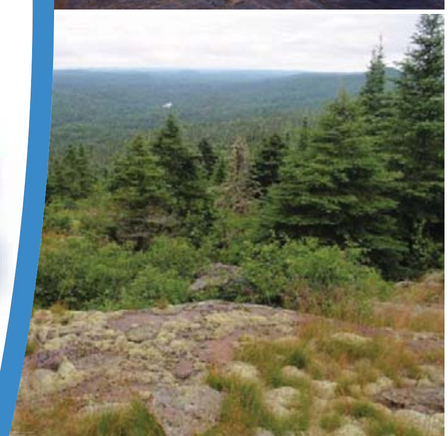
ENVIRONMENTAL ASSESSMENT FOR THE MARATHON PGM-Cu PROJECT AT MARATHON, ONTARIO

STILLWATER CANADA INC.
MARATHON PGM-Cu PROJECT

SUPPORTING INFORMATION DOCUMENT No. 6 - WATER QUALITY AND COPC FATE MODELING FOR THE MARATHON PGM-Cu PROJECT



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MARATHON PLATINUM GROUP METALS, COPPER PROJECT

Water Quality and COPC Fate Modeling for the Marathon PGM-Cu Project Site

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Water Quality and COPC Fate Modeling for the Marathon PGM-Cu Project Site

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EXECUTIVE SUMMARY

The following report evaluates the potential surface water quality effects associated with the proposed Marathon PGM-Cu mine during all phases of the Project. This document also provides an overview of the mine components, the site water balance, source loadings, and the characteristics and baseline quality of the watersheds that drain the Project site.

The main infrastructure for the mining operation consist of site access road, power transmission corridor, open pits, a mine rock storage area (MRSA), ore stockpile, primary and secondary crusher, concentrate building (mill), concentrate handling facility, water management system, process solids management facility (PSMF), and other ancillary structures located on the plant site in the vicinity of the main pit (Knight Piésold, 2012). The key components of the mine, as it pertains to releases to the aquatic environment, include the open pits, the mill, the PSMF, and the MRSA.

No direct discharge to the environment will occur during the site preparation and construction phase.

During operations, all waters collected from the Project site, except for water from the MRSA, will be managed in the PSMF for use in the milling process. Excess water not needed in the mill will be discharged, following treatment as necessary, to Hare Lake via an overland pipeline and offshore diffuser. Drainage from the MRSA will be collected, stored, tested, treated and discharged as necessary to the Pic River through an offshore diffuser.

Post-closure, surface runoff and seepage from the PSMF will collect in ponds prior to release to Stream 6, and surface runoff and seepage from the MRSA will discharge to the Pic River.

As a minimum, the quality of the discharge from the PSMF and MRSA will comply with the authorized limits prescribed in the Metal Mining Effluent Regulations (MMER). The assessment of surface water quality effects considered two additional means of characterizing the discharge quality:

- the source based discharge quality derived from the water balance and source loadings for the Project site, which represents the expected discharge characteristics based on Project activities; and

- the receiving-water based discharge quality derived from the receiving water's assimilative capacity, which represents the maximum discharge that ensure protection of the downstream aquatic environment.

Discharge quality considers contaminants of potential concern (COPC) as defined through geochemical testing of source materials (EcoMetrix, 2012c). These COPC include aluminum, arsenic, cadmium, cobalt, copper, iron, molybdenum, nickel, lead, selenium, uranium, vanadium and zinc. Cyanide, radium 226, total suspended solids, acute lethality and pH are additional COPC defined by MMER, and un-ionized ammonia is included based on source and receiving water considerations.

Watersheds and watercourses within or near the Project site include small streams, ponds and lakes, many of which are maintained by active or inactive beaver dams or debris jams. Many of the smaller water bodies are fishless likely as a result of the steep relief which isolates the interior of the watershed (EcoMetrix, 2012a). Project activities are limited within most of these smaller watersheds.

Water bodies that receive releases from Project activities include Hare Lake, the Pic River and Stream 6.

Hare Lake receives the discharge from the PSMF during the operations phase. The discharge enters Hare Lake through an offshore multi-port diffuser. The diffuser induces mixing within the vicinity of the discharge and circulation processes within the lake advect and disperse the discharge throughout the lake. The discharge is expected to have negligible effect on water quality in Hare Lake. The water quality in Hare Lake will remain below the surface water quality benchmark for all identified COPC, and will be indistinguishable from background water quality for most COPC.

The Pic River receives the discharge from the MRSA during the operations phase and post-closure. The Pic River has a significant capacity to assimilate the discharge from the MRSA since the discharge represents a small fraction of the total flow in the river—1,240 times smaller under the annual average flow and 150 times small under extreme low flow.

The discharge enters the Pic River through an offshore diffuser. The diffuser induces rapid mixing within its immediate vicinity. At 50 m from the discharge and over a width of approximately 10 m, the discharge mixes with ambient river water at a ratio of approximately 240:1 under the annual average river flow and approximately 36:1 under the extreme low river flow. These high mixing ratios provide ample capacity to assimilate the discharge from the MRSA.

The concentrations of all COPC comply with the surface water quality benchmarks for the Pic River within 50 m from the diffuser under all flow conditions, including an extreme low flow. Under typical flows, the water quality downstream from the diffuser will remain indistinguishable from background.

After mine closure, the natural flow regime of the Stream 6 subwatershed will be restored. The PSMF will be revegetated and natural stream channels and ponds will be created to collect surface runoff and seepage prior to release to Stream 6. The runoff water quality should be similar to existing baseline conditions, but subsurface flows seeping from the PSMF may contain trace levels of COPC from the process solids. Downstream of the ponds and within fish-bearing waters, the water quality in Stream 6 should comply with the surface water quality benchmarks for all COPC.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ACRONYMS AND ABBREVIATIONS

CAR	Canadian Aviation Regulations
CCME	Canadian Council of Ministers of the Environment
CEA Agency	Canadian Environmental Assessment Agency
COPC	Contaminants of Potential Concern
CORMIX	Cornell Mixing Zone Expert System
Cu	Copper
CWQC	Canadian Water Quality Guidelines
CYSP	Marathon Municipal Airport
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPT	Ephemeroptera, Plecoptera,and Trichoptera
Fe	Iron
ha	hectare
HO	Harmonization Order
Hwy	highway
JRP	Joint Review Panel
kg	kilogram
km	kilometre
L	litre
LEL	lowest effects level
MMER	Metal Mining Effluent Regulations
MPGM	Marathon PGM Corp.
MPI	Marathon Pulp Inc.
MRSA	Mine Rock Storage Area
m	metre
m^2	square metres
m^3	cubic metres
mg	milligram
NAG	non-acid generating
Ni	Nickel
NoC	Notice of Commencement
OEA Act	Ontario Environmental Assessment Act
PAG	potentially acid generating

PGM	Platinum Group Metal
PSMF	Process Solids Management Facility
PSQG	Provincial Sediment Quality Guidelines
PWQO	Provincial Water Quality Objectives
s	seconds
SCI	Stillwater Canada Inc.
SEL	Severe Effects Level
SFL	Sustainable Forest License
SWC	Stillwater Mining Company
TKN	Total Kjeldahl nitrogen
TOC	total organic carbon
ToR	Terms of Reference
TP	total phosphorus
TSS	total suspended solids
VA	Voluntary Agreement
VEC	valued ecosystem component
wk	week
WSC	Water Survey of Canada

1.0 INTRODUCTION

Stillwater Canada Inc. (SCI) proposes to develop a platinum group metals (PGMs), copper (Cu) and possibly iron (Fe) open-pit mine and milling operation near Marathon, Ontario. A Notice of Commencement (NoC) of an environmental assessment (EA) in relation to the proposed Marathon PGM-Cu Project (the Project) was filed by the Canadian Environmental Assessment Agency (CEA Agency) under Section 5 of the Canadian Environmental Assessment Act on April 29, 2010 (updated July 19, 2010).

The EA was referred to an independent Review Panel by the Federal Minister of the Environment on October 7, 2010. On March 23, 2011 SCI entered into a Voluntary Agreement (VA) with the Province of Ontario to have the Project subject to the Ontario Environmental Assessment Act (OEA Act). This agreement was the instrument that permitted the provincial government to issue a Harmonization Order (HO) under Section 18(2) of the Canada-Ontario Agreement on Environmental Assessment Cooperation to establish a Joint Review Panel for the Project between the Minister of the Environment, Canada and the Minister of the Environment, Ontario.

The HO was issued on March 25, 2011. The Terms of Reference (ToR) for the Project Environmental Impact Statement (EIS) and the agreement establishing the Joint Review Panel (JRP) were issued on August 8, 2011.

The following provides an overview of the proposed development including its location, surrounding land uses, the exploration history of the site and the primary conceptual features of the mining and milling facilities. The information provided below, in the Environmental Impact Statement Report and supporting technical studies is based on the conceptual mine design for the Project. The conceptual design provides planning level information for the environmental assessment process. Final detailed design will commence following EA approval in concordance with the concepts presented herein.

1.1 Project Location

The Project is located approximately 10 km north of the Town of Marathon, Ontario (Figure 1-1). The town, with a population of 3,353 (2011 Census), is situated adjacent to the Trans-Canada Highway 17 (Hwy 17) on the northeast shore of Lake Superior, about 300 km east and 400 km northwest (by highway) of Thunder Bay and Sault Ste. Marie, respectively.

The centre of the Project footprint sits at approximately 48° 47’ N latitude and 86° 19’ W longitude. The Project site is in an area characterized by relatively dense vegetation, comprised largely of a birch and, to a lesser extent, spruce-dominated mixed wood forest. The terrain is moderate to steep, with frequent bedrock outcrops and prominent east to west oriented valleys. The climate of this area is typical of northern areas within the Canadian Shield, with long winters and short, warm summers.

Figure 1-1: Location of the Proposed Marathon PGM-Cu Project Site near Marathon, Ontario

1.2 Surrounding Land Uses

The Project site lies partially within the municipal boundaries of the Town of Marathon, as well as partially within the unorganized townships of Pic, O'Neil and McCoy. The primary zoning designation within the Project Site is 'rural'.

In the immediate vicinity of the Project there are several authorized aggregate sites, including SCI's licensed aggregate site located to the northeast of Hwy 17 along the existing site access road (Camp 19 Road).

The Marathon Municipal Airport (CYSP), which operates as a Registered Airport (Aerodrome class) under the Canadian Aviation Regulations (CARs; Subsection 302), is adjacent to, and south of the Project site. The airport occupies a land area of approximately 219 hectares and is accessed from Hwy 17.

Several First Nations and Métis peoples claim the Project site as falling within their traditional land use boundaries. Based on Aboriginal accounts, prior to the construction of the forestry road, the land and water uses associated with (or close to) the site would have typically been limited to the Pic River corridor, the Bamoos Lake-Hare Lake-Lake Superior corridor and the Lake Superior shoreline and near-shore area, rather than the interior of the Project site. Traditional land and water uses (or rights conferred by Treaty) that can be ascribed to the site could include:

- Hunting;
- Trapping;
- Fishing; and,
- Plant harvesting for food, cultural and medicinal uses.

Primary industries supporting the Town of Marathon, as well as the region, have historically been forestry, pulp and paper, mining and tourism. The Project site is located within the Big Pic Forest Management Area. The Big Pic Forest includes Crown land east and north of Lake Superior and is generally north, south and west of the community of Manitouwadge and includes the communities of Marathon, Caramat and Hillsport.

Until July 2010 the forest was managed under the authority of a Sustainable Forest License (SFL), which was held by Marathon Pulp Inc. This SFL was revoked, with the forest reverting to the Crown as a Crown Forest. Until recently, Marathon Pulp Inc. (MPI) operated a kraft pulp mill in Marathon on the shore of Peninsula Harbour. The mill announced its indefinite shut down (effective at the end of February 2009) on February 11, 2009, and as a result there has been a significant downturn in the local economy. A second mill operated in Terrace Bay was temporarily closed in December 2011.

The Hemlo Mining Camp is located 30 km to the southeast. There are currently two mines in production at the Camp (David Bell Mine, Williams Mine), which are estimated to be in operations until 2025.

1.3 Exploration History of the Site

Exploration for copper and nickel deposits on the Project site started in the 1920s and continued until the 1940s with the discovery of titaniferous magnetite and disseminated chalcopyrite occurrences. During the past four decades, the site has undergone several phases of exploration and economic evaluation, including geophysical surveys, prospecting, trenching, diamond drill programs, geological studies, resource estimates, metallurgical studies, mining studies, and economic analyses. These studies have successively enhanced the knowledge base of the deposit.

In 1963, Anaconda acquired the Marathon property and carried out systematic exploration work including diamond drilling of 36,531 m in 173 drill holes. This culminated in the discovery of a large copper-PGM deposit. Anaconda discontinued further work on the project in the early 1980s due to low metal prices at the time.

In 1985, Fleck purchased a 100% interest in the Marathon PGM-Cu Project with the objective of improving the project economics by focusing on the platinum group element (PGE) values of the deposit. The Fleck drilling totaled 3,615 m in 37 diamond drill holes. In 1986, H.A. Symons carried out a feasibility study for Fleck based on a 9,000 tonnes per day conventional flotation plant with marketing of copper concentrate and Kilborn Limited carried out a prefeasibility review for Fleck that included preliminary results from the Lakefield pilot plant tests (Kilborn Limited, 1987). The feasibility study indicated a low internal rate of return which was confirmed by Teck Corporation who concluded the project was uneconomic due to low metal prices at the time. On June 10, 1998, Fleck changed its name to PolyMet Mining Corp.

In 2000, Geomaque acquired certain rights to the Marathon PGM-Cu Project through an option agreement with Polymet. Geomaque and its consultants carried out a study of the economic potential of the Marathon PGM-Cu Project. The study included a review of the geology and drill hole database, interpretation of the mineralized zones, statistics and geostatistics, computerized block model, resource estimation, open pit design and optimization, metallurgy, process design, environmental aspects, capital and operating cost.

Marathon PGM Corp. acquired the Marathon PGM-Cu deposit from Polymet in December 2003. Marathon PGM Corp. funded programs of advanced exploration and diamond drilling on a continuous basis between June 2004 and 2009. Approximately 320 holes and 65,000 m were drilled from 2007 to 2009 to define and expand the resource and for condemnation holes outside of the pit area. A feasibility study was published in 2008 and updated in 2010.

Stillwater Mining Company (SWC) and Marathon PGM entered into an agreement on September 7, 2010 pursuant to which SWC would acquire all of the outstanding shares of Marathon PGM. The acquisition agreement received ministerial approval under the Investment Canada Act on November 24, 2010 and the agreement closed on November 30, 2010. On December 31, 2010 Stillwater Mining Company formed a Canadian corporation, Stillwater Canada Inc. In March 2012, MC MINING LTD (MC) purchased 25% interest in Stillwater Canada Inc. who is the proponent of the Marathon PGM-Cu Project.

1.4 Project Overview

The Project is based on the development of an open pit mining and milling operation. The conceptual general layout of the components of the mine site, the transmission line corridor and access road is provided in Figure 1-3 below. One primary pit and a satellite pit complex to the south (currently envisaged to be comprised of four satellite pits) are proposed to be mined. Ore will be processed (crushed, ground, concentrated) at an on-site processing facility. Final concentrates containing copper and platinum group metals will be transported off-site via road and/or rail to a smelter and refinery for subsequent metal extraction and separation. The total mineral reserve (proven and probable) is estimated to be approximately 91.5 million tonnes. It is possible that an iron concentrate may also be produced, depending upon the results of further metallurgical testing and market conditions at that time.

During the operations phase of the Project, ore will be fed to the mill at an average rate of approximately 22,000 tonnes per day. The operating life of the mine is estimated to be approximately 11.5 years. The construction workforce will average approximately 400 people and will be required for between 18 and 24 months. During operations the work force will comprise an estimated 365 workers. The mine workforce will reside in local and surrounding communities, as well as in an Accommodations Complex that will be constructed in the Town of Marathon.

Approximately 288 million tonnes of mine rock[1] will be excavated. It is estimated that 85% to 90% of this material is non-acid generating (NAG) and will be permanently stored in a purposefully built Mine Rock Storage Area (MRSA) located east of the primary pit. The NAG or so-called Type 1 mine rock will also be used in the construction of access roads, dams and other site infrastructure as needed. Drainage from the MRSA will be collected, stored, treated and discharged as necessary to the Pic River. During mine operations, approximately 20 million tonnes of mine rock could have the potential to generate acid if left exposed for extended periods of time. This mine rock is referred to as Type 2 mine rock or potentially acid generating (PAG). The Type 2 mine rock will be managed on surface during mine operations in temporary stock piles with drainage directed into the open pits. This

[1] Mine rock is rock that has been excavated from active mining areas but does not have sufficient ore grades to process for mineral extraction.

material will be relocated to the bottom of the primary and satellite pits and covered with water to prevent potential acid generation and covered with Type 1 materials.

Process solids[2] will be managed in the Process Solids Management Facility (PSMF), as well as in the satellite pit complex. The PSMF will be designed to hold approximately 61 million m^3 of material, and its creation will require the construction of dams. Two streams of process solids will be generated. An estimated 85% to 90% of the total amount of process solids produced will be non-acid generating, or so-called Type 1 process solids. The remaining 10% to 15% of the process solids could be potentially acid generating and referred to as Type 2 process solids. The Type 2 process solids will be stored below the water table in the PSMF or below water in the pits to mitigate potential acid generation and covered with Type 1materials. Water collected within the PSMF, as well as water collected around the mine site other than from the MRSA will be managed in the PSMF for eventual reclamation in the milling process. Excess water not needed in the mill will be discharged, following treatment as is necessary, to Hare Lake.

Access to the Project site is currently provided by the Camp 19 Road, opposite Peninsula Road at Hwy 17. The existing road runs east towards the Pic River before turning north along the river to the Project site (approximately 8 km). The existing road will be upgraded and utilized from its junction with Hwy 17 for approximately 2.0 km. At this point a new road running north will be constructed to the future plant site. The primary rationale for developing the new road is to move traffic away from the Pic River. The new section of road will link two sections of forest access roads located on the site.

Power to the Project site will be provided via a new 115 kV transmission line that will be constructed from a junction point on the Terrace Bay-Manitouwadge transmission line (M2W Line) located to the northwest of the primary pit. The new transmission line will run approximately 4.1 km to a substation at the mill site. The width of the transmission corridor will be approximately 30 m.

Disturbed areas of the Project footprint will be reclaimed in a progressive manner during all Project phases. Natural drainage patterns will be restored as much as possible. The ultimate goal of mine decommissioning will be to reclaim land within the Project footprint to permit future use by resident biota and as determined through consultation with the public, Aboriginal peoples and government. A certified Closure Plan for the Project will be prepared as required by Ontario Regulation (O.Reg.) 240/00 as amended by O.Reg.194/06 "Mine Development and Closure under Part VII of the Mining Act" and "Mine Rehabilitation Code of Ontario".

Maps showing the existing features and topography of the site, as well as the proposed conceptual development of the site are provided in Figure 1-2 and Figure 1-3.

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[2] Process solids are solids generated during the ore milling process following extraction of the ore (minerals) from the host material.

