Volume 2 -

Aquatic Effects Monitoring Program Design Plan Framework

Aquatic Effects Monitoring Program Design Plan Framework

for the

Pine Point Project

Purpose

This framework document is provided in support of the Mackenzie Valley Environmental Impact Review Board (MVEIRB) Environmental Assessment Initiation Package for the Pine Point Project (Project). The intent of this document is to describe how this environmental mitigation and monitoring plan relates to the Project, what information will be provided as the Project develops and to list applicable guidelines and standards. It was developed with the available Project information. This document is not intended for approval but is provided for review purposes and will be refined as the regulatory process proceeds.

Version History

The Pine Point Mining Limited is responsible for the distribution, maintenance, and updating of this document. Changes that do not affect the intent of the document will be made as required (e.g., phone numbers, names of individuals). The table below indicates the version of this document, and a summary of revisions made.

Revision #	Section(s) Revised	Description of Revision	Issue Date
0	-	Framework version for MVEIRB Initiation Package	15 December 2020

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Figures

Abbreviations

Abbreviation	Definition
AEMP	Aquatic Effects Monitoring Program
AEMP Framework	Aquatic Effects Monitoring Program Design Plan Framework
Beak	Beak Consultants Ltd.
CCME	Canadian Council of the Ministry of Environment
Cominco	Cominco Ltd.
EA	environmental assessment
EBA	EBA Engineering Consultants Ltd.
EEM	Environmental Effects Monitoring
GNWT	Government of the Northwest Territories
Golder	Golder Associates Ltd.
ITK	Indigenous Traditional Knowledge
MVLWB	Mackenzie Valley Land and Water Board
NWT	Northwest Territories
QA	quality assurance
QC	quality control
PPML	Pine Point Mining Limited
the historical mine	Historical Pine Point Mine
Project	Pine Point Project
VCs	valued components

Units of Measure

Units	Definition
%	percent
ºC	degrees Celsius
km	kilometre
km^2	square kilometre
km^3	cubic kilometre
masl	metres above sea level
m	metre
m^3/s	cubic metres per second

1 INTRODUCTION

1.1 Background

Pine Point Mining Limited (PPML) is the sole proponent of the Pine Point Project (Project) and is a 100% owned subsidiary of Osisko Metals Incorporated. PPML acquired the Project in February 2018 with the objective of redeveloping a mine at the Pine Point property, which is a brownfield site resulting from historical mining and milling activities by Cominco Ltd (Cominco). PPML is proposing to mine mineralized material and produce concentrates of lead and zinc for shipment to independent smelters worldwide. The Project will consist of open pit and underground mining for zinc and lead.

1.2 Purpose and Scope

An Aquatic Effects Monitoring Program (AEMP) is a requirement of a Type A Water Licence. The purpose of the AEMP will be to provide a systematic framework to monitor and assess environmental effects from the Project on surrounding watercourses, and to respond with appropriate actions if, or when adverse effects from the Project are identified.

This AEMP Design Plan Framework (AEMP Framework) was developed to support the Mackenzie Valley Environmental Impact Review Board Environmental Assessment (EA) Initiation Package for the Project. It is intended to provide a preliminary outline of approaches to monitoring, data analysis, and the Response Framework for the AEMP. This AEMP Framework is based on guidance provided in the *Guidelines for Aquatic Effects Monitoring Programs* (MVLWB/GNWT 2019). The AEMP Framework is meant to provide a basis for PPML to engage with regulatory agencies and Indigenous communities and elicit feedback on the planned aquatic effects monitoring activities associated with the Project. An updated, conceptual AEMP Design Plan for the Project will be developed during the permitting phase of the Project (i.e., for water licencing) or potentially earlier, if required, based on feedback through the EA process. The conceptual AEMP Design Plan will incorporate the feedback received on this AEMP Framework, as well advancement in the Project design and water balance studies. A final AEMP Design Plan will be submitted to the Mackenzie Valley Land and Water Board (MVLWB) for approval prior to commencement of monitoring activities.

1.3 Document Organization

The content of this AEMP Framework follows the *Guidelines for Aquatic Effects Monitoring Programs* (MVLWB/GNWT 2019). To meet the EA requirements (MVEIRB 2018) and provide appropriate supporting information, this document is organized as follows:

- Section 2 – Project Description: briefly describes the Project.
- Section 3 – Description of the Environment: briefly describes the environmental setting around the Project, including traditional uses and a description of the relevant environmental components that could be affected by the Project.
- Section 4 – Problem Formulation: describes the issues that may need to be tracked throughout the monitoring program and provides a conceptual site model which identifies and describes potential pathways of exposure.

- Section 5 – AEMP Design: provides a framework for the conceptual study design, which includes a brief description of the study area and a preliminary sampling design (i.e., provides options for the where, when, and how).
- Section 6 – Methods and Analysis: describes an overview of component-specific details related to the sampling design for consideration in the conceptual AEMP design (i.e., field methods and data analysis approach).
- Section 7 – Special Studies: describes the purpose of special studies that may be conducted as part of the AEMP.
- Section 8 – Response Framework: describes the purpose of AEMP Response Framework, which will be developed for the AEMP Study Design.
- Section 9 – AEMP Reporting: describes the AEMP reporting system.
- Section 10 – References: provides the list of references.

1.4 Objectives

The objective of the AEMP will be to assess mine-related effects on watercourses in the area surrounding the Project in a scientifically defensible manner. The AEMP will provide the necessary data to inform adaptive management of potential aquatic effects resulting from operation of the proposed Pine Point Mine. The AEMP is one of the monitoring programs and management plans that will be employed to make decisions on reducing the magnitude, frequency, and extent of effects on the environment.

The objective of the AEMP Framework is to provide an initial high-level outline of the AEMP for the Project to allow for engagement on the AEMP Framework prior to developing the AEMP Design Plan for the Water Licence.

1.5 Aquatic Effect Monitoring Program Team and Accountability

1.5.1 Corporate Contact Information

Primary Pine Point Mining Limited Contact	Andrew Williams
Title	Environmental Manager
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Province	Québec
Postal Code	H3B 2S2
Telephone	416-209-2056
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1.5.2 Consultant Contact Information

Golder Associates Ltd. (Golder) will support PPML in developing and implementing the AEMP for the Project. Key contacts for this AEMP Framework are:

Damian Panayi
Project Director
Golder Associates Ltd.
4905 48 St. #9, Yellowknife, NWT, X1A 3S3
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1.6 Traditional Knowledge and Engagement

Indigenous Traditional Knowledge (ITK), also known as Indigenous Knowledge, is sought for use in environmental monitoring programs by involving Indigenous communities in program planning and implementation and providing opportunities for community members to share ITK with those involved in the program.

