes* – Metals analysis is conducted on an ashless filter that is swiped over the pre-cleaned bowl for 10% of the samples to assess the cleaning procedures. The significance of any metal detected on this filter is evaluated by comparing this amount to the measured concentrations in the sediment samples. Where comparisons were required, the concentration of metals originating from any equipment was estimated by dividing the amount detected on the filter (weight) by the surface area of 2 Petite Ponar grabs (assuming a thickness of 3 cm was collected from each), that was multiplied by the density of sediment (assumed to be 2 g/cm^3).

2.5.3. Phytoplankton

Field duplicates are collected for phytoplankton during each sampling event in coordination with water sample duplicates and are taken in order to assess sampling variability and sample homogeneity. A RPD of 50% for density and biomass concentrations is considered acceptable.

As a measure of laboratory QA/QC on the enumeration method, replicate counts are performed on 10% of the samples. Replicate samples are chosen at random and processed at different times from the original analysis to reduce biases. The laboratory replicate is a new aliquot (10 ml) from the sample jar and is counted from the start in the same manner as the original aliquot (10 ml) taken from the jar.

2.5.4. Benthic Invertebrates

Field replicates (5 per area) are collected for benthos to determine natural variability and heterogeneity. Replicates are collected at least 20 m apart from one another, within the defined sampling areas.

The laboratory (ZEAS) incorporates the following set of QA/QC procedures in all benthic projects undertaken by the company to ensure the generation of high quality and reliable data:

- Samples are logged upon arrival, inspected, and enumerated;
- Samples are checked for proper preservation;

- Samples are stained to facilitate sorting;
- Taxonomic identifications are based on the most updated and widely used keys;
- 10% of the samples are re-sorted, and re-counted, targeting >90% recovery;
- Precision and accuracy estimates are calculated;
- A voucher collection is compiled;
- Sorted sediments and debris are re-preserved in 10% formalin and are retained for up to three months. For samples subject to subsampling, sorted and unsorted fractions are re-preserved separately.

2.6. Data Evaluation Criteria

The specific methods used to develop triggers and thresholds are described in detail in the CREMP Design Document 2012 (Azimuth, 2012a). Since 2012, the water chemistry triggers/thresholds were updated in 2013, with minor updates in 2014, to include more recent monitoring data, to reflect new thresholds (e.g., adopted from other jurisdictions where not covered by CCME), or to add field pH triggers. These updates have been prepared as an amendment to Appendix A of the CREMP Design Document 2012 (Azimuth, 2012a), were included in the 2014 CREMP report (Azimuth, 2015), and are provided in **Appendix D** for completeness.

The specific methods used to apply triggers/thresholds in the evaluation of CREMP monitoring parameters vary by variable group; details are presented in the following sections. As discussed in **Section 2.3.1**, the evaluation process focuses on comparisons to early warning triggers; only when triggers are exceeded are monitoring results compared to thresholds. Consequently, methods for applying numerical decision criteria focus on triggers only, but apply equally to threshold values.

It is important to note that trigger values (and threshold values) may be exceeded for reasons unrelated to mining activity. For example, trigger values for parameters derived in the absence of effects-based thresholds (or where such thresholds were already exceeded prior to mine development) are set at the 95th percentile of the background data; we would expect 5% of values to exceed triggers naturally, in the absence of any mine-related changes. Thus, to avoid making false positive errors (i.e., characterizing a change or difference as mine-related when it is not), when triggers are exceeded we compare the observed pattern of change to our expectations of a mine-related effect (e.g., we would generally expect to see a gradient with NF>MF>FF); where a pattern was absent (e.g., an increase only seen at a FF area), the observed change is inferred as unrelated to mining activity. Thus, it is important to realize that trigger exceedences do not necessarily mean that mine-related changes have occurred. Rather, they highlight cases that should be looked at more closely to determine the most plausible.

2.6.1. Water Chemistry

As discussed in the CREMP Design Document 2012 (Azimuth, 2012a) while monthly mean values are compared to trigger values to identify short-term, episodic exceedences in water chemistry parameters, formal application of the trigger for decision-making purposes is to the yearly mean for each sampling area. Current thresholds and trigger values for Meadowbank, Wally, and Baker Lakes are shown in **Table 2-4** (total metals), **Table 2-5** (dissolved metals), and **Table 2-6** (nutrients and conventional parameters).

The hierarchical process for water chemistry variables is as follows (implemented separately for Meadowbank lakes and Baker Lake, for which triggers were independently derived [Azimuth, 2012a]):

1. *Computation of Yearly Means* – monthly means calculated first for each parameter, then yearly means on an area-specific (i.e., lake or basin-specific) basis. Note that values < MDL are conservatively set equal to the MDL.
2. *Comparisons of Yearly Means to Triggers* – yearly means for each sampling area are compared to the triggers to identify all cases for which the mean equals or exceeds the trigger.
3. *Statistical Testing of Yearly Means Exceeding Triggers* – cases where the yearly means exceed the triggers are formally tested using statistical analyses; this process is conducted differently for Meadowbank lakes and Baker Lake:

   Meadowbank Lakes

   - Before-After-Control-Impact statistical framework with multiple paired "before" and "after" period events (BACIP) is applied.
   - INUG is used as the reference ("control") area; the other areas are tested as exposure ("impact") areas. Neither PDL nor TEFF can be utilized as controls for BACIP as no data exists for 2006 – 2008 for these areas[4]. Instead, these areas are used to compare reference and exposure area data patterns.
   - True "pre-impact" data (i.e., when both INUG and the test area had "control" ("C") status; see **Table 2-2**) are used for the "before" data; the data for the year being tested (e.g., 2015) are used as the "after" data (only events when both INUG and the test area were sampled).
   - All data are log-transformed (natural logs). Thus, the exponent of the BACI interaction term coefficient provides the proportional change in the year being tested (e.g., 2015) relative to the "before" period.
   - One-tailed tests of the null hypothesis (i.e., that test areas experienced no relative change) are conducted; the alternative hypothesis is a relative increase in a parameter at the test area.

   Baker Lake (where different from above)

   - Baker Lake areas are designated as "control" or "impact" when sampling started in 2008 (i.e., there was no detailed baseline sampling was conducted for Baker Lake; see **Table 2-2**), so there are no true "pre-impact" "before" data. While a spatial "CI" design could be used to test for differences between reference "control" and exposure "impact" areas, the design does not allow for distinguishing natural differences between areas from development-related changes. Rather, since no development-related changes have been identified to date, all years of data up to and including the year prior to the year being tested (e.g., 2014) are considered "before" and the year being tested (e.g., 2015) data as "after" period data (i.e., allowing the more robust BACIP analysis). Thus, while the trend plots are used to assess temporal trends at the "impact" areas since monitoring started, the BACIP analyses specifically looks at changes in the year being tested (e.g., 2015) at the two "impact" areas relative to previous years.
   - The Akilahaarjuk Point (BAP) area is used as the reference "control" area.

[4] This does not apply to WAL, which does have overlapping baseline data with both PDL and TEFF. That said, effects relative to PDL and TEFF will only be looked at to provide additional context should changes be identified at WAL relative to INUG.

In addition to the trigger/threshold evaluation, annual CREMP water chemistry data will now also be compared to the maximum whole lake average water quality predictions (shown in **Table 2-7**) for Third Portage, Second Portage, and Wally Lakes from modelling conducted during the environmental assessment process (Cumberland, 2005a). While direct comparisons will be made, the difference in spatial focus (i.e., the CREMP at the basin scale and the water quality model at the lake scale) warrants caution interpreting any differences. To that end, the significance criteria used to assess changes in water quality (Cumberland, 2005a) will be used to provide the appropriate context for interpreting the results.

Annual CREMP reporting includes a process to streamline the interpretation process. Many water quality parameters have concentrations that are routinely below laboratory MDLs, thus providing little insight into the assessment of mine-related changes to water quality. We use a conservative three-step screening process to identify parameters for inclusion into the formal trend assessment:

1. *Overall Detection Frequency* - Only those water quality parameters that exceeded MDLs in at least 10% of the samples were included in this discussion. Because the project lakes are ultra-oligotrophic, it is normal for many parameters to routinely be below MDLs.
2. *Control-Impact Detection Frequency Comparison* – In order to avoid screening out infrequently detected parameters that were detected more often in association with mining activities, the proportion of samples exceeding MDLs between "control" and "impact" samples were compared; the intent of this screen was to identify parameters with <10% detection frequency (i.e., those screened out above) for which there were detection frequency changes potentially associated with mining activity (i.e., where the proportion of detected values increased by 0.1 or more).
3. *Apparent Detection Pattern Matching Mining Activity* – In order to avoid screening out infrequently detected parameters that may be associated with mining activities, trend plots were used to identify parameters with measured values associated with periods/locations of known mining activities. Where such patterns were observed, or where parameters were measured at > 5x MDL at near-field sampling areas in at least one event, these parameters were added back into the trend assessment process.

2.6.2. Sediment Chemistry

As discussed in the CREMP Design Document 2012 (Azimuth, 2012a), the sediment coring samples are used to screen against trigger values. In years when sediment cores are collected, the core chemistry results are compared to site-specific triggers/thresholds and cases where means exceed triggers are formally tested using a before-after (BA) statistical model. In years when only sediment grabs are collected, the approach to describing trends is purely visual. Methods for years when sediment cores are collected, which did not vary between the Meadowbank lakes and Baker Lake, are as follows:

1. *Computation of Yearly Means* – the sediment coring data for the year being tested (e.g., 2014) are used to calculate means for each parameter at each sampling area. Note that values < MDL are conservatively set equal to the MDL.
2. *Comparisons of Yearly Means to Triggers* – yearly means for core samples from each sampling area are compared to the triggers to identify all cases for which the mean equals or exceeds the trigger.
3. *Statistical Testing of Yearly Means Exceeding Triggers* – cases where the yearly means exceed the triggers are formally tested using statistical analyses. Unlike water chemistry, as sediment concentrations are not expected to vary annually due to climatic changes, a "before" – "after" (BA) analysis is used to test for temporal differences at each exposure "impact" area. Sediment is

inherently much more variable than water however, and greater natural variability is to be expected.

2.6.3. Phytoplankton

As discussed in the CREMP Design Document 2012 (Azimuth, 2012a), triggers and thresholds are set to relative changes (increases or decreases of 20% and 50%, respectively) in total biomass and species richness at test areas using the BACIP framework (i.e., paired monthly sampling events at "control" [INUG or BAP] and "impact" [i.e., NF or MF areas] areas over two periods ["before" and "after"], with "months" as the unit for temporal replication). The evaluation procedure is analogous to that used for water chemistry, except that area means for the year being tested (e.g., 2015) are not directly comparable to triggers (i.e., since the triggers/thresholds are based on the relative change over time in a parameter rather than on a finite value), so the process started with the BACIP testing. Two-tailed tests of the null hypothesis (i.e., that test areas experienced no relative change up or down) are conducted.

2.6.4. Benthic Invertebrates

Similar to phytoplankton, triggers and thresholds are set to relative changes (decreases of 20% and 50%, respectively) in total biomass and species richness at test areas using the BACI framework. As discussed in the CREMP Design Document 2012 (Azimuth, 2012a), statistical power increases with consideration of more "after" period years (Note: benthic invertebrates are sampled yearly in August). Consequently, BACI analyses (analogous to phytoplankton, except that unit of temporal replication is "years" instead of "months") are conducted on four "after" data period lengths: one year (e.g., 2015 only), two years (e.g., 2014-2015), three years (e.g., 2013-2015), and four years (e.g., 2012-2015).

Similar to water chemistry (**Section 2.6.1**), there is no baseline benthic community data for Baker Lake, so there are no true "pre-impact" "before" data. While a spatial "CI" design could be used to test for differences between reference "control" and exposure "impact" areas, the design does not allow for distinguishing natural differences between areas from development-related changes. Rather, since no development-related changes have been identified to date, the temporal scenarios for Baker Lake use all the data (e.g., 2015 is compared to 2008 – 2014; 2014/2015 is compared to 2008 – 2013…and so on).

Table 2-4. Total metals: summary of thresholds and of trigger values for Meadowbank, Wally and Baker Lakes' water quality.

			Meadowbank						**Wally**						**Baker**					
Variable	Threshold	DL	N	>DL	Med	P95	Trigger	M	N	>DL	Med	P95	Trigger	M	N	>DL	Med	P95	Trigger	M
Aluminum (T)	0.1	0.003	204	169	0.007	0.014	0.054	A	34	23	0.006	0.011	0.053	A	31	30	0.011	0.023	0.056	A
Antimony (T)	0.02	0.0001	204	0	NA	NA	0.010	A	34	0	NA	NA	0.010	A	31	0	NA	NA	0.010	A
Arsenic (T)	0.005	0.0001	204	14	NA	NA	0.0026	A	34	14	0.00025	0.00029	0.0026	A	31	4	0.00015	NA	0.0026	A
Barium (T)	1.0	0.00005	204	79	0.0021	0.0030	0.50	A	34	14	0.0019	0.0030	0.50	A	31	14	0.0177	0.0196	0.51	A
Beryllium (T)	0.0053	0.0001	204	0	NA	NA	0.0027	A	34	0	NA	NA	0.0027	A	31	0	NA	NA	0.0027	A
Boron (T)	1.5	0.01	204	1	NA	NA	0.76	A	34	0	NA	NA	0.76	A	31	3	0.011	0.011	0.76	A
Cadmium (T)	0.00004	0.00001	204	10	NA	NA	0.000025	A	34	1	NA	NA	0.000025	A	31	0	NA	NA	0.000025	A
Chromium (T)	0.001	0.0001	204	14	0.00011	0.00046	0.00056	A	34	0	NA	NA	0.00055	A	31	2	NA	NA	0.00055	A
Copper (T)	0.002	0.0005	204	61	0.00047	0.00068	0.00124	A	34	16	0.00098	0.00129	0.00149	A	31	11	0.00049	0.00060	0.00125	A
Iron (T)	0.3	0.01	204	26	NA	NA	0.155	A	34	6	0.015	0.025	0.157	A	31	9	0.020	0.063	0.160	A
Lead (T)	0.001	0.00005	204	7	NA	NA	0.00053	A	34	2	NA	0.00015	0.00053	A	31	1	NA	NA	0.00053	A
Lithium (T)	0.096	0.0005	204	6	0.00042	0.00063	0.048	A	34	2	0.00085	NA	0.048	A	31	6	0.0010	0.0036	0.048	A
Manganese (T)	See text	0.00005	204	198	0.0013	0.0043	0.316	A	34	34	0.0014	0.0020	0.330	A	31	31	0.0024	0.0038	0.340	A
Mercury (T)	0.000026	0.00001	204	1	NA	NA	0.000018	A	34	0	NA	NA	0.000018	A	31	0	NA	NA	0.000018	A
Molybdenum (T)	0.073	0.00005	204	5	NA	NA	0.037	A	34	3	0.00013	0.00019	0.037	A	31	4	0.00008	NA	0.037	A
Nickel (T)	0.025	0.0005	204	8	0.0005	0.0007	0.013	A	34	0	NA	NA	0.013	A	31	0	NA	NA	0.013	A
Selenium (T)	0.001	0.0001	204	0	NA	NA	0.00055	A	34	0	NA	NA	0.00055	A	31	0	NA	NA	0.00055	A
Strontium (T)	0.049	0.0002	192	188	0.0068	0.0095	0.028	A	32	32	0.016	0.022	0.033	A	31	31	0.025	0.056	0.056	B
Thallium (T)	0.0008	0.00001	204	0	NA	NA	0.00041	A	34	0	NA	NA	0.00041	A	31	0	NA	NA	0.00041	A
Tin (T)		0.0001	204	2	NA	NA	0.0002	C	34	0	NA	NA	0.0002	C	31	0	NA	NA	0.0002	C
Titanium (T)	2.0	0.01	204	14	0.00016	0.00044	1.0	A	34	3	0.00013	0.00049	1.0	A	31	4	0.00038	NA	1.0	A
Uranium (T)	0.015	0.00001	204	20	0.00004	0.00006	0.0075	A	34	2	0.00004	NA	0.0075	A	31	4	0.00005	NA	0.0075	A
Vanadium (T)	0.006	0.001	204	0	NA	NA	0.0035	A	34	0	NA	NA	0.0035	A	31	0	NA	NA	0.0035	A
Zinc (T)	See text	0.003	204	4	NA	NA	0.0063	A	34	2	NA	NA	0.0106	A	31	0	NA	NA	0.0132	A

Notes: For each variable, thresholds (guidelines) are shown if applicable (see **Appendix D** for discussion); DL = current detection limit; N = sample measurements; >DL = number of measurements above DL; Med = median if estimable; P95 = 95th percentile if estimable; M = method used to determine the trigger, where A = halfway from median (or DL if median not estimable) to threshold, B = 95th percentile, and C = 2*DL.

Table 2-5. Dissolved metals: summary of thresholds and of trigger values for Meadowbank, Wally and Baker Lakes' water quality.