Figure 1-2: Existing Conditions at the Marathon PGM-Cu Project Site

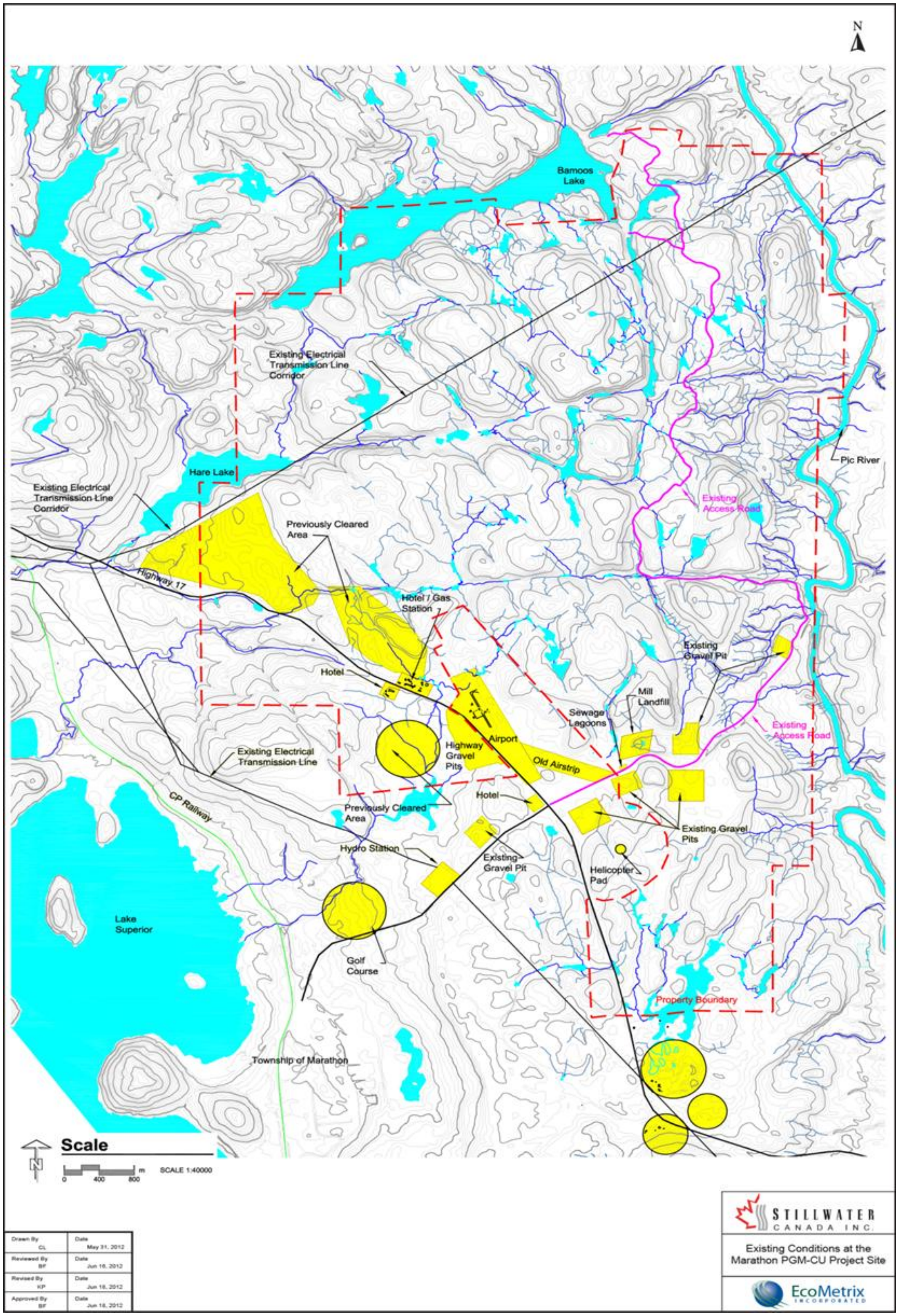
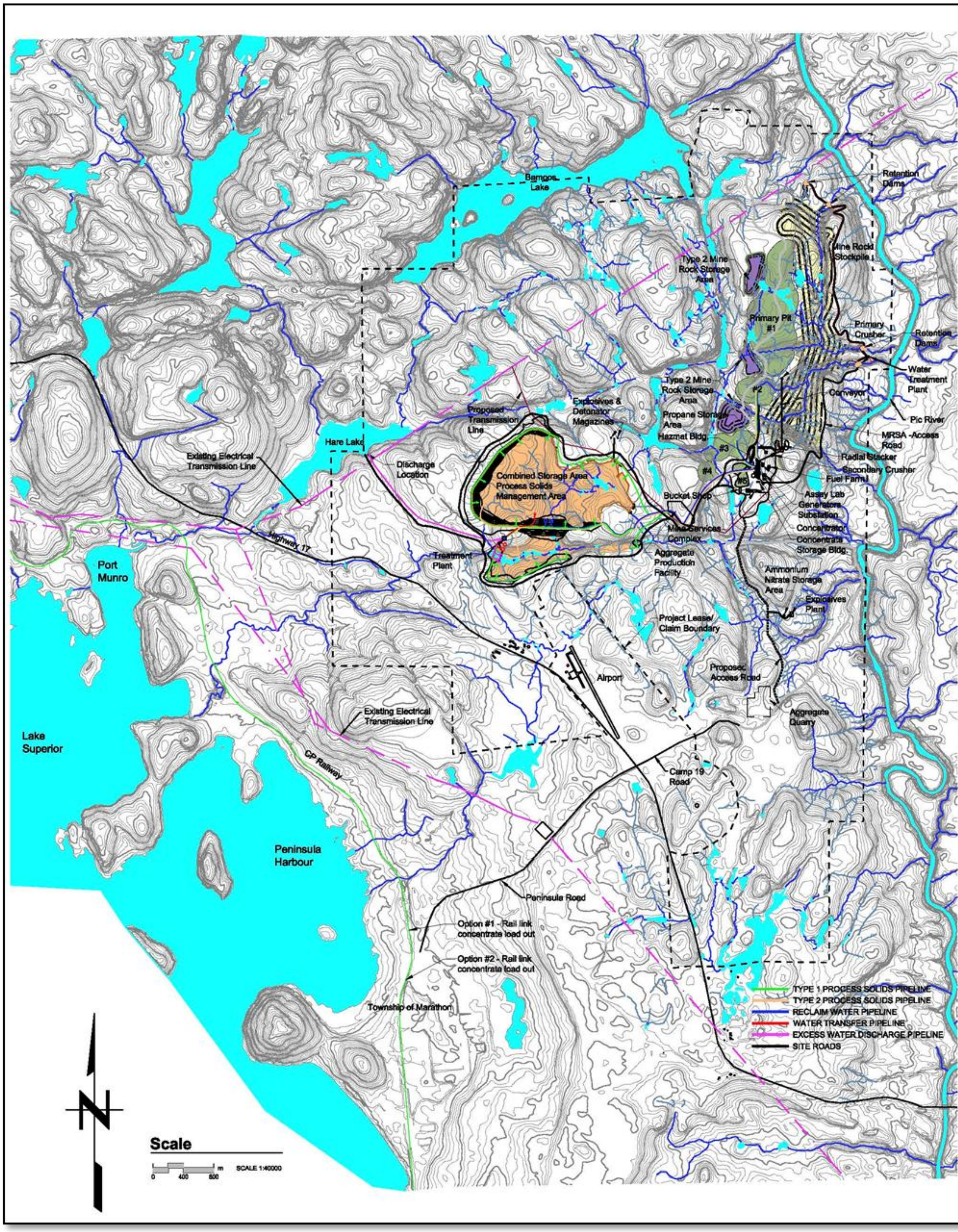


Figure 1-3: Marathon PGM-Cu Project Conceptual General Site Layout



1.5 Scope of Work

The main objective of this investigation to evaluate the potential surface water quality affects at the proposed Marathon PGM-Cu mine during all phases of the Project. This document also provides an overview of the mine components, the site water balance, source loadings, and the characteristics and baseline quality of the watersheds that drain the Project site and the three receiving environments—Hare Lake, Pic River, and Stream 6. EcoMetrix (2012e) completed various investigations to characterize the source term concentrations for the various mine components. Knight Piesold (2012) provides detailed water balance and water management information for the PSMF, and Calder (2012b) provides detailed water balance and site hydrology pertaining for the MRSA. The aquatic resources (EcoMetrix, 2012a) and the hydrologic assessment (Calder, 2012a) provide detailed information on investigations conducted on surface water receiving environments. This information supports the assessment of expected surface water quality in the receiving environment resulting from mine activities.

The scope of this assessment includes evaluation of potential effects on surface water quality during all phases of the Project; however, discharge to the environment is only anticipated during the operations and closure/post-closure phases. The Project has three identified discharges—the PSMF discharge to Hare Lake during operations; the MRSA discharge to the Pic River during operations and post-closure; and the PSMF discharge to Stream 6 post-closure.

1.6 Report Format

Following the introductory section the remainder of the report is organized as follows:

- Section 2.0 provides an overview of the Marathon PGM-Cu Project including mine components;
- Section 3.0 discusses the watersheds within and near the Project site and the different receiving environments;
- Section 4.0 outlines the anticipated discharges from the Project site;
- Section 5.0 provides an assessment of the potential effects on surface water quality; and
- Section 6.0 provides a list of the references cited in the preparation of this report.

2.0 THE MARATHON PGM-Cu PROJECT

The following section provides an overview of the primary components of the Marathon PGM-Cu Project and presents information to support the assessment of potential surface water quality effects. The information presented draws from several other supporting documents, including: the geochemical assessment (EcoMetrix 2012e); the site water balance (Calder, 2012b); and the process solids management plan (Knight Piésold, 2012).

2.1 Project Description

The conceptual design for the Project is based on the development of an open pit mining and milling operation for extraction of PGMs, copper, and possibly iron. The main infrastructure for the mining operation will consist of site access road, power transmission corridor, open pits, a mine rock storage area (MRSA), ore stockpile, primary and secondary crusher, concentrate building (mill), concentrate handling facility, water management system, process solids management facility (PSMF), and other ancillary structures located on the plant site in the vicinity of the main pit. The key components of the mine, as it pertains to releases to the aquatic environment, include the open pits, the MRSA, the PSMF, and the mill.

2.1.1 The Pits

The ore body is hosted within the eastern portion of the Coldwell Complex along a north-south axis over a distance of approximately 3 km. One primary pit and four smaller satellite pits—located south of the primary pit—are proposed to be mined. The pits will be excavated through blasting, followed by segregation of ore and mine rock. Mine rock is rock that has been excavated from active mining areas but does not have sufficient ore grades to process for mineral extraction. Samples will be taken from a sufficient and strategic number of drill holes and analyzed on-site at the Assay Lab to determine ore and waste boundaries within blasted material and also to segregate Type 1 (classified as non-acid generating) and Type 2 (classified as potentially acid generating) mine rock.

Ore will be hauled from the open pits and crushed at the Primary Crusher, located on the eastern side of the primary pit. Crushed ore will be transported via a covered conveyor over a distance of approximately 1 km south and stockpiled adjacent to the mill. Approximately 110,000 tonnes of ore will be stockpiled at any one time. Drainage from the ore stockpile will be directed back to the pit areas and managed through the PSMF. Stockpiled ore will be transported for secondary crushing or directly to the mill for mineral extraction, as discussed in Section 2.1.4.

The conceptual plan for pit development is to mine the primary pit and satellite pits simultaneously. A majority of the higher grade ore is found in the primary pit, whereas medium to low grade ore is primarily in the satellite pits. By approximately year 6, a number of the satellite pits will be completely mined out to allow for storage of process solids and Type 2 mine rock. Table 2-1 presents the conceptual dimensions and surface areas of the pits at the cessation of mining operations.

During mine operation and open pit development, water will be pumped from the pits and directed to the PSMF. As the open pit is developed, watersheds will contribute surface water and some groundwater to the open pit, which will have contact with the pit walls and rock on benches and on the working floor of the pits.

Once mining operations have ceased, and the pit begins to flood, the amount of pit rock surface area exposed to the atmosphere, and thus subjected to oxidation, will decrease, reducing the amount of reactive area. It is estimated that the pit will reach a final flooded level decades after mining operations have ceased. Some of the pit walls will remain exposed to the atmosphere above the natural final water level in the pit after filling with water. The area exposed after flooding was considered in the assessment of metal loadings and estimates of metal leaching from the pit walls post decommissioning.

Table 2-1: Conceptual Dimensions and Surface Areas of the Primary Pit and Satellite Pits at the Marathon PGM-Cu Project

Pit	Dimensions and Surface Area			
	North-South Axis (m)	East-West Axis (m)	Depth (m)	Surface Area (ha)
Primary Pit	2,000	670	340	78.7
Satellite Pit 2	400	500	180	15.3
Satellite Pit 3	400	700	120	18.9
Satellite Pit 4	260	250	170	4.9
Satellite Pit 5	340	280	120	6.3

2.1.2 Mine Rock Storage Area

Approximately 288 million tonnes of mine rock will be excavated during mining of the ore. Mine rock will be managed in two streams. Type 1 mine rock is defined as mine rock with less than 0.3% sulphur (by weight), which has been assessed to be NAG. Type 2 mine rock is defined as mine rock with greater than 0.3% sulphur (by weight), which has been assessed to be PAG (EcoMetrix, 2012e). Based on sulphur distribution through the host material it has been estimated that about 20 million tonnes of Type 2 mine rock will be excavated during mine life (EcoMetrix, 2012e). Type 1 rock will be used for construction of access roads, dams and other site infrastructure as needed. Excess Type 1 mine rock will be permanently stored in the MRSA located east of the primary pit. The MRSA has the capacity to store all of the mine rock generated during the 11.5 year mine life. Drainage from the MRSA will be collected, stored, tested, treated and discharged as necessary to the Pic River.

Type 2 rock will be managed at the surface during mine operations in temporary stockpiles with drainage directed into the open pits. Once excavation of the pits is complete, Type 2 mine rock will be relocated to the bottom of the primary and satellite pits where natural filling of water will ensure that the Type 2 rock will be covered with water to prevent acid generation after closure. If the Type 2 material is demonstrating acid generation prior to its relocation to the bottom of the pits, the pits will be pro-actively flooded to create a water-cover and stop the acid production cycle. Type 1 process solids will provide cover material for the Type 2 mine rock in the satellite pits to prevent acid generation.

The conceptual development of the MRSA throughout the operational life of the mine is represented in Figure 2-1 through Figure 2-4. Ultimate closure of the MRSA is described in more detail in TGCL (2012d).

2.1.3 Process Solids Management

Approximately 61 million m^3 of process solids will be generated over the life of the mine. Type 1 and Type 2 process solids that are generated during the ore milling process will be managed in the PSMF, as well as in the satellite pit complex. The PSMF is located to the west of the pit area, and will be created through the construction of dams, as discussed in Knight Piesold (2012). Dams will be raised through mine life to provide sufficient storage capacity for process solids and for site water management.

The Type 1 solids will comprise approximately 85% to 90% of the total amount of process solids and will be benign. Type 1 solids will be pumped to and stored in the PSMF in a typical on-land impoundment that will safely contain the solids. The remaining 10% to 15% of the process solids, Type 2 process solids, will be stored under water or below the water table in the PSMF or in the satellites pits to prevent acid generation. As an additional preventative measure, the Type 2 solids will also be covered by Type 1 process solids in the PSMF so that all Type 2 solids will remain below the water table and will be isolated from the atmosphere. A conceptual process solids deposition plan and the proposed staging of the construction of the PSMF is provided by Knight Piesold (2012) and is illustrated in Figure 2-1 through Figure 2-4. Conceptual closure of the PSMF is described in TGCL (2012d).

Except for water collected from the MRSA, all water collected in the PSMF and around the mine site, including water pumped from the pits, run-off collected around the mill site, will be managed in the PSMF for use in the milling process. Excess water not needed in the mill will be discharged, following treatment as necessary, to Hare Lake.

The proposed PSMF includes two cells separated by a lined embankment. During the initial phases of operation, Cell 1 will be used for process solids storage and for reclaim water for the mill. Cell 1 is the smaller of the cells and will ultimately store approximately 5 million m^3 of process solids. Water collected around the mine site (pit water including drainage off the Type 2 mine rock and ore stockpiles and drainage from the mill site) will be managed in Cell 1. After the first couple of years of operation water from Cell 1 will be pumped to Cell 2 for recycling in the mill. Cell 2 is the larger of the cells and will ultimately store approximately 45 million m^3 of process solids. Cell 2 will act as the reclaim pond with process water cycling between it and the mill for most of the operational phase of mine life. Excess water will be treated as required and discharged to Hare Lake.

Satellite pits will be used later in mine life for process solids storage (Type 1 and Type 2 material), as well as for Type 2 mine rock storage.

2.1.4 Mill Operation

During the operations phase of the Project, ore will be fed to the mill at an average rate of approximately 22,000 tonnes per day. Ore will be processed in a conventional two-step process through grinding and floatation, to separate the economic minerals from the other minerals in the ore. The final stages of the conceptual concentrate production process involve thickening and de-watering of concentrates to a final moisture content of less than 8%. The sand sized economic minerals are collected as a concentrate that will be shipped off-site for refinement.

The milling of ore requires water to transfer the crushed ore and to extract the economic minerals. The water in the mill is referred to as process water. To service the mill's process water needs, water will be reclaimed from the PSMF to the mill via a pump and pipeline system from Cell 2. However, during the initial stages of operation, Cell 1 of the PSMF will be used to manage the process water stream to the mill.

The remaining non-economic minerals in the ore will comprise the process solids that will be stored at site, as discussed in Section 2.1.3.