PPML will complete a thorough engagement process throughout the EA process and leading up the Water Licence application to gather input from stakeholders on the EA and documents to be submitted to support the Water Licence. PPML has identified a number of Indigenous communities, municipal, territorial, and federal government agencies, and other interested organizations as parties to be engaged as part of the process. These parties, and the details of the planned engagement activities, are presented in the Engagement and Collaboration Framework for the Project (Volume 2).

1.7 Regulatory Instruments for AEMP

Following the EA process, the Project will enter the permitting phase of the Project. A Type A Water Licence for Mining and Milling will be required for the Project and will be applied for after approval of the EA. The Water Licence is required prior to beginning construction to ensure that the construction, operation, and closure and reclamation of the Project complies with the *Mackenzie Valley Resource Management Act* and the *Waters Act*. Other permits and authorizations relevant to the Project will also be applied for and would require approval to be granted prior to construction and operation (i.e., an Aurora Research Institute Scientific Research Licence and a Fisheries and Oceans Canada *Fisheries Act* Authorization).

2 PROJECT DESCRIPTION

The Project is located in the Northwest Territories (NWT) within the South Slave Mining District, south of Great Slave Lake, approximately 175 km directly south of Yellowknife, 75 km east of Hay River, and 53 km southwest of Fort Resolution (Figure 1). The closest major transportation hubs are Yellowknife and Hay River. Access to the Project is presently via all-weather Highways 5 and 6.

A description of the Project, including a summary of the site history and Project components and alternatives is provided in the Project Description (Volume 1). The Project will consist of open pit and underground mining for lead and zinc, construction and operation of a processing mill (or “concentrator”) and pre-concentration facilities, storage and management of mineralization waste and water, construction and operation of ancillary support facilities including a camp for workers, and the transportation of zinc and lead concentrates to global markets. As much as possible, the construction of processing facilities, the camp, and ancillary support structures will be located on previously disturbed land.

The Project includes underground mines in the areas west of the Buffalo River and open-pit mining in the sector east of the Buffalo River. The area surrounding the Project includes approximately 50 existing open pits, which were developed during previous mining activity. Existing open pits will be used to manage waste rock generated from future mining and from pre-concentration (rejects). Tailings and mine water will also be stored in the existing open pits. Water stored in existing pits during operation may include excess water from tailings, mine dewatering, dust suppression, and drainage systems from the vehicle and machinery maintenance facilities.

The use of the existing open pits for water storage is currently the preferred approach for the management of mine water on site; however, direct discharge to the aquatic receiving environment may be used as an alternative, if required. As part of the ongoing design of water management for the Project, a water balance will be developed to understand the capacity of existing pits, and the need for mine water discharge will be determined; if required, potential discharge location(s) will be selected.

Sewage and domestic wastewater from the camp and other facilities will be sent to a septic system or, as an alternative, to a sewage treatment plant and then discharged to the environment. Surface water runoff for the site will be managed using ditches and collection ponds, and potentially other infrastructure.

Water use for the project will include water requirements related to the mine process and for domestic water use. The quantity of water needed will be evaluated as part of ongoing design of water management for the Project. It is anticipated that water will be withdrawn from Great Slave Lake using infrastructure previously developed by Cominco.

The conceptual project timeline for the permitting, construction, and operational stages are presented in the Project Description (Volume 1, Section 1.0).

LEGEND

- FORMER PINE POINT TOWN SITE
- POPULATED PLACE
- ALL-SEASON ROAD
- PARK/PROTECTED AREA
- WATERBODY
- GENERAL PROJECT LOCATION

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REFERENCE(S)

1. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
2. PARKS AND PROTECTED AREAS OBTAINED FROM CONSERVATION AREAS REPORTING AND TRACKING SYSTEM (CARTS), CANADIAN COUNCIL ON ECOLOGICAL AREAS, 2017.

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CLIENT
PINE POINT MINING LTD.

PROJECT
PINE POINT PROJECT

CONSULTANT
GOLDER

YYYY-MM-DD	2020-10-07
DESIGNED	DC
PREPARED	BW / MM / JE
REVIEWED	DP
APPROVED	DP

TITLE
PROJECT LOCATION

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3 DESCRIPTION OF THE ENVIRONMENT

3.1 General Setting

The Project is located at the edge of the Boreal Plains and Taiga Plains Ecozones, and within the Slave River and Hay River Lowland Ecoregions. These ecoregions are classified as having a sub-humid, mid-boreal ecoclimate (Environment Canada 2000, as cited in EBA 2005a). The area is characterized by short, cool summers and long, cold winters. The average monthly temperatures in 2019 at the closest monitoring stations (Hay River Airport) ranged from a minimum of -22.7°C in February to maximum of 15.5°C in July. The winter months are typically the driest with the most precipitation usually occurring in August.

The two nearest drainages in the area of the Project are the Buffalo River and Twin Creek. These watercourses flow north into Great Slave Lake. Figure 2 illustrates the location of these waterbodies.

The Project is located in an area of sporadic discontinuous permafrost with generally subdued topography, which suggests that between 10% and 50% of the land area is underlain by permafrost, and the ground ice content in the upper 10 to 20 m of the ground is low. The vegetation in the surrounding area is characterized by medium to tall, closed stands of jack pine and trembling aspen. White and black spruce dominate older stands of forest. Poorly drained fens and bogs in this region are covered with low, open stands of larch, black spruce, and ericaceous shrubs (Environment Canada 2000, as cited in EBA 2005a). Wildfires have been a common occurrence in the region.