			Meadowbank						**Wally**						**Baker**					
Variable	Threshold	DL	N	>DL	Med	P95	Trigger	M	N	>DL	Med	P95	Trigger	M	N	>DL	Med	P95	Trigger	M
Aluminum (D)	0.05	0.001	164	69	0.003	0.005	0.026	A	27	13	0.003	0.006	0.026	A	28	17	0.005	0.006	0.027	A
Antimony (D)	0.02	0.0001	164	0	NA	NA	0.010	A	27	0	NA	NA	0.010	A	28	0	NA	NA	0.010	A
Arsenic (D)	0.005	0.0001	164	12	NA	NA	0.0026	A	27	13	0.00024	0.00034	0.0026	A	28	6	0.00012	0.00024	0.0026	A
Barium (D)	1.0	0.00005	164	79	0.0020	0.0029	0.50	A	27	13	0.0018	0.0030	0.50	A	28	14	0.0178	0.0200	0.51	A
Beryllium (D)	0.0053	0.0001	164	0	NA	NA	0.0027	A	27	0	NA	NA	0.0027	A	28	0	NA	NA	0.0027	A
Boron (D)	1.5	0.01	164	0	NA	NA	0.76	A	27	0	NA	NA	0.76	A	28	0	NA	NA	0.76	A
Cadmium (D)	0.00004	0.00001	164	3	NA	NA	0.000025	A	27	0	NA	NA	0.000025	A	28	0	NA	NA	0.000025	A
Chromium (D)	0.001	0.0001	164	1	NA	NA	0.00055	A	27	0	NA	NA	0.00055	A	28	1	NA	NA	0.00055	A
Copper (D)	0.002	0.0002	164	77	0.00038	0.00049	0.00119	A	27	15	0.00087	0.00148	0.00148	B	28	13	0.00033	0.00044	0.00116	A
Iron (D)	0.3	0.01	164	0	NA	NA	0.155	A	27	0	NA	NA	0.155	A	28	1	NA	NA	0.155	A
Lead (D)	0.001	0.00005	164	3	NA	NA	0.00053	A	27	2	NA	0.00015	0.000525	A	28	0	NA	NA	0.000525	A
Lithium (D)	0.096	0.0005	164	2	NA	0.00053	0.048	A	27	2	0.00099	NA	0.048	A	28	4	0.0008	NA	0.048	A
Manganese (D)	See text	0.00005	164	114	0.0004	0.0029	0.315	A	27	22	0.0004	0.0015	0.330	A	28	24	0.0006	0.0019	0.339	A
Mercury (D)	0.000026	0.00001	153	2	NA	NA	0.000018	A	25	0	NA	NA	0.000018	A	26	0	NA	NA	0.000018	A
Molybdenum (D)	0.073	0.00005	164	17	0.00010	0.00018	0.037	A	27	8	0.00011	0.00019	0.037	A	28	3	0.00006	NA	0.037	A
Nickel (D)	0.025	0.0005	164	6	NA	NA	0.013	A	27	1	NA	NA	0.013	A	28	0	NA	NA	0.013	A
Selenium (D)	0.001	0.0001	164	0	NA	NA	0.00055	A	27	0	NA	NA	0.00055	A	28	0	NA	NA	0.00055	A
Strontium (D)	0.049	0.002	164	161	0.0069	0.0090	0.028	A	27	27	0.016	0.023	0.033	A	28	28	0.023	0.049	0.049	B
Thallium (D)	0.0008	0.00001	164	0	NA	NA	0.00041	A	27	0	NA	NA	0.00041	A	28	0	NA	NA	0.00041	A
Tin (D)		0.0001	164	0	NA	NA	0.0002	C	27	0	NA	NA	0.0002	C	28	0	NA	NA	0.0002	C
Titanium (D)	2.0	0.01	164	0	NA	NA	1.0	A	27	0	NA	NA	1.0	A	28	0	NA	NA	1.0	A
Uranium (D)	0.015	0.00001	164	20	0.00003	0.00005	0.0075	A	27	2	0.00004	NA	0.0075	A	28	4	0.00004	NA	0.0075	A
Vanadium (D)	0.006	0.001	164	0	NA	NA	0.0035	A	27	0	NA	NA	0.0035	A	28	0	NA	NA	0.0035	A
Zinc (D)	See text	0.001	164	6	NA	0.0021	0.0053	A	27	2	NA	NA	0.0096	A	28	2	NA	0.0028	0.0122	A

Notes: For each variable, thresholds (guidelines) are shown if applicable (see **Appendix D** for discussion); DL = current detection limit; N = sample measurements; >DL = number of measurements above DL; Med = median if estimable; P95 = 95th percentile if estimable; M = method used to determine the trigger, where A = halfway from median (or DL if median not estimable) to threshold, B = 95th percentile, and C = 2*DL.

Table 2-6. Nutrients and conventional parameters: summary of thresholds and of trigger values for Meadowbank, Wally and Baker Lakes' water quality.

			Meadowbank						**Wally**						**Baker**					
Variable	Threshold	DL	N	>DL	Med	P95	Trigger	M	N	>DL	Med	P95	Trigger	M	N	>DL	Med	P95	Trigger	M
Ammonia-N	0.126	0.005	204	52	0.005	0.046	0.065	A	34	12	0.007	0.024	0.067	A	31	13	0.007	0.031	0.067	A
TKN		0.05	204	178	0.097	0.170	0.170	B	34	31	0.111	0.163	0.163	B	31	28	0.157	0.214	0.214	B
Nitrate-N	3.0	0.005	204	26	NA	0.025	1.503	A	34	2	NA	NA	1.503	A	31	26	0.014	0.030	1.507	A
Nitrite-N	0.06	0.001	204	6	NA	NA	0.031	A	34	2	NA	NA	0.031	A	31	2	NA	NA	0.031	A
Ortho-phosphate		0.001	192	10	NA	0.0010	0.0020	C	34	3	NA	0.0010	0.0020	C	31	5	0.0007	0.0013	0.0020	C
T. phosphorous	0.004	0.002	192	84	0.0019	0.0060	0.0060	B	34	21	0.0028	0.0067	0.0067	B	31	23	0.0036	0.0096	0.0096	B
TOC		0.5	204	204	1.74	2.79	2.79	B	34	34	2.18	4.11	4.11	B	31	31	3.16	4.25	4.25	B
DOC		0.5	204	204	1.70	2.60	2.60	B	34	34	2.20	3.21	3.21	B	31	31	3.17	4.05	4.05	B
Reactive silica		0.5	185	56	0.28	0.44	1.00	C	32	14	0.74	1.08	1.08	B	28	10	0.31	0.42	1.00	C
Bicarb. alkalinity		2.0	192	192	5.2	8.6	8.6	B	34	34	10.0	17.8	17.8	B	31	31	9.3	10.6	10.6	B
Chloride	120	0.1	204	141	0.550	0.809	60.3	A	34	15	0.469	0.639	60.2	A	31	31	24.4	95.7	95.7	B
Carb. alkalinity		2.0	192	0	NA	NA	4.0	C	34	0	NA	NA	4.0	C	31	0	NA	NA	4.0	C
Conductivity		2.0	204	204	15.2	23.5	23.5	B	34	34	28.7	36.6	36.6	B	31	31	110.0	494.5	494.5	B
Hardness		0.5	204	204	5.7	8.5	8.5	B	34	34	12.2	16.7	16.7	B	31	31	16.5	41.2	41.2	B
Calcium		0.5	204	204	1.30	2.15	2.15	B	34	34	3.34	4.88	4.88	B	31	31	3.02	4.50	4.50	B
Potassium		0.1	204	79	0.37	0.50	0.50	B	34	14	0.37	0.59	0.59	B	31	20	0.93	2.43	2.43	B
Magnesium		0.1	204	204	0.64	0.83	0.83	B	34	34	0.96	1.36	1.36	B	31	31	2.61	7.44	7.44	B
Sodium		0.05	204	79	0.55	0.98	0.98	B	34	14	0.48	0.72	0.72	B	31	31	12.1	54.0	54.0	B
Sulphate	128	0.5	204	204	1.42	2.83	64.7	A	34	34	2.34	3.38	65.2	A	31	31	3.84	13.80	65.9	A
pH Field (Upper)	9.0	0.1	174	174	7.24	8.25	8.25	B	32	32	7.67	8.26	8.34	A	26	26	7.41	8.32	8.32	B
pH Field (Lower)	6.5	0.1	174	174	7.24	6.30[a]	6.30	B	32	32	7.67	6.54[a]	6.54	B	26	26	7.41	6.50[a]	6.50	B
pH Lab (Upper)	9.0	0.1	204	204	6.89	7.27	7.94	A	34	34	7.35	7.44	8.17	A	31	31	7.21	7.66	8.11	A
pH Lab (Lower)	6.5	0.1	204	204	6.89	6.50[a]	6.50	B	34	34	7.35	7.00[a]	6.92	A	31	31	7.21	6.99[a]	6.86	A
Total Alkalinity		2.0	192	192	5.20	8.55	8.55	B	34	34	10.0	17.8	17.8	B	31	31	9.3	10.6	10.6	B
TDS		3.0	204	134	11.0	18.0	18.0	B	34	34	18.0	25.3	25.3	B	31	31	64.0	208.0	208.0	B
TSS	5.0	1.0	204	9	NA	NA	3.00	A	34	1	NA	NA	3.00	A	31	2	NA	NA	3.00	A

Notes: For each variable, thresholds (guidelines) are shown if applicable (see **Appendix D** for discussion); DL = current detection limit; N = sample measurements; >DL = number of measurements above DL; Med = median if estimable; P95 = 95th percentile if estimable; M = method used to determine the trigger, where A = halfway from median (or DL if median not estimable) to threshold, B = 95th percentile, and C = 2*DL.

Table 2-7. Predicted maximum whole lake water quality for Third Portage, Second Portage and Wally Lakes (from Cumberland, 2005a).

Lake	Simulated Maximum Whole Lake Concentration (mg/L)									
	Third Portage Lake[1]				Second Portage Lake[2]				Wally Lake[3]	
Model Scenario	Mid-range Mixing Estimate (92 Mm^3)		Upper Mixing Estimate (169 Mm^3)		Lower Mixing Estimate (92 Mm^3)		Upper Mixing Estimate (169 Mm^3)			
	Without Dike Leaching	With Dike Leaching	Without Dike Leaching	With Dike Leaching	Without Dike Leaching	With Dike Leaching	Without Dike Leaching	With Dike Leaching	Without Dike Leaching	With Dike Leaching
Conventional Parameters										
Hardness	6.0	6.4	5.7	6.0	8.9	8.9	8.9	8.9	17.2	17.2
pH	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Dissolved Anions										
Total Alkalinity	4.23	4.24	4.13	4.14	7.00	7.00	7.00	7.00	13.24	13.34
Chloride	1.0	1.1	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7
Fluoride	0.07	0.09	0.07	0.08	0.070	0.071	0.070	0.071	0.05	0.05
Sulphate	2.0	2.0	1.7	1.7	2.8	2.8	2.8	2.8	5.3	5.3
Nutrients										
Ammonia (as N)	0.0497	0.0497	0.0333	0.0333	0.031	0.031	0.025	0.025	0.0890	0.0890
Total Kjeldahl Nitrogen	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Nitrate (as N)	0.0569	0.0588	0.0351	0.0363	0.025	0.025	0.017	0.017	0.1020	0.1020
Nitrite (as N)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ortho Phosphate (as P)	0.0024	0.0024	0.0022	0.0022	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030
Phosphorus (P)-Total	0.0032	0.0035	0.0027	0.0029	0.0031	0.0031	0.0030	0.0030	0.0039	0.0040
Organic Parameters										
Dissolved Organic Carbon	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cyanides										
Total Cyanide	0	0	0	0	0	0	0	0	0	0
Total Metals										
Aluminum	0.007	0.010	0.007	0.009	0.007	0.007	0.007	0.007	0.012	0.013
Antimony	0.00060	0.00062	0.00056	0.00057	0.0005	0.0005	0.0005	0.0005	0.0009	0.0009
Arsenic	0.00072	0.00072	0.00062	0.00062	0.0006	0.0006	0.0005	0.0005	0.005	0.006
Barium	0.020	0.023	0.020	0.022	0.02	0.02	0.02	0.02	0.02	0.02
Beryllium	0.001	0.001	0.001	0.001	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010
Boron	0.104	0.104	0.102	0.102	0.1	0.1	0.1	0.1	0.100	0.100
Bismuth	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Cadmium	<0.000052	<0.000052	<0.000051	<0.000051	<0.000051	<0.000051	<0.000050	<0.000050	0.00018	0.00019
Calcium	1.5	1.5	1.3	1.4	2.3	2.3	2.3	2.3	4.7	4.7
Chromium	0.001	0.001	0.001	0.001	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010
Cobalt	0.0004	0.0017	0.0040	0.0013	0.0003	0.0004	0.0003	0.0004	0.0003	0.0003
Copper	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0011	0.002	0.002
Iron	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Lead	0.0006	0.0007	0.0006	0.0006	0.0009	0.0009	0.0009	0.0009	0.0007	0.0007
Lithium	0.005	0.005	0.005	0.005	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
Magnesium	0.6	0.7	0.6	0.6	0.8	0.8	0.8	0.8	1.3	1.3
Manganese	0.015	0.072	0.009	0.052	0.0066	0.0089	0.0044	0.0067	0.002	0.002
Mercury	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.0001	0.0001
Molybdenum	0.001	0.001	0.001	0.001	0.0010	0.0010	0.0010	0.0010	0.002	0.002
Nickel	0.0020	0.0021	0.0016	0.0016	0.001	0.001	0.001	0.001	0.0010	0.0010
Potassium	2.0	2.1	2.0	2.1	2.0	2.0	2.0	2.0	2.0	2.0
Selenium	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.0010	0.0010
Silver	0.00002	0.00002	0.00002	0.00002	0.00001	0.00001	0.00001	0.00001	0.00002	0.00002
Silicon	0.02	0.12	0.01	0.08	0.01	0.01	0.01	0.01	0.04	0.04
Sodium	2.0	2.1	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Strontium	0.004	0.007	0.002	0.005	0.8	0.8	0.8	0.8		
Thallium	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Tin	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Titanium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Uranium	0.0002	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0007	0.0007
Vanadium	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Zinc	0.015	0.015	0.011	0.011	0.009	0.009	0.007	0.007	0.013	0.013

Notes: [1]Whole lake data are given for a range of mixing conditions, representing lower and upper mixing estimate for the north basin discharge location. [2]The Second Portage Lake water quality model includes substance loading from the Third Portage and East Dikes and inflow from Third Portage and Wally lakes. [3]Preliminary modelling of whole lake water quality in the receiving environment water bodies incorporates long-term loadings from the Vault Dike and effluent releases from the Vault Attenuation pond (Cumberland, 2005a).

3. MEADOWBANK PIT FLOODING MONITORING

Flooding of the Goose Pit, Portage Pit, Vault Pit and Phaser Pits (and nearby attenuation ponds; e.g., Vault Attenuation Pond) will begin after completion of mining in these areas. The expectation, based on current pit water quality modelling, is that upon completion of this gradual flooding process (i.e., on the order of 5 to 8 years), water quality in these areas will be considered acceptable for aquatic life, thus allowing the breaching of the dikes and the repatriation of these areas with the surrounding receiving environments. While the primary water sources (i.e., Third Portage Lake and Wally Lake) are uncontaminated, water quality in the other contributing sources (e.g., dike seepage, pit seepage, TSF water) may be sufficiently poor as to detrimentally affect final pit lake water quality and therefore may not allow for dike breaching to occur.

This issue was identified early in the mine planning process and was included in both the EIS (*Meadowbank Gold Project: Aquatic Ecosystem/Fish Habitat Impact Assessment*; Cumberland, 2005b) and the NWB A Licence application (*Meadowbank Gold Project: Type A Water Licence Application;* AEM, 2007). Recognizing that it would be far more efficient to treat a water quality problem at its source rather than in a fully-diluted pit lake, the NWB Type A Licence includes a requirement for monitoring and modelling end pit water quality (NWB, 2015).

As part of their annual Water Management Plan, AEM has been monitoring source water quality and quantity to forecast pit lake water quality using a mass balance model. Work conducted in 2014 to support this effort predicted that source water treatment might be needed for various parameters in order to meet CCME water quality guidelines. Monitoring details for this effort are included in AEM's *Water Quality and Flow Monitoring Plan* (v4 January 2015).

The renewed NWB A Licence (2AM-MEA1525) identifies specific monitoring locations, parameters and frequencies for operations (early/late) and closure phases for each of the pits (NWB, 2015):

- *Pit Sumps* (Operations) – each of the pit sumps (i.e., the North Portage Pit Sump [ST-17], South Portage Pit Sump [ST-19], Goose Sump [ST-20], and Vault Pit Sump [ST-23]) will be monitored during open water monthly for water quality (for Group 1 parameters, except for ST-23, which is Group 2[5]) and daily for discharge volume.
- *Pit Lakes* (Late Operations/Closure) – Upon flooding, the two Portage Pit basins will join to form Portage Pit Lake, but will still be monitored separately (on a monthly basis during open water for the Group 2 parameters) during operations. During closure, ST-17 and ST-19 will become a single station to be monitored bi-annually (the licence does not specify the frequency/parameter details included in this phase specifically for this location, so this is based on the requirements for the other pit lakes) for Group 2 parameters. For Goose Pit, the monitoring station name changes to Goose Pit Lake (ST-20) during late operations (monitored monthly during open water for Group 2); at closure, monitoring frequency of ST-20 drops to bi-annual (Group 2). For Vault Pit, the monitoring station name changes to Vault Pit Lake upon closure and will be subject to bi-annual monitoring of Group 2 parameters during open water.
- *Pit Lakes* (Post Closure) – For post-closure, the licence identifies Portage-Goose Pit Lake (ST-12) and Vault Pit Lake (ST-13) for annual monitoring of the Full Suite[6] parameters during open water.