Figure 2-1: Conceptual Year 1 Development of the MRSA and the PSMF

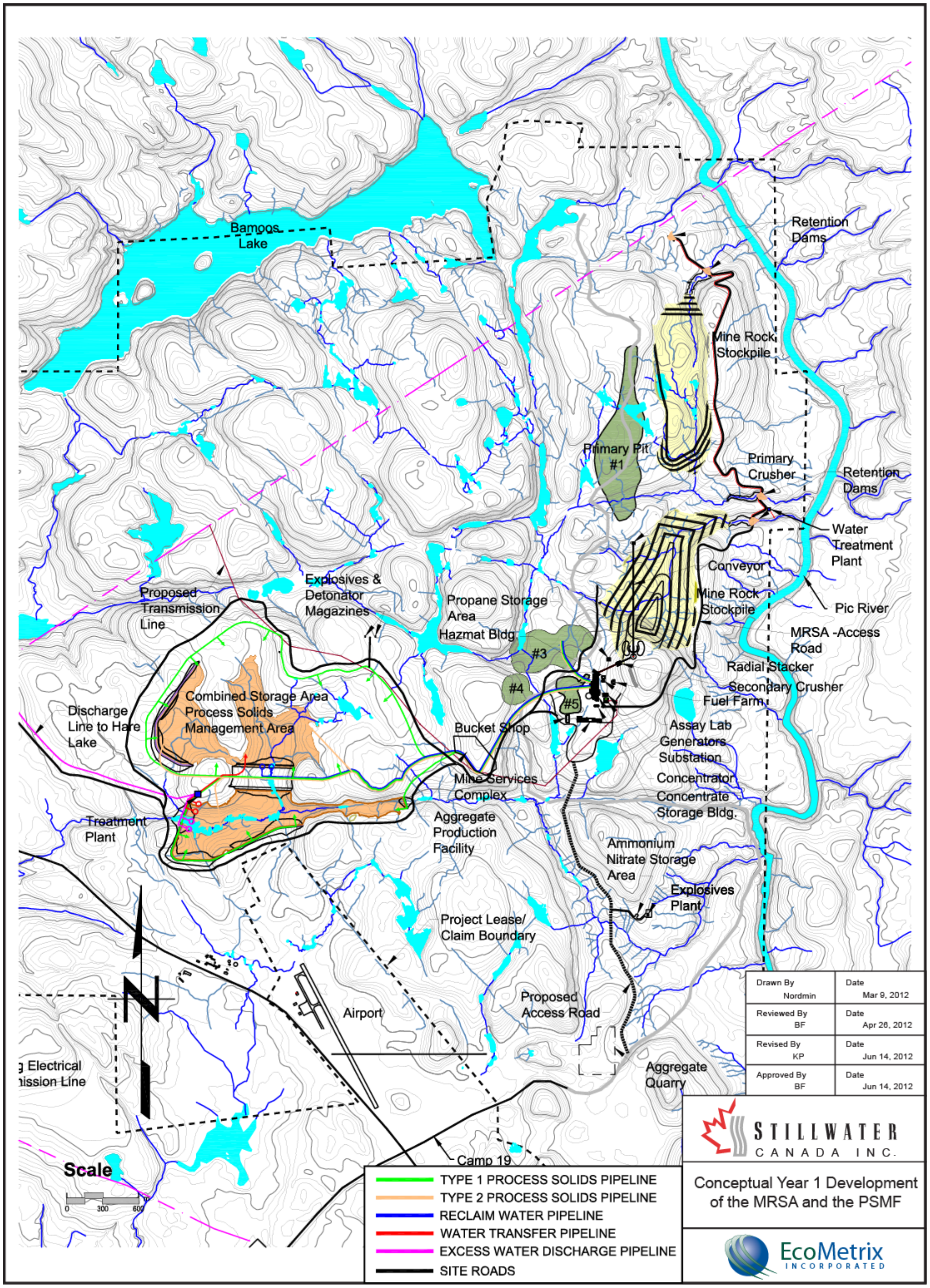


Figure 2-2: Conceptual Year 4 Development of the MRSA and the PSMF

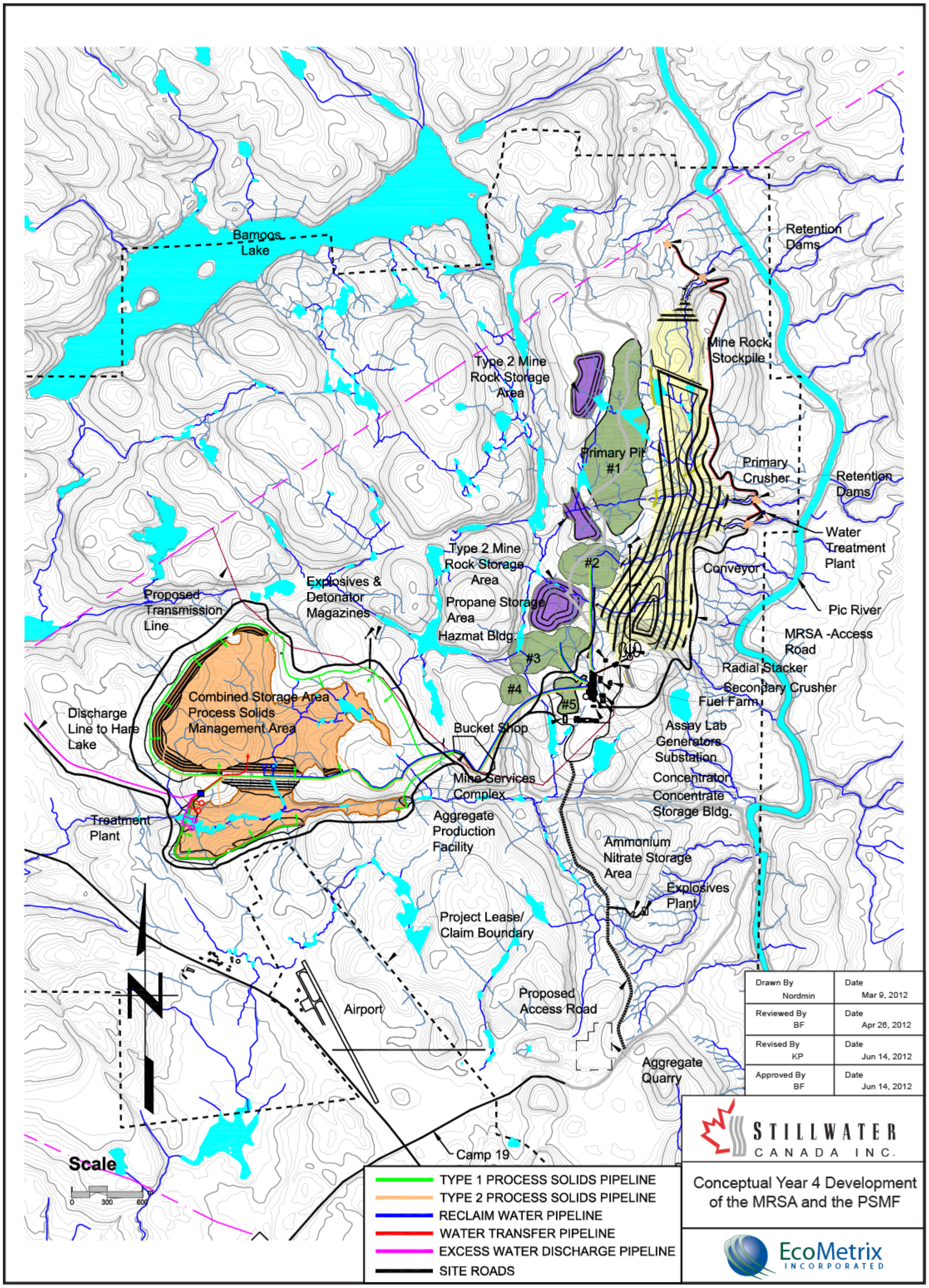


Figure 2-3: Conceptual Year 10 Development of the MRSA and the PSMF

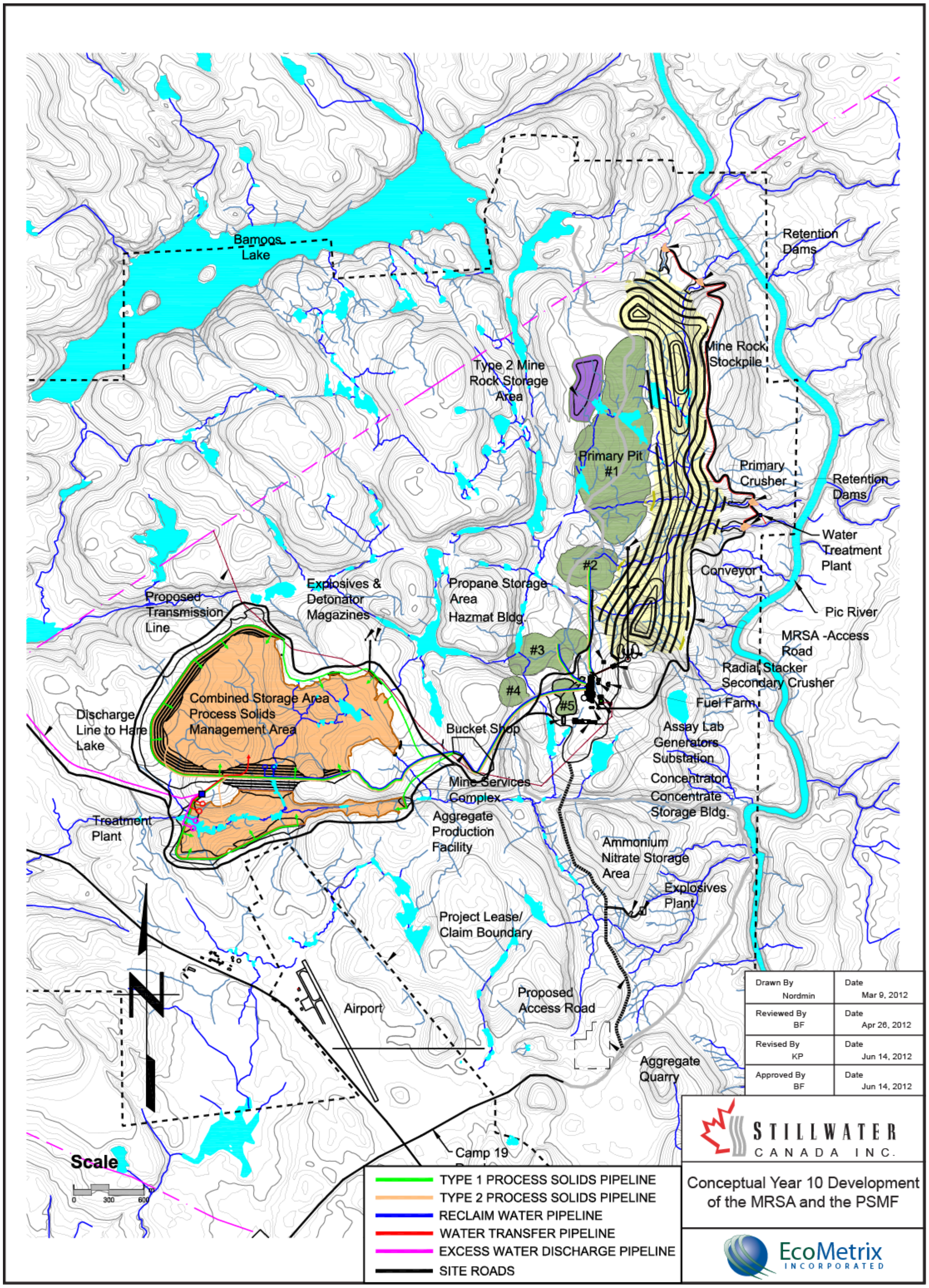
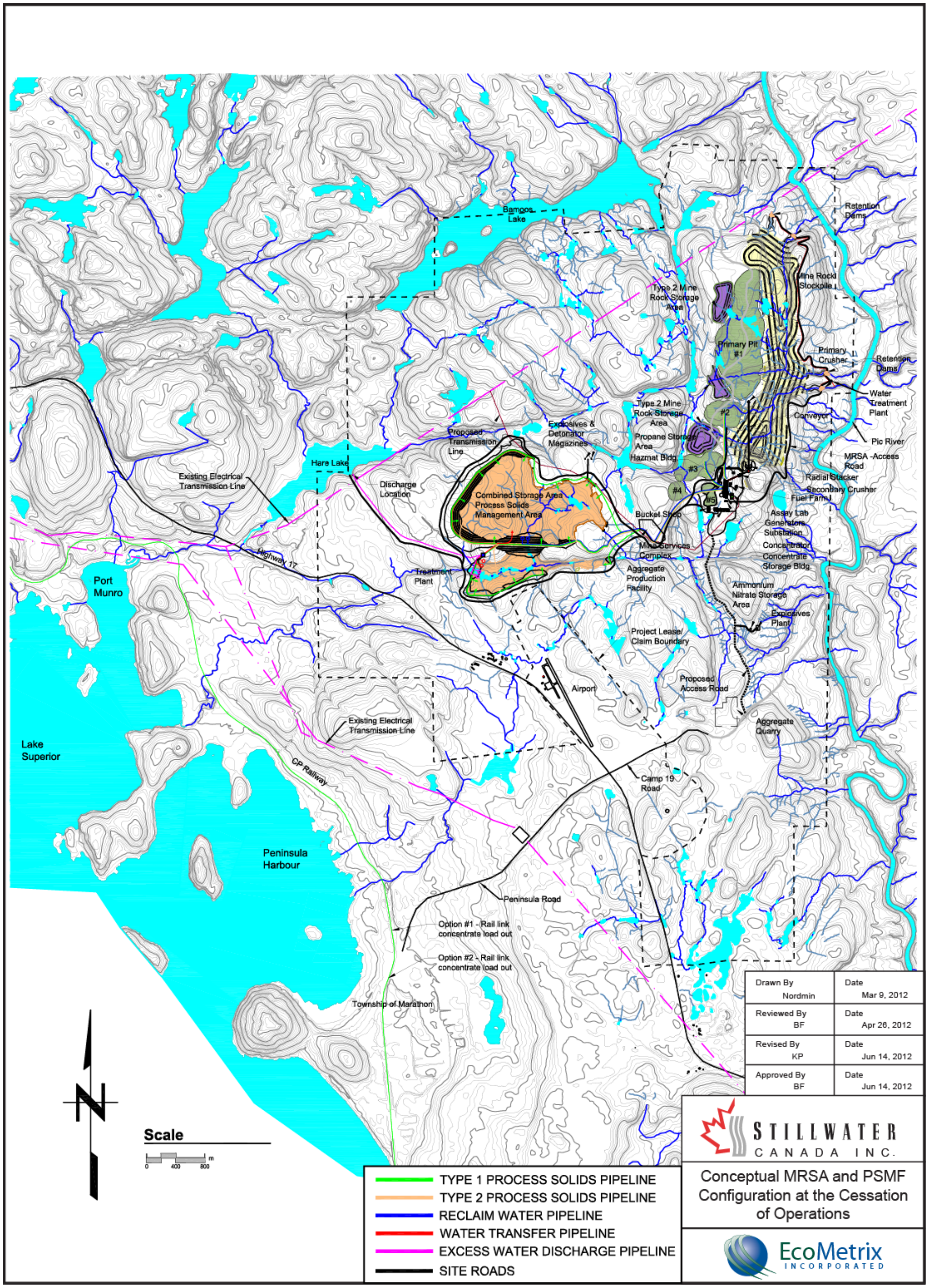


Figure 2-4: Conceptual MRSA and PSMF Configuration at the Cessation of Operations



2.2 Mine Schedule

The Project includes site preparation, construction, operations, decommissioning and closure. It is expected that it will take approximately 18 to 24 months to reach commercial production, from the time site preparation commences. The operations phase is anticipated to last approximately 11.5 years, followed by a closure phase of site reclamation and infrastructure decommissioning over a period of two years. After decommissioning the site will return to an end use that would permit future use by resident biota and be supported by Aboriginal people, the public and government.

The primary open pit will be approximately 2 km long, 600 m maximum width, and 340 m maximum depth with an estimated 91 Mt of total mineral reserves. The pit walls and rubble on the pit benches will contribute loadings to the pit water during operations. The conceptual pit development during operations is presented in Table 2-2 showing the rock excavated, rubble, ore stockpile, and Type 2 mine rock inventory, and pit wall surface area.

Table 2-2: Conceptual Pit and MRSA Development during Operations Phase

Year	Rock Excavated (tonnes)	Rubble (tonnes)	Pit Wall Surface Area (m^2)	Ore Stockpile (tonnes)	Type 2 mine rock inventory (tonnes)	MRSA[a] (tonnes)
0	2.40E+06	1.32E+03	4.07E+03	0	0	0
1	3.47E+07	2.04E+04	1.78E+04	2.20E+05	2.18E+06	4.46E+07
2	3.95E+07	4.21E+04	3.89E+04	2.20E+05	4.36E+06	8.47E+07
3	3.60E+07	6.19E+04	6.74E+04	2.20E+05	6.54E+06	1.20E+08
4	3.60E+07	8.17E+04	1.03E+05	2.20E+05	8.73E+06	1.52E+08
5	3.60E+07	1.02E+05	1.47E+05	2.20E+05	1.09E+07	1.79E+08
6	3.60E+07	1.21E+05	1.97E+05	2.20E+05	1.31E+07	2.01E+08
7	2.60E+07	1.36E+05	2.55E+05	2.20E+05	1.53E+07	2.20E+08
8	2.60E+07	1.50E+05	3.21E+05	2.20E+05	1.75E+07	2.34E+08
9	2.60E+07	1.64E+05	3.94E+05	2.20E+05	1.96E+07	2.43E+08
10	2.60E+07	1.79E+05	4.74E+05	2.20E+05	2.18E+07	2.44E+08
11	2.01E+07	1.90E+05	5.62E+05	2.20E+05	2.40E+07	2.45E+08
12	9.58E+06	1.95E+05	6.57E+05	0	0	2.46E+08

[a] Interpolated from 1.21E+08 tonnes in Year 3, 2.01E+08 tonnes in Year 6 and 2.46E+08 tones in Year 12.

It is anticipated that the MRSA will be constructed with an overall slope of approximately 2.2:1 (horizontal to vertical) with 30 m tall benches with mid slopes at 2:1 and 10 m wide mid-slope benches. Bench heights will vary, but will typically be approximately 30 m with 10 m bench widths between the individual bench slopes. The MRSA will be developed over the life of the mine. The total height of the MRSA at the end of the operational life of the mine is expected to range between 125 m and 175 m. Table 2-2 presents the total mass of the MRSA as it evolves during the operations phase of the Project. The total mass is based on the density of the mine rock and the anticipated volume of the MRSA.

2.3 Site Water Balance

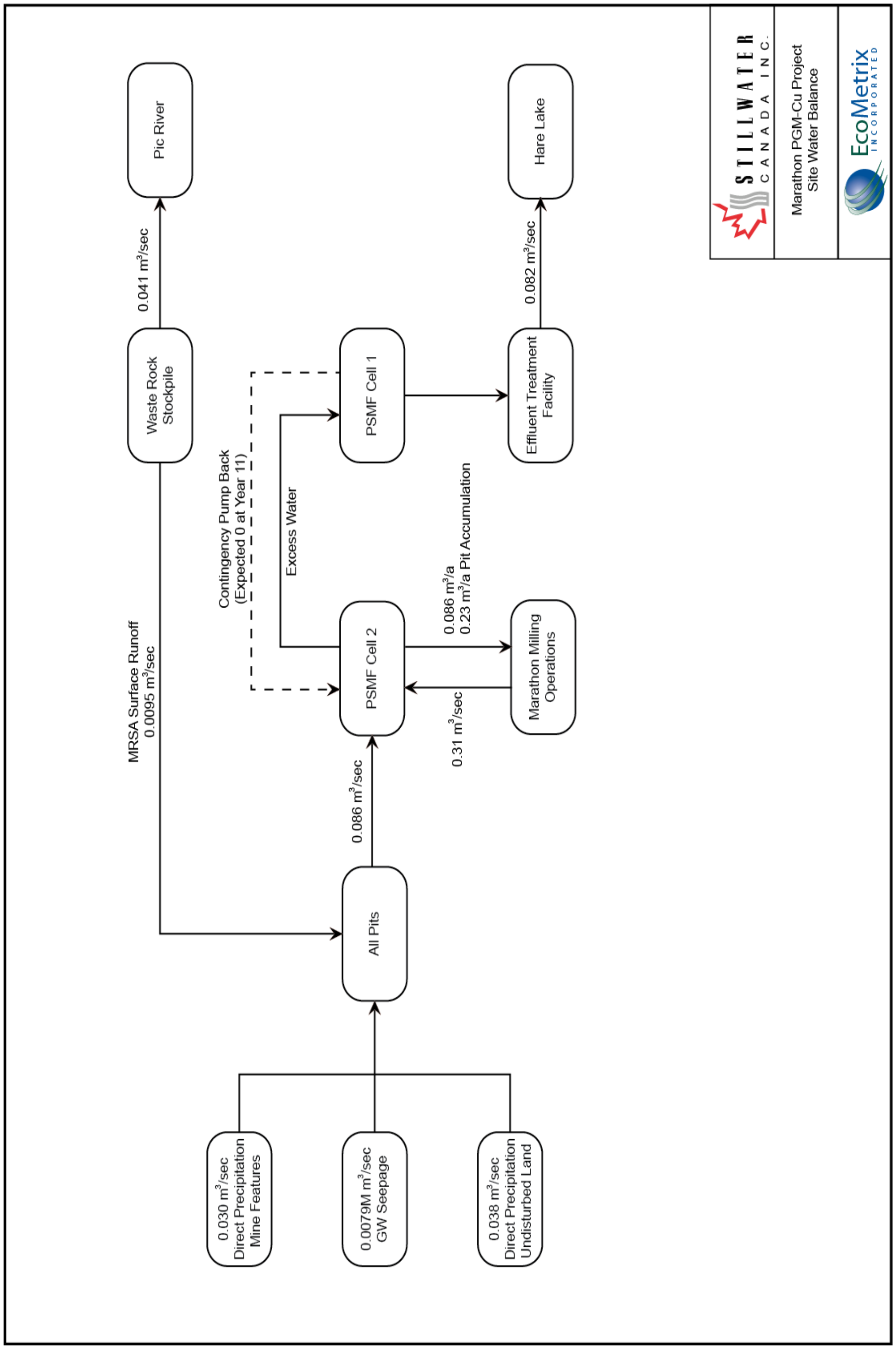
No direct discharge to the environment will occur during site preparation and construction. During operations, the discharge will release from the Project site to two water bodies—Hare Lake and the Pic River. Post-closure water will release to Stream 6. Detailed water balance and water management information for the PSMF is provided by Knight Piesold (2012). Detailed water balance and site hydrology pertaining to the MRSA are provided by Calder (2012b). The overall site water balance over the life of the mine is briefly described below and shown in Figure 2-5.

Water (primarily precipitation) draining the MRSA will be periodically discharged as required. The MRSA sits within four small subwatersheds. Water draining each of these subwatersheds will be collected in retention ponds at the natural drainage locations of the MRSA. Water from the retention ponds will be pumped when required to a common water treatment plant, treated if necessary, and released into the Pic River via an offshore diffuser. The MRSA collection system will be managed so as to minimize the amount of water discharged to the Pic River. It is anticipated that discharge will typically occur during spring runoff and periodically thereafter until late fall. Any water coming from the settling basins will be managed through a single discharge location. It is anticipated that the annual average discharge rate will be approximately 0.041 m^3/s (1.3 million $m^3/year$) to the Pic River from the MRSA, and will reduce to approximately 0.028 m^3/s during prolonged dry weather periods. Approximately 0.0095 m^3/s (300,000 $m^3/year$) of the surface run-off from the MRSA will be directed west into the pits and be managed in the PSMF with the rest of the pit water.

As the open pits are developed surface water run-off, precipitation, and groundwater seepage will enter the pits. Additionally, drainage from the Type 2 rock and ore stockpiles will be directed to the pits. A small portion of water will be lost from the pits through evaporation. During mine operation and open pit development, water will be pumped from the primary pit and directed to the PSMF. Approximately 0.086 m^3/s (2.7 million $m^3/year$) will be directed from the pits to the PSMF for use in the milling process.

Water pumped from the pits to the PSMF will be managed in Cell 1. Water in Cell 1 will be pumped to Cell 2 to augment the reclaim water supply as required. Excess water from Cell 1 will be discharged to Hare Lake following treatment as is necessary. The annual average discharge rate to Hare Lake is estimated to be approximately 0.086 m^3/s (2.7 million $m^3/year$) but will vary with the natural hydrologic cycle, mine schedule and water management strategy.

Figure 2-5: Marathon PGM-Cu Project Site Water Balance



Cell 2 will act as the reclaim pond with process water cycling between it and the mill for most of the operational phase of mine life. Water in Cell 2 will be derived from the liquid component of the process solids slurry and the natural run-off associated with the drainage area of the cell, which together accounts for approximately 0.22 m^3/s (7 million m^3/year) on average. Water will be reclaimed to the mill via a pump and pipeline system from Cell 2 to the mill to service the mill's process water needs.

Excess water from the PSMF not needed in the mill will be pumped from Cell 2 to Cell 1 and then discharged to Hare Lake following treatment if necessary through an offshore diffuser. Under average conditions, discharge rates from the PSMF to Hare Lake vary over the operations phase from 0 m^3, at the beginning of operations when there is storage capacity in the PSMF as the result of the initial raise of the dams, to a maximum of 0.086 m^3/s (2.7 million m^3/year), when storage capacity is relatively low (i.e., during year 11).