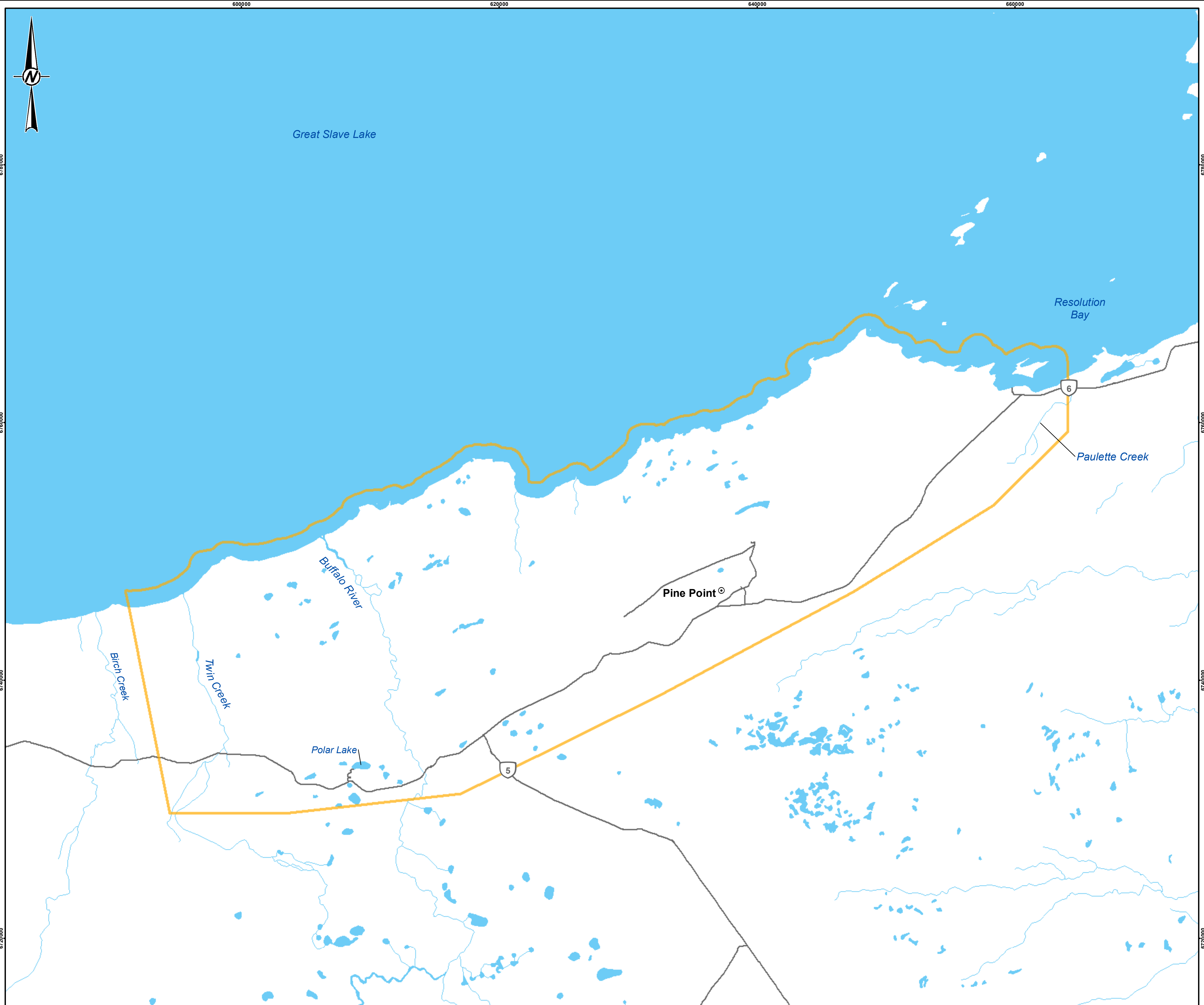
Hunting, fishing, and trapping activities occur in the vicinity of the Project. Wildlife identified as being present and/or harvested include caribou, moose, wood bison, lynx, wolf, otter, black bear, rabbit, porcupine, ptarmigan, ruffed grouse, and waterbirds. Fishing for subsistence, recreational and commercial purposes also occurs in the vicinity of the Project.

3.2 Existing Conditions

The environmental components that could be affected by the Project and that are relevant to the AEMP include, surface water quantity, water quality, and fish and fish habitat. A brief summary of existing environmental conditions pertaining to these components is included below; additional details are provided in the Existing Environment for the Pine Point Project (Golder 2020a).

3.2.1 Surface Water Quantity

As indicated above, the two main drainages located in the immediate area of the Project are the Buffalo River and Twin Creek. Twin Creek is a small stream that drains several small lakes and wetlands approximately 20 km to the south of the Highway 5 northward into Great Slave Lake. The drainage area of Twin Creek at the mouth of Great Slave Lake is approximately 220 km^2. The overall length of Twin Creek is approximately 45 km, with a typical seasonal water flow and higher flows occurring during spring snow melt (EBA 2005b). The stream channel is often undefined and flows through sphagnum bogs (EBA 2005b). After turning into a large, open, almost treeless, and swampy area, the stream re-emerges as a defined creek channel before reaching Great Slave Lake (Beak 1980).



LEGEND

- FORMER PINE POINT TOWN SITE
- ALL-SEASON ROAD
- WATERCOURSE
- GENERAL PROJECT LOCATION
- WATERBODY

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1:300,000 KILOMETRES

REFERENCE(S)

1. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
2. PARKS AND PROTECTED AREAS OBTAINED FROM CONSERVATION AREAS REPORTING AND TRACKING SYSTEM (CARTS), CANADIAN COUNCIL ON ECOLOGICAL AREAS, 2017.
3. POTENTIAL EFFLUENT DISCHARGE LOCATIONS PROVIDED BY ANDRÉE DROLET, PPML, BY EMAIL ON 27 JUNE 2019.

PROJECTION: UTM ZONE 11 DATUM: NAD 83

CLIENT

PINE POINT MINING LTD.

PROJECT

PINE POINT PROJECT

TITLE

WATERCOURSES AND WATERBODIES IN THE AREA SURROUNDING THE PROJECT

CONSULTANT

GOLDER

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DESIGNED	SB
PREPARED	MM
REVIEWED	KM
APPROVED	KM

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Buffalo River is a large river originating from Buffalo Lake located in the southernmost portion of the NWT. It receives drainage from many other small lakes and wetlands upstream (south) and northward towards Great Slave Lake. The total drainage area of the Buffalo River where it empties into Great Slave Lake is approximately 18,400 km^2. The overall length of Buffalo River is approximately 155 km. Water flows strongly and is generally turbid. The river has a mud bottom, with gravel and cobbles present in faster flowing areas. Buffalo River water flows year-round with higher levels of flow occurring during the annual spring melt. The Buffalo River is moderately incised into the surrounding terrain. Based on discharge records from 1969 to 1990, it has a mean annual flow of 49 m^3/s, with a mean maximum daily flow of 187 m^3/s during May or June.