[5] The Group 2 parameters are the same as those specified for the CREMP.

[6] The "Full Suite" is comprised of the Group 2 water quality parameters (i.e., the same as the CREMP) as well as Total Petroleum Hydrocarbons, and Turbidity (but not the acute lethality tests, which are for discharges only).

While the NWB Type A Licence (2AM-MEA1525) describes specific pit-related monitoring requirements for each mine development phase, there are no details regarding the transitions between phases.

Consistent with the ideals of progressive reclamation, it is assumed herein that those transitions are defined on a location-specific basis rather than on the general stage of mine development for the project. For example, mining (i.e., operations) at Goose Pit was completed in early 2015 and flooding (i.e., starting closure for this feature) is scheduled to start in June 2016 and finish by September 2021; the post-closure phase would only start once water quality was deemed acceptable and the dikes were breached (i.e., at the point when the pit lakes and surrounding impoundments formally become part of the receiving environment). This approach ensures that monitoring is tailored to the specific requirements of the pit lake and not to the general status of the mine development. Following this logic, pit lake monitoring would formally move from falling under the *Water Quality and Flow Monitoring Plan* to the CREMP at the transition to the post-closure phase (i.e., when the pit lakes are deemed receiving environment). Thus, CREMP monitoring would target Portage-Goose Pit Lake (ST-12) and Vault Pit Lake (ST-13) after breaching the dikes following the parameter and frequency stipulations in the licence.

Part E(7) of the NWB A Licence presents the expectations of breaching the dikes (NWB, 2015):

> *The Licensee shall not breach dikes until the water quality in the re-flooded area meets CCME Water Quality Guidelines for the Protection of Aquatic Life, baseline concentrations, or appropriate site specific water quality objectives. Subject to the Board approval, if water quality parameters are above CCME Guidelines, a site specific risk assessment must be conducted to identify water quality objectives that are protective of the aquatic environment.*

AEM's commitment is to meet CCME water quality guidelines in each of the fully-flooded pit lakes. AEM's annual monitoring and water quality forecast modelling efforts will support making timely management decisions regarding the need for water treatment to achieve this commitment. If early forecasting predicts that AEM's objectives will not be met, then the potential use of site-specific water quality objectives or of site-specific risk assessment to provide further clarity on water quality acceptability will be considered as early as possible.

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APPENDICES

APPENDIX A

STANDARD OPERATING PROCEDURE
MEADOWBANK LAKES AND BAKER LAKE
CREMP WATER & PHYTOPLANKTON SAMPLING

Standard Operating Procedure
Meadowbank Lakes & Baker Lake
CREMP Water & Phytoplankton Sampling

GENERAL:

Project Coordinator:
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In case of **emergency**, contact Gary Mann ([redacted]).
Azimuth office telephone number 604-730-1220.

LOCATION AND TIMING FOR FIELD ACTIVITIES:

Twelve (12) sampling stations have been chosen for water quality monitoring in the Meadowbank project lakes and Baker Lake:

Meadowbank Lakes

- Third Portage Lake – North Basin (TPN)
- Third Portage Lake – East Basin (TPE)
- Second Portage Lake (SP)
- Tehek Lake (TE)
- Inuggugayualik Lake (INUG)
- Tehek Lake – Far-field (TEFF)
- Third Portage Lake – South Basin (TPS)
- Wally Lake (WAL)
- Pipedream Lake (PDL)

Baker Lake

- Baker Lake – Barge Dock (BBD)
- Baker Lake – Proposed Jetty (BPJ)
- Baker Lake – Akilahaarjuk Point (BAP)

Water sampling activities are scheduled roughly once a month for 6 months (5 months in some years), including winter ice sampling. The first 5 stations listed above are sampled through the ice in April, May, and November. All of the above stations are sampled during open water in July, August, and September. Sampling will not be conducted in June and October because of thin ice conditions. **Check the monthly water sampling schedule to confirm which samples are to be collected where, BEFORE going into the field.**

All samples are now collected from **3 m below the water surface**, which is indicated by "-S" at the end of the sample ID (S=Surface). **Two** target sample locations for each station listed above have been

randomly pre-determined and recorded in MapSource and in the hand-held GPS units (NAD 83). Confirm before going into the field.

MONTHLY CREMP WATER CHEMISTRY & PHYTOPLANKTON SAMPLING:

1. Prior to leaving camp gather the appropriate type and number of sampling vessels and acid vials for preservation. Prepare appropriate labels for containers, affix them to the appropriate bottle (see below), and wrap label with packing tape. Use the following information:
   - Azimuth company name
   - Station abbreviation (e.g. TPE-36-S, INUG-24-S)
   - Date of sample collection
   - Parameters to be measured from individual bottle (TOC, total metals, etc.)

2. Gather **field collection materials**:
   In the boat:
   - Field collection data forms, pencils, waterproof markers & clipboard
   - GPS unit, batteries
   - Water pump & 12V battery
   - Tubing (4 meter length and 1 meter length) & weight (& extra C-clamps and cable ties)
   - In-line filter and a spare
   - YSI meter, batteries
   - Secchi disk
   - Hand held pH meter, batteries
   - Depth meter, batteries
   - Rope
   - Sampling gloves
   - Field sample bottles & preservatives (per sample) see **Table 1** below
   - Glass vials (50 mL) for phytoplankton. Preserve with Lugol's back at the laboratory
   - Extra sample bottles in case of breakage or loss
   - QA/QC field duplicate sampling containers & preservatives (same as above)
   - Take one set of Travel Blank bottles into the field and transport and treat as other samples. Note that the Travel Blank bottles are not to be opened and no preservatives added.

   In camp:
   - Hand pump, filters, tweezers, and black tubes for chlorophyll-a
   - De-ionized water for rinsing equipment and collected field equipment blank
   - Coolers (for storing and shipping samples)
   - Ice packs (for shipping samples to laboratories)
   - Address labels for coolers
   - Chain-of-custody forms
   - Large Ziploc bags (for sending chain-of-custody form in cooler)
   - Packing tape (for affixing labels to sampling containers & sealing cooler)

Starting in 2015, some of the water analyses with short hold-times are being shipped by express and the rest are being shipped by ground, but all parameters are being analysed at ALS laboratory in Burnaby, BC. The specific bottles to be filled, parameters to be measured and preservatives required for each is in **Table 1**. ALS Laboratory data quality objectives for individual water parameter analyses are in **Table 2**. Affix the labels to the sampling containers and then prior to shipping, wrap packing tape around the labels to ensure a waterproof seal.

Table 1. Water samples collected as part of the CREMP program.

ALS Burnaby Parameters	Bottle and Sample Volume	Preservative	Filter?
Alkalinity species, pH, Turbidity, EC, Cconductivity, Anions (F, NO_2, NO_3, Br, SO_4), Low-level Chloride, Silicate, Ortho-PO_4, Total Dissolved Phosphorus	1L HDPE Bottle	None	No
TSS (low-level), TDS (low-level)	1L HDPE Bottle	None	No
TOC, Total Phosphorus, TKN, NH_3	250mL Amber glass bottle	1 mL H_2SO_4	No
DOC	125mL Amber Glass Bottle	1 mL H_2SO_4	Yes
Cyanide (total low-level and free low-level)	145 mL HDPE Bottle	0.5 mL 50% NaOH	No
Total Mercury	40 mL Glass Vial	0.5 mL Hydrochloric Acid	No
Dissolved Mercury	40 mL Glass Vial	0.5 mL Hydrochloric Acid	Yes
Total Metals	250 mL HDPE Bottle	3 mL Nitric Acid	No
Dissolved Metals	250 mL HDPE Bottle	3 mL Nitric Acid	Yes
Chlorophyll-a	filter 500 mL through 0.45um MCE Filter place filter in 15 mL Black Tube	Freeze	No

Table 2. Laboratory data quality objectives (from ALS) for water chemistry analyses.

Parameter	Target D.L.	Units	Accuracy [1] DQO	Matrix Spike [2] DQO	Precision [3] (RPD) DQO	Hold Times	Bottle Required	Bottle Volume	Filter (Yes/No)	Preservative	Method Reference
Water - Physical Tests											
Conductivity	2	µS/cm	90-110%	n/a	10%	28 days	Plastic	1.0 L	No	None	APHA 2510 Auto. Conduc.
Hardness (as $CaCO_3$)	0.5	S/c	75-125%	65-135%	25%	6 months	Plastic, Verified	250 ml	No	HNO_3	APHA 2340B
pH	0.1	pH	± 0.10 pH units	n/a	± 0.20 pH units	0.25 hours	Plastic	1.0 L	No	None	APHA 4500-H pH Value
Total Suspended Solids	1	mg/L	85-115%	n/a	20%	7 days	Plastic	1.0 L	No	None	APHA 2540 D
Total Dissolved Solids	3	mg/L	85-115%	n/a	20%	7 days	Plastic	1.0 L	No	None	APHA 2540 C
Turbidity	0.1	NTU	85-115%	n/a	15%	3 days	Plastic	1.0 L	No	None	APHA 2130 Turbidity
Water - Anions and Nutrients											
Alkalinity, Bicarbonate (as $CaCO_3$)	2	mg/L	85-115%	n/a	20%	14 days	Plastic	1.0 L	No	None	APHA 2320
Alkalinity, Carbonate (as $CaCO_3$)	2	mg/L	85-115%	n/a	20%	14 days	Plastic	1.0 L	No	None	APHA 2320
Alkalinity, Hydroxide (as $CaCO_3$)	2	mg/L	85-115%	n/a	20%	14 days	Plastic	1.0 L	No	None	APHA 2320
Alkalinity, Total (as $CaCO_3$)	2	mg/L	85-115%	n/a	20%	14 days	Plastic	1.0 L	No	None	APHA 2320
Ammonia, Total (as N)	0.005	mg/L	85-115%	75-125%	20%	28 days	Amber Glass	250 ml	No	H_2SO_4	J. ENV. MONIT.,2005,7,37-42,RSC
Bromide (Br)	0.05	mg/L	85-115%	75-125%	20%	28 days	Plastic	1.0 L	No	None	EPA 300.1 (mod)
Chloride (Cl)	0.1	mg/L	90-110%	75-125%	20%	28 days	Plastic	1.0 L	No	None	EPA 300.1 (mod)
Fluoride (F)	0.02	mg/L	90-110%	75-125%	20%	28 days	Plastic	1.0 L	No	None	EPA 300.1 (mod)
Nitrate (as N)	0.005	mg/L	90-110%	75-125%	20%	3 days	Plastic	1.0 L	No	None	EPA 300.1 (mod)
Nitrite (as N)	0.001	mg/L	90-110%	75-125%	20%	3 days	Plastic	1.0 L	No	None	EPA 300.1 (mod)
Total Kjeldahl Nitrogen	0.05	mg/L	75-125%	70-130%	20%	28 days	Amber Glass	250 ml	No	H_2SO_4	APHA 4500-NORG D.
Orthophosphate-Dissolved (as P)	0.001	mg/L	80-120%	70-130%	20%	3 days	Plastic	1.0 L	No	None	APHA 4500-P Phosphorous
Phosphorus (P)-Total Dissolved	0.002	mg/L	80-120%	70-130%	20%	3 days	Plastic	1.0 L	No	None	APHA 4500-P Phosphorous
Phosphorus (P)-Total	0.002	mg/L	80-120%	70-130%	20%	28 days	Amber Glass	250 ml	No	H_2SO_4	APHA 4500-P Phosphorous
Silicate (SiO_2)	0.5	mg/L	85-115%	75-125%	20%	28 days	Plastic	1.0 L	No	None	APHA 4500-SiO2 E.
Sulfate (SO_4)	0.3	mg/L	90-110%	75-125%	20%	28 days	Plastic	1.0 L	No	None	EPA 300.1 (mod)
Water - Organic / Inorganic Carbon											
Dissolved Organic Carbon	0.5	mg/L	80-120%	70-130%	20%	28 days	Amber Glass	125 ml	Yes	H_2SO_4	APHA 5310B TOTAL ORGANIC CARBON
Total Organic Carbon	0.5	mg/L	80-120%	70-130%	20%	28 days	Amber Glass	250 ml	No	H_2SO_4	APHA 5310B TOTAL ORGANIC CARBON
Chlorophyll-*a*											
Chlorophyll-*a* [4]	0.01	µg/L	80-120%	n/a	35%	28 days	15 ml plastic tube	500 ml	Footnote 4	Freeze	EPA Method 445.0
Cyanides											
Total Cyanide	0.001	mg/L	80-120%	70-130%	20%	14 days	Plastic	145 ml	No	NaOH	ISO 14403:2002
Free Cyanide	0.001	mg/L	80-120%	70-130%	20%	14 days	Plastic	145 ml	No	NaOH	ASTM 7237

Table 2 con't. Laboratory data quality objectives (from ALS) for water chemistry analyses.

Parameter	Target D.L.	Units	Accuracy [1] DQO	Matrix Spike [2] DQO	Precision [3] (RPD) DQO	Hold Times	Bottle Required	Bottle Volume	Filter (Yes/No)	Preservative	Method Reference
Water - Total Metals											
Aluminum (Al)-Total	0.003	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Antimony (Sb)-Total	0.0001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Arsenic (As)-Total	0.0001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Barium (Ba)-Total	0.00005	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Beryllium (Be)-Total	0.00002	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod)
Bismuth (Bi)-Total	0.00005	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Boron (B)-Total	0.01	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Cadmium (Cd)-Total	0.000005	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Calcium (Ca)-Total	0.05	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Chromium (Cr)-Total	0.0001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Cobalt (Co)-Total	0.0001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Copper (Cu)-Total	0.0005	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Iron (Fe)-Total	0.01	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Lead (Pb)-Total	0.00005	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Lithium (Li)-Total	0.001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Magnesium (Mg)-Total	0.1	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Manganese (Mn)-Total	0.0001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Mercury (Hg)-Total	0.000005	mg/L	80-120%	70-130%	20%	28 days	Glass	40 ml	No	HCl	EPA 1631E (mod)
Molybdenum (Mo)-Total	0.00005	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Nickel (Ni)-Total	0.0005	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Phosphorus (P)-Total	0.05	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Potassium (K)-Total	0.1	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Selenium (Se)-Total	0.00005	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Silicon (Si)-Total	0.05	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Silver (Ag)-Total	0.00001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Sodium (Na)-Total	0.05	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Strontium (Sr)-Total	0.0002	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Sulfur (S)-Total	0.5	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA SW-846 3005A/6010B
Thallium (Tl)-Total	0.00001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Tin (Sn)-Total	0.0001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Titanium (Ti)-Total	0.0003	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Uranium (U)-Total	0.00001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Vanadium (V)-Total	0.0005	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Zinc (Zn) - Total	0.003	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B
Zirconium (Zr) - Total	0.0003	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	No	HNO_3	EPA 200.2/6020A (mod) or EPA 3005A/6010B

Table 2 con't. Laboratory data quality objectives (from ALS) for water chemistry analyses.

Parameter	Target D.L.	Units	Accuracy [1] DQO	Matrix Spike [2] DQO	Precision [3] (RPD) DQO	Hold Times	Bottle Required	Bottle Volume	Filter (Yes/No)	Preservative	Method Reference
Water - Dissolved Metals											
Aluminum (Al)-Dissolved	0.001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Antimony (Sb)-Dissolved	0.0001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Arsenic (As)-Dissolved	0.0001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Barium (Ba)-Dissolved	0.00005	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Beryllium (Be)-Dissolved	0.00002	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod)
Bismuth (Bi)-Dissolved	0.00005	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Boron (B)-Dissolved	0.01	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Cadmium (Cd)-Dissolved	0.000005	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Calcium (Ca)-Dissolved	0.05	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Chromium (Cr)-Dissolved	0.0001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Cobalt (Co)-Dissolved	0.0001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Copper (Cu)-Dissolved	0.0002	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Iron (Fe)-Dissolved	0.01	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Lead (Pb)-Dissolved	0.00005	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Lithium (Li)-Dissolved	0.001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Magnesium (Mg)-Dissolved	0.1	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Manganese (Mn)-Dissolved	0.0001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Mercury (Hg)-Dissolved	0.000005	mg/L	80-120%	70-130%	20%	28 days	Glass	40 ml	Yes	HCl	APHA 3030B/EPA 1631E (mod)
Molybdenum (Mo)-Dissolved	0.00005	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Nickel (Ni)-Dissolved	0.0005	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Phosphorus (P)-Dissolved	0.05	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Potassium (K)-Dissolved	0.1	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Selenium (Se)-Dissolved	0.00005	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Silicon (Si)-Dissolved	0.05	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Silver (Ag)-Dissolved	0.00001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Sodium (Na)-Dissolved	0.05	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Strontium (Sr)-Dissolved	0.0002	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Sulfur (S)-Dissolved	0.5	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	EPA SW-846 3005A/6010B
Thallium (Tl)-Dissolved	0.00001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Tin (Sn)-Dissolved	0.0001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Titanium (Ti)-Dissolved	0.0003	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Uranium (U)-Dissolved	0.00001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Vanadium (V)-Dissolved	0.0005	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Zinc (Zn) - Dissolved	0.001	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B
Zirconium (Zr) - Dissolved	0.0003	mg/L	80-120%	70-130%	20%	6 months	Plastic, Verified	250 ml	Yes	HNO_3	APHA 3030 B/6020A (mod) or EPA 3005A/6010B

Notes: All bottles should be kept cool from sampling to lab receiving. If possible, Dissolved Metals should be filtered and preserved as soon as possible.