2.4 Source Loadings

The kinetic test results from mine rock and process solids in humidity cells and process solids in submerged high sulphur column tests form the basis for estimating the loading rates of contaminants of potential concern (COPC) from the mine materials to the contact water, whether as drainage from stockpiles or as overlying water for submerged process solids. Details on laboratory experiments performed are provided in EcoMetrix (2012e).

These laboratory loading rates were adjusted to simulate conditions in the field by considering differences in particle size and temperature among other possible factors. A grain size adjustment is made because leaching or loading rates of constituents from rock or process solids depends on the exposed surface area of the particles that is directly related to particle size. Leaching rates are also affected by temperature with lower rates corresponding to lower temperatures. Both laboratory and field adjusted loading rates (in mg/kg/wk or mg/m^2/wk) for mine rock and process solids are presented in Table 2-3, Table 2-4 and Table 2-5. Process solids decant water concentration is presented in Table 2-6.

These field-adjusted loading rates were applied to the exposed mass of material in a facility or exposed surface area to estimate COPC loadings (in mg/s or mg/a) to the receiving environment.

Table 2-3: Summary of Mine Rock Material Laboratory and Field Loading Rates for Type 1 and Type 2 Mine Rock

	Type 1 Mine Rock		Type 2 Mine Rock	
COPC	**Laboratory Rate (mg/kg/wk)**	**Field Rate [1] (mg/kg/wk)**	**Laboratory Rate (mg/kg/wk)**	**Field Rate [1] (mg/kg/wk)**
Sulphate	0.71	0.0012	12.2	2.07E-02
Aluminum [2]	0.13 [3]	0.13	0.13 [3]	0.13
Arsenic	0.0013	2.14E-06	1.53E-03	2.60E-06
Cadmium	3.26E-06	5.54E-09	1.01E-05	1.71E-08
Cobalt	8.60E-05	1.46E-07	1.63E-03	2.78E-06
Copper	0.00047	7.94E-07	4.53E-03	7.70E-06
Iron [2]	0.0044 [3]	0.0044	0.0044 [3]	0.0044
Molybdenum	0.00028	4.75E-07	1.39E-04	2.36E-07
Nickel	0.00024	4.00E-07	5.82E-03	9.89E-06
Lead	3.34E-05	5.68E-08	3.34E-05	5.68E-08
Selenium	0.00048	8.11E-07	4.67E-04	7.93E-07
Uranium	0.00014	2.33E-07	2.46E-04	4.17E-07
Vanadium	0.00094	1.60E-06	2.19E-04	3.71E-07
Zinc	0.00095	1.62E-06	1.41E-03	2.40E-06

NOTES:
1 - Adjusted for surface area (particle size) and temperature
2 - Dependent on geochemical characteristics of solubility and pH control
3 - Constant concentration in mg/L

Table 2-4: Summary of Mine Rock Material Laboratory and Field Loading Rates for Pit Walls, Rubble and Ore Material

	Pit Walls		Rubble[4]	Ore Material	
COPC	**Laboratory Rate[3] (mg/m²/wk)**	**Field Rate [1] (mg/m²/wk)**	**Field Rate[1] (mg/kg/wk)**	**Laboratory Rate (mg/kg/wk)**	**Field Rate (mg/kg/wk)**
Sulphate	0.062	0.011	1.21E-01	21.0	3.56
Aluminum [2]	0.011 [5]	0.011	0.13	0.13	0.13
Arsenic	0.00011	1.86E-05	2.14E-04	4.37E-04	7.42E-05
Cadmium	2.84E-07	4.82E-08	5.54E-07	1.94E-05	3.29E-06
Cobalt	7.48E-06	1.27E-06	1.46E-05	1.12E-03	1.91E-04
Copper	4.06E-05	6.90E-06	7.94E-05	9.65E-03	1.64E-03
Iron [2]	0.00038 [5]	0.00038	0.0044	0.0044	0.0044
Molybdenum	2.43E-05	4.13E-06	4.75E-05	1.12E-04	1.90E-05
Nickel	2.05E-05	3.48E-06	4.00E-05	4.29E-03	7.29E-04
Lead	2.90E-06	4.94E-07	5.68E-06	6.15E-05	1.04E-05
Selenium	4.15E-05	7.05E-06	8.11E-05	4.44E-04	7.55E-05
Uranium	1.19E-05	2.03E-06	2.33E-05	1.44E-04	2.44E-05
Vanadium	8.16E-05	1.39E-05	1.60E-04	6.95E-05	1.18E-05
Zinc	8.30E-05	1.41E-05	1.62E-04	1.33E-03	2.27E-04

NOTES:
1 - Adjusted for temperature
2 - Dependent on geochemical characteristics of solubility and pH control
3 - Converted from Type 1 mass rate (mg/kg/wk) to surface area rates ($mg/m^2/wk$)
4 - Laboratory rate based on Type 1 Mine Rock loading rate
5 - Constant concentration per surface area in $mg/L/m^2$

Table 2-5: Summary of Process Solids Laboratory and Field Loading Rates

	Type 1 Process Solids		Type 2 Process Solids (Flux)		Bulk Process Solids (Flux)	
COPC	Laboratory Rate (mg/kg/wk)	Field Rate [1] (mg/kg/wk)	Laboratory Rate (mg/m^2/wk)	Field Rate [2] (mg/m^2/wk)	Laboratory Rate (mg/m^2/wk)	Field Rate [2] (mg/m^2/wk)
Sulphate	10.92	1.86	825	825	404	404
Aluminum [3]	0.12	0.020	0.098	0.098	0.145	0.145
Arsenic	0.00013	0.00002	0.0037	0.004	0.0011	0.0011
Cadmium	0.000010	0.000002	0.00031	0.0003	0.000080	0.000080
Cobalt	0.00010	0.000018	0.00034	0.000	0.00093	0.00093
Copper	0.00053	0.00009	0.041	0.041	0.0055	0.0055
Iron [3]	0.030	0.0051	0.054	0.05	0.102	0.102
Molybdenum	0.00024	0.00004	0.065	0.065	0.181	0.181
Nickel	0.00056	0.00009	0.0092	0.009	0.0091	0.0091
Lead	0.000051	0.00001	0.00057	0.0006	0.00041	0.00041
Selenium	0.00027	0.00005	0.0025	0.002	0.0024	0.0024
Uranium	0.00010	0.00002	0.0028	0.003	0.0026	0.0026
Vanadium	0.0010	0.00018	0.0034	0.003	0.010	0.010
Zinc	0.0033	0.00056	0.019	0.019	0.031	0.031

NOTES:
1 - Adjusted for temperature
2 - No Adjustment
3 - Water quality concentration predictions dependent on geochemical characteristics of solubility and pH control

Table 2-6: Summary of Process Solids Decant Water Concentrations

Parameter	Units	PWQO[1]	2004 Process Solids Decant Water[2]	2008 Process Solids Decant Water	Geomean Average of 2004 and 2008 Decant Water[3]
			Dissolved	Dissolved	Dissolved
pH	---	6.5-8.5	-	7.43	7.43
Conductivity	uS/cm	No Value	-	370	370
Alkalinity ($CaCO_3$)	mg/L	No Value	-	Not Measured	Not Measured
Acidity	mg/L	No Value	-	5.0	5.0
Sulphate	mg/L	No Value	-	96	96
Chloride	mg/L	No Value	-	Not Measured	Not Measured
Aluminum	mg/L	0.015 - 0.075 [4]	0.3	0.034	0.101
Antimony	mg/L	0.02	0.003	0.005	0.0039
Arsenic	mg/L	0.005	0.001	0.001	0.0010
Barium	mg/L	No Value	0.01	0.01	0.010
Beryllium	mg/L	0.011 - 1.1 [5]	0.00002	0.001	0.00010
Bismuth	mg/L	No Value	0.00001	0.001	7.07E-05
Boron	mg/L	0.2	0.1	0.067	0.082
Cadmium	mg/L	0.0001 - 0.0005 [5]	0.000003	0.00039	3.42E-05
Calcium	mg/L	No Value	8.7	21.1	13.5
Chromium	mg/L	0.001	0.001	0.001	0.0010
Cobalt	mg/L	0.0009	0.0002	0.0005	0.00022
Copper	mg/L	0.001 - 0.005 [5]	0.0005	0.001	0.00050
Iron	mg/L	0.3	0.6	0.05	0.17
Lead	mg/L	0.001 - 0.005 [5]	0.0001	0.001	0.00022
Lithium	mg/L	No Value	0.002	Not Measured	0.0020
Magnesium	mg/L	No Value	1.8	3.59	2.54
Manganese	mg/L	No Value	0.02	0.0132	0.016
Mercury	mg/L	0.0002	0.0001	Not Measured	0.00010
Molybdenum	mg/L	0.04	0.06	0.0836	0.071
Nickel	mg/L	0.025	0.003	0.0035	0.0032
Phosphorus	mg/L	0.03 [6]	1	2.89	1.7
Potassium	mg/L	No Value	10.6	18.6	14.0
Selenium	mg/L	0.1	0.001	0.005	0.0016
Silicon	mg/L	No Value	3.8	2.61	3.15

Silver	mg/L	0.0001	0.00001	0.0001	2.24E-05
Sodium	mg/L	No Value	69	51.3	59.5
Strontium	mg/L	10 Bq/L	0.1	0.196	0.14
Thallium	mg/L	0.0003	0.000004	0.0003	2.45E-05
Tin	mg/L	No Value	0.003	0.001	0.0017
Titanium	mg/L	No Value	0.002	0.002	0.0020
Uranium	mg/L	0.005	0.0001	0.005	0.00050
Vanadium	mg/L	0.006	0.002	0.001	0.0014
Zinc	mg/L	0.02	0.03	0.0131	0.020

NOTES:
1 - PWQO = Provincial Water Quality Objectives (MOEE, 1999)
2 - From Golder, 2008.
3 - 1/2 Detection Limit (D.L.) used for 2008 Decant water results, when 2004 results were reported below 2008 D.L.
4 - pH Dependant
5 - Hardness Dependant
6 - PWQO based on Total P

3.0 THE RECEIVING ENVIRONMENTS

The following section provides an overview of the surface water receiving environments within and near to the Project site. It draws from several other supporting documents, including: the aquatic resources assessment (EcoMetrix, 2012a); and the hydrologic assessment (Calder, 2012a). The information presented supports the assessment of potential surface water quality effects presented in Section 5.0.

Section 3.1 provides a general description of the Project site and surrounding watersheds. Section 3.2 provides a summary of the aquatic environments of watersheds within and near the Project site. Section 3.3, Section 3.4 and Section 3.5 provide further information regarding morphology, hydrology and water quality within the three respective receiving environments—Hare Lake, the Pic River and Stream 6.

3.1 General Site Description

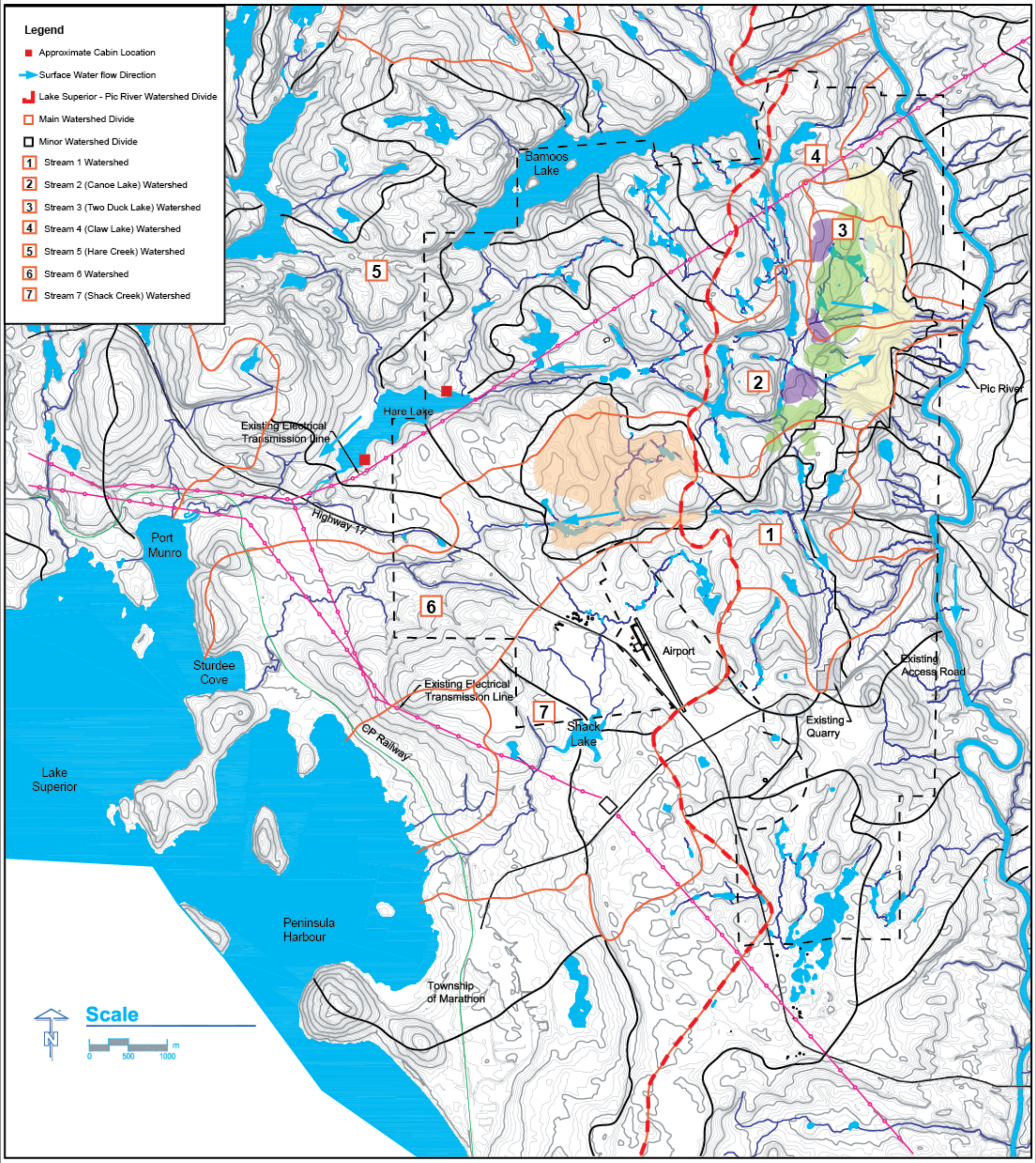
The proposed Project site is in an area characterized by dense vegetation, moderate to steep hilly terrain with a series of streams, ponds and small lakes. The climate is typical of northern areas within the Canadian Shield, with long winters and short, warm summers.

Land used in the immediate vicinity of the site include several authorized aggregate sites and the Marathon Municipal Airport (CYSP). Primary industries supporting the Town of Marathon, as well as the region, have historically been forestry, pulp and paper and mining. The Project site is located within the Big Pic Forest Management Area.

Figure 3-1 provides an overview of the watersheds draining the Project site. The Project site is bounded by the Pic River to the east and Lake Superior to the west. The Project site interacts directly or indirectly with seven watersheds which are designated ‘Stream 1 Watershed’ through ‘Stream 7 Watershed’ for the purpose of this assessment. Stream 1 through Stream 4 watersheds drain in a general eastward direction to the Pic River. Stream 5 through Stream 7 watersheds drain in a general westward direction to Lake Superior.

Water bodies that are expected to receive releases from Project activities are Hare Lake in the Stream 5 watershed during operations, Pic River during operations and post-closure and Stream 6 post-closure.

Figure 3-1: Watersheds Draining the Marathon PGM-Cu Project Site



Drawn By	Date
CL	Jan 28, 2010
Reviewed By	Date
BF	Jan 28, 2010
Revised By	Date
KP	July 15, 2010
Approved By	Date
BF	July 15, 2010
Revised By	Date
KP	July 4, 2012
Approved By	Date
BF	July 4, 2012

STILLWATER CANADA INC.

Watersheds Draining the Project Site

EcoMetrix INCORPORATED

3.2 Watersheds Within and Near the Project Site

Watersheds and watercourses within or near the Project site include small streams, ponds and lakes, many of which are maintained by active or inactive beaver dams or debris jams. Many of these water bodies are fishless likely as a result of the steep relief which isolates the interior of the Project site from the Pic River to the east and Lake Superior to the west. The aquatic resource assessment (EcoMetrix, 2012a) describes the aquatic resources identified within each of these watersheds and provides greater detail regarding the environmental conditions within each watershed. The following sections provide a brief overview of each watershed.

3.2.1 Stream 1 Watershed

The Stream 1 watershed drains a surface area of approximately 436 hectares. Lakes 1 and 2 are at the headwaters of the drainage, as illustrated in Figure 3-2. They flow into Stream 1 which flows southeast to the Pic River.

The mill site, access road and a small portion of the PSMF are to be located within the Stream 1 drainage area, but no direct discharge to Stream 1 is anticipated during any Project phase.

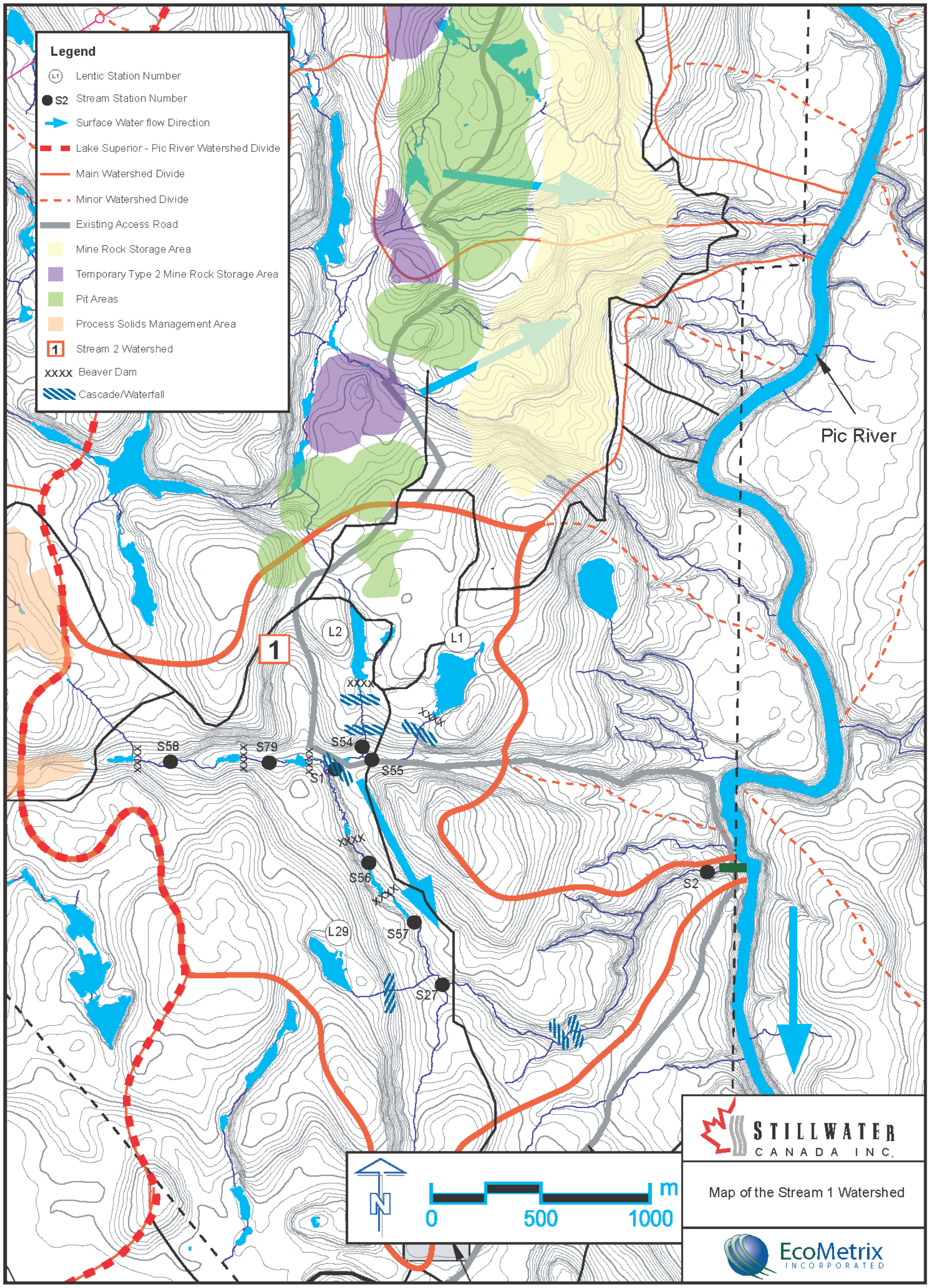
Lake 1 is a round bowl-shaped lake with a surface area of approximately 2.9 hectares. More than half of the lake is deeper that 2 m with the shallower habitats limited within a littoral band around the perimeter of the lake. Lake 2 is a long relatively narrow lake, approximately 340 m long and 50 m wide, with a maximum depth of approximately 3.5 m. Beaver dams were present at the outlet of both lakes in 2009, which substantially increased lake surface area and maintained high water levels.