Great Slave Lake is the final receptor of the drainages from Twin Creek and the Buffalo River systems. Great Slave Lake is the second largest lake in the NWT (after Great Bear Lake), the deepest lake in North America (616 m), and the sixth largest lake in the world. It is 456 km long, 19 to 109 km wide, and covers an area of 28,400 km^2 with an approximate lake volume of 2,090 km^3. At Hay River (Station 070B002), the mean lake level is 156.63 meters above sea level (masl) with normal seasonal variations between 156.34 and 156.96 masl, and the highest levels occurring in mid-summer (WSC 2020).

3.2.2 Water Quality

Water quality in the general area surrounding the Project has been investigated by various parties over the last 30 years, including Environment and Climate Change Canada, previous mine operators, BC Research, Beak, EBA Engineering Consultants Ltd. (EBA), and Golder. Recent baseline data collection for the Project occurred in 2019 and 2020.

The Buffalo River is slightly alkaline with high water hardness. High turbidity and total suspended solids concentrations were characteristic of the Buffalo River, particularly during September and October, with corresponding high metals concentrations. As a result, total aluminum, cadmium, chromium, copper, and iron concentrations were consistently above Canadian Council of the Ministry of Environment (CCME) guidelines (EBA 2005b; Rescan 2012a; Tamerlane 2007; Golder 2020b). Aluminum is typically associated with the limestones, dolomites, sandstones, and shales that occur in the LSA, while elevated iron concentrations are commonly linked to the mafic minerals that occur across the region (EBA 2005b). The concentrations of all major ions and other metals were below CCME guidelines. Buffalo River can be characterized as eutrophic based on elevated total phosphorus concentrations (0.028 to 0.13 mg/L; CCME 2004); however, these levels are attributed to the elevated total suspended solids in the river.

In general, Twin Creek was slightly alkaline with very hard water, particularly in September. Low turbidity and total suspended solids concentrations were measured in Twin Creek, with low major ion and metal concentrations that were typically below CCME guidelines. Twin Creek is also an oligotrophic watercourse and as noted for Birch Creek, total fluoride concentrations were above the interim CCME guidelines; all other major ions and metal concentrations were below CCME guidelines.

3.2.3 Fish and Fish Habitat

Studies on the aquatic life of the major watercourses and waterbodies in the vicinity of the Project have occurred since the early 1970s by various parties including BC Research (1977), Beak (1980), EBA (2005b, 2006), Rescan (2012b), and Fisheries and Oceans Canada (2013).

Fish habitat assessments were completed in 2005 at six sites on the Buffalo River (EBA 2005b). Fish habitat in the Buffalo River was predominantly run habitat with some riffles and rapids. Bed substrates consisted mostly of gravel, with some fines and cobble. There was minimal cover for fish but when cover was present, it consisted of boulders, depth, or large organic debris. No instream overhead vegetation was observed.

Fish habitat assessments were completed in 2005 at nine locations in Twin Creek (EBA 2005b) and at five locations in 2011 (Rescan 2012b). The upstream reaches of Twin Creek flowed through a bog/wetland or underground channels and no visible channel was observed. The lower reaches of Twin Creek were low gradient. Fish habitat in Twin Creek consisted predominantly of pools with water depths of 0.5 to 1 m, with some runs and riffles. Bed substrates consisted mostly of fines with some cobble and gravel with cover for fish provided by instream and overhead vegetation (EBA 2005b; Rescan 2012b). Potential barriers to fish movement (e.g., debris piles) were observed at several reaches in Twin Creek.

Benthic invertebrates were sampled in Twin Creek, and the Buffalo River in 2011. The benthic invertebrate community in Twin Creek was dominated by aquatic insects and chironomids (Rescan 2012a). The Buffalo River had higher total abundances of benthic invertebrates than Twin Creek and consisted of chironomids, true bugs (i.e., Hemiptera), gastropods, bivalve molluscs, and oligochaete worms (Rescan 2012a). Freshwater mussel shells were also observed at the Buffalo River during fish baseline studies in 2005 (EBA 2005b).

The Buffalo River and Twin Creek are both fish bearing waterbodies with connectivity to Great Slave Lake. A total of 34 fish species occur in Great Slave lake. Many of these species have also been documented in the Buffalo River and Twin Creek. In the Buffalo River, Burbot, Inconnu, Lake Whitefish, Northern Pike, Goldeye, and Walleye have been recorded (Beak 1980; Evans et al. 1998; Stewart 1999; Tamerlane 2007). The mouth of the Buffalo River has also been known as a key area for fishing of Inconnu, Lake Whitefish, and Lake Trout by residents of Fort Resolution during the open water season (Beak 1980; Stewart 1999).

White Sucker, Longnose Sucker, Northern Pike, and Brook Stickleback are known or likely to occur in Twin Creek (EBA 2005b; Tamerlane 2007). ITK interviews indicated that although Twin Creek is not used as a traditional harvesting area, Walleye, Sucker species (Catostomidae), and Stickleback species (Gasterostidae) were present. Lake Trout and Northern Pike were identified to potentially be present (Tamerlane 2007). Fish sampling was completed in 2011 at three watercourses (Twin Creek and two unnamed creeks) and 23 waterbodies (i.e., lakes, ponds, wetlands). Brook Stickleback were captured at one location in Twin Creek and one shallow pond located within the historical Pine Point mine footprint (Rescan 2012b).

3.3 Traditional Land Use

The Project is located within the traditional territories of the Akaitcho Dene First Nation, K'atl'odeeche First Nation, and the Northwest Territories Métis Nation. Traditional uses in the area include use of the water and land for hunting and harvesting. In particular, the local water is used for drinking and harvesting fish. Traditional land uses include hunting and gathering; caribou, in particular, are a highly valued resource (Treaty 8 Tribal Council 2020).

Potential effects on traditional land uses will be addressed as part of the Wildlife Protection Plan, and effects on traditional water uses will be addressed as part of the AEMP. Where available, further discussion of relevant ITK and information regarding traditional water use in the area will be integrated into future iterations of the AEMP Design Plan.

3.4 Nearby Facilities

There are two major gold mining operations located on the northern shore of Great Slave Lake near the city of Yellowknife, which are currently in remediation: Giant Mine and Con Mine. These operations, although in remediation, may still contribute to legacy contamination and cumulative effects in Great Slave Lake. These mines are located approximately 160 km north of the Project.