[1] Accuracy is measured as Percent Difference from True Value or Certified Target for Reference Materials and/or Method Analyte Spikes and Surrogates where applicable. For Matrix Spikes, accuracy is measured as the measured amount minus the sample background amount divided by the spiked amount. For low level results the accuracy objective is for the measured result to lie within +/- 1 times the LOR from the target.

[2] Matrix Spike (MS) recovery, expressed as a percentage is defined as:

100 * {[(Measured Concentration) - (Background Analyte Concentration in Sample)] ÷ (Spike Concentration)}

High analyte background may prevent accurate determination of MS recovery. MS recoveries are not calculated or evaluated when the spiked amount is less than the background analyte concentration in the sample.

[3] Precision is measured as the absolute value of Relative Percent Difference (RPD) for Laboratory Duplicate Samples. RPD = |(Result2 - Result1) / Mean| * 100. For low level results, the precision objective is for the difference of the two results to be less than 2 times the LOR.

[4] Filter 500 ml through a 0.45um MCE filter, place filter in 15 mL black plastic tube provided by ALS and freeze.

3. For **QAQC** purposes four kinds of samples are required:

Field duplicate: All parameters measured in the original sample are measured in the field duplicate. The sampling station is selected at random and labeled as station CREMP [month] DUP-1, -2, -3, -4, etc. Prepare the QAQC labels and affix to the sampling containers, as described in step 2.

Travel blank: These are to be carried into the field and treated like the other sampling vessels except that the bottles are not to be opened or anything added to them. Ship back to the lab, each set with different shipment.

Equipment blank: For this sample you should be using one 4-L jug of DI-water just to re-circulate water through the pump for at least 2 minutes. Then DISCARD those 4L. Use a new 4-L jug of DI-water to first rinse out another 2L, discard that, empty the pump, then start filling bottles with the remaining 2L plus whatever is needed from a third new 4-L jug of DI-water. PRESERVE and FILTER the sample bottles as indicated in **Table 1**, using the most recent filter you've used in the field during this event. ***Discard any DI-water that is left in the 4-L jugs and recycle the empty jugs***. Use the new COC, fill in for every parameter except chlorophyll-a. Label this sample according to the name listed in the excel sheet "Water data sheet & stations 2015 -CREMP" under the tab for whichever month you are in. Be sure to label all 9 sample bottles also.

DI (De-ionized water) Blank: Using a second set of sample bottles you will be collecting a DI Blank. To do this, use another brand new 4-L jug of DI (***do not use DI water from last year or DI water that you have just had the pump tubing sitting in!***). You will simply fill the entire set of sample bottles using the new clean DI-water (you may need more than one 4-L jug) by pouring from the DI jugs into the sample bottles. PRESERVE as indicated above. You will NOT need to filter anything, as you will not be using the pump to collect these samples. Fill up sample bottles for dissolved parameters anyway. Add this sample to the same COC, fill in for every parameter except chlorophyll-a. Label this sample according to the name listed in the excel sheet "Water data sheet & stations 2015 -CREMP" under the tab for whichever month you are in. Be sure to label all 9 sample bottles also.

4. Before and during sampling fill in the requested information on the field data form; complete one field data form in its entirety for each sampling station and sampling event. Forms are made of waterproof paper; print all information on the form using a lead pencil or a write-in-the-rain pen.

5. With the aid of a GPS unit, navigate the boat to the sampling station using the UTM coordinates (in NAD 83) provided. Approach the station from downstream of the wind direction. In windy conditions, anchor the boat upstream of the station and drift back; it is not necessary to anchor the boat in calm conditions providing the boat remains in the same position. Do not allow the anchor to drag through the sampling station. Record the **UTM coordinates** on the field data form.

6. Measure **water depth** at the sampling station using the 'Hawkeye' hand-held depth meter (or transom-mounted lowrance). Hold the meter in the water, facing the lake bottom, until the meter measures the depth. Record this information on the field data form. If you are in water that is too shallow (i.e., **must have at least 5 meters depth**), move to deeper water near the assigned station.

7. Measure the light attenuation at the sampling station using the **Secchi disk**. Lower the disk into the water, on the shady side of the boat, so that you can no longer see it. Slowly raise the disk to the point that you can see it and measure this depth using the markings on the disk rope.

8. Measure the pH of the water at the sampling station using the **pH meter** (unless the YSI includes this parameter). Hold the probe portion of the meter in the lake until the meter measures the pH. Record this information on the field data form.

9. Calibrate the YSI probe prior to going into the field; confirm elevation (m) of sampling environment. Check the DO calibration (adjust barometric pressure based on airport data) but also check the DO membrane (it may need to be replaced). At Meadowbank DO readings should be about 8 – 12mg/L; if meter is reading much lower/higher than this, membrane likely needs to be replaced. Keep a calibration log which includes date and time, type of calibration, results, and troubleshooting.

10. Lower the **YSI probe** into the lake to just below the water surface level. Measure the temperature (^{o}C), specific conductance (i.e., temperature corrected) (uS/cm) and dissolved oxygen concentration (mg/L) in the water and record on the field data form. Lower the meter to a depth of 1 m and record the field measurements. Allow the concentrations on the meter to stabilize for 10 to 15 seconds before recording the concentrations. Continue recording the field measurements at **1 m depth intervals** until you reach the whole metre mark above the lake bottom (i.e. if the lake depth is 9.3 meters, record field measurements up to a depth of 9 meters).

    It is important to ensure your instruments are calibrated, as mentioned above, but also to check that the readings are 'making sense' while collecting data in the field. If you notice that a reading is ***abnormally low*** (for DO) ***or abnormally high*** (for conductivity or temperature) and the meter appears to be working correctly, then you should collect a second water chemistry sample at the anomalous depth (following the steps below). To help guide field crew, **Table 3** shows limnological parameter values (conductivity, DO, temperature) that should be achieved under normal circumstances. Note that these values are a guide for the open-water months only and for near-field stations only (TPE, TPN, SP, and WAL).

    Table 3. The parameter value should be as indicated under normal circumstances, during each month-parameter combination.

Sampling Month	Parameter (units)	TPN	TPE	SP	WAL
July	Conductivity (µS/cm)	< 20	< 22	< 25	< 28
	Temperature (°C)	< 13	< 15	< 18	< 17
	DO (mg/L)	> 8	> 8	> 7	> 6
August	Conductivity (µS/cm)	< 28	< 31	< 38	< 35
	Temperature (°C)	< 12	< 14	< 14	< 16
	DO (mg/L)	> 6	> 7	> 7	> 8
September	Conductivity (µS/cm)	< 31	< 30	< 36	< 35
	Temperature (°C)	< 10	< 11	< 11	< 10
	DO (mg/L)	> 7	> 6	> 6	> 7

    As an example, in August at station TPE, conductivity should be less than 31 uS/cm, temperature should be less than 14 ^{o}C, and DO should be greater than 7 mg/L. If the profile shows that at 7 meters depth conductivity is 36 uS/cm or that DO is 5 mg/L, for example, then collect a full water chemistry sample at 7 meters (no phytoplankton, no chlorophyll-a) following the steps below.

11. Set up the **water pump** in the boat; attach the tubing to the pump using the C-clamps and attach the 12-V battery. Attach the 4 meter length of tubing to the intake valve, and the 1 meter length to the output valve. Attach the plastic coated ball weight to the end of the 4 meter length of tubing. Lower the 4 meter length of tubing into the water to ***3 meters depth*** and place the 1 meter length of tubing over the edge of the boat. Run the pump for ***2 minutes*** to flush the sampling device.

12. For each sampling station, **fill** the required **pre-labeled sampling containers** with water from the 1 meter length of tubing.

13. Dissolved metals and dissolved organic carbon samples are to be collected with an in-line high capacity filter with 0.45 um pore size. After all unfiltered samples have been collected, disconnect the battery from the pump and fix the filter onto the end of the discharge hose. Re-connect the pump and allow the water to discharge and flush through the filter for 15 – 20 seconds. Direct filtered water into the DOC and dissolved metals (and dissolved Hg) bottles. Flow from the hose can be controlled by pinching the incurrent end of the tube (***not the excurrent***). Once filtered samples have been collected remove the filter and place into a plastic or zip-loc bag for re-use. In the Meadowbank environment where the amount of suspended solids is typically low, filters can be re-used for up to 10 samples. Remember to use the same filter when collecting equipment blank samples, not a new filter.

14. **Add the specified preservatives** to the appropriate sampling containers (according to the information on the labels and tables above), seal and mix thoroughly by turning upside down and then upright a number of times.

15. To collect a phytoplankton sample, add site water from appropriate depth (i.e., 3 m) into the 50 mL vial provided. Make sure that site information is appropriately labeled on the jar. In the field or the lab, add a few drops of Lugol's solution to the sample so that it has the color of weak tea.

16. Back in the office, to process the chlorophyll-a sample, use the hand-held pump apparatus and filters. Using the tweezers, place an ashless filter paper on the screen in the water filter apparatus, then screw the two sections together and attach the hand-held vacuum pump. **Filter 500 mL of water** through the water filter apparatus. After filtering the 500 mL of water, remove the filter and place in the 15 mL black plastic tube provided by ALS. With a sharpie pen, write the appropriate sampling information on a label and stick to the plastic tube. Place the tubes in a Ziploc bag and put into the **freezer**. Mark on the field collection data sheet the volume of water filtered.

17. Until ready for shipping, the water samples are stored **chilled** in a refrigerator in camp, if space is available. The filter for chlorophyll-a analysis must be **frozen**; store this bag in a deep freezer in the camp. Bottles should be put in plastic bubble bags prior to storage on ice to protect the labels from water damage. The phytoplankton samples are stored at **room temperature**.

18. If this sampling station is selected as the QAQC **field duplicate**, collect a second set of water samples, fill the pre-labeled sampling containers, including the phytoplankton vial (repeat step 11-15) and collect a second filtered chlorophyll-a sample (step 16). Record which sampling station the QAQC samples are collected from on the appropriate field data form.

19. Fill out a **chain-of-custody** form for the water samples and filters being sent to **ALS Environmental**. The COC form must be completed carefully and in its entirety to ensure proper analysis. This

includes listing all of the specific conventional parameters (see tables above), Azimuth and ALS contact names, and checking off all of the specific boxes for requested analyses. The ALS laboratory quote number must be printed on the COC form to ensure proper billing. Note that there are pre-made COCs for ALS water chemistry – separated by Ground shipments, Express shipments and Chlorophyll-a. These have been separated because they will be shipped separately.

A **digital COC** form is most commonly used; this form can be filled out in advance to ensure accuracy and efficiency and amended in the field as required. Note that using a digital copy of the COC requires printing 2 copies of the document in the field (one for the laboratory, one for Azimuth). Any questions regarding the COC form should be directed to the Azimuth project coordinator – Eric Franz. Put the completed COC form in a sealed ziploc plastic bag in a cooler with the water samples.

20. Fill out a **chain-of-custody** form for the phytoplankton samples being sent to **Plankton R Us Inc.**, Winnipeg, MB. Complete all of the required fields and then put the form in a sealed ziploc plastic bag in the cooler with the phytoplankton samples.

PACKAGING & SHIPPING SAMPLES:

1. Ensure all **water samples** are **sealed** securely. Prior to shipping, it is advisable to wrap the label of each sample bottle with clear tape to make sure that the label does not come off during shipping and handling. Dry the water bottle and wrap with tape. **Pack** water sampling containers upright in coolers with ice packs, and packing material, to ensure samples do not spill or break during transport. (Ideal storage and transport temperature is 4°C). Separate all the 1-L plastic bottles from the rest of the bottles, the former will be shipped express and the latter will be shipped ground. Chlorophyll-a samples tubes will be sent in their own mini cooler with plenty of ice packs.

2. Ensure the COC form is enclosed and then seal the cooler(s). **Label the cooler**(s) with the following address:
   ALS Environmental
   101-8081 Lougheed Hwy.
   Burnaby, BC, Canada
   V5A 1W9
   Tel: 604-253-4188
   Attention: Brent Mack

   Ship the water samples to ALS in Burnaby as indicated on the label (either 'ground' or 'express'). Please email Eric Franz at Azimuth (efranz@azimuthgroup.ca) when water samples are being sent from Meadowbank.

3. Ensure **phytoplankton samples** are **sealed** securely and **pack** in a cooler with packing material to ensure samples do not break during transport. It is not necessary to keep samples cool.

4. Ensure the COC form is enclosed and then seal the cooler. **Label the cooler** with the following address:
   Plankton R Us Inc.
   Dave Findlay
   39 Alburg Drive
   Winnipeg, MB

R2N 1M1
Tel: 204-254-7952

5. Ship the phytoplankton samples to Dave Findlay at the end of each month or event.

6. Send completed **COC forms** and **field data forms** to Azimuth Consulting Group, attention the project coordinator – Eric Franz.

APPENDIX B

STANDARD OPERATING PROCEDURE
MEADOWBANK LAKES AND BAKER LAKE
CREMP BENTHOS & SEDIMENT SAMPLING

Standard Operating Procedure
Meadowbank Lakes & Baker Lake
CREMP Benthos & Sediment Sampling

GENERAL:

Project Coordinator:
Morgan Finley
Azimuth Consulting Group
304-2537 Beacon Avenue,
Sidney, BC, V8L 1Y3
Telephone: 778-426-0112
Email: mfinley@azimuthgroup.ca

In case of **emergency**, contact Gary Mann ([redacted]).
Azimuth office telephone number 604-730-1220 or 778-426-0112.

LOCATION AND TIMING FOR FIELD ACTIVITIES:

Thirteen (13) sampling stations have been chosen for benthos and sediment quality monitoring in the Meadowbank project lakes. These stations (with their corresponding abbreviation) are:

- Third Portage Lake – North Basin (TPN)
- Third Portage Lake – East Basin (TPE)
- Second Portage Lake (SP)
- Tehek Lake (TE)
- Inuggugayualik Lake (INUG)

- Tehek Lake – Far-field (TEFF)
- Third Portage Lake – South Basin (TPS)
- Wally Lake (WAL)
- Pipedream Lake (PDL)

- Baker Lake – Barge Dock (BBD)
- Baker Lake – Proposed Jetty (BPJ)
- Baker Lake – Akilahaarjuk Point (BAP)
- Baker Lake – East Shore (BES)

Field activities are scheduled for once per year, in **mid/late August**. The **target water depth** at each sampling station is approximately **8 meters +/- 1.5 m**.

BENTHOS & SEDIMENT CHEMISTRY SAMPLING:

1. Gather **field collection materials**:
   In the boat:
   - Field collection data forms, waterproof paper, pencils, waterproof markers & clipboard

- GPS unit, batteries
- Depth meter, batteries
- pH meter, batteries
- Rope
- Petite Ponar grab and rope
- 500 micron sieve bag
- 3 stainless steel bowls
- 2 stainless steel spoons
- Liquinox detergent and dish cleaning brush
- Plastic squirt bottle
- Sampling gloves
- Safety glasses
- Field sample jars & preservatives (per sampling station):
  - 11 – 125 mL glass jars (sediment samples : 2 jars for 5 reps; 1 jar for composite)
  - 5 – 500 mL plastic jars (benthos: 1 jar for each rep)
- QA/QC field duplicate sediment jars
- Ashless filter paper & tweezers; 1-125 mL glass jar

In camp:

- Formalin (10% of pure Formaldehyde)
- Labels for sampling containers
- Coolers, action packers (for storing and shipping samples)
- Ice packs (for shipping sediment samples to lab)
- Address labels for coolers
- Chain-of-custody forms
- Large Ziploc bags (for sending chain-of-custody form in coolers)
- Electrical tape (for sealing benthos jars)
- Packing tape (for affixing labels to sediment sample containers & sealing coolers)

2. Before going into the field, **label the lids** of all sampling containers using a permanent waterproof marker. After sampling, prepare appropriate labels for containers and affix them when bottles are dry enough to stick to. Use the following information:
   - Azimuth company name
   - Station abbreviation (e.g. TPE-1, INUG-3)
   - Date of sample collection
   - Parameters to be measured from individual jar (5 x 125 mL – total metals, pH, moisture; 5 x 125 mL – grain size (PSA), TOC; 1 x 125 mL – PAHs, LEPHs & HEPHs, Mineral Oil & Grease.