Sediment samples collected in Lakes 1 and 2 show a number of parameters exceeding the Provincial Sediment Quality Guideline (PSQG). Total Kjeldahl nitrogen (TKN), total organic carbon (TOC) and copper exceed their respective Severe Effects Level (SEL) values in at least one of the samples and total phosphorous, arsenic, iron, cadmium, lead, nickel and zinc exceed their respective Lowest Effects Level (LEL) values.

The benthic community includes biotic groups with a wide range of tolerances including some generally sensitive taxa in both lakes species such as Ephemeroptera, Plecoptera,and Trichoptera (EPT) (mayflies, stoneflies and caddisflies respectively). Lakes 1 and 2 have been classified as having fair water quality according to the Hilsenhoff Biotic Index which measures the tolerance of the benthic community (macroinvertebrate assemblage) to organic, or nutrient, enrichment.

Lakes 1 and 2 are situated at the top of a fairly steep gradient which likely impedes fish migration from downstream source populations. Small bait-fish species have been inventoried in the upper reaches and coldwater salmonids such as Brook trout in the lower reaches of Stream 1. No fish have been observed in Lake 1 and Lake 2.

Figure 3-2: Map of the Stream 1 Watershed



3.2.2 Stream 2 Watershed

The Stream 2 watershed drains a surface area of approximately 347 hectares. Stream 2 flows generally eastward to the Pic River and discharges at a point approximately 2 km upstream (north) of the mouth of Stream 1. A number of lakes and ponds are situated within the watershed, as illustrated in Figure 3-3. Major lakes and ponds in the sub-basin include, L8, L14, L15, and L20 (Terru Lake).

Project activities within the Stream 2 watershed include the MRSA, access road and satellite pit. Surface runoff and seepage from the MRSA will collect in catch basins and discharge to the Pic River through an offshore diffuser. Runoff from the access road will be directed to the pit, and pit dewatering water will be directed to the PSMF. The Project will not discharge stormwater or process water to Stream 2.

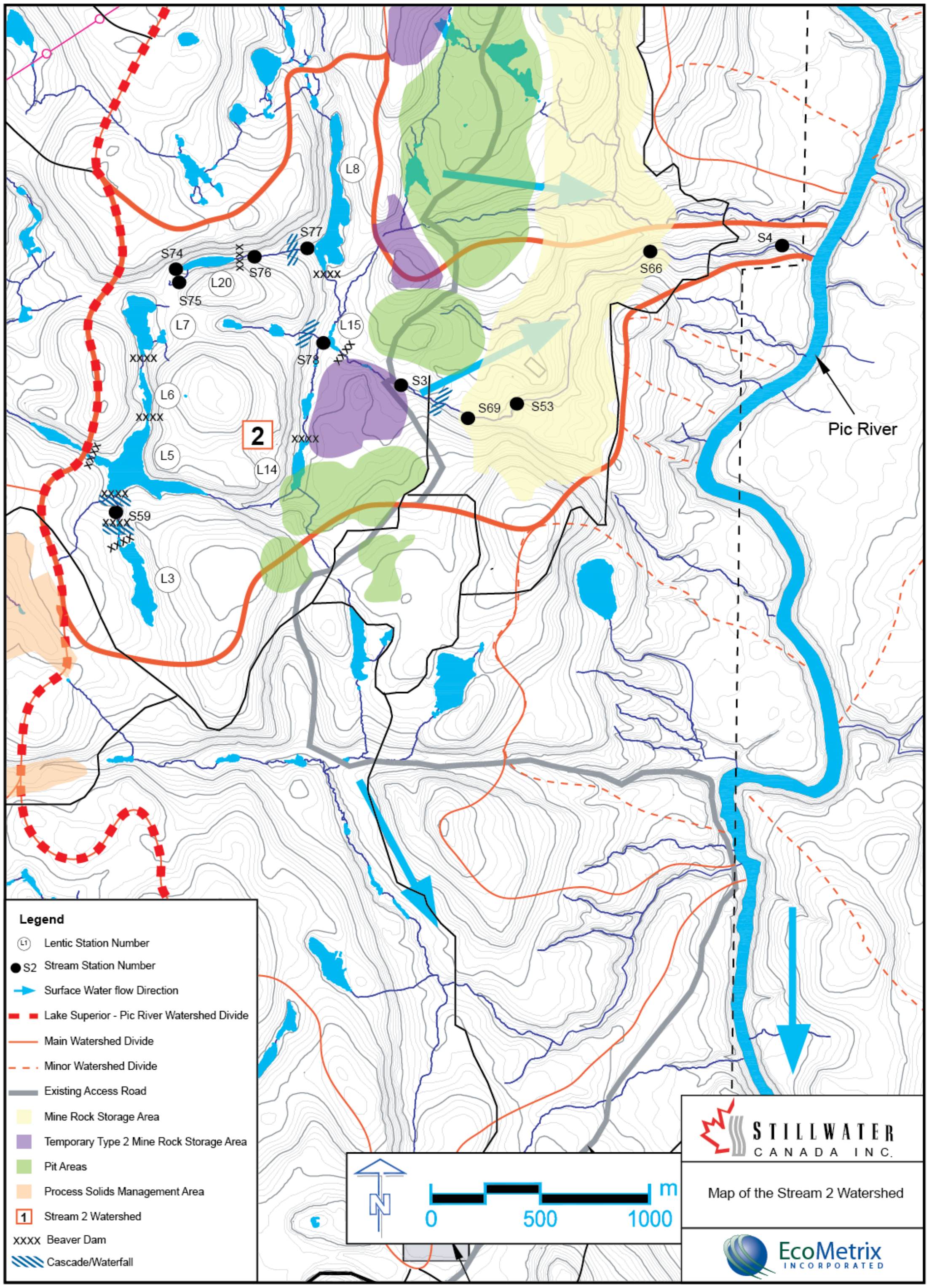
Sediment samples collected in 2006 indicate a number of parameters exceeding the PSQG. TKN, TOC and TP exceed their respective SEL values in a majority of sampled lakes. Copper exceeds the SEL value in Lake 15 and exceeds the LEL value in all other sample lakes except for Lake 6. Arsenic exceeds the LEL value in Lake 7 but not in any other lakes. Cadmium, iron, lead, nickel and zinc exceed their respective LEL values in three or more lakes throughout the watershed.

Similar to the Stream 1 watershed, Stream 2 supports a variety of benthic invertebrates. The different habitats demonstrate expected differences in the community composition. Sensitive benthic invertebrate species (EPT) are more prevalent at both the upstream and downstream stations and are generally absent in the middle reaches. Generally, lakes are classified as having fair water quality according to the Hilsenhoff Biotic Index, with the exception of Lake 3 (Station L3) and Lake 20 (Station L20) which were classified as having fairly poor water quality.

Lake 7 is the only headwater lake of Stream 2 to support a fish population. A number of factors such as low pH in Lakes 3 and 20 (in the 4 to 5.5 range), reduced oxygen at depth, beaver damming and low flows in connecting channels may contribute to the lack of fisheries in the headwaters of the watershed. In addition, there are a number of waterfalls and cascades in the upper- and mid-reach sections of Stream 2 that may impede fish migration.

Lake Chub and/or Brook Stickleback have been observed in lakes within the middle portion of the watershed. Brook Trout, Slimy Sculpin and Rainbow Trout have been observed in the mid-reaches of Stream 2. The lower reaches afford potential coldwater spawning and nursery habitat and support a diverse fishery.

Figure 3-3: Map of the Stream 2 Watershed



3.2.3 Stream 3 (Two Duck Lake) Watershed

The Stream 3 watershed drains an area of approximately 211 hectares. Stream 3 flows eastwards towards the Pic River and discharges approximately 150 m upstream of the mouth of Stream 2. A number of lakes and ponds are located within the catchment, including Lakes 9, 10, 11, 12, 13, 13a and 16, as illustrated in Figure 3-4.

Project activities within the Stream 3 watershed include the MRSA and the primary mine pit. Surface runoff and seepage from the MRSA will collect in catch basins and discharge to the Pic River through an offshore diffuser. Pit dewatering water will be directed to the PSMF. The Project will not discharge stormwater or process water to Stream 3.

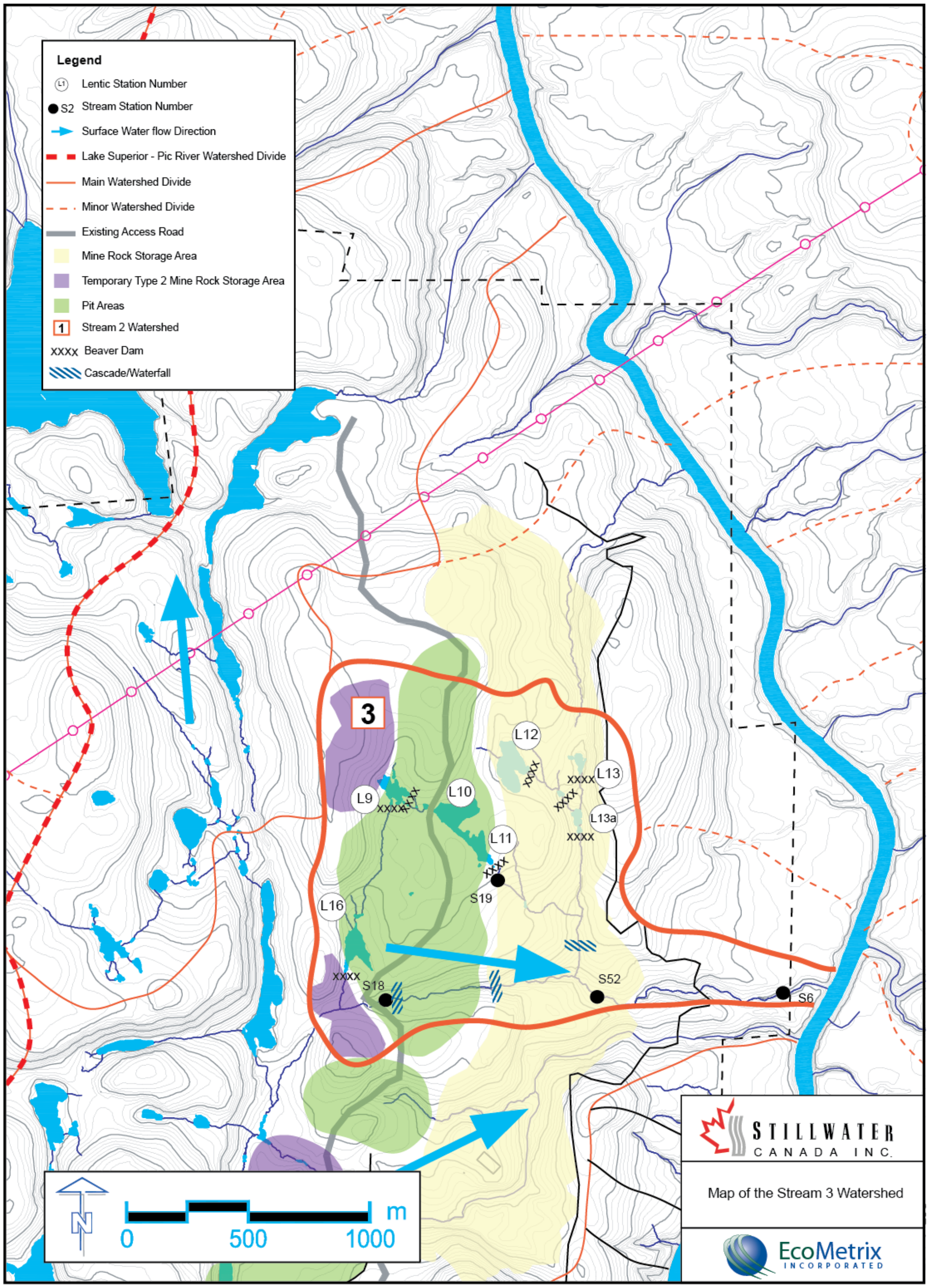
Sediment samples from 2006 and 2009 surveys indicate a number of parameters exceeding the PSQG. TKN, TOC and copper exceed their respective SEL values in the majority of the lakes within the watershed, whereas total phosphorous (TP), nickel and cadmium generally exceed their respective LEL values. Additionally there are occurrences of iron and lead exceeding the LEL values.

The Stream 3 watershed supports a variety of benthic invertebrates. Sensitive benthic invertebrate species (EPT) are present in both the upstream and downstream reaches. All reaches are classified as having fair water quality according to the Hilsenoff Biotic Index.

The topography of the Stream 3 watershed is characterized by steep relief which is a likely impediment to upstream fish migration. In addition, much of the upper reach area is affected by beaver activity which has modified the natural system. Lakes and ponds within upper - and mid-reaches of the Stream 3 watershed do not appear to support fish populations.

The lower reach of Stream 3 has a fairly diverse fishery and appears to support a coldwater spawning and nursery habitat for a community of migratory and resident salmonids as well as other small baitfish species.

Figure 3-4: Map of the Stream 3 Watershed



3.2.4 Stream 4 (Claw Lake) Watershed

The Stream 4 watershed drains an area of approximately 339 hectares. Stream 4 flows northeast and discharges into the Pic River approximately 4 km upstream of the mouth of Stream 3. The catchment includes Lakes 18, 19, 21 and 22, as illustrated in Figure 3-5.

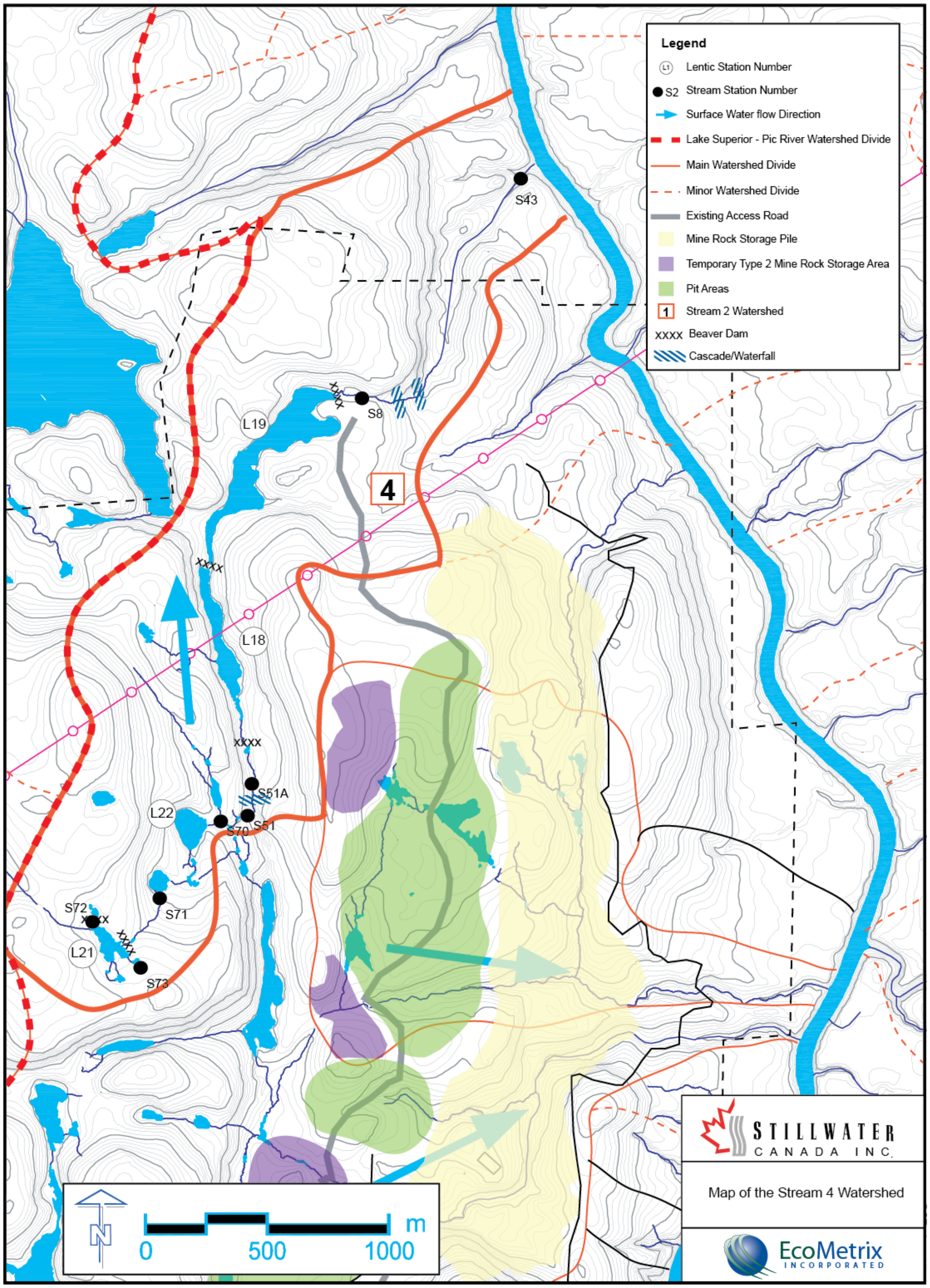
Project activities within the Stream 4 watershed include the MRSA. Surface runoff and seepage from the MRSA will collect in catch basins and discharge to the Pic River through an offshore diffuser. The Project will not discharge stormwater or process water to Stream 4.

Sediment samples from 2007 and 2009 surveys resulted in a number of parameters exceeding the PSQG. TOC exceeds the SEL value in all lakes except Lake 18, whereas copper exceeds the SEL value in Lakes 18 and 19 and the LEL value in Lake 22. Cadmium and nickel exceed their respective LEL values in Lakes 18, 19 and 22. Nickel exceeds and copper is equal to or exceeds the LEL value at all stream stations. In the upstream and downstream stations TP exceeds the SEL and LEL values, respectively, whereas TOC exceeds the LEL value in the upper and mid-reach stations. Zinc, arsenic, and iron also exceed some guideline values in Stream 4 sediments.

The Stream 4 watershed supports a relatively diverse benthic community. Sensitive taxa (EPT) comprise a larger proportion of the benthic community at the downstream and upstream reaches (42% and 31% respectively) when compared to the mid-stream reach (11%). Lakes 18, 19 and 21 present fairly poor water quality whereas Lake 22 presents fair water quality according to the Hilsenoff Biotic index. The upstream and downstream reaches of Stream 4 have good water quality, whereas the mid-stream reach has fair quality.

The headwater lakes of Stream 4 do not appear to support fish populations. The lack of fish in the upstream reaches could be caused by steep cascades and beaver activity within the mid-reaches of Stream 4 which could prevent upstream migration of fish, unsuitable water quality such as low pH in some of the areas of the upper watershed (i.e., pH of 4.4 in Lake 21), as well as a lack overwintering habitat. Lakes 18 and 19 and the mid-stream reach of Stream 4 support a variety of fish species. The lower reach affords potential coldwater spawning and nursery habitat for both migratory and resident salmonids as well as other small species.

Figure 3-5: Map of the Stream 4 Watershed



3.2.5 Stream 5 (Hare Lake and Hare Creek) Watershed

The Stream 5 watershed drains an area of approximately 4,833 hectares. The watershed includes Stream 5, Bamoos Lake, Seeley Lake, Bill Lake, Hare Lake and Hare Creek, and a number of smaller waterbodies, as illustrated in Figure 3-6. Stream 5 flows westward, discharging into the eastern end of Hare Lake. Hare Lake receives flows from Bamoos Lake via Bamoos Creek and Seeley Lake. The outlet at the southwestern end of Hare Lake forms Hare Creek, which flows westward towards Lake Superior. Hare Creek discharges to Lake Superior at Port Munroe.

The Stream 5 watershed is beyond the bounds of the Project site with the exception of a relatively small overlap with the PSMF along the southern portion of the watershed. Hare Lake will receive the discharge from the PSMF via an overland pipeline and offshore diffuser. Section 3.3 provides greater detail regarding Hare Lake, and Section 5.1 presents the assessment of surface water quality effects associated with the PSMF discharge to Hare Lake.