Giant Mine began operating in 1948 and continued producing gold until 1999. The gold produced at this site was bound in arsenopyrite ore and consequently had to be roasted at extremely high temperatures. This process released toxic dust and arsenic trioxide waste into the surrounding environment, including the waters of Yellowknife Bay in Great Slave Lake. Giant Mine was officially abandoned in 2005. The Giant Mine Remediation Project is responsible for the remediation of the site (INAC 2018).

Con Mine, the first gold mine in the NWT, opened in 1938. The mine operated until the late 1990s, and officially closed in 2003. The site is now owned by Newmont Mining Corporation and is under remediation (Silke 2012).

4 PROBLEM FORMULATION

Conceptual site models illustrate potential linkages between stressors of potential concern, exposure pathways, and receptors of potential concern. A preliminary conceptual site model was developed for the AEMP Framework to assist with communicating the potential effects of the Project on the structure and function of the ecological components in the area surrounding the Project. The conceptual site model for the AEMP involves the identification of potential stressors to the aquatic ecosystem; these stressors will be modified and refined as the Project develops.

4.1 Aquatic Ecosystems in the Area Surrounding the Project

A simple model illustrating a typical aquatic food-web in the area of the Project is presented in Figure 3. For lake environments, the base of the food-web is comprised of phytoplankton in the water column and periphyton on shoreline rocks, which use nutrients and light to produce carbon for growth and provide food to benthic invertebrates and zooplankton. Zooplankton feed on phytoplankton, while benthic invertebrates feed on periphyton and decaying organic material (dead plankton or sloughed-off periphyton) that settle onto the sediments. Fish feed on zooplankton and benthic invertebrates, and larger predatory fish feed on smaller fish.

The riverine environment is similar to the lake environment, although plankton play a smaller role and periphyton and benthic invertebrates play a larger role in the flowing water ecosystem of the streams. Wildlife and waterfowl also use water and biota in lakes and streams as drinking water and as a food source.

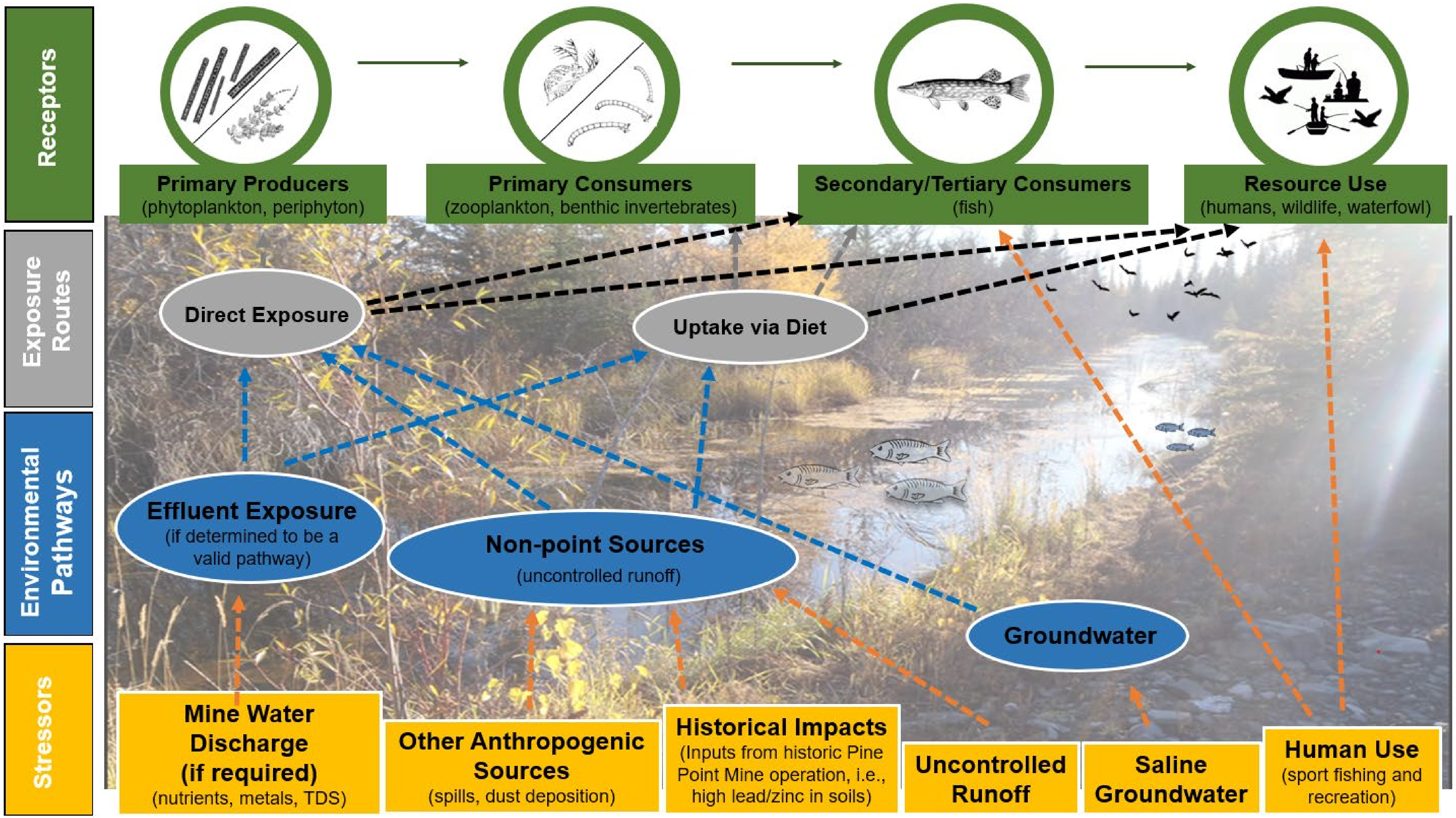

Figure 3: Preliminary Conceptual Site Model for the Aquatic Environment in the Area Surrounding the Project

4.2 Receptors of Potential Concern

The biological receptors identified in the preliminary conceptual site model (Figure 3) include:

- Primary producers: macrophytes, periphyton, and phytoplankton communities.
- Primary consumers: zooplankton and benthic invertebrate communities.
- Secondary/tertiary consumers: fish.
- Resource use: humans, wildlife, and birds.

These broad categories are considered as receptors of potential concern in the aquatic ecosystem; however, the decision of which receptors will be included in the AEMP, particularly with regard to primary producers and consumers, will be determined based on the outcomes of the EA and once additional Project design details are available.