   ALS Laboratory data quality objectives for individual water parameter analyses are in **Table 1**. Affix the labels to the sediment jars and then wrap packing tape around the labels to ensure a waterproof seal.

Table 1. Laboratory data quality objectives (from ALS) for sediment chemistry analyses.

Parameter	Target D.L.	Units	Accuracy [1] DQO	Matrix Spike [2] DQO	Precision [3] (RPD) DQO	Hold Times	Bottle Required	Volume Required	Method Reference
Soil - Physical Tests									
Moisture	0.25	%	90-110%	n/a	20%	14 days	Glass	125 ml	ASTM D2974-00 Method A
pH (1:2 soil:water)	0.10	pH	± 0.3 pH units	n/a	± 0.3 pH units	1 year	Glass	125 ml	BC WLAP METHOD: PH, ELECTROMETRIC, SOIL
Soil - Particle Size									
% Gravel (>2mm)	0.10	%	LTM ± 5% [5 6]	n/a	Diff < 5% [6]	6 months	Glass	125 ml	SSIR-51 METHOD 3.2.1
% Sand (2.0mm - 0.063mm)	0.10	%	LTM ± 5% [5 6]	n/a	Diff < 5% [6]	6 months	Glass	125 ml	SSIR-51 METHOD 3.2.1
% Silt (0.063mm - 4um)	0.10	%	LTM ± 5% [5 6]	n/a	Diff < 5% [6]	6 months	Glass	125 ml	SSIR-51 METHOD 3.2.1
% Clay (<4um)	0.10	%	LTM ± 5% [5 6]	n/a	Diff < 5% [6]	6 months	Glass	125 ml	SSIR-51 METHOD 3.2.1
Soil - Organic / Inorganic Carbon									
Total Organic Carbon	0.10	%	80-120%	70-130%	30%	28 days	Glass	125 ml	SSSA (1996) p. 973
Soil - Metals									
Aluminum (Al)	50	mg/kg	70-130% [4]	n/a	40%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Antimony (Sb)	0.10	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Arsenic (As)	0.100	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Barium (Ba)	0.50	mg/kg	70-130% [4]	n/a	40%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Beryllium (Be)	0.10	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Bismuth (Bi)	0.20	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Boron (B)	5.0	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Cadmium (Cd)	0.020	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Calcium (Ca)	50	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Chromium (Cr)	0.50	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Cobalt (Co)	0.10	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Copper (Cu)	0.50	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Iron (Fe)	50	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Lead (Pb)	0.50	mg/kg	70-130% [4]	n/a	40%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Lithium (Li)	2.0	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Magnesium (Mg)	20	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Manganese (Mn)	1.0	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Mercury (Hg)	0.0050	mg/kg	70-130% [4]	n/a	40%	28 days	Glass	125 ml	EPA 200.2/1631E (mod)
Molybdenum (Mo)	0.10	mg/kg	70-130% [4]	n/a	40%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Nickel (Ni)	0.50	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Phosphorus (P)	50	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Potassium (K)	100	mg/kg	70-130% [4]	n/a	40%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Selenium (Se)	0.20	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Silver (Ag)	0.10	mg/kg	70-130% [4]	n/a	40%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Sodium (Na)	50	mg/kg	70-130% [4]	n/a	40%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Strontium (Sr)	0.50	mg/kg	70-130% [4]	n/a	40%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Thallium (Tl)	0.050	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Tin (Sn)	2.0	mg/kg	70-130% [4]	n/a	40%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Titanium (Ti)	1.0	mg/kg	70-130% [4]	n/a	40%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Uranium (U)	0.050	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Vanadium (V)	0.20	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Zinc (Zn)	2.0	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)
Zirconium (Zr)	1.0	mg/kg	70-130% [4]	n/a	30%	6 months	Glass	125 ml	EPA 200.2/6020A (mod)

Table 1 con't. Laboratory data quality objectives (from ALS) for sediment chemistry analyses.

Parameter	Target D.L.	Units	Accuracy [1] DQO	Matrix Spike [2] DQO	Precision [3] (RPD) DQO	Hold Times	Bottle Required	Volume Required	Method Reference
Soil - Aggregate Organics									
Mineral Oil and Grease	500	mg/kg	70-130%	60-140%	40%	28 days	Glass	125 ml	CCME PETROLEUM HYDROCARBONS-GRAVIMETRIC
Soil - Hydrocarbons									
EPH10-19	200	mg/kg	70-130%	60-140%	40%	14 days	Glass	125 ml	BC MOE EPH GCFID
EPH19-32	200	mg/kg	70-130%	60-140%	40%	14 days	Glass	125 ml	BC MOE EPH GCFID
LEPH	200	mg/kg	70-130%	60-140%	40%	14 days	Glass	125 ml	BC MOE LABORATORY MANUAL (2005)
HEPH	200	mg/kg	70-130%	60-140%	40%	14 days	Glass	125 ml	BC MOE LABORATORY MANUAL (2005)
Soil - Polycyclic Aromatic Hydrocarbons									
Acenaphthene	0.0050	mg/kg	60-130%	50-140%	50%	14 days	Glass	125 ml	EPA 3570/8270
Acenaphthylene	0.0050	mg/kg	60-130%	50-140%	50%	14 days	Glass	125 ml	EPA 3570/8270
Anthracene	0.0040	mg/kg	60-130%	50-140%	50%	14 days	Glass	125 ml	EPA 3570/8270
Benz(a)anthracene	0.010	mg/kg	60-130%	50-140%	50%	14 days	Glass	125 ml	EPA 3570/8270
Benzo(a)pyrene	0.010	mg/kg	60-130%	50-140%	50%	14 days	Glass	125 ml	EPA 3570/8270
Benzo(b)fluoranthene	0.010	mg/kg	60-130%	50-140%	50%	14 days	Glass	125 ml	EPA 3570/8270
Benzo(b+j+k)fluoranthene	0.015	mg/kg	60-130%	50-140%	50%	14 days	Glass	125 ml	EPA 3570/8270
Benzo(g,h,i)perylene	0.010	mg/kg	60-130%	50-140%	50%	14 days	Glass	125 ml	EPA 3570/8270
Benzo(k)fluoranthene	0.010	mg/kg	60-130%	50-140%	50%	14 days	Glass	125 ml	EPA 3570/8270
Chrysene	0.010	mg/kg	60-130%	50-140%	50%	14 days	Glass	125 ml	EPA 3570/8270
Dibenz(a,h)anthracene	0.0050	mg/kg	60-130%	50-140%	50%	14 days	Glass	125 ml	EPA 3570/8270
Fluoranthene	0.010	mg/kg	60-130%	50-140%	50%	14 days	Glass	125 ml	EPA 3570/8270
Fluorene	0.010	mg/kg	60-130%	50-140%	50%	14 days	Glass	125 ml	EPA 3570/8270
Indeno(1,2,3-c,d)pyrene	0.010	mg/kg	60-130%	50-140%	50%	14 days	Glass	125 ml	EPA 3570/8270
2-Methylnaphthalene	0.010	mg/kg	60-130%	50-140%	50%	14 days	Glass	125 ml	EPA 3570/8270
Naphthalene	0.010	mg/kg	50-130%	50-140%	50%	14 days	Glass	125 ml	EPA 3570/8270
Phenanthrene	0.010	mg/kg	60-130%	50-140%	50%	14 days	Glass	125 ml	EPA 3570/8270
Pyrene	0.010	mg/kg	60-130%	50-140%	50%	14 days	Glass	125 ml	EPA 3570/8270

Notes: All jars should be kept cool from sampling to lab receiving.

[1] Accuracy is measured as Percent Difference from True Value or Certified Target for Reference Materials and/or Method Analyte Spikes and Surrogates where applicable. For Matrix Spikes, accuracy is measured as the measured amount minus the sample background amount divided by the spiked amount. For low level results the accuracy objective is for the measured result to lie within +/- 1 times the LOR from the target.

[2] Matrix Spike (MS) recovery, expressed as a percentage is defined as:

100 * {[(Measured Concentration) - (Background Analyte Concentration in Sample)] ÷ (Spike Concentration)}

High analyte background may prevent accurate determination of MS recovery. MS recoveries are not calculated or evaluated when the spiked amount is less than the background analyte concentration in the sample.

[3] Precision is measured as the absolute value of Relative Percent Difference (RPD) for Laboratory Duplicate Samples. RPD = |(Result2 - Result1) / Mean| * 100. For low level results, the precision objective is for the difference of the two results to be less than 2 times the LOR.

[4] Accuracy targets for metals in soils are expressed relative to the ALS long term mean for each method where certified method-specific reference material targets are unavailable. Full recovery of matrix-bound elements is not expected or intended for environmental acid digestion methods.

[5] Long Term Mean (LTM) ± 5% sand, silt, clay.

[6] The recovery is calculated from the absolute difference (DIFF).

For the **benthos containers**, print the following information directly onto both the jar and jar lid using a permanent waterproof marker:

- Azimuth company name
- Station abbreviation (e.g. TPE, INUG) and replicate number (e.g. TPE-1, TPE-2); there are a total of 5 replicates per sampling station
- Date of sample collection

Prepare **internal labels** for each of the benthos containers. On a small piece of waterproof paper, write, using a lead pencil, the station abbreviation and replicate number (e.g. TPE-1). If no waterproof paper is available, use regular paper. Store the labels in their corresponding sampling container.

3. For **QAQC** purposes, sediment samples are collected in duplicate from 8 replicate station every sampling event (DUP + Swipe). All parameters measured in the original sample are measured in the field duplicate. The sampling station is selected randomly from the 65 replicate stations, and labeled as station DUP (or Swipe). Prepare the QAQC labels and affix to the sediment jars, as described in step 2. And label one new 125 mL glass jars with the Azimuth company name, date, QAQC filter and total metals for each swipe sample.

4. A 100% formalin solution is equivalent to a solution of 37% formaldehyde. The **target formalin concentration** in each of the sampling containers is 10%. A neutral buffered formalin solution is achieved by adding a sufficient amount of calcium carbonate powder or pellets to render the solution pH neutral (pH = 7.0). Borax powder may be substituted for calcium carbonate powder if necessary.

   Transport Canada allows the free transport of formalin at concentrations less than 25% formaldehyde. Consequently, the formalin transported up to Meadowbank will be diluted in half (18.5% formaldehyde / 50% formalin solution).

   To **prepare** the **neutral buffered formalin**, add a small amount of calcium carbonate powder or pellets to the 50% formalin solution, seal the container and shake until mixed. Check the pH of the solution using the pH pen. Continue adding the powder/pellets until the pH of the solution reaches approximately 7.0. Store at room temperature until ready to use. Only prepare the required volume of neutral buffered formalin for that sampling event. Buffered formalin will not store for long periods of time. Follow all **safety precautions** when preparing the formalin solution. Formalin is a carcinogen and irritant. Wear sampling gloves and safety glasses when mixing the solution and prepare the solution in a well ventilated area.

5. Before and during the benthos and sediment sampling fill in the requested information on the **field data form**; complete one field data form in its entirety for each sampling station and sampling event. Forms are made of waterproof paper; **print** all information on the form using a **pencil** or write-in-the-rain pen.

6. With the aid of a GPS unit, **navigate the boat** to the sampling station using the UTM coordinates (in NAD 83) provided. Approach the station from downstream of the wind direction. In windy conditions, anchor the boat upstream of the station and drift back; it is not necessary to anchor the boat in calm conditions providing the boat remains within a 50 meter radius of the position. Do not

allow the anchor to drag through the sampling station. Record the UTM coordinates on the field data form.

7. Measure the **water depth** at the sampling station. It is recommended to use a transom mounted sonar to first "view" each rep location looking for a smooth, relatively flat lake bottom. Record the depth information on the field data form. Ensure sample depth is within the target (8 meters +/- 1.5 m).

8. Begin collecting the benthos samples. Collecting the sediment first would disturb the benthic community.

9. Ensure the rope is securely attached to the **Ponar**. Rinse the Ponar grab, 3 stainless steel bowls and a spoon with lake water. **Wash** each of these items with liquinox soap by scrubbing with the dish cleaning brush and then thoroughly rinse with lake water. Put aside two stainless steel bowls and spoon until later (step 18) and ready the largest stainless bowl for the Ponar.

10. Lower the **Ponar** to within 1 meter of the bottom of the lake. Lower the Ponar very slowly over the last meter and allow the rope to go slack. Raise the Ponar to the edge of the boat and check the grab for **acceptability**. The grab is acceptable if the sample:
    - does not contain large foreign objects;
    - has adequate penetration depth (i.e., 10-15 centimeters though in some locations if the substrate is particularly hard it may be necessary to accept smaller grabs);
    - is not overfilled (sediment surface must not be touching the top of the Ponar, though in reality there will be occasions when the Ponar is full, careful judgment is required to determine if the grab is too full);
    - did not leak (there is overlying water present in Ponar); and
    - is undisturbed (sediment surface relatively flat).

    Once the grab is deemed acceptable, open the Ponar jaws and drop the sample into the large stainless steel bowl. Rinse the ponar with squirt bottles to make sure all of the material is in the bowl. Gently pour the contents of the bowl into the 500 micron sieve bag.

11. **Sieve the sample** in the lake water until only the benthic organisms and coarse materials remain. Care must be taken to ensure the benthic organisms are not damaged or crushed. Do not disturb the sample to the point that it is splashing out of the sieve. Do not forcibly push materials through the sieve; gently massage apart any small clay balls. Rinse off any pieces of larger plant material or rocks in the sample and discard.

12. **Flush** the **remaining sample** in the bottom of the sieve into the pre-labeled plastic sampling container (i.e. station-1 jar). A plastic squirt bottle filled with lake water is useful for this purpose.

13. **Repeat steps 10-12**, flushing the sample into the same pre-labeled plastic sampling container (i.e., station-1 jar). Ensure the sample is collected in an area not previously disturbed by the Ponar. The two independent grabs (per replicate) are composited to increase the surface area sampled.

14. **Rinse the sieve** bag to clear out any debris in the screen. To rinse, hold the sieve upside down and raise and lower the sieve into the water.

15. Refer to step 18. At this point while you are still at the first rep you can also collect the Ponar grabs for the sediment chemistry composite.

16. **Repeat steps 10-14** four more times; there must be a separation of ***20 meters*** or more from other replicate stations. Prior to collecting the next REP, clean ponar and both bowls with liquinox and scrub brush, rinse with lake water. Record the depth and GPS coordinates of each replicate station on the field data form. Put the samples from each replicate in pre-labeled station replicate jars 2 through 5. In total, 10 Ponar grabs will be collected for benthos collection, two grabs per replicate.

17. Ensure internal labels are in each sample container. Shake the formalin to ensure all of the calcium carbonate powder is in solution. **Add** a sufficient volume of **formalin** to each sampling container to make a corresponding formalin solution of approximately 10%. Volumes of formalin are added by 'eye' (for a 10% solution, a ratio of 4 parts water and 1 part 50% formalin solution). Overall, there must be enough liquid in the jar to cover the entire sample. Seal the sample container securely and gently roll the container to mix the sample and formalin solution. Do not shake the sample container; this will crush the benthic organisms inside.

18. Begin collecting the sediment samples. Lower the **Ponar** to within 1 meter of the bottom of the lake, in an area not previously disturbed by the Ponar. Lower the Ponar very slowly over the last meter and allow the rope to go slack. Raise the Ponar to the edge of the boat and check the grab for **acceptability** (see step 10 for criteria).

19. Once the grab is deemed acceptable, open the top of the Ponar and remove any overlying water. Using the pre-cleaned stainless steel spoon, scoop out the **top 3-5 centimeters** of **sediment** and place in the pre-cleaned stainless steel bowl. Empty the remainder of the grab sample into a bucket in the boat, not directly into the lake, to ensure the area is not disturbed.

20. **Repeat steps 18 and 19** one more time, placing the sediment into the bowl with the other sediment sample(s).

21. **Homogenize** the sediment samples in the stainless steel bowl (by stirring with the spoon) until the sediment is thoroughly mixed. Scoop the sediment into pre-labeled sediment sampling containers. **Fill the jars** to the top and seal securely.

22. Add one level-scoop of sediment from the sediment chemistry bowl to the last, clean, stainless bowl. This process is completed at each rep until there are 5 good scoops (one from each rep) in the "composite" bowl. Homogenize thoroughly and fill 1 x 125 mL jar for analysis (LEPHs&HEPHs, MOG, and PAHS). Be sure label ID includes "COMP" (e.g., TPE-COMP).

23. If this station is selected as the QAQC **field duplicate**, using the tweezers and a set of clean sampling gloves, **swipe** the stainless steel bowl and spoon with one piece of ashless **filter paper** (or a "ghost wipe") and store in the pre-labeled 125 mL glass jar. Collect the duplicate sediment sample from the same sediment collected in steps 18-20. Fill the sampling containers labeled as station DUP. Record that the QAQC samples were collected from this sampling station on the field data form.