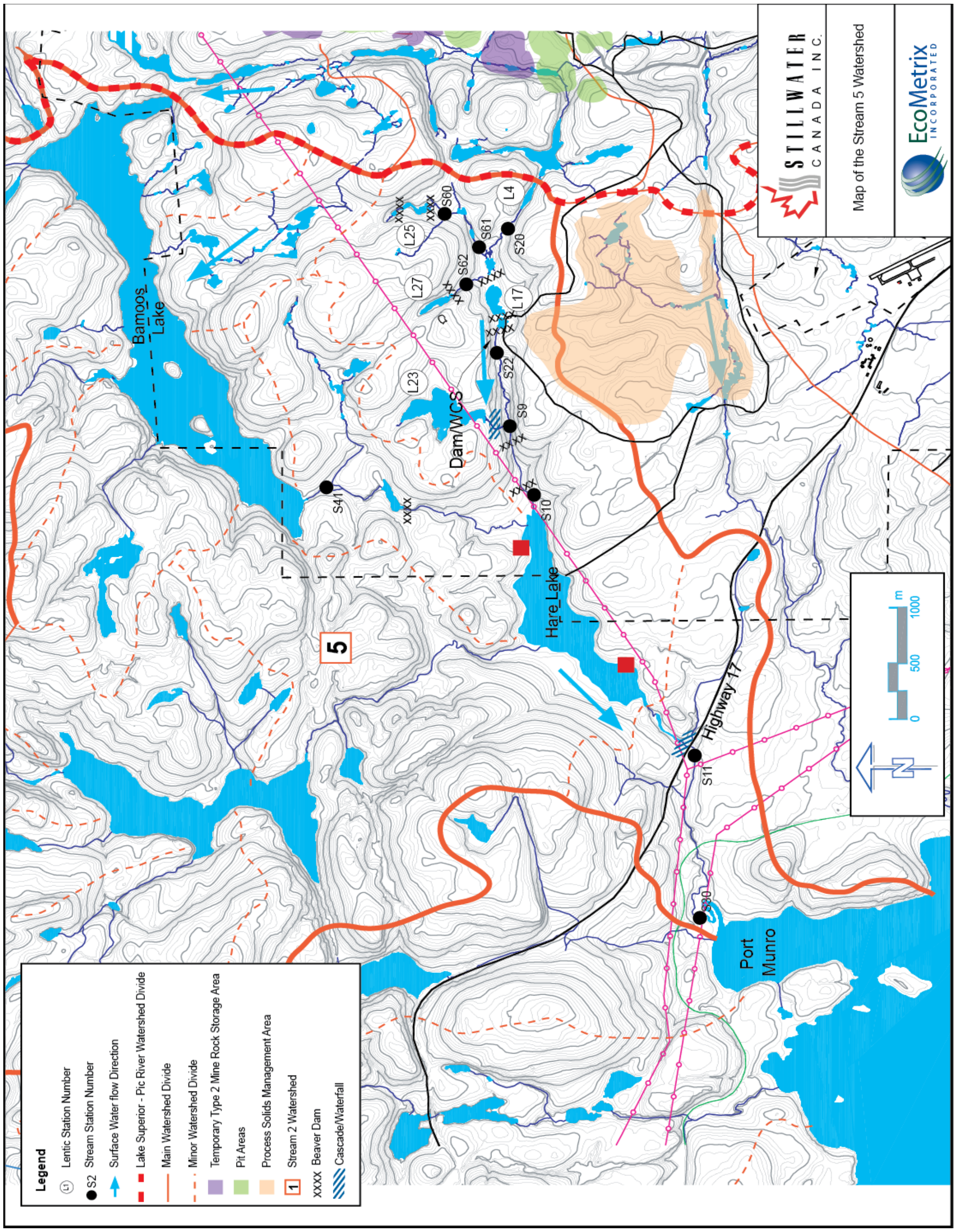
Sediment samples from 2007 and 2009 surveys indicate a number of parameters exceeding the PSQG. TOC and TP exceed their respective LEL values at all sampled stations. TKN and copper exceed their LEL or SEL values in Hare and Bamoos Lakes and in Bamoos Creek. Cadmium, zinc, manganese, iron, arsenic, lead and nickel have also exceeded their LEL values in at least one station in the Stream 5 watershed.

The benthic communities in Stream 5 are generally dominated by sensitive taxa (EPT) with other taxa such as mollusks (clams), dipterans (flies and midges) and oligochaetes (worms) and leeches comprising substantial proportions of most stream station benthic communities. In Bamoos and Hare Lakes dipterans and clams dominate the benthic communities in both lakes. A survey conducted in 2007 classified the water quality of Lake 4 as fair.

Small headwater lakes within the Hare Lake watershed either do not appear to support fish or support a limited community. Lake Chub and Brook Stickleback have been observed in some lakes. A lack of overwintering habitat, combined with barriers such as beaver dams may contribute to the lack of fish resources in the upstream reaches of Stream 5. Brook Stickleback have been collected within the mid reaches of Stream 5 while a small number of resident coldwater fish species have been observed in the lower reaches, upstream of Hare Lake, and in Bamoos Creek.

Bamoos Lake is the largest lake within the study area with a maximum depth of approximately 80 m and a surface area of approximately 174 hectares. Bamoos Lake is a deep, coldwater lake with limited littoral zone habitat, usually associated with tributary inflows. It supports a diverse coldwater community which includes fourteen reported species.

Figure 3-6: Map of the Stream 5 Watershed



Hare Lake provides coldwater habitat; that supports a primarily coolwater community, with only low numbers of coldwater fish. Fish community surveys indicated that the lower portions of Hare Creek afford potential spawning and nursery habitat for both migratory and resident coldwater fishes and support a relatively diverse coldwater fish community including both migratory and resident salmonid species.

3.2.6 Stream 6 Watershed

The Stream 6 watershed drains a total area of approximately 1,098 hectares. Within the Stream 6 watershed, water flows westward, draining the southwestern portion of the Project area. Stream 6 discharges to Lake Superior at Sturdee Cove. Lakes 24 and 26 are within the Stream 6 watershed, as illustrated in Figure 3-7. Lake 24 was a former beaver pond and at the time of the baseline studies it had drained and was primarily a beaver meadow. Lake 26 is a small headwater pond with substantial aquatic macrophyte beds and a limited amount of open water. The maximum water depth of Lake 26 is approximately 5 m and the surface area is approximately 1.9 hectares.

The PSMF and mill are located within the headwaters of the Stream 6 watershed. During operations, the runoff from the headwaters areas within the Project site will be collected in the PSMF and discharged via overland pipeline and offshore diffuser to Hare Lake. No direct discharge to Stream 6 is anticipated during this Project phase. Following the cessation of operations, when natural drainage is restored, Stream 6 will receive runoff and some seepage from the decommissioned PSMF. Section 3.5 provides greater detail regarding Stream 6, and Section 5.3 presents the assessment of surface water quality effects associated with the PSMF discharge to Stream 6 post-closure.

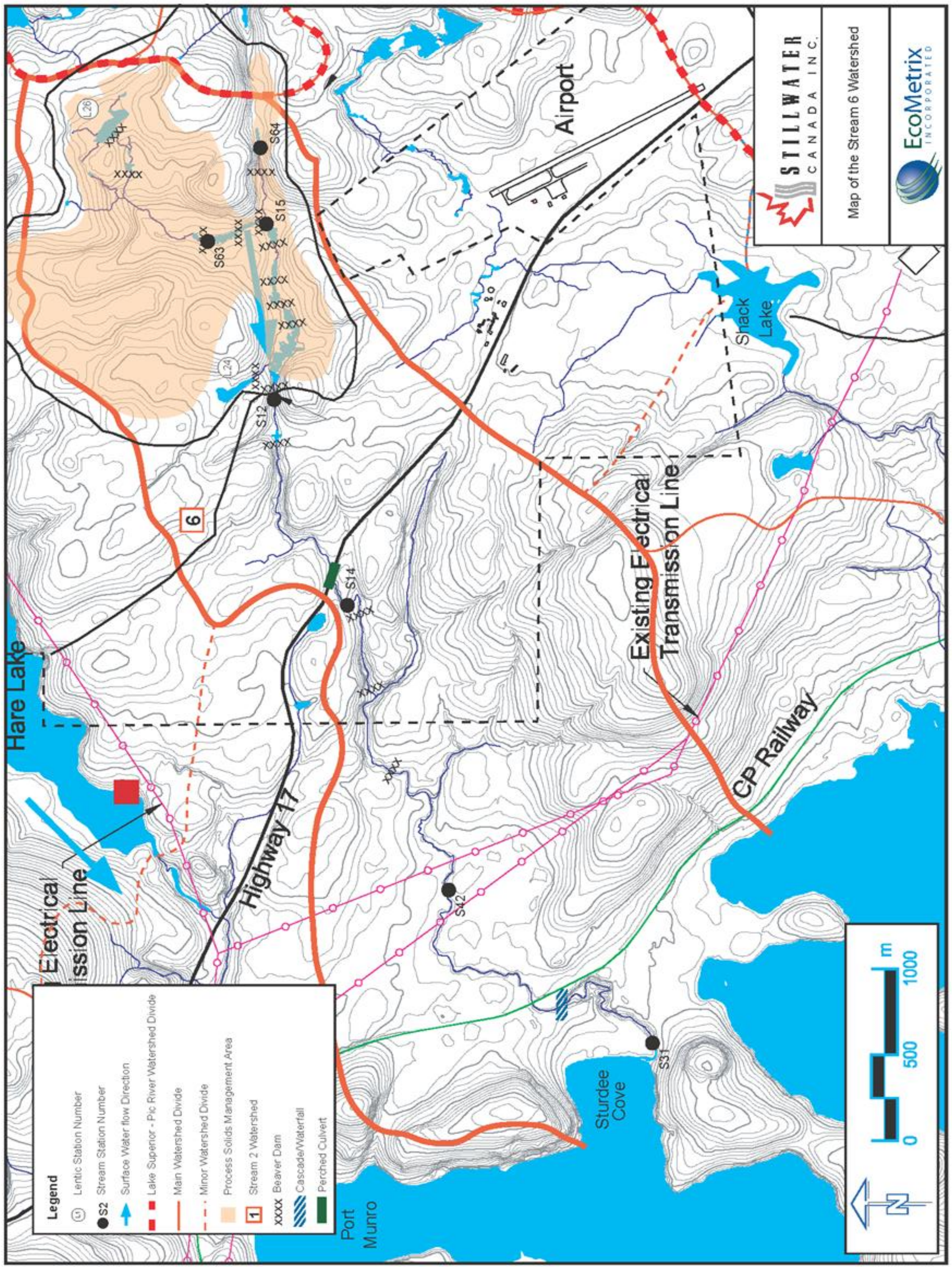
Constituents that exceed benchmark values in sediments in the Stream 6 drainage include: TP, TKN and TOC in Lake 24; TP, TKN, TOC and cadmium in Lake 26; TKN and TOC in the upper reach of Stream 6; TP, TKN, TOC and iron in the mid-reach of Stream 6; and TKN in the lower-reach of Stream 6.

Water quality is categorized as excellent at the headwaters and fair downstream according to the Hilsenoff Biotic Index for benthic communities.

The upper reaches of Stream 6 support a limited fish community. There are several potential natural barriers to the upstream migration of fish from Lake Superior in the mid-reach section of the stream and in the lower reach section near the confluence with Lake Superior. Brook Stickleback have been collected in the mid-reach section of the stream.

Within the lower reaches, near the mouth with Lake Superior, a small number of coldwater migratory salmonids have been observed. The lower reach of Stream 6 provides limited amount of nursery and spawning habitat for coldwater migratory species from Lake Superior as well as some other small-bodied species.

Figure 3-7: Map of the Stream 6 Watershed



3.2.7 Stream 7 (Shack Creek) Watershed

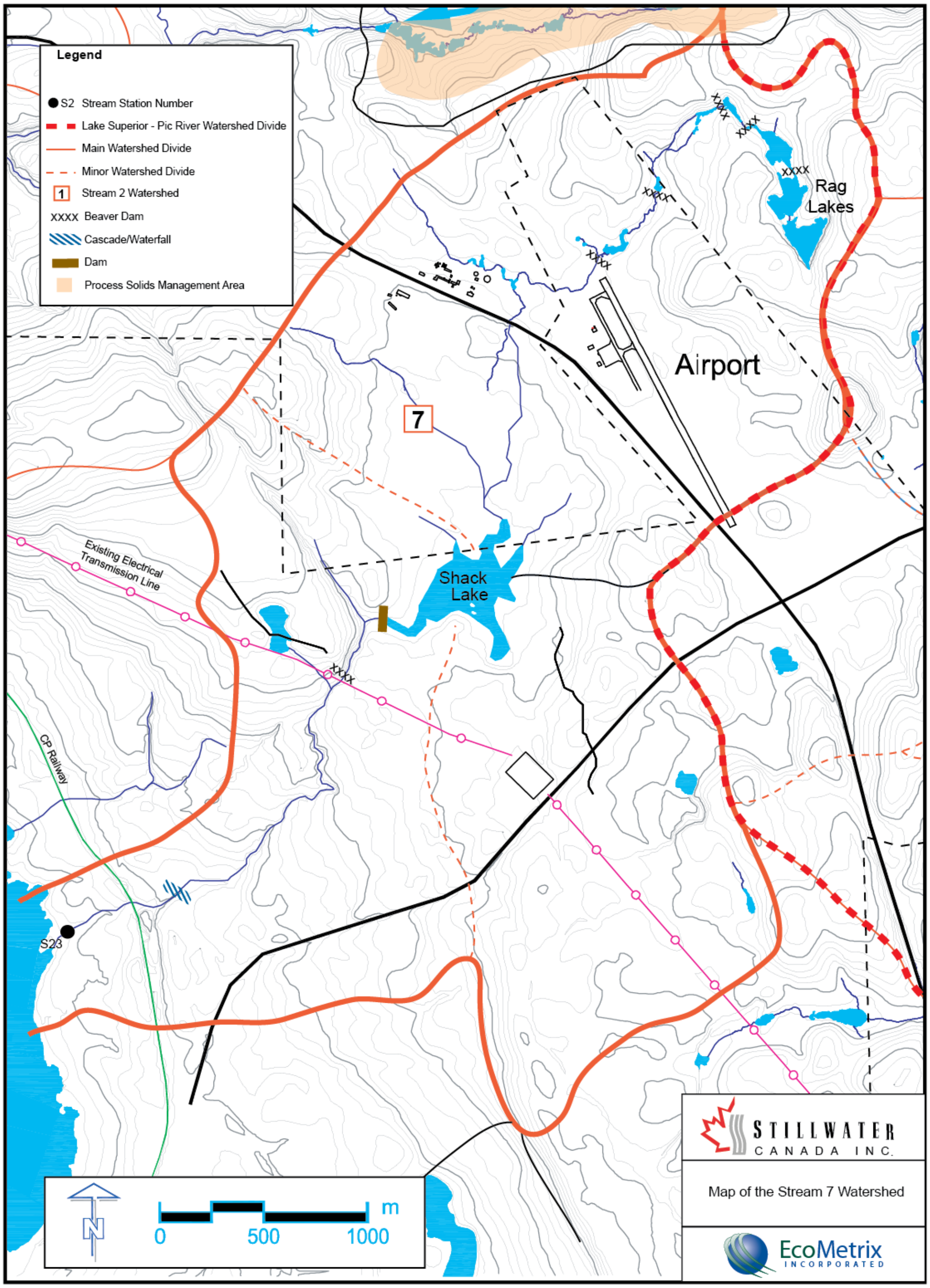
The Stream 7 watershed includes Shack Creek, the Rag Lakes at the headwaters and Shack Lake, a man-made lake, in the mid-reach section. The airport for the town of Marathon is located within the drainage area. Stream 7 discharges to Lake Superior at Peninsula Harbour, as illustrated in Figure 3-8.

A relatively small portion of the Project site is located within the Stream 7 watershed, but beyond the direct footprint of the Project activities. No direct discharge to Stream 7 is anticipated during any Project phase.

Rag Lakes and Shack Lake have historically been coldwater Brook Trout lakes. Active stocking of Brook trout has been undertaken at both lakes until the 1960s in the case of Rag Lakes and until the 1980s in the case of Shack Lake. The current state of the Rag Lakes fishery is not known.

Shack Lake, although historically a coldwater lake, appears to have transitioned to a coolwater lake dominated by Yellow Perch. Within its lower reaches, Shack Creek provides spawning and nursery habitat for migratory and resident salmonids, other migratory Lake Superior fish and some resident small-bodied species.

Figure 3-8: Map of the Stream 7 Watershed



3.2.8 Pic River and Small Tributaries

The Pic River is a relatively large river with a drainage area of approximately 427,000 hectares that discharges to Lake Superior. Several small tributaries of the Pic River reside within the vicinity of the Project site, as illustrated in Figure 3-9. These tributaries generally consist of small, intermittent first-order streams approximately 1 km in length that originate at higher elevation and flow east towards the Pic River. The Malpa Lake sub-watershed is similar to these other tributaries except that a small headwater lake is the source.

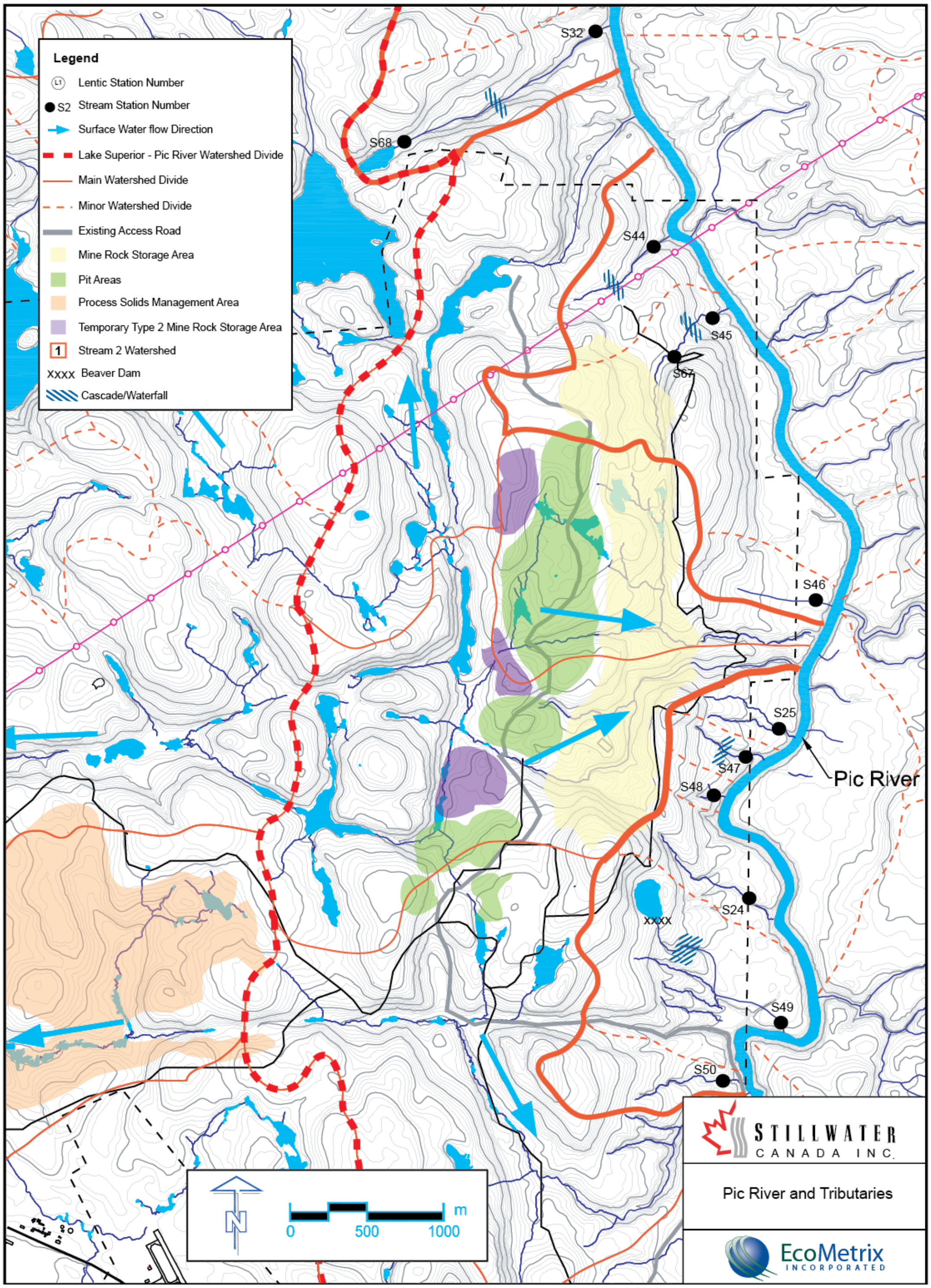
The MRSA is located within the sub-catchment areas for these small tributaries. Surface runoff and seepage from the MRSA will be collected in catch basins and discharge through an offshore diffuser to the Pic River. Section 3.4 provides greater detail regarding the Pic River, and Section 5.2 presents the assessment of surface water quality effects associated with the MRSA discharge to the Pic River.

Results from a 2006 sediment sample from Malpa Lake determined that eight parameters (TKN, TOC, TP, cadmium, copper, lead, nickel and zinc) exceed their respective LEL or SEL values. In 2009, sediment samples were collected at the different tributaries. Some exceedances of PSQGs were identified within most of the tributaries. Sediments exceed the LEL values for TP, TKN, copper, iron and nickel in one tributary. TKN is equal to or exceeds the LEL value within three of the tributaries. TOC also exceeds the LEL value in one tributary.