4.3 Potential Stressors of Concern

The potential stressors of concern identified in the preliminary conceptual site model (Figure 3) are based on the mine components and activities identified in the Project Description (Volume 1, Section 3.0) that are the primary sources of stress to aquatic ecosystems. The primary exposure routes for biological receptors include the release of mine-affected water to the surface water environment (if required for the Project) and runoff from historic mine facilities. Other potential stressors include uncontrolled mine runoff (i.e., spills and leaching from flooded lands) and human resource use (i.e., sport fishing and recreation).

These potential stressors could affect biological receptors in the aquatic ecosystem; however, the stressors considered in the AEMP will be confirmed based on the outcomes of the EA and once additional Project design details are available.

4.4 Environmental Pathways

The pathways by which Project-related sources and stressors may influence the aquatic ecosystem are both direct and indirect. Direct pathways involve a direct influence on a receptor, for example, direct toxicity to fish may occur as a result of elevated concentrations of an ion or a metal in the downstream environment. Indirect pathways often include several levels of receptors; for example, mining activities may result in an increase in nutrient concentrations and primary productivity in downstream environments, which in turn may reduce dissolved oxygen concentrations and the capacity of a waterbody to support aquatic life (e.g., invertebrates and fish).

The potential pathways relevant to the AEMP are:

- Direct contact of aquatic organisms with mine-affected water (i.e., total dissolved solids and associated ions and metals).
- Reduction in the quality of aquatic habitat through eutrophication associated with increased nutrient concentrations.

Alteration of the quantity and quality of habitat from changes to water levels and flows is not currently expected to be a key effects pathway for the EA, and consequently the AEMP.

4.5 Preliminary Impact Hypotheses

Impact hypotheses are specific and testable questions that are used to help focus the AEMP on the key pathways of concern for downstream aquatic ecosystems. The Project-specific impact hypotheses will be developed for the AEMP based on information gathered during the EA process and will be informed based on the results of engagement and through additional collection of ITK.

4.6 Assessment Endpoints and Measurement Indicators

Assessment endpoints are the ultimate properties of valued components (VCs) that should be protected or developed for use by future human generations. Assessment endpoints are formal narrative expressions of the environmental values to be protected (Suter 1993; Suter et al. 2000). Considerations in the selection of assessment endpoints include ecological relevance, policy goals, future land use, societal values, susceptibility to substances of potential concern, and the ability to define the endpoint in operational terms. At a minimum, assessment endpoints include an ecological component and a property (attribute) of that ecological component to be evaluated.

Measurement indicators represent physical and biological attributes of the aquatic environments that can be measured and used to characterize changes to VCs. An overarching objective of AEMPs is the collection of monitoring data to support the protection of VCs. Measurement indicators will be used to monitor for changes in the environment, and thus effects on traditional water use. The VCs, assessment endpoints, and measurement indicators that will be used in the AEMP will be identified during the EA process and during development of the AEMP Design Plan.

5 AQUATIC EFFECTS MONITORING PROGRAM DESIGN

5.1 Monitoring Components

The following core components of the AEMP will be considered for monitoring, depending on Project design and the outcome of the EA:

- surface water quantity
- water quality
- benthic invertebrates
- fish health

These monitoring components are based on the broad categories of receptors of potential concern in the aquatic ecosystem listed in Section 4.2; however, the monitoring components ultimately included in the AEMP, in particular, the benthic invertebrate and fish components, will be dependent on the Project design and water management plan (i.e., if mine water discharge is required), as well as the outcome of the EA.

5.2 Study Areas

The predicted zone of influence of the Project, includes the Project footprint and surrounding areas that may be disturbed by mining activities, including the potential for mine water discharge. The predicted zone of influence applicable to the AEMP Framework is likely to include the Buffalo River and Twin Creek, as the two main watercourses which may have Project-related effects. The predicted zone of influence and associated study areas will be further refined in subsequent versions of the AEMP Design Plan, once additional Project details are known. Information on existing conditions for these two watercourses is provided in Section 3.0.

Great Slave Lake is the final receptor of the drainages from the Twin Creek and the Buffalo River systems (Figure 3). If Project effects are observed in Twin Creek or the Buffalo River, as part of regular AEMP monitoring, water quality sampling may be considered along the southern shoreline of Great Slave Lake. However, due to the size of the lake and expected mixing within shoreline areas, Project effects are likely to be non-measurable in Great Slave Lake.

There are other watercourses flowing into the southern portion of Great Slave Lake (i.e., Little Buffalo River, Paulette Creek); however, only Twin Creek and Buffalo River are currently considered likely to experience Project-related effects (Figure 2). There are also many small shallow lakes scattered throughout the region between the Project site and Great Slave Lake (Figure 2); however, most of these lakes have no visible drainage.

5.3 Reference Area Selection

In the Metal Mining Environmental Effects Monitoring Technical Guidance Document (Environment Canada 2012), a reference area is defined as “water frequented by fish that is not exposed to effluent and that has fish habitat that, as far as is practicable, is most similar to that of the exposure area”. Inclusion of reference areas in monitoring programs allow comparisons to evaluate differences in monitored watercourses relative to background conditions, as well as tracking of regional trends unrelated to the effects of the Project being monitored.

Birch Creek is identified as a possible reference location for Twin Creek and Buffalo River because it is outside the zone of influence of the Project (Figure 2). It has been used as a reference area for previous aquatic studies for the site. Information regarding habitat conditions in Birch Creek is available in the Existing Environment for the Pine Point Project (Golder 2020a). However, the selection of a suitable reference location will be determined following additional studies and engagement; specifically, ITK input will be sought during the selection of a reference location for Twin Creek and Buffalo River.

5.4 Sampling Design and Frequency

The sampling design used for the AEMP will be determined during development of the conceptual AEMP Design Plan and will incorporate information from ongoing baseline data collection and the EA process. The number of stations and specific locations of each station will be determined based on the Project Description submitted with the Water Licence application and an understanding of the potential effects from the Project. Not all watercourses may necessarily be sampled for all components. The study design will take into consideration the potential for Project effects on individual components and study area. The number of stations to be sampled (i.e., sample size) will be determined based on the results of a power analysis that will be completed for the AEMP once additional information is available, as per guidance provided in *Guidelines for Aquatic Effects Monitoring Programs* (MVLWB/GNWT 2019).