24. **Complete** the **field data form**, including a description of the sediment (grain size, consistency, colour, presence of biota, sheen, unusual appearance) and the sampling effort (equipment failure, control of vertical descent of sampler) required to collect the benthos and sediment samples.

25. **Rinse** out the Ponar, stainless steel bowl and spoon with lake water. Dump the sediment and water from the plastic bin into the lake.

26. Until ready for shipping, store the sediment samples and QAQC filter paper **chilled** (on ice) in a cooler or in a refrigerator in camp, if space is available. The sediment sampling containers may be put in plastic bags prior to storage on ice to further protect the labels from water damage. Benthos samples are stored in a cooler or action packer at **room temperature**.

27. Fill out a **chain-of-custody** form for the sediment samples being sent to **ALS Environmental**. The COC form must be completed carefully and in its entirety to ensure proper analysis. This includes listing all of the specific parameters to be analyzed (see step 2), Azimuth and ALS contact names, and checking off all of the specific boxes for requested analyses. The ALS laboratory quote number must be printed on the COC form to ensure proper billing.

    A **digital COC** form is most commonly used; this form can be filled out in advance to ensure accuracy and efficiency and amended in the field as required. However, using a digital copy of the COC requires printing 2 copies of the document in the field (one for the laboratory, one for Azimuth). Any questions regarding the COC form should be directed to the Azimuth project coordinator – Morgan Finley. Put the completed COC form in a sealed ziploc plastic bag in the cooler with the samples.

28. Fill out a **chain-of-custody** form for the benthos samples being sent to **Zaranko Environmental Assessment Services** (ZEAS). Complete all of the required fields and then put the form in a sealed ziploc plastic bag in the cooler with the benthos samples.

PACKAGING & SHIPPING SAMPLES:

1. Ensure all **sediment samples** are **sealed** securely. **Pack** sediment sampling containers upright in a cooler with ice packs, and packing material, to ensure containers do not break during transport. (Ideal storage and transport temperature is 4°C).

2. Ensure the COC form is enclosed and then seal the cooler(s). **Label the cooler**(s) with the following address:

    ALS Environmental
    101-8081 Lougheed Hwy.
    Burnaby, BC, Canada
    V5A 1W9
    Tel: 604-253-4188
    Attention: Brent Mack

3. Ensure **benthos samples** are **sealed** securely. Wrap electrical tape around the edge of the lids to ensure a tight seal. **Pack** benthos sampling containers upright in a cooler or action packer; ensure the cooler/action packer is well packed so the jars are not able to move around.

4. Ensure the COC form is enclosed and then seal the cooler(s). **Label the cooler**(s) with the following address:

    Zaranko Environmental Assessment Services (ZEAS)

36 McCutcheon Avenue
P.O. Box 1045
Nobleton, ON
L0G 1N0
Tel: 905-859-7976

5. **Ship** the sediment **samples** to ALS Environmental as quickly as possible. Ship the benthos samples to ZEAS when convenient. Coordinate shipping with the camp manager.
6. Send completed **COC forms** and **field data forms** to **Azimuth** Consulting Group, attention the project coordinator – Morgan Finley and Eric Franz (efranz@azimuthgroup.ca).

APPENDIX C

STANDARD OPERATING PROCEDURE
MEADOWBANK LAKES AND BAKER LAKE
CREMP SEDIMENT CORE SAMPLING

Standard Operating Procedure
Meadowbank Lakes & Baker Lake
CREMP Sediment Core Sampling

GENERAL:

Project Coordinator:
Morgan Finley
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LOCATION AND TIMING FOR FIELD ACTIVITIES:

Thirteen (13) sampling stations have been chosen for benthos and sediment quality monitoring in the Meadowbank project lakes. These stations (with their corresponding abbreviation) are:

- Third Portage Lake – North Basin (TPN)
- Third Portage Lake – East Basin (TPE)
- Third Portage Lake – East Basin B (TPE-B)
- Second Portage Lake (SP)
- Tehek Lake (TE)
- Inuggugayualik Lake (INUG)

- Tehek Lake – Far-field (TEFF)
- Third Portage Lake – South Basin (TPS)
- Wally Lake (WAL)
- Pipedream Lake (PDL)

- Baker Lake – Barge Dock (BBD)
- Baker Lake – Proposed Jetty (BPJ)
- Baker Lake – Akilahaarjuk Point (BAP)
- Baker Lake – East Shore (BES)

Field activities are scheduled for once per year, in **mid/late August**. The **target water depth** at each sampling station is approximately **8 meters +/- 1.5 m**.

Sediment Coring Program:

An average top 1.5cm of sediment chemistry at all CREMP stations will be characterized using sediment cores. Note that this complements, rather than replaces, the grab samples (top 3 to 5 cm) collected synoptically with benthic community samples in late August. This is in addition to the traditional

composite sample using the petite Ponar grab. Ten (10) independent cores are to be collected from each of the stations. Cores will be collected within a 250 m radius around the center of each sampling area. The intent is to collect cores over a wide area, targeting depths of 6.5-9.5 m to match benthos sampling within the basin being sampled. The protocol for collecting sediment cores is as follows:

1. Core sampling is conducted prior to benthic sampling and will most often be paired with benthic sampling reps. Consideration can be given to identifying core sample locations prior to field collections.
2. If conditions are windy, anchor the boat. If calm, anchoring is not necessary. Survey the area to be sampled with the sonar to determine bottom type.
3. Deploy the corer from the boat and try to ensure that the core barrel is perpendicular with the surface before penetration. Depending on results, the corer can free-fall from 1 m above the surface. Avoid sampling over steep gradient slopes or over coarse grain substrate.
4. When the boat is anchored, deploy the corer from the boat and lower it when the boat has reached its furthest point in its swing to the right. This will be an odd numbered core. For the second core wait until the boat swings to the left, check the GPS to make sure this is around 5 m from the first core. This core will be an even numbered core. Cores can be taken from new locations each time and do not need to be at the exact same location as the other benthos work.
5. Raise the core to just below the water surface and cap prior to bringing above the water to ensure sediment is not lost out the bottom.
6. Check to make sure that the surface of the core is intact and is not mixed or disturbed and that the overlying water is clear. Record water depth and UTM location (NAD 83) of all successful core samples.
7. Process the core on the boat. Decant overlying water and collect only the top 1.5 cm of sediment.
8. Place the entire 1.5 cm slice into a 125 mL glass jar. Discard the remaining core sample.
9. Label the jars as per CREMP protocol (e.g., TE-x) but with a suffix indicating a core sample (e.g., TE-SC-01 to TE-SC-10).
10. Fill in the data sheet and record any observations about the core sample such as presence of varves, distinct changes in color, grain size, or any other unusual features.
11. Repeat the procedure above until all 5 or 10 core samples (depending on the needs outlined in the planning phase) have been collected, randomly covering the general area depicted on the map.
12. For 2014 ten cores from TPE, TPE-B, TPN, SP, TE, WAL, BBD, and BPJ. Five samples from TPS, TEFF, PDL, INUG, BAP, and BES.
13. Randomly from one of the 10 coring locations, take a duplicate core (independent deployment of corer) for QAQC purposes.

14. Even number core samples will be archived for those sites where ten samples are collected. For the 2014 sampling year, TPE and TPE-B will have 10 samples collected in each location with no archival.
15. All core samples are to be analysed for total metals, pH and total organic carbon. Fill in CoCs as necessary.
16. Hold on ice or in the refrigerator until shipping to ALS, Vancouver.
17. Hold times for pH and grease are only 14 days. TOC is 28 days.
18. Fill out a chain-of-custody form for the sediment samples being sent to ALS Environmental. The COC form must be completed carefully and in its entirety to ensure proper analysis. This includes listing all of the specific parameters to be analyzed (see step 2), Azimuth and ALS contact names, and checking off all of the specific boxes for requested analyses. The ALS laboratory quote number must be printed on the COC form to ensure proper billing.
19. A digital COC form is most commonly used; this form can be filled out in advance to ensure accuracy and efficiency and amended in the field as required. However, using a digital copy of the COC requires printing 2 copies of the document in the field (one for the laboratory, one for Azimuth). Any questions regarding the COC form should be directed to the Azimuth project coordinator – Morgan Finley. Put the completed COC form in a sealed ziploc plastic bag in the cooler with the samples.

PACKAGING & SHIPPING SAMPLES:

1. Ensure all **sediment samples** are **sealed** securely. **Pack** sediment sampling containers upright in a cooler with ice packs, and packing material, to ensure containers do not break during transport. (Ideal storage and transport temperature is 4°C).

2. Ensure the COC form is enclosed and then seal the cooler(s). **Label the cooler**(s) with the following address:

   ALS Environmental
   101-8081 Lougheed Hwy.
   Burnaby, BC, Canada
   V5A 1W9
   Tel: 604-253-4188
   Attention: Brent Mack

3. Send completed **COC forms** and **field data forms** to **Azimuth** Consulting Group, attention the project coordinator – Morgan Finley and Eric Franz (efranz@azimuthgroup.ca).

APPENDIX D

UPDATED THRESHOLD AND TRIGGER DEVELOPMENT FOR CREMP WATER PARAMETERS

Updated threshold and trigger development for CREMP water parameters

Data – The data used to develop triggers were the standard control ("baseline") samples – duplicates and depth replicates were excluded as they are pseudo-replicates of standard samples. All baseline samples through December 2013 were used. The number of baseline samples collected for each system was 204 for Meadowbank, 34 for Wally, and 31 for Baker (total = 269). The development of triggers was based on baseline data specific to each system (Meadowbank, Wally, and Baker).

Methods – The main text has described the rationale and approach for development of thresholds and triggers. There were three basic methods of trigger development as follows:

1. When a threshold (e.g., CCME guideline) was established, the trigger was set as the maximum of either (a) the value halfway between the baseline median and the threshold ("Method A"), or (b) the 95th percentile of the baseline data ("Method B").
2. When a threshold was not established, the trigger was set equal to the maximum of either the 95th percentile of the baseline data ("Method B") or two times the current detection limit ("Method C").

Medians and 95th percentiles were chosen as metrics rather than means, standard deviations, or maximums, because the former are generally robust to skewed distributions and potential outliers. When required, robust methods were used to estimate medians and 95th percentiles to account for values below detection limits (i.e., censored data; Helsel 2012). The analytical procedures for a given variable were as follows. First, all data reported detection limits greater than the maximum observed value were removed (such values contain no information regarding summary statistics of the data distribution; Helsel 2012). Next, classical estimates of medians and 95th percentiles were computed if possible (i.e., when there was the required number of observations exceeding detection limits). When there was insufficient data to compute a classical estimate, the median and/or 95th percentile were estimated using the robust "Regression on Order Statistics" (ROS) method as recommended by Helsel (2012) and implemented in the function "cenros" in the R package NADA. However, Helsel (2012) suggests that estimates of summary statistics such as the median are typically unreliable when more than 80% of the observations are censored (below detection limits). Thus, ROS estimates were only used when at least 20% of the observations were above detection limits. When a threshold was established but there was no viable estimate of the median, the current detection limit was used in "Method A" above. When a threshold was not established and there was no viable estimate of the 95th percentile, "Method C" was used.

There were special considerations for several variables, specifically t-Al, t-Cd, t-Mn, t-Zn, d-Al, ammonia-N, t-P, pH and TSS. These cases are explained in detail below.

Results – Thresholds and triggers are summarized in **Tables 1-3** for total metals, dissolved metals, and nutrients/conventionals. Thresholds were established for 54 variables based on water-quality guidelines (**Table 4**). In most cases, the threshold was equal to a given guideline, but there were exceptions for a few variables as discussed below. Note that in cases where a

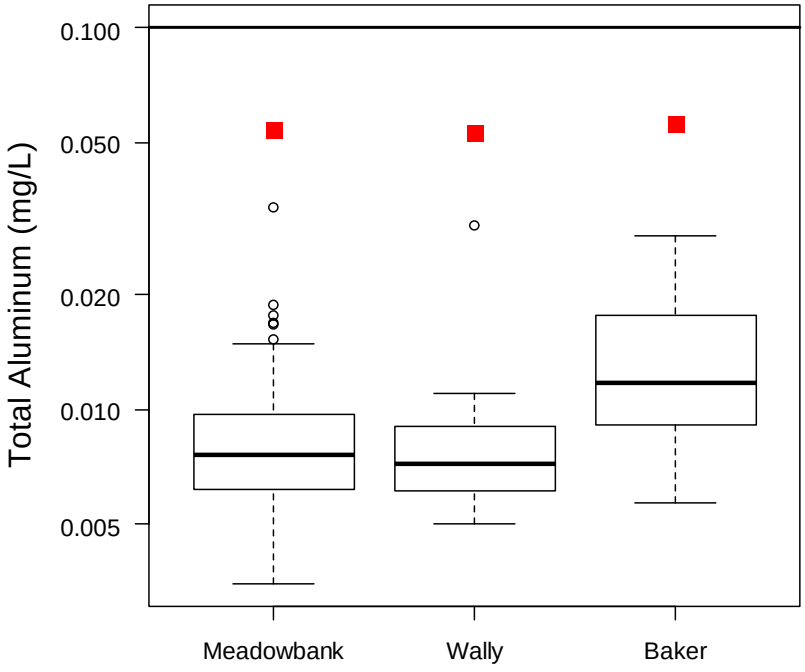
water quality guideline exists but Method B was used for trigger development (i.e., cases where baseline data already exceed the guideline for > 5% of cases), it is possible for the trigger to equal or exceed the guideline (e.g., this occurs for total phosphorus, the lower pH trigger for Meadowbank, and the Baker triggers for total and dissolved strontium). In such cases, the guideline is reported as the threshold but is not used as a criterion for action; rather, the trigger is the only criterion for action as is the case for variables lacking water quality guidelines.

There are three variables (t-Cu, t-Pb, t-Ni) for which the water quality guidelines are specific to water hardness ranges below 82, 60, and 60 mg/L $CaCO_3$, respectively. Hardness levels for Meadowbank, Wally, and Baker samples were consistently below 60 mg/L $CaCO_3$. For example, as reported in **Table 3**, the 95th percentiles for hardness were 8.5, 16.7, and 41.2 for Meadowbank, Wally, and Baker samples, respectively. Thus for these three variables, the guidelines associated with low hardness ranges were used as thresholds.

Special Cases – There were several variables that warranted special consideration in the development of thresholds and/or triggers. These are discussed in the following pages.

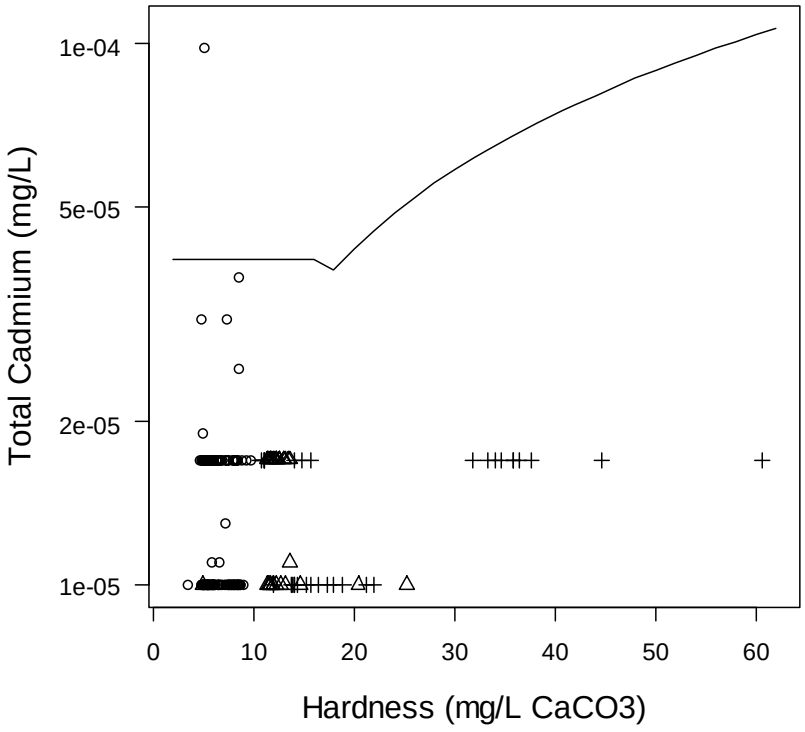
Total aluminum -- The CCME guideline for t-Al in water is 0.005 mg/L when pH < 6.5, and 0.1 mg/L when pH ≥ 6.5. Across baseline samples for Meadowbank/Wally/Baker (n = 269), there were only 9 cases of pH < 6.5 (two for station TPE, six for TPS, and one for INUG), of which only three were below pH = 6.47 (values = 6.18, 6.20, and 6.34). For these nine samples, only four t-Al measurements were above the current DL (0.005 mg/L), with a maximum value of 0.0076 mg/L.