Most of the small tributaries rely on precipitation runoff as a primary source of flow and five of these watercourses only flow during part of the year and have severely limited fisheries habitat potential.

The fish community within the Pic River is diverse, with reported fish species including Lake Sturgeon, Walleye, Longnose Sucker, Silver Redhorse, Muskellunge, Trout-perch, Spottail Shiner, Northern Redbelly Dace, Rainbow Trout, Coho Salmon, Chinook Salmon, Brook Trout, Rainbow Smelt, Northern Pike, White Sucker and Shorthead Redhorse.

Figure 3-9: Map of the Pic River and Tributaries



3.2.9 Lake Superior

The Lake Superior watershed is the regional watershed that encompasses all water bodies within and near the Project site. Lake Superior is the northern most and largest of the five Great Lakes. Lake Superior has an average depth of approximately 147 m and a maximum depth of approximately 406 m with a surface area of approximately 8,210,000 hectares and a total watershed area of approximately 12,770,000 hectares.

Stream 5 (Hare Lake and Hare Creek) watershed, Stream 6 and the Pic River discharge to Lake Superior at Port Munroe at the mouth of Hare Creek, Sturdee Cove at the mouth of Stream 6, and Heron Bay near the mouth of the Pic River.

Sediment samples collected at the mouth of Hare Creek and Sturdee Cove indicate that no parameters of concern exceed their SEL value and only a small number of parameters, TKN, TP, TOC and copper, exceed their LEL value in Port Munroe. No parameters exceed the LEL values in Sturdee Cove sediments.

The nearshore embayments of Lake Superior provide habitat for a wide variety of fishes, including both coldwater and coolwater species. These embayments offer nursery habitats for many species including whitefish, salmon, trout and suckers. Spawning habitat for species such as whitefish is also likely present. In addition, many Lake Superior species migrate through the embayments to spawning tributaries, such as Hare Creek which discharges to the lake.

Lake Superior is beyond the area of influence for the Project since all compliance objectives are achieved within the respective receiving environments prior to the lake.

3.3 Receiving Environment – Hare Lake

Hare Lake is identified as a receiving environment for the Project as it will receive discharge of excess water, treated as necessary, from the PSMF via an overland pipeline and offshore diffuser. The sections below provide greater detail regarding the morphology, hydrology and water quality of Hare Lake to support the assessment of surface water quality effects.

Figure 3-10 presents a map of Hare Lake along with information regarding its general characteristics. Plate 3-1 and Plate 3-2 show oblique aerial photographs of the lake looking towards the inlet and outlet. Hare Lake is within the Stream 5 watershed which discharges to Lake Superior at Port Monroe. A dirt road from Highway #17 provides public access to Hare Lake and access for two private cabins located on the lake. Hare Lake supports a predominantly coolwater fish community with Northern Pike and Yellow Perch the most abundant sport fish species with some elements of a coldwater fishery such as Burbot, Cisco and Lake Trout.

Figure 3-10: Receiving Environment – Hare Lake

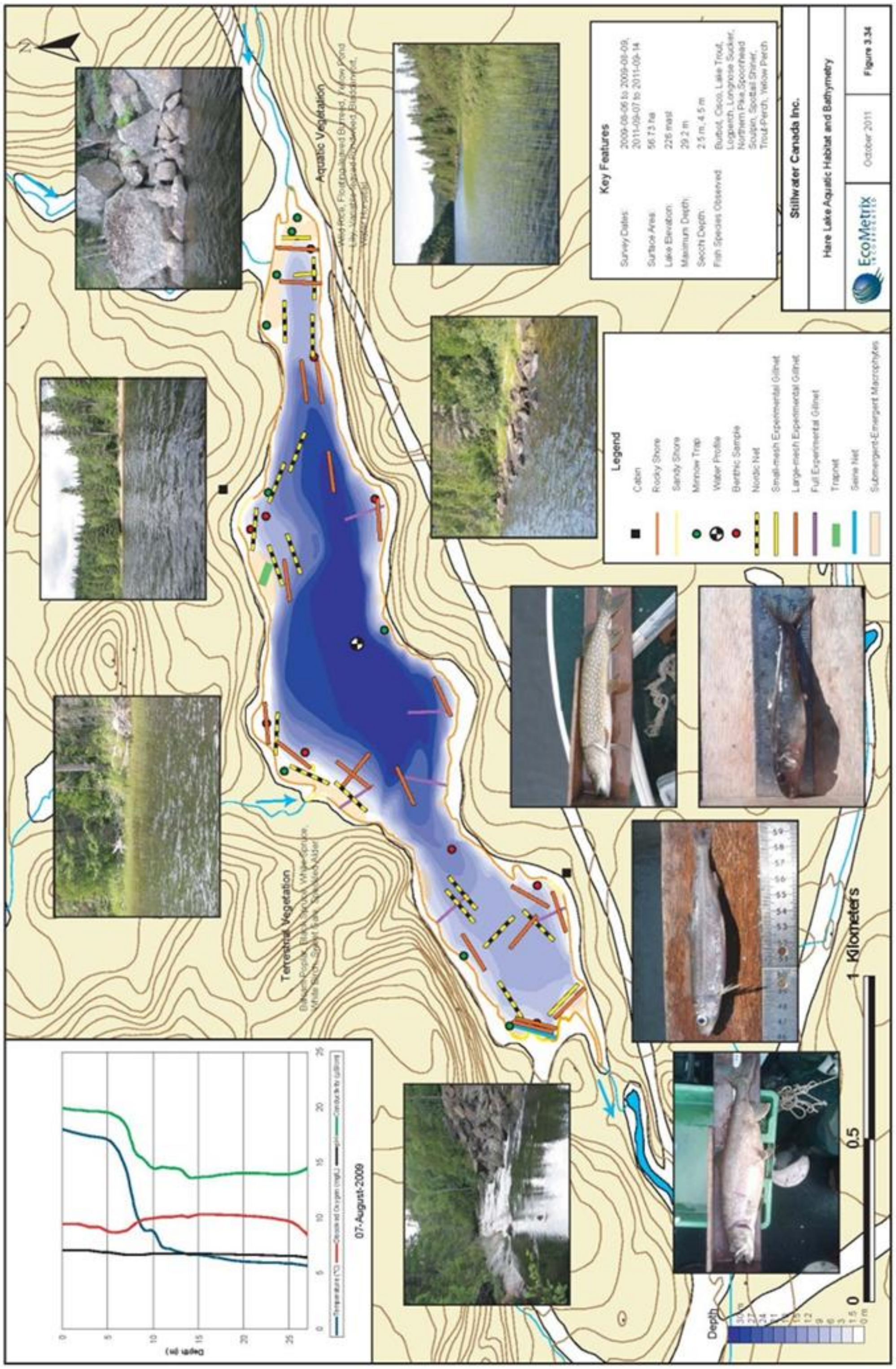


Plate 3-1: Hare Lake—looking Northeast to the inlets at the far end of the lake

Plate 3-2: Hare Lake—looking Southwest to the outlet at the far end of the lake

3.3.1 Morphometry

Hare Lake is considered a medium-sized lake with a surface area of approximately 57 hectares, a mean depth of approximately 15 m, and a maximum depth of approximately 30 m. The deepest waters occur in the central basin. The lake stratifies during the summer with a recorded thermocline at approximately 5 m depth. It has a water volume of approximately 9,685,000 m^3.

The lake has a drainage area of approximately 4,600 hectares, and receives inflows from Bamoos Creek and Stream 5 at the eastern end of the lake, and inflows from an unnamed creek originating from a group of lakes which includes Seeley Lake located approximately 2 km to the north. Hare Lake discharges at the western end to Hare Creek, which subsequently drains to Lake Superior approximately 3 km downstream. The total area of the Stream 5 watershed is approximately 4,833 hectares.

3.3.2 Hydrology

The streamflow rate in Hare Creek is not routinely monitored, so it is necessary to estimate the streamflow from measured flows in other nearby watersheds.

The Water Survey of Canada (WSC) records flows at various locations in Ontario and elsewhere in Canada. Table 3-1 lists the fourteen stations that are located within the general vicinity of the Project site.

Table 3-1: WSC Gauging Stations in Proximity to the Project Site

No	Station	Watershed	Location	Drainage Area (km^2)	Years of record
1	02AC001	Wolf River	at Highway No. 17	736	37
2	02AC002	Black Sturgeon River	at Highway No. 17	2,980	40
3	02AE001	Gravel River	near Cavers	608	37
4	02BA005	Whitesand River	above Schreiber at Minova	21	22
5	02BA003	Little Pic River	near Coldwell	1,320	39
6	02BB003	Pic River	near Marathon	4,270	41
7	02BB004	Cedar Creek	near Hemlo	201	27
8	02BC004	White River	below White Lake	4,170	52
9	02BC006	Pukaskwa River	below Fox River	450	5
10	02BC007	White Lake	at White Lake Provincial Park	-	4
11	02BA006	Steel River	below Santoy Lake	-	8
12	02BD005	Magpie River	at Esnagi Lake	-	22
13	02BD007	Magpie River	near Wawa	-	9
14	02BD006	Wawa Creek	at Wawa	34	5

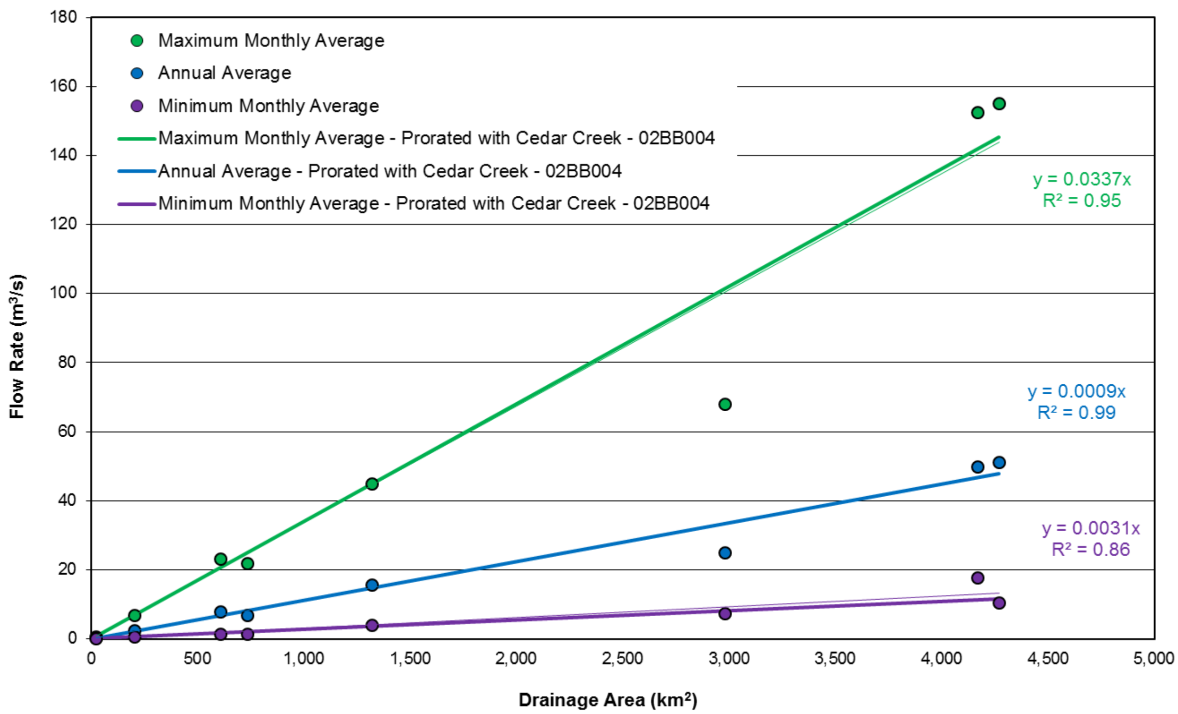
Table 3-2 summarizes the annual and monthly flows for eight of these stations. The remaining six stations lack sufficient record or information regarding the drainage area.

Figure 3-11 compares the annual average and maximum and minimum monthly average flows against drainage area for each respective watershed. As illustrated, the comparison shows a strong correlation between flow and drainage area— $r^2 \geq 0.99$ for the annual average flow, $r^2 \geq 0.95$ for the maximum monthly average flow, and $r^2 \geq 0.88$ for the minimum monthly average flow.

Table 3-2: Summary of Flows for Identified WSC Gauging Stations

	Station Number							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
	Drainage Area (km^2)							
	736	2,980	608	20.9	1,320	4,270	201	4,170
	Annual Average Flow (m^3/s)							
	6.75	24.8	7.89	0.18	15.6	51.2	2.25	49.8
	Monthly Average Flow (m^3/s)							
Jan	2.09	9.80	1.97	0.03	4.98	14.5	0.84	28.1
Feb	1.41	7.42	1.29	0.03	3.88	10.4	0.55	20.5
Mar	1.63	7.19	1.42	0.06	4.28	11.1	0.55	17.7
Apr	14.3	28.1	13.5	0.45	30.5	94.1	4.25	49.2
May	21.8	67.9	23.0	0.52	44.8	155	6.84	152
Jun	10.5	47.3	10.0	0.17	21.0	72.0	2.42	82.1
Jul	5.52	30.0	7.23	0.11	13.9	48.3	1.84	45.4
Aug	3.11	17.3	4.25	0.06	9.17	32.1	0.98	26.6
Sep	4.03	16.4	7.44	0.14	11.3	35.3	1.16	27.6
Oct	6.44	24.1	10.2	0.29	18.6	60.9	2.88	50.0
Nov	6.43	25.5	10.0	0.21	16.8	52.0	3.07	56.4
Dec	3.82	16.5	4.44	0.06	8.25	28.3	1.63	42.3

Figure 3-11: Comparison of Monthly and Annual Average Flows to Drainage Area



The correlation between flow and drainage area provides a basis to estimate flows within Hare Creek. Equation 3-1 represents this relationship, where Q is the estimated flow at drainage area A, and Q_o is the measured flow at drainage area A_o.

$$Q = \frac{Q_o}{A_o} A \qquad \textbf{Equation 3-1}$$

Measured flows for Cedar Creek near Hemlo (Station #7, WSC gauge 02BB004) were used for the assessment since it has a relatively small drainage area and sufficiently long and complete record. The daily flows measured in Cedar Creek are prorated by drainage area using Equation 3-1 to predict the corresponding flows for Hare Creek.

The points below summarize the main characteristics of the flows in Hare Creek at the outlet of Hare Lake:

- Figure 3-12 presents the estimated daily flows for Hare Creek at the outlet of Hare Lake. As illustrated, the flows vary over the period of record from a minimum daily flow of 0.006 m^3/s to a maximum daily flow of 8.4 m^3/s.

- Figure 3-13 summarizes the estimated annual average flows for Hare Creek at the outlet of Hare Lake. The annual average flow is approximately 0.53 m^3/s, ranging from a minimum of approximately 0.22 m^3/s in 2010 to a maximum of approximately 0.91 m^3/s in 1997.

- Figure 3-14 summarizes the estimated monthly average flows for Hare Creek at the outlet of Hare Lake. High flows typically occur in spring (May), with a monthly average of approximately 1.56 m^3/s. Low flows typically occur in winter (January through March), with a monthly average of approximately 0.13 m^3/s, and in summer (August and September), with a monthly average of 0.23 m^3/s.

- Figure 3-15 presents the flow frequency distribution of daily average flows for the February and August low flow periods. During winter, the daily average flow exceeds 0.13 m^3/s approximately 50% of the time on average, and exceeds 0.06 m^3/s approximately 95% of the time on average. During summer, the daily average flow exceeds 0.25 m^3/s approximately 50% of the time on average, and exceeds 0.07 m^3/s approximately 95% of the time on average.

- The 7Q20 low flow is often used for the assessment of assimilative capacity. Figure 3-16 summarizes the frequency distribution of the 7-day average low flow for winter and summer. The 7Q20 low flow is approximately 0.045 m^3/s based on winter low flows and approximately 0.00328 m^3/s based on summer low flows.