Monitoring frequency may initially be annual for surface water quantity and quality but may be reduced based on monitoring results. If benthic invertebrates and fish are included in the AEMP Design Plan, a sampling frequency of every three to five years is recommended. This approach follows that used by other AEMPs in the NWT. It is also consistent with the requirements of the federal *Metal and Diamond Mining Effluent Regulations* Environmental Effects Monitoring (EEM) program, which employs annual water and toxicological sampling paired with a tiered, three-year cycle for biological sampling (Environment Canada 2012). The AEMP re-evaluation process will be used to determine schedule and frequency on an ongoing basis.

Surface water quantity and quality sampling may initially occur seasonally, with programs recommended for spring (freshet), summer (July), fall (September), and winter (under-ice cover conditions). Hydrology monitoring may also include the use of continuous data loggers to collect year-round water-level and temperature data.

If deemed necessary based on the outcome of the EA, the benthic invertebrate sampling program is recommended to occur concurrently with the fall water quality program, during the period of peak benthic invertebrate productivity, following the approach used by other AEMPs in the NWT (Golder 2014; De Beers 2016). Similarly, the decision of whether a fish sampling program will be included in the AEMP will depend on the outcome of the EA. If required, the timing of the fish sampling program will depend on which target species are selected for monitoring and the timing of spawning.

5.5 Data Analysis and Interpretation

The primary objectives of the AEMP data analysis and interpretation for each component will be to inform the AEMP Response Framework through the Action Levels (Section 8.0), and to provide input to the overall integration of the results of individual monitoring components. The details of the AEMP sampling design will be partly determined by the requirements of the AEMP Response Framework, which has yet to be developed (Section 8.0); however, analysis and interpretation of the AEMP data are expected to focus on guideline and threshold comparisons, and temporal and spatial analyses.

5.6 Quality Assurance and Quality Control

Quality assurance (QA) refers to plans or programs encompassing internal and external management and technical practices designed to ensure that data of known quality are collected, and that such collections match the intended use of those data (Environment Canada 2012). Quality control (QC) is an internal aspect of quality assurance. It includes the techniques used to measure and assess data quality and the remedial actions to be taken when QC assessment criteria are not met. The QA/QC procedures ensure that field sampling, laboratory analyses, data entry, data analysis, and report preparation produce technically sound and scientifically defensible results.

The QA/QC procedures will govern all aspects of the AEMP, including the field methods, laboratory analysis, data management and analysis, and reporting. Field QA/QC procedures pertain to the maintenance and operation of equipment and instrumentation, sampling methods, sample handling, and shipping. Laboratory QA/QC procedures incorporate protocols developed by analytical laboratories. Office QA/QC procedures include validation of field measurements and analytical results provided by analytical laboratories. Results from the QC assessments will be used to adjust, the program to improve data quality, when necessary.

5.7 Integration with Other Monitoring Programs

The AEMP is one of the environmental monitoring programs associated with the Project. The AEMP will incorporate information from other management and monitoring programs, where applicable.

6 METHODS AND ANALYSIS

6.1 Surface Water Quantity

6.1.1 Objectives and Scope

The surface water quantity component will evaluate short- and long-term changes to surface water quantity in the watercourses influenced by the Project, evaluate predictions made in the EA, and assess the efficacy of impact mitigation strategies proposed in the mine plan. The specific objectives for the surface water quantity component of the AEMP will be developed following the EA and prior to water licencing.

6.1.2 Field Methods

Field methods will follow standard hydrological monitoring methods (Terzi et al. 1994; WMO 2010) and may include continuous water level data collection (i.e., automated stations which record stream water level), discharge, current velocity measurements, and hydrometric surveys (i.e., levelling surveys and/or channel geometry surveys to define channel-geometry of the gauged stream section). Specific field methods will be determined following completion of the EA.

6.1.3 Data Analysis

Standard hydrologic indices will be calculated including annual runoff, mean annual discharge, peak flows, and low flows.

6.1.4 Quality Assurance Quality Control

Field QA/QC procedures for the surface water quantity component pertain to the maintenance and operation of equipment and instrumentation, and field survey methods. The office QA/QC procedures for the surface water quantity component will include validation of field measurements and results.

6.2 Water Quality

6.2.1 Objectives and Scope

The water quality component will evaluate short- and long-term changes to surface water quality in the watercourses influenced by the Project, evaluate predictions made in the EA, and assess the efficacy of impact mitigation strategies proposed in the mine plan to minimize the water quality effects of the Project. The specific objectives for the water quality component of the AEMP will be developed following the EA and prior to water licencing.

6.2.2 Field Methods

6.2.2.1 Sample Collection

Physico-chemical water column field measurements of dissolved oxygen, pH, water temperature, and conductivity will be collected annually at each AEMP station in the watercourses. A target parameter list for water quality samples, along with the desired analytical methods/instrumentation, and target detection limits will be determined based on the outcomes of the EA, accepted laboratory standards, and experience gained from other AEMPs.

Water will be sampled according to standard water quality methods (Environment Canada 1983, 2012; APHA 2012). These methods represent accepted procedures for collecting water samples, collecting field measurements, recording field notes, calibrating instruments, and maintaining QA/QC functions.

6.2.3 Data Analysis

Water quality data will be compared to various guidelines, which include protection of aquatic life, protection of water for wildlife consumption, and protection of source for drinking water (as applicable) and potentially to site-specific benchmarks.

6.2.4 Quality Assurance and Quality Control

Field QA/QC procedures for the water quality component pertain to the maintenance and operation of equipment and instrumentation, sampling methods, sample handling, and shipping. Water samples will be submitted only to laboratories accredited by the Canadian Association for Laboratory Accreditation. Laboratory QA/QC procedures incorporate protocols developed by analytical laboratories, while the office QA/QC procedures include validation of field measurements and analytical results provided by the analytical laboratories.

Quality control samples will also be used to detect and reduce systematic and random errors that may occur during field sampling and laboratory procedures. The QC samples may consist of field, equipment and travel blanks and duplicate samples, based on Environment and Climate Change Canada's recommendations (Environment Canada 1983, 2012). All QC samples will be collected in the same manner as water samples, conforming to standard sampling methods.

6.3 Benthic Invertebrate Community

6.3.1 Objectives

A benthic invertebrate community survey will be included in the AEMP, if deemed necessary based on the outcome of the EA. The benthic invertebrate component, which may include periphyton sampling in the watercourses, will evaluate short- and long-term changes to the benthic invertebrate community in the watercourses surrounding the Project and evaluate predictions made in the EA. The specific objectives for the benthic invertebrate habitat component of the AEMP will be developed following the EA.