Given the strong tendency for pH to equal or exceed 6.5 across baseline samples, the CCME guideline of 0.1 mg/L was adopted as the threshold for t-Al (**Table 1**). Triggers were computed for each system based on Method A (**Table 1**). For example, across the 204 Meadowbank samples, the median t-Al was 0.007 mg/L and the 95th percentile was 0.014 mg/L (**Table 1**). Based on Method A, the value halfway between the median t-Al and the threshold is 0.054 mg/L (i.e., [0.1 – 0.007]/2 = 0.054), which is larger than the 95% percentile (Method B), and thus the proposed trigger for Meadowbank t-Al is 0.054 mg/L. Similar trigger values were computed for Wally and Baker (**Table 1**). As an example, the following figure shows box-plots of t-Al values (> DL; in log scale) for each of Meadowbank/Wally/Baker, as well as the guideline (solid line) and proposed triggers (solid red squares).



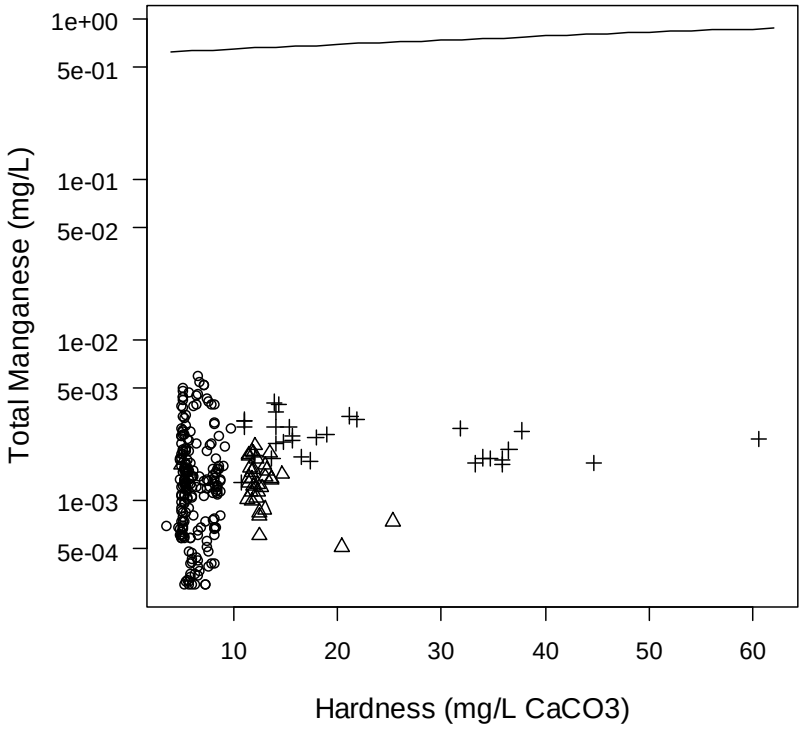
Total cadmium -- The hardness-dependent CCME guideline for t-Cd (mg/L) is 0.00004 when water hardness (mg/L $CaCO_3$) is less than 17.0, and equal to $0.001*10^{0.83*\log10(H)-2.46}$ (where H = hardness) when water hardness is ≥ 17.0 and ≤ 280. The relationship is illustrated in the figure below (solid curve) across the range of baseline observations of hardness for Meadowbank (circles), Wally (triangles), and Baker ("+"). Note that baseline measurements of t-Cd exceeded detection limits for only 10 of 204 Meadowbank samples and one of 34 Wally samples, and just one measure exceeded the CCME guideline (station TPE, hardness = 5.05, t-Cd = 0.000098 mg/L).

For simplicity, we propose a single t-Cd trigger applicable to all three systems (**Table 1**). The median sample values of hardness for Meadowbank (5.7), Wally (12.2), and Baker (16.5) were all less than 17.0 mg/L $CaCO_3$, and hence, the CCME guideline of 0.00004 mg/L was set as the threshold for each system. Because there were insufficient data to compute medians or 95th percentiles, the trigger was computed via Method A using the current detection limit (i.e., halfway between 0.00001 and 0.00004), providing a trigger value of 0.000025 (**Table 1**).



Total manganese -- There is no CCME water quality guideline for t-Mn. The hardness-dependent BC MOE guideline for t-Mn (mg/L) is 0.0044*H + 0.605, where H = hardness (mg/L $CaCO_3$). This guideline is based on numerous studies for fish, invertebrates and plants. The relationship is illustrated in the figure below (solid curve) across the range of baseline observations of hardness for Meadowbank (circles), Wally (triangles), and Baker ("+"). The guideline greatly exceeds observed t-Mn values for all samples.

For simplicity, we propose a single t-Mn trigger for each system. To compute the t-Mn trigger, we first computed the guidelines corresponding to the median values of hardness observed for Meadowbank samples (median hardness = 5.70, t-Mn guideline = 0.63), Wally samples (median hardness = 12.2, t-Mn guideline = 0.66), and Baker samples (median hardness = 16.5, t-Mn guideline = 0.68). The corresponding lake-specific triggers for t-Mn (using Method A) are 0.32 for Meadowbank, 0.33 for Wally, and 0.34 for Baker (**Table 1**).

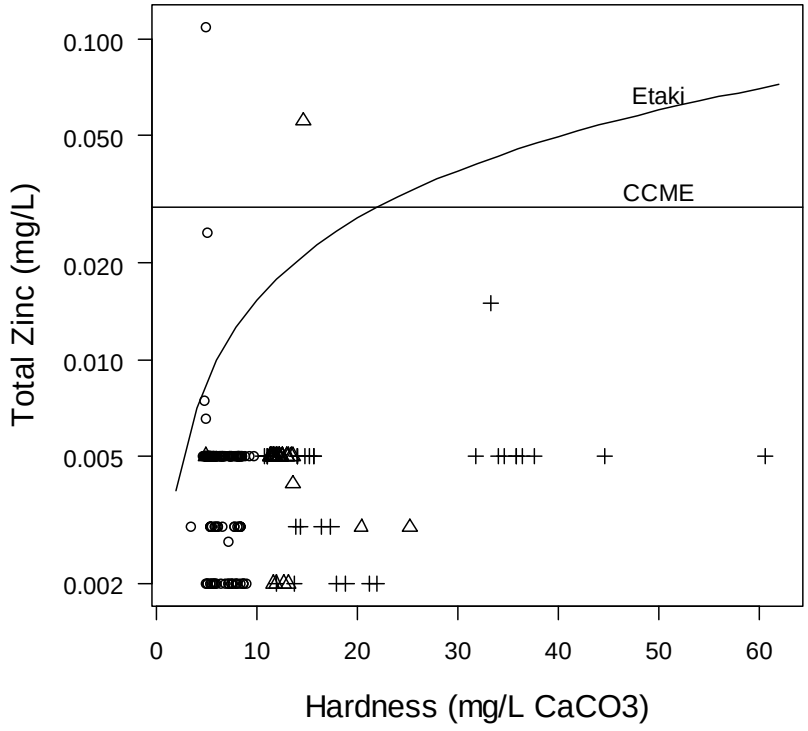


Total zinc -- The CCME water quality guideline for Zn is 0.030 mg/L. However, this guideline does not take into account hardness, and zinc toxicity is known to be hardness-dependent. An assessment for Ekati by EVS (2004) compiled data on species applicable to oligotrophic systems with low hardness, and developed a chronic benchmark for that was hardness dependent. The Ekati benchmark, denoted HC_5, represents the concentration of t-Zn at which 95% of species are likely to be protected against chronic effects (EVS 2004):

Hardness (mg/L CaCO3)	t-Zn level (HC_5) (mg/L)
5	0.0085
10	0.0153
15	0.0216
20	0.0276
25	0.0334
30	0.0389
35	0.0444
40	0.0497
45	0.0549
50	0.0600
55	0.0651
60	0.0700
65	0.0750
70	0.0798
75	0.0846
80	0.0894

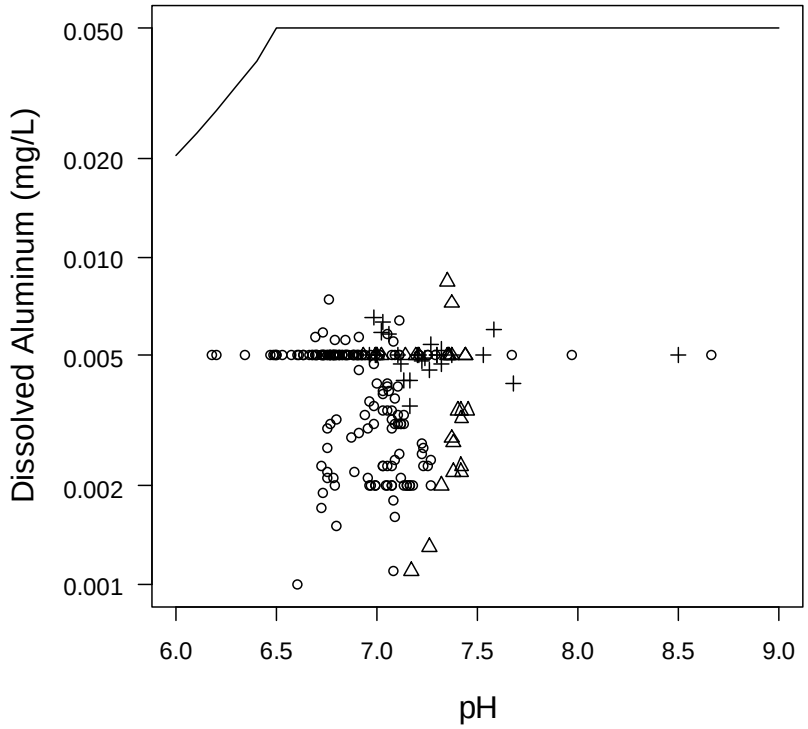
To express benchmarks as a continuous relationship, we fit a power function to the hardness-HC_5 data, which provided a near-perfect fit: t-Zn (HC_5) in mg/L $= 0.00217*H^{0.8486}$, where H = hardness (mg/L $CaCO_3$). This relationship is illustrated in the figure below (solid curve) across the range of baseline observations of hardness for Meadowbank (circles), Wally (triangles), and Baker ("+"). Note that the Ekati t-Zn benchmark is lower than the CCME guideline of 0.03 mg/L for hardness less than about 23. Only six of 269 baseline measurements of t-Zn have exceeded detection limits (four for Meadowbank, including the anomalous high value of t-Zn = 0.109 mg/L that occurred for station TPS in July 2009, and two for Wally).

As for t-Mn, we propose a single t-Zn trigger for each system. First, we computed the t-Zn benchmark (HC_5) corresponding to the median values of hardness observed for Meadowbank samples (median hardness = 5.70, t-Zn benchmark = 0.0095), Wally samples (median hardness = 12.2, t-Zn benchmark = 0.0181), and Baker samples (median hardness = 16.5, t-Zn benchmark = 0.0234). The corresponding lake-specific triggers for t-Zn (using Method A with the current DL = 0.003 mg/L) are 0.006 for Meadowbank, 0.011 for Wally, and 0.013 for Baker (**Table 1**).


0.100
0.050
0.020
0.010
0.005
0.002
Total Zinc (mg/L)
Etaki
CCME
0
10
20
30
40
50
60
Hardness (mg/L CaCO3)

Dissolved aluminum – There is no CCME guideline for d-Al in water. However, a pH-dependent water quality guideline for d-Al (mg/L) has been developed by BC MOE for protection of freshwater aquatic life. For pH < 6.5, the guideline is as follows: $d\text{-}Al = e^{(1.6-3.327*pH + 0.402*K)}$ where $K = pH^2$. For pH ≥ 6.5, the guideline is 0.05 mg/L. This relationship is illustrated in the figure below (solid curve) across the range of baseline observations of pH for Meadowbank (circles), Wally (triangles), and Baker ("+"). The BC MOE guideline greatly exceeds all observed values of d-Al.

Again, we propose a single d-Al trigger for each system. Based on the median pH observed for Meadowbank (6.89), Wally (7.35), and Baker (7.21), the corresponding BC MOE guideline for d-Al is 0.05 mg/L in each case. As documented in **Table 2**, the proposed triggers for d-Al (based on Method A and ROS estimates for median d-Al) are 0.026 for Meadowbank, 0.026 for Wally, and 0.027 for Baker.



Ammonia-N -- The CCME guideline for total ammonia in freshwater is pH and temperature dependent, with more stringent guidelines applying at higher pH and higher temperature. The proposed threshold for Ammonia-N (Meadowbank and Baker) was conservatively derived using two discrete CCME guidelines corresponding to specific pH and temperature values. Note that the maximum pH among baseline data for Meadowbank/Wally/Baker is 8.66, while maximum temperatures in the lakes are around 16 to 18 degrees. The two CCME guidelines that span these maximum (i.e., worst-case) conditions are as follows: (1) total ammonia = 0.239 mg/L for pH = 8.5 and temperature = 15 degrees; and (2) total ammonia = 0.067 mg/L for pH = 9.0 and temperature = 20 degrees. The mid-point of these two values is 0.153 mg/L, which when converted from total ammonia to total ammonia as N is 0.126 mg/L.

Thus, the proposed threshold for ammonia-N is 0.126 mg/L. Application of this threshold provided trigger values of 0.065, 0.067, and 0.067 mg/L respectively for Meadowbank, Wally, and Baker (**Table 3**). Only at extreme pH and temperature would this trigger potentially exceed the CCME guideline. Whenever the trigger is exceeded, the concentrations of ammonia-N should be compared to the CCME guideline based on the specific pH and field temperature of each sample.

Total P -- The CCME does not specify a particular guideline for total phosphorus, but instead establishes a guidance framework for site-specific application. Under that framework, the specification for ultra-oligotrophic lakes is for total-P of <0.004 mg/L. The framework notes that up to a 50% increase in total-P over baseline is generally considered acceptable. Regardless, the 95th percentiles for Total-P exceeded 0.004 mg/L for both Meadowbank samples and Baker samples (**Table 3**). Consequently, the proposed lake-specific triggers were set equal to these 95th percentiles (Method B, **Table 3**).

pH -- The CCME guideline for pH in freshwater is a range from 6.5 to 9.0. Thus, for pH, there is both an upper threshold (9.0) and a lower threshold (6.5), with associated upper and lower triggers (**Table 3**). In the case of Meadowbank data, the lower trigger was based on Method B because the 5th percentile of the baseline data was equal to the lower threshold of 6.50 (**Table 3**).

TSS -- For water bodies with low natural TSS, the CCME guideline is a maximum increase of 25 mg/L over background for short periods (e.g., 24h) and a maximum increase of 5 mg/L over background for longer periods (e.g., 24h to 30 days). If we conservatively assume a background TSS of 0 mg/L, then thresholds of 25 mg/L and 5 mg/L would apply for short-term and long-term exposures, respectively. However, because sampling occurs only at most once per month, it will be unknown whether a given TSS measure is a short-term (< 24 h) or longer term (> 24 h) phenomenon. We therefore propose a TSS trigger based on the lower threshold of 5 mg/L, which thereby addresses both short and long durations. The resulting triggers, based on Method A, were 3.0 mg/L for all three systems (**Table 3**).

Table 1. Total metals: summary of trigger values for Meadowbank, Wally, and Baker stations.

Notes: For each variable, thresholds (guidelines) are shown if applicable (see text for discussion); DL = current detection limit; N = sample measurements; >DL = number of measurements above DL; Med = median if estimable; P95 = 95th percentile if estimable; M = method used to determine the trigger, where A = halfway from median (or DL if median not estimable) to threshold, B = 95th percentile, and C = 2*DL.