Figure 3-12: Estimated Daily Flows – Hare Creek at Outlet of Hare Lake

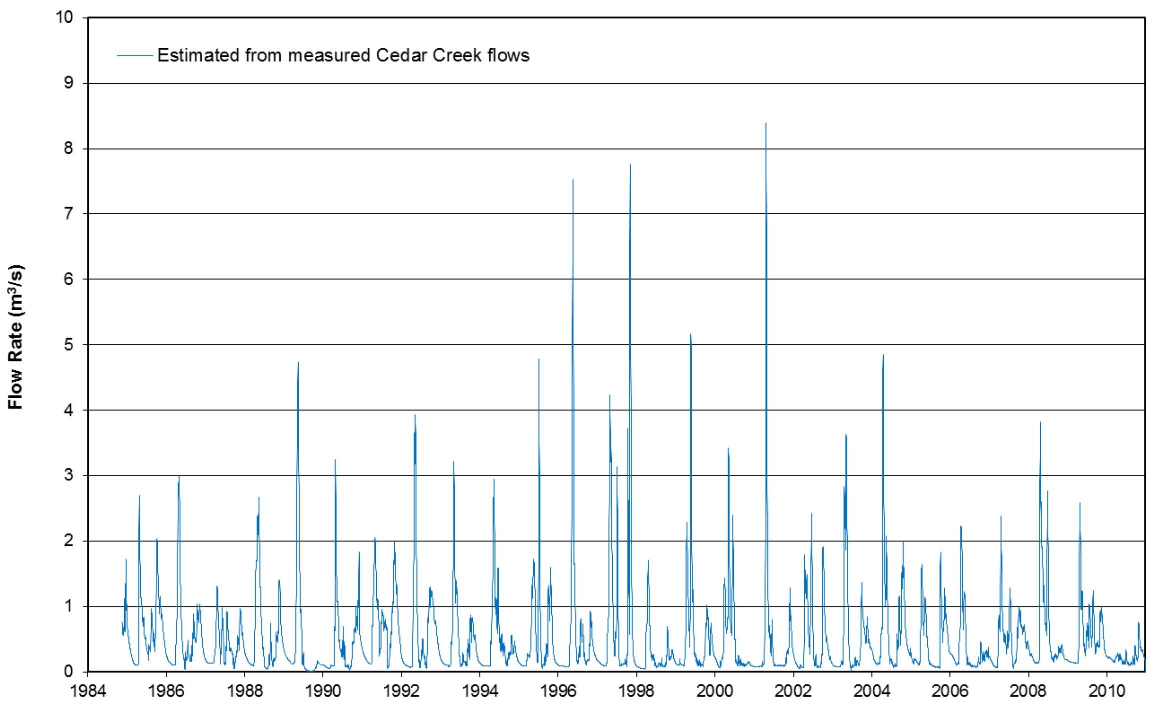


Figure 3-13: Estimated Annual Average Flows – Hare Creek at Outlet of Hare Lake

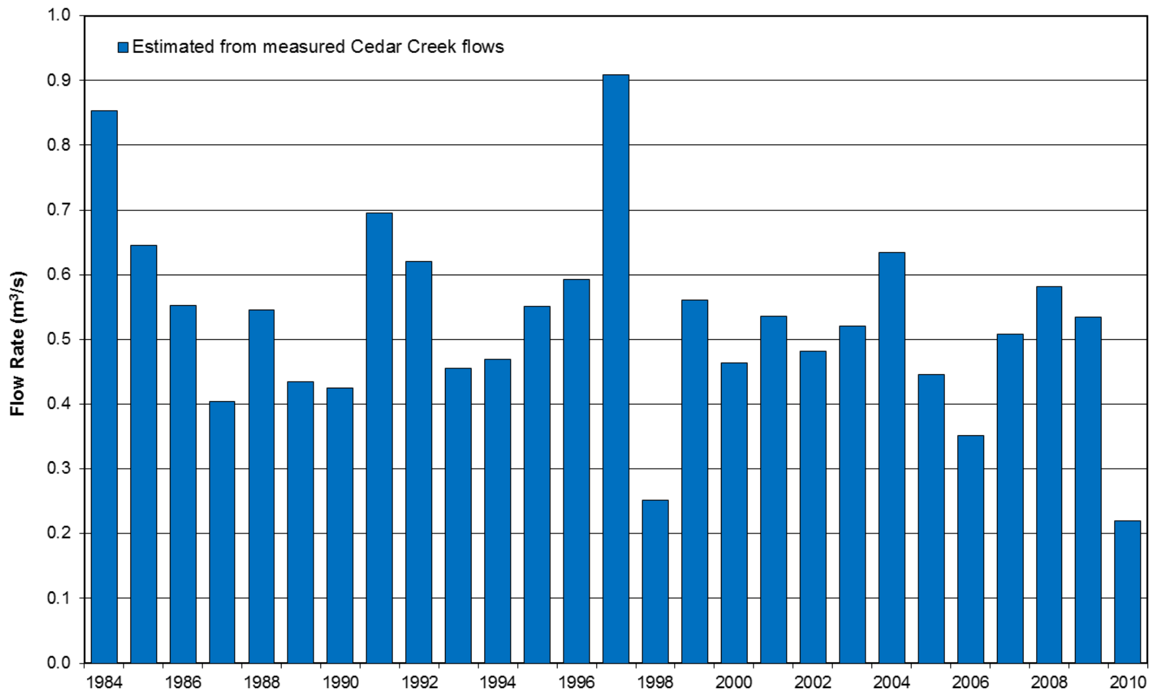


Figure 3-14: Estimated Monthly Average Flows – Hare Creek at outlet of Hare Lake

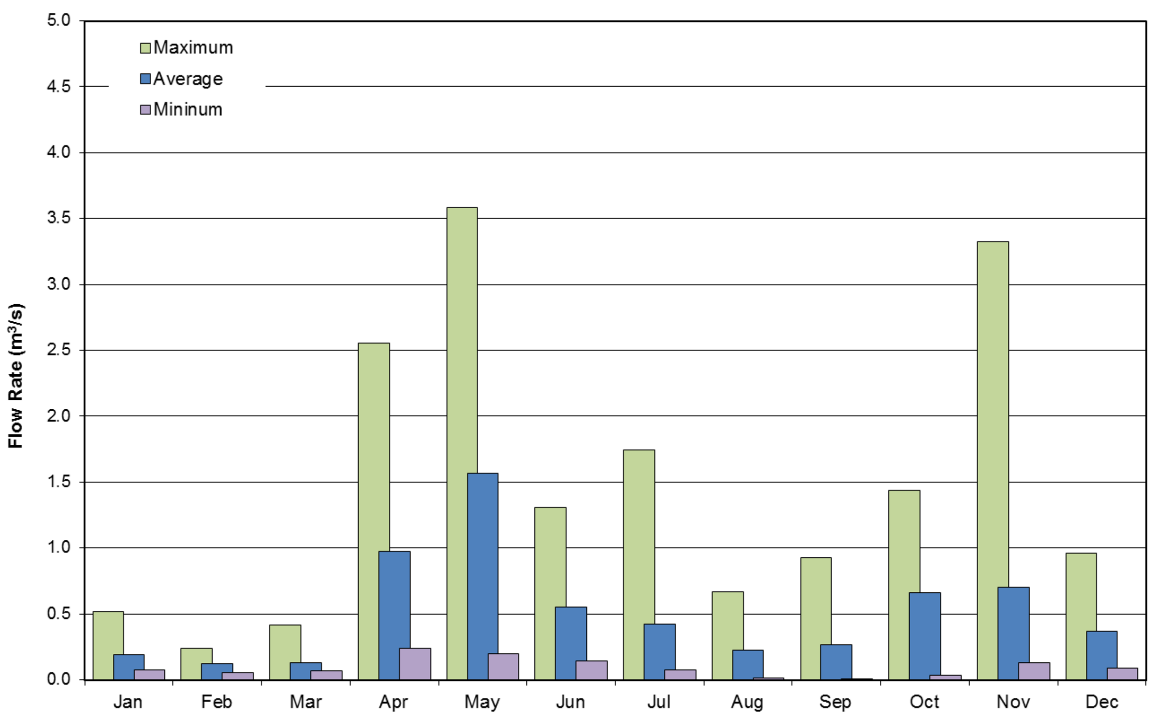


Figure 3-15: Flow Frequency Distribution – Hare Creek at outlet of Hare Lake

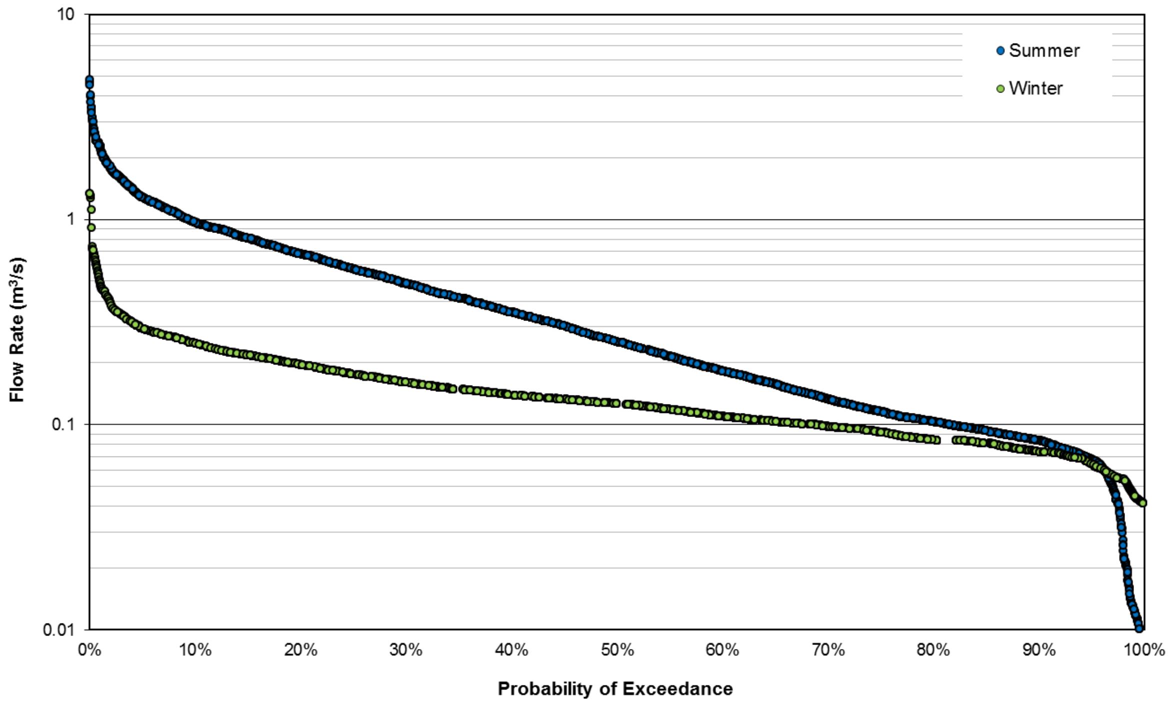
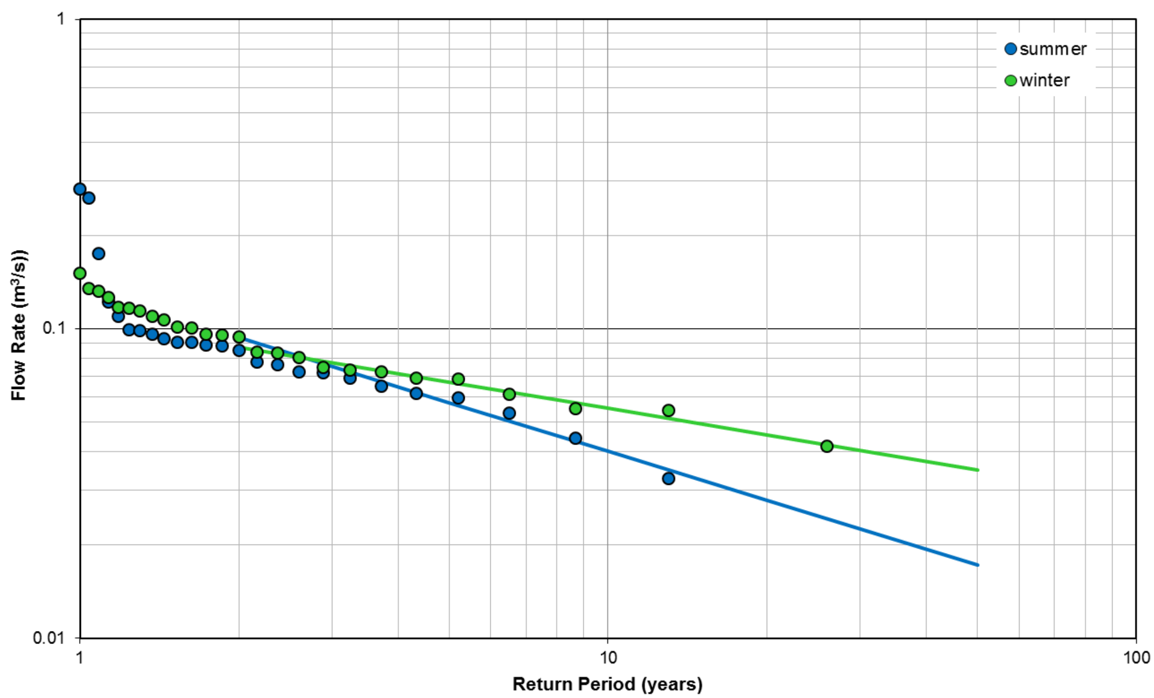


Figure 3-16: 7-Day Average Low-Flow Frequency – Hare Creek at outlet of Hare Lake



3.3.3 Background Surface Water Quality for Hare Lake

The aquatic resources assessment (EcoMetrix, 2012a) presents the background surface water quality data for the watersheds within and near the Project site, including Hare Lake and Hare Creek. An extensive network of water quality monitoring stations has been established that comprises 58 stations, including lake stations, stream stations and Pic River stations. The dataset includes physical analytes, anions, nutrients, dissolved organic carbon, metals, aggregate organics and radium-226, as presented in EcoMetrix (2012c).

Sampling of this network began in the spring of 2008 and is ongoing. Sampling was initially conducted on a monthly basis through the ice-free season, and more recently at a rate of four times during the ice-free season. Winter samples were collected under ice from the lake stations within the Project area in 2007 and 2009. The dataset also includes spot measurements of water quality that have been collected coincident with other sampling events dating back to the early 2000s.

The available data provide a comprehensive record of the surface water quality characteristics. This assessment considered the available data for Stream 5 and Stream 6 watersheds since these watersheds are similar receiving environments and have an assumed common background water quality. Hare Lake is located within the Stream 5 watershed. Data for the Pic River were addressed separately in Section 3.4.3 since the Pic River differs from these smaller receiving waters.

Table 3-3 presents a summary of the surface water quality data for Stream 5 and Stream 6 watersheds. The table includes a comprehensive list of water quality parameters, and summarizes the data collected from nine monitoring stations over the period 2009 to 2011. The table presents the number of samples, the minimum, median, 75th percentile and maximum concentration. Values shown as a less than (“<”) indicate a non-detectable concentration. In such cases, the concentration is assumed to be the analytical detection limit.

Background water quality is characterized by the 75th percentile value. This definition follows MOE’s Procedure B-1-5 (MOEE, 1994b).

Table 3-3: Summary of Surface Water Quality for Stream 5 and Stream 6[1]

Parameter	Units	Count	Minimum	Median	75th Percentile	Maximum
Alkalinity	mg/L	136	<5.0	12	20	99
Ammonia Total	mg/L	137	<0.021	0.021	0.031	0.14
Ammonia Un-ionized	mg/L	137	<0.00032	0.00032	0.00048	0.0021
Chloride	mg/L	137	<0.098	0.40	2.0	24
Conductivity	µS/cm	58	3.3	22	39	171
Fluoride	mg/L	136	<0.030	0.090	0.11	0.28
Hardness	mg/L	137	<7.3	16	25	106
Nitrite as N	mg/L	8	<0.10	0.11	0.16	0.48
Nitrate as N	mg/L	117	<0.030	0.079	0.11	0.31
pH	units	57	5.5	7.4	7.7	9
Sulphate	mg/L	135	<0.80	3.3	3.6	5.8
TDS	mg/L	137	<10	50	71	224
TKN	mg/L	137	<0.0050	0.29	0.43	0.81
DOC	mg/L	136	3.8	8.0	11	23
TSS	mg/L	137	<0.50	2.0	3.0	38
Aluminum (dissolved)	mg/L	71	0.018	0.10	0.14	0.490
Aluminum	mg/L	137	0.037	0.17	0.28	0.91
Arsenic	mg/L	137	<0.0010	<0.0010	<0.0010	0.012
Barium	mg/L	137	<0.0010	0.010	0.012	0.024
Boron	mg/L	137	<0.0050	<0.050	<0.050	<0.050
Calcium	mg/L	101	1.9	4.3	6.5	29
Cadmium	mg/L	137	<0.000090	<0.000090	<0.000090	0.0013
Cobalt	mg/L	137	<0.00050	<0.00050	<0.00050	0.010
Chromium	mg/L	137	<0.0010	<0.0010	<0.0010	0.0017
Copper	mg/L	137	<0.0010	<0.0010	<0.0010	0.019
Iron	mg/L	137	<0.050	0.46	1.0	4.2
Lead	mg/L	137	<0.0010	<0.0010	<0.0010	0.0049
Magnesium	mg/L	101	0.41	0.9	1.8	5.6
Manganese	mg/L	137	0.0036	0.054	0.093	1.3
Mercury	mg/L	64	<0.00010	<0.00010	<0.00010	<0.0010
Molybdenum	mg/L	137	<0.00010	<0.00100	<0.00100	<0.00100
Nickel	mg/L	137	<0.0020	<0.00200	<0.00200	0.0045
Phosphorus (total)	mg/L	117	<0.0050	0.0077	0.011	0.40
Potassium	mg/L	101	<0.030	1.0	1.0	1.0
Selenium	mg/L	137	<0.00040	<0.00040	<0.00040	<0.0050
Sodium	mg/L	98	0.19	0.75	1.3	12
Uranium	mg/L	137	<0.0050	<0.0050	<0.0050	<0.0050
Vanadium	mg/L	137	<0.0010	<0.0010	<0.0010	0.0020
Zinc	mg/L	137	<0.0030	0.0040	0.0060	0.016

1. Used as surface water quality for Hare Lake

3.3.4 Surface Water Quality Benchmarks for Stream 5 and Stream 6

Surface water quality benchmarks are numeric criteria which serve as chemical and physical indicators representing a satisfactory level for surface waters. They are set at a level of water quality which is protective of all forms of aquatic life and all aspects of the aquatic life cycles during indefinite exposure to the water.

The selection of surface water quality benchmarks considered three criteria:

- The Provincial Water Quality Objectives (PWQO), which are provincial objectives defined by the Ontario Ministry of Environment (MOE, 1994a);
- The Canadian Water Quality Guidelines (CWQG), which are federal guidelines defined by the Canadian Council of Ministers of the Environment (CCME); and
- For those parameters that naturally exceed the PWQO and/or CWQG, the natural background concentration based on the 75^{th} percentile of recorded values.

The surface water quality benchmarks considered the more protective of the two guidelines—PWQO and CWQG. But, where natural background exceeded these guidelines, the natural background value was selected as the appropriate surface water quality benchmark. Surface water quality benchmarks were applied to only those parameters having a defined PWQO and/or CWQG.

Table 3-4 presents the surface water quality benchmarks for Stream 5 and 6 which are appropriate for application in Hare Lake, and the basis for the selection.

Table 3-4: Surface Water Quality Benchmarks for Stream 5 and 6[1]

	Units	Background	PWQO	CWQG	Benchmark	Comment
Alkalinity	mg/L	20	15 as min	-	15 as min	PWQO
Ammonia total	mg/L	0.031	1.3	1.2	1.2	CWQG
Ammonia un-ionized	mg/L	0.00048	0.020	0.019	0.019	CWQG
Chloride	mg/L	2.0	-	120	120	CWQG
Conductivity	µS/cm	39	-	-	-	N/A
Fluoride	mg/L	0.11	-	0.12	0.12	CWQG
Hardness	mg/L	25	-	-	-	N/A
Nitrite as N	mg/L	0.16	-	0.060	0.16	Background
Nitrate as N	mg/L	0.11	-	2.9	2.9	CWQG
pH	units	7.7	6.5 to 8.5	6.5 to 9	6.5 to 8.5	PWQO
Sulphate	mg/L	3.6	-	-	-	N/A
TDS	mg/L	71	-	-	-	N/A
TKN	mg/L	0.43	-	-	-	N/A
DOC	mg/L	11	-	-	-	N/A
TSS	mg/L	3.0	-	-	-	N/A
Aluminum (dissolved)	mg/L	0.14	0.075	0.10	0.14	Background
Aluminum	mg/L	0.28	-	-	-	N/A
Arsenic	mg/L	<0.0010	0.0050	0.0050	0.0050	PWQO
Barium	mg/L	0.012	-	-	-	N/A
Boron	mg/L	<0.050	0.20	1.5	0.20	PWQO
Calcium	mg/L	6.5	-	-	-	N/A
Cadmium	mg/L	<0.00009	0.00010	0.00001	0.00009	Background
Cobalt	mg/L	<0.00050	0.00090	-	0.00090	PWQO
Chromium	mg/L	<0.0010	See Note 2	See Note 2	-	PWQO
Copper	mg/L	0.0010	0.0050	0.0020	0.0020	CWQG
Iron	mg/L	0.97	0.30	0.30	0.97	Background
Lead	mg/L	<0.0010	0.0010	0.0010	0.0010	PWQO
Magnesium	mg/L	1.8	-	-	-	N/A
Manganese	mg/L	0.093	-	-	-	N/A
Mercury	mg/L	<0.00010	0.00020	0.00026	0.00020	PWQO
Molybdenum	mg/L	<0.0010	0.040	0.073	0.040	PWQO
Nickel	mg/L	<0.0020	0.025	0.025	0.025	PWQO
Phosphorus (total)	mg/L	0.011	0.020	0.020	0.020	PWQO
Potassium	mg/L	1.0	-	-	-	N/A
Selenium	mg/L	<0.00040	0.10	0.0010	0.0010	CWQG
Sodium	mg/L	1.3	-	-	-	N/A
Uranium	mg/L	<0.0050	0.0050	0.015	0.0050	PWQO
Vanadium	mg/L	<0.0010	0.0060	-	0.0060	PWQO
Zinc	mg/L	0.0060	0.020	0.030	0.020	PWQO

2. Used as surface water quality benchmarks for Hare Lake

3.4 Receiving Environment – Pic River

The Pic River is identified as a receiving environment for the Project as it will receive direct discharge of treated surface waters from the MRSA via an offshore diffuser. The sections below provide greater detail regarding the morphology, hydrology and water quality of the Pic River to support the assessment of surface water quality effects.

Plate 3-3 and Plate 3-4 show photographs of the Pic River looking upstream and downstream in the general location of the discharge.

3.4.1 Morphometry

The Pic River is situated east of the Project area and meanders through a clay, silt and fine sand till plain to Lake Superior. High turbidity and high load of suspended clay and silt characterizes the Pic River.

The river is considered medium sized with a drainage area of approximately 427,000 hectares. In general, the channel morphology consists of relatively flat runs, with several shallow riffle areas and pools. During high flows the riffles are submerged and not discernible from the surface.

3.4.2 Hydrology

The streamflow rate in the Pic River is routinely monitored by the WSC near the town of Marathon. Table 3-5 summarizes the general information regarding the gauging station. Data are available for the period 1970 to 2010.

Table 3-5: WSC Gauging Station on the Pic River

No	Station	Watershed	Location	Drainage Area (km^2)	Years of record
6	02BB003	Pic River	near Marathon	4,270	41

Note: the gauging station on the Pic River was listed as station #6 in Table 3-1.

Plate 3-3: Pic River—looking North in the upstream direction

Plate 3-4: Pic River—looking South in the downstream direction

The points below summarize the main characteristics of the flows in the Pic River near the Project site:

- Figure 3-17 presents the measured daily flows for the Pic River near the Project site. As illustrated, the flows vary over the period of record from a minimum daily flow of 3.1 m^3/s to a maximum daily flow of 723 m^3/s.

- Figure 3-18 summarizes the measured annual average flows for the Pic River near the Project site. The annual average flow is approximately 51.4 m^3/s, ranging from a minimum of approximately 22.1 m^3/s in 2010 to a maximum of approximately 78.9 m^3/s in 2004.

- Figure 3-19 summarizes the measured monthly average flows for the Pic River near the Project site. High flows typically occur in spring (May), with a monthly average of approximately 155 m^3/s. Low flows typically occur in winter (January through March), with a monthly average of approximately 10.4 m^3/s, and in summer (August and September), with a monthly average of approximately 32.1 m^3/s.

- Figure 3-20 presents the flow frequency distribution of daily average flows for the winter and summer low flow periods. During winter, the daily average flow exceeds 10.6 m^3/s approximately 50% of the time on average, and exceeds 5.4 m^3/s approximately 95% of the time on average. During summer, the daily average flow exceeds 35.8 m^3/s approximately 50% of the time on average, and exceeds 7.6 m^3/s approximately 95% of the time on average.

- The 7Q20 low flow is often used for the assessment of assimilative capacity. Figure 3-21 summarizes the frequency distribution of the 7-day average low flow for winter and summer. The 7Q20 low flow is approximately 4.31 m^3/s based on winter low flows and approximately 4.19 m^3/s based on summer low flows. (Calder, 2012b, estimated the annual 7Q20 low flow of 4.45 m^3/s).

Figure 3-17: Measured Daily Flows – Pic River near the Project Site