6.3.2 Field Methods

Benthic invertebrate samples will be collected in watercourses in the Project area. Supporting periphyton samples (as chlorophyll *a* or ash-free dry mass) will be collected in the watercourses potentially affected by the Project. A benthic invertebrate sampling device appropriate for the habitat conditions will be used to collect benthic invertebrate samples from the watercourses in the Project area. A Surber sampler or Hess sampler may be used for erosional habitats, whereas an Ekman grab may be used for depositional habitats. Benthic invertebrate samples will be collected at a frequency of once every three years, as per EEM standards (Environment Canada 2012) during the fall. Samples will be submitted to a qualified taxonomist for taxonomic composition (to the lowest practical taxonomic level) and density.

6.3.3 Data Analysis

Benthic invertebrate community data will be qualitatively reviewed based on density and taxonomic results. The data analysis will focus on evaluating responses in indicators such as benthic invertebrate density, richness, diversity and community composition.

6.3.4 Quality Assurance and Quality Control

Quality assurance and quality control procedures will be applied during all aspects of the benthic invertebrate component to verify that the data collected are of acceptable quality. Replicate samples will be submitted to the taxonomist and a proportion of the samples will be re-counted by the taxonomist to verify counting efficiency.

6.4 Fish Health

6.4.1 Objectives

A fish health survey will be included in the AEMP, if deemed necessary based on the outcome of the EA. The fish health component would evaluate short- and long-term changes in fish health in the watercourses influenced by the Project and will evaluate predictions made in the EA. It is anticipated that the main objective of the fish health component will be to determine whether stressors such as the mine water discharge (if required), or surface runoff from the mine site, are having a significant effect on the growth, reproduction, survival, and condition of fish in the watercourses downstream of the Project. The specific objectives for the fish health component of the AEMP will be developed following the EA and will consider the potential for effects on indicators of fish health.

6.4.2 Field Methods

Fish present in the watercourses will be sampled using a combination of methods, which may include minnow trapping, backpack electrofishing, or the use of nets (e.g., trap nets or fyke nets), as appropriate. A single species, potentially Ninespine or Brook Stickleback, may be chosen as a target species for the fish health assessment. Non-lethal and/or lethal surveys may be employed depending on the specific objectives of the monitoring, which will be defined during development of the conceptual AEMP Design Plan. The target sample size would be 20 males and 20 females, consistent with EEM guidance.

6.4.3 Data Analysis

Catch-per-unit-effort will be used as an estimate of relative abundance of fish (Ricker 1975). Length-frequency distributions will be used to describe the fish community data, as well as condition factor. If a lethal fish survey is used, a number of fish health endpoints will be calculated (e.g., age, size-at-age, relative gonad size, relative liver size, and fecundity) and compared between the exposure and reference areas to identify whether an effect has occurred on the fish population as per EEM guidelines (Environment Canada 2012).

6.4.4 Quality Assurance and Quality Control

Field staff will be knowledgeable of fish health survey requirements and fish identification and will be trained to be proficient in standardized procedures, data recording, and equipment operations applicable to the field sampling. The office QA/QC procedures for the fish health component will include validation of field measurements and results.

7 SPECIAL EFFECTS STUDIES

Special studies are not core components of the AEMP, but rather consist of targeted studies or research activities that support the overall objectives of the AEMP. Special effect studies may be identified as a requirement of a Water Licence or as part of the response to an exceedance of an Action Level in the Response Framework (Section 8.0). These studies may be initiated on an “as needed” basis to address potential data gaps, investigate new sampling and analytical methods, and other topics that require additional investigation to support effects monitoring, or to integrate ITK.

No specific special studies have been identified within this AEMP Framework. Special studies may be identified based on ongoing engagement and initial findings of the AEMP and would be completed during the implementation of the AEMP.

8 RESPONSE FRAMEWORK

The MVLWB defines a Response Framework as a “systematic approach to responding to the results of a monitoring program through adaptive management actions” (MVLWB/GNWT 2019). The goal of the Response Framework is to systematically respond to monitoring results such that the potential for significant adverse effects are identified and mitigation actions are undertaken and confirmed effective to prevent such effects from occurring. This is accomplished by implementing appropriate mitigation at predefined Action Levels, which are triggered before a significant adverse effect could occur.

8.1 Significance Threshold

Significance thresholds are the levels of change in monitored components of the aquatic ecosystem that, if exceeded, would result in significant adverse effects to the environment. Significance thresholds represent the “no-go zone”, such that management actions and adaptive management are used to prevent a significance threshold from being reached. Significance thresholds will be developed for the AEMP Design Plan and will be based on information provided in the EA and through engagement activities.

8.2 Action Levels and Responses

The MVLWB defines an Action Level as “a predetermined change, to a monitored parameter or other qualitative or quantitative measure, that requires the Licensee to take appropriate actions…”. In a Response Framework, Action Levels are set to trigger management actions to ensure that Project-related effects on the aquatic receiving environment remain within an acceptable range or are otherwise minimized to the extent practical. Action Levels range from Low, Medium, and High, with each new level initiating a new set of management actions. Action Levels will be developed for each Impact Hypothesis and for relevant measurement indicators in the AEMP Design Plan.

The AEMP Response Framework will provide suggested types of actions (e.g., mitigation and design changes) to be taken if an Action Level is exceeded. If an Action Level requiring response is exceeded (i.e., Moderate or High), an MVLWB-approved AEMP Response Plan will be implemented, which may include additional monitoring and possibly management responses (e.g., changes to mitigation), as appropriate. Exact responses detailed in a Response Plan will depend on the component affected, the likely cause of the effect, and the type and magnitude of effect.

9 AQUATIC EFFECTS MONITORING PROGRAM REPORTING

Reporting for the AEMP involves four types of documents: AEMP Design Plans, AEMP Annual Reports, Aquatic Effects Re-evaluation Reports, and AEMP Response Plans. These documents represent different chronological events over the AEMP life. First, the AEMP Design Plan, provided as a framework here, is generated to describe how aquatic effects monitoring in the Project area is proposed to take place; this document is typically updated over the life of the Project to incorporate changes to the mine plan and lessons learned from the earlier monitoring results. Next, monitoring is summarized yearly in the Annual Report. After several years of data have been collected (specified by the MVLWB), an Aquatic Effects Re-evaluation Report is prepared. If, along the way, impacts to the aquatic environment are identified (e.g., if a Moderate or High Action Level is triggered), then an AEMP Response Plan is generated.

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