			Meadowbank						**Wally**						**Baker**					
Variable	Threshold	DL	N	>DL	Med	P95	Trigger	M	N	>DL	Med	P95	Trigger	M	N	>DL	Med	P95	Trigger	M
Aluminum (T)	0.1	0.003	204	169	0.007	0.014	0.054	A	34	23	0.006	0.011	0.053	A	31	30	0.011	0.023	0.056	A
Antimony (T)	0.02	0.0001	204	0	NA	NA	0.010	A	34	0	NA	NA	0.010	A	31	0	NA	NA	0.010	A
Arsenic (T)	0.005	0.0001	204	14	NA	NA	0.0026	A	34	14	0.00025	0.00029	0.0026	A	31	4	0.00015	NA	0.0026	A
Barium (T)	1.0	0.00005	204	79	0.0021	0.0030	0.50	A	34	14	0.0019	0.0030	0.50	A	31	14	0.0177	0.0196	0.51	A
Beryllium (T)	0.0053	0.0001	204	0	NA	NA	0.0027	A	34	0	NA	NA	0.0027	A	31	0	NA	NA	0.0027	A
Boron (T)	1.5	0.01	204	1	NA	NA	0.76	A	34	0	NA	NA	0.76	A	31	3	0.011	0.011	0.76	A
Cadmium (T)	0.00004	0.00001	204	10	NA	NA	0.000025	A	34	1	NA	NA	0.000025	A	31	0	NA	NA	0.000025	A
Chromium (T)	0.001	0.0001	204	14	0.00011	0.00046	0.00056	A	34	0	NA	NA	0.00055	A	31	2	NA	NA	0.00055	A
Copper (T)	0.002	0.0005	204	61	0.00047	0.00068	0.00124	A	34	16	0.00098	0.00129	0.00149	A	31	11	0.00049	0.00060	0.00125	A
Iron (T)	0.3	0.01	204	26	NA	NA	0.155	A	34	6	0.015	0.025	0.157	A	31	9	0.020	0.063	0.160	A
Lead (T)	0.001	0.00005	204	7	NA	NA	0.00053	A	34	2	NA	0.00015	0.00053	A	31	1	NA	NA	0.00053	A
Lithium (T)	0.096	0.0005	204	6	0.00042	0.00063	0.048	A	34	2	0.00085	NA	0.048	A	31	6	0.0010	0.0036	0.048	A
Manganese (T)	See text	0.00005	204	198	0.0013	0.0043	0.316	A	34	34	0.0014	0.0020	0.330	A	31	31	0.0024	0.0038	0.340	A
Mercury (T)	0.000026	0.00001	204	1	NA	NA	0.000018	A	34	0	NA	NA	0.000018	A	31	0	NA	NA	0.000018	A
Molybdenum (T)	0.073	0.00005	204	5	NA	NA	0.037	A	34	3	0.00013	0.00019	0.037	A	31	4	0.00008	NA	0.037	A
Nickel (T)	0.025	0.0005	204	8	0.0005	0.0007	0.013	A	34	0	NA	NA	0.013	A	31	0	NA	NA	0.013	A
Selenium (T)	0.001	0.0001	204	0	NA	NA	0.00055	A	34	0	NA	NA	0.00055	A	31	0	NA	NA	0.00055	A
Strontium (T)	0.049	0.0002	192	188	0.0068	0.0095	0.028	A	32	32	0.016	0.022	0.033	A	31	31	0.025	0.056	0.056	B
Thallium (T)	0.0008	0.00001	204	0	NA	NA	0.00041	A	34	0	NA	NA	0.00041	A	31	0	NA	NA	0.00041	A
Tin (T)		0.0001	204	2	NA	NA	0.0002	C	34	0	NA	NA	0.0002	C	31	0	NA	NA	0.0002	C
Titanium (T)	2.0	0.01	204	14	0.00016	0.00044	1.0	A	34	3	0.00013	0.00049	1.0	A	31	4	0.00038	NA	1.0	A
Uranium (T)	0.015	0.00001	204	20	0.00004	0.00006	0.0075	A	34	2	0.00004	NA	0.0075	A	31	4	0.00005	NA	0.0075	A
Vanadium (T)	0.006	0.001	204	0	NA	NA	0.0035	A	34	0	NA	NA	0.0035	A	31	0	NA	NA	0.0035	A
Zinc (T)	See text	0.003	204	4	NA	NA	0.0063	A	34	2	NA	NA	0.0106	A	31	0	NA	NA	0.0132	A

Table 2. Dissolved metals: summary of trigger values for Meadowbank, Wally, and Baker stations.

Notes: For each variable, thresholds (guidelines) are shown if applicable (see text for discussion); DL = current detection limit; N = sample measurements; >DL = number of measurements above DL; Med = median if estimable; P95 = 95th percentile if estimable; M = method used to determine the trigger, where A = halfway from median (or DL if median not estimable) to threshold, B = 95th percentile, and C = 2*DL.

			Meadowbank						**Wally**						**Baker**					
Variable	Threshold	DL	N	>DL	Med	P95	Trigger	M	N	>DL	Med	P95	Trigger	M	N	>DL	Med	P95	Trigger	M
Aluminum (D)	0.05	0.001	164	69	0.003	0.005	0.026	A	27	13	0.003	0.006	0.026	A	28	17	0.005	0.006	0.027	A
Antimony (D)	0.02	0.0001	164	0	NA	NA	0.010	A	27	0	NA	NA	0.010	A	28	0	NA	NA	0.010	A
Arsenic (D)	0.005	0.0001	164	12	NA	NA	0.0026	A	27	13	0.00024	0.00034	0.0026	A	28	6	0.00012	0.00024	0.0026	A
Barium (D)	1.0	0.00005	164	79	0.0020	0.0029	0.50	A	27	13	0.0018	0.0030	0.50	A	28	14	0.0178	0.0200	0.51	A
Beryllium (D)	0.0053	0.0001	164	0	NA	NA	0.0027	A	27	0	NA	NA	0.0027	A	28	0	NA	NA	0.0027	A
Boron (D)	1.5	0.01	164	0	NA	NA	0.76	A	27	0	NA	NA	0.76	A	28	0	NA	NA	0.76	A
Cadmium (D)	0.00004	0.00001	164	3	NA	NA	0.000025	A	27	0	NA	NA	0.000025	A	28	0	NA	NA	0.000025	A
Chromium (D)	0.001	0.0001	164	1	NA	NA	0.00055	A	27	0	NA	NA	0.00055	A	28	1	NA	NA	0.00055	A
Copper (D)	0.002	0.0002	164	77	0.00038	0.00049	0.00119	A	27	15	0.00087	0.00148	0.00148	B	28	13	0.00033	0.00044	0.00116	A
Iron (D)	0.3	0.01	164	0	NA	NA	0.155	A	27	0	NA	NA	0.155	A	28	1	NA	NA	0.155	A
Lead (D)	0.001	0.00005	164	3	NA	NA	0.00053	A	27	2	NA	0.00015	0.000525	A	28	0	NA	NA	0.000525	A
Lithium (D)	0.096	0.0005	164	2	NA	0.00053	0.048	A	27	2	0.00099	NA	0.048	A	28	4	0.0008	NA	0.048	A
Manganese (D)	See text	0.00005	164	114	0.0004	0.0029	0.315	A	27	22	0.0004	0.0015	0.330	A	28	24	0.0006	0.0019	0.339	A
Mercury (D)	0.000026	0.00001	153	2	NA	NA	0.000018	A	25	0	NA	NA	0.000018	A	26	0	NA	NA	0.000018	A
Molybdenum (D)	0.073	0.00005	164	17	0.00010	0.00018	0.037	A	27	8	0.00011	0.00019	0.037	A	28	3	0.00006	NA	0.037	A
Nickel (D)	0.025	0.0005	164	6	NA	NA	0.013	A	27	1	NA	NA	0.013	A	28	0	NA	NA	0.013	A
Selenium (D)	0.001	0.0001	164	0	NA	NA	0.00055	A	27	0	NA	NA	0.00055	A	28	0	NA	NA	0.00055	A
Strontium (D)	0.049	0.002	164	161	0.0069	0.0090	0.028	A	27	27	0.016	0.023	0.033	A	28	28	0.023	0.049	0.049	B
Thallium (D)	0.0008	0.00001	164	0	NA	NA	0.00041	A	27	0	NA	NA	0.00041	A	28	0	NA	NA	0.00041	A
Tin (D)		0.0001	164	0	NA	NA	0.0002	C	27	0	NA	NA	0.0002	C	28	0	NA	NA	0.0002	C
Titanium (D)	2.0	0.01	164	0	NA	NA	1.0	A	27	0	NA	NA	1.0	A	28	0	NA	NA	1.0	A
Uranium (D)	0.015	0.00001	164	20	0.00003	0.00005	0.0075	A	27	2	0.00004	NA	0.0075	A	28	4	0.00004	NA	0.0075	A
Vanadium (D)	0.006	0.001	164	0	NA	NA	0.0035	A	27	0	NA	NA	0.0035	A	28	0	NA	NA	0.0035	A
Zinc (D)	See text	0.001	164	6	NA	0.0021	0.0053	A	27	2	NA	NA	0.0096	A	28	2	NA	0.0028	0.0122	A

Table 3. Nutrients and conventional parameters: summary of trigger values for Meadowbank, Wally, and Baker stations.

Notes: For each variable, thresholds (guidelines) are shown if applicable (see text for discussion); DL = current detection limit; N = sample measurements; >DL = number of measurements above DL; Med = median if estimable; P95 = 95th percentile if estimable; M = method used to determine the trigger, where A = halfway from median (or DL if median not estimable) to threshold, B = 95th percentile, and C = 2*DL. **Red bolded** text indicates parameter values that are new for 2014 reporting (Azimuth, 2015).

			Meadowbank						**Wally**						**Baker**					
Variable	Threshold	DL	N	>DL	Med	P95	Trigger	M	N	>DL	Med	P95	Trigger	M	N	>DL	Med	P95	Trigger	M
Ammonia-N	0.126	0.005	204	52	0.005	0.046	0.065	A	34	12	0.007	0.024	0.067	A	31	13	0.007	0.031	0.067	A
TKN		0.05	204	178	0.097	0.170	0.170	B	34	31	0.111	0.163	0.163	B	31	28	0.157	0.214	0.214	B
Nitrate-N	3.0	0.005	204	26	NA	0.025	1.503	A	34	2	NA	NA	1.503	A	31	26	0.014	0.030	1.507	A
Nitrite-N	0.06	0.001	204	6	NA	NA	0.031	A	34	2	NA	NA	0.031	A	31	2	NA	NA	0.031	A
Ortho-phosphate		0.001	192	10	NA	0.0010	0.0020	C	34	3	NA	0.0010	0.0020	C	31	5	0.0007	0.0013	0.0020	C
T. phosphorous	0.004	0.002	192	84	0.0019	0.0060	0.0060	B	34	21	0.0028	0.0067	0.0067	B	31	23	0.0036	0.0096	0.0096	B
TOC		0.5	204	204	1.74	2.79	2.79	B	34	34	2.18	4.11	4.11	B	31	31	3.16	4.25	4.25	B
DOC		0.5	204	204	1.70	2.60	2.60	B	34	34	2.20	3.21	3.21	B	31	31	3.17	4.05	4.05	B
Reactive silica		0.5	185	56	0.28	0.44	1.00	C	32	14	0.74	1.08	1.08	B	28	10	0.31	0.42	1.00	C
Bicarb. alkalinity		2.0	192	192	5.2	8.6	8.6	B	34	34	10.0	17.8	17.8	B	31	31	9.3	10.6	10.6	B
Chloride	120	0.1	204	141	0.550	0.809	60.3	A	34	15	0.469	0.639	60.2	A	31	31	24.4	95.7	95.7	B
Carb. alkalinity		2.0	192	0	NA	NA	4.0	C	34	0	NA	NA	4.0	C	31	0	NA	NA	4.0	C
Conductivity		2.0	204	204	15.2	23.5	23.5	B	34	34	28.7	36.6	36.6	B	31	31	110.0	494.5	494.5	B
Hardness		0.5	204	204	5.7	8.5	8.5	B	34	34	12.2	16.7	16.7	B	31	31	16.5	41.2	41.2	B
Calcium		0.5	204	204	1.30	2.15	2.15	B	34	34	3.34	4.88	4.88	B	31	31	3.02	4.50	4.50	B
Potassium		0.1	204	79	0.37	0.50	0.50	B	34	14	0.37	0.59	0.59	B	31	20	0.93	2.43	2.43	B
Magnesium		0.1	204	204	0.64	0.83	0.83	B	34	34	0.96	1.36	1.36	B	31	31	2.61	7.44	7.44	B
Sodium		0.05	204	79	0.55	0.98	0.98	B	34	14	0.48	0.72	0.72	B	31	31	12.1	54.0	54.0	B
Sulphate	128	0.5	204	204	1.42	2.83	64.7	A	34	34	2.34	3.38	65.2	A	31	31	3.84	13.80	65.9	A
pH **Field** (Upper)	**9.0**	**0.1**	**174**	**174**	**7.24**	**8.25**	**8.25**	**B**	**32**	**32**	**7.67**	**8.26**	**8.34**	**A**	**26**	**26**	**7.41**	**8.32**	**8.32**	**B**
pH **Field** (Lower)	**6.5**	**0.1**	**174**	**174**	**7.24**	**6.30**[a]	**6.30**	**B**	**32**	**32**	**7.67**	**6.54**[a]	**6.54**	**B**	**26**	**26**	**7.41**	**6.50**[a]	**6.50**	**B**
pH Lab (Upper)	9.0	0.1	204	204	6.89	7.27	7.94	A	34	34	7.35	7.44	8.17	A	31	31	7.21	7.66	8.11	A
pH Lab (Lower)	6.5	0.1	204	204	6.89	6.50[a]	6.50	B	34	34	7.35	7.00[a]	**6.92**	A	31	31	7.21	6.99[a]	**6.86**	A
Total Alkalinity		2.0	192	192	5.20	8.55	8.55	B	34	34	10.0	17.8	17.8	B	31	31	9.3	10.6	10.6	B
TDS		3.0	204	134	11.0	18.0	18.0	B	34	34	18.0	25.3	25.3	B	31	31	64.0	208.0	208.0	B
TSS	5.0	1.0	204	9	NA	NA	3.00	A	34	1	NA	NA	3.00	A	31	2	NA	NA	3.00	A

[a] For pH (Lower), the 5th percentile is reported.

Table 4. Summary of thresholds for water variables.

Variable	Source	Description of guidelines
t-Aluminum (Al)	CCME	The CCME guideline for t-Al in water is 0.005 mg/L when pH < 6.5, and 0.1 mg/L when pH ≥ 6.5. See text for details.
t-Arsenic (As) **d-Arsenic	CCME	The CCME water quality guideline (aquatic life) for t-As is 0.005 mg/L.
t-Boron (B) **d-Boron	BC MOE	There is no CCME guideline for t-B. However, the BC Ministry of Environment (BC MOE, www.env.gov.bc.ca) guideline for freshwater aquatic life is 1.2 mg/L.
t-Cadmium (Cd) **d-Cadmium	CCME	The hardness-dependent CCME guideline for t-Cd (mg/L) is 0.00004 mg/L when hardness > 0 to < 17 mg/L $CaCO_3$ and is $0.001*10^{0.83*\log(H)-2.46}$ where H = hardness (mg/L $CaCO_3$) when hardness is >= 17 to <= 280 mg/L $CaCO_3$. For hardness > 280 mg/L $CaCO_3$, the guideline is 0.00037 mg/L.
t-Chromium (Cr) **d-Chromium	CCME	The CCME guideline for hexavalent chromium (the most common form in surface waters) is 0.001 mg/L.
t-Copper (Cu) **d-Copper	CCME	The CCME guideline for t-Cu is 0.002 mg/L for hardness < 82 mg/L $CaCO_3$.
t-Iron (Fe) **d-Iron	CCME	The CCME guideline for t-Fe is 0.3 mg/L.
t-Lead (Pb) **d-Lead	CCME	The CCME guideline for t-Pb is 0.001 mg/L for hardness < 60 mg/L $CaCO_3$.
t-Manganese (Mn) **d-Manganese	BC MOE	There is no CCME guideline for t-Mn in water. The hardness-dependent BC MOE guideline for t-Mn in mg/L is 0.0044*H + 0.605, where H = hardness (mg/L $CaCO_3$). See text for details.
t-Mercury (Hg) **d-Mercury	CCME	The CCME guideline for total inorganic mercury is 26 ng/L (0.00026 mg/L).
t-Molybdenum (Mo) **d-Molybdenum	CCME	The CCME guideline for t-Mo in water is 0.073 mg/L.
t-Nickel (Ni) **d-Nickel	CCME	The CCME guideline for t-Ni is 0.025 mg/L for hardness < 60 mg/L $CaCO_3$.
t-Selenium (Se) **d-Selenium	CCME	The CCME guideline for t-Se in water is 0.001 mg/L.
t-Thallium (Tl) **d-Thallium	CCME	The CCME water quality guideline for t-Tl is 0.0008 mg/L.
t-Zinc (Zn) **d-Zinc	CCME Ekati	The CCME water quality guideline for t-Zn is 0.030 mg/L. However, this guideline does not take into account hardness, and zinc toxicity is known to be hardness-dependent. An assessment for Ekati by EVS (2004) compiled data on species applicable to oligotrophic systems with low hardness, and developed a chronic benchmark for t-Zn that was

		hardness dependent. See text for details.
d-Aluminum (Al)	BC MOE	A pH-dependent water quality guideline for d-Al (mg/L) has been developed by BC MOE for protection of freshwater aquatic life when pH <6.5 as follows: $d\text{-}Al = e^{(1.6-3.327*pH + 0.402*K)}$ where $K = pH^2$. For pH >= 6.5 the guideline is 0.05 mg/L See text for details.
Ammonia-N	CCME	The CCME guidelines for total ammonia in freshwater are pH and temperature dependent, with more stringent guidelines applying at higher pH and higher temperature. See text for details.
Nitrate-N	CCME	The CCME guideline for NO3-N is 2.9 mg/L.
Nitrite-N	CCME	The CCME guideline for nitrite-N is 0.06 mg/L.
t-Phosphorous (P)	CCME	The CCME does not specify a particular guideline for t-P, but instead establishes a guidance framework for site-specific application. See text for details.
pH	CCME	The CCME guideline for pH is a range from 6.5 to 9.0. See text for details.
TSS	CCME	For water bodies with low natural TSS, the CCME guideline is a maximum increase of 25 mg/L over background for short periods (e.g., 24h) and 5 mg/L for longer periods (e.g., 24h to 30 days). See text for details.

****** where thresholds for total metals were developed, those thresholds were also applied to dissolved metal parameters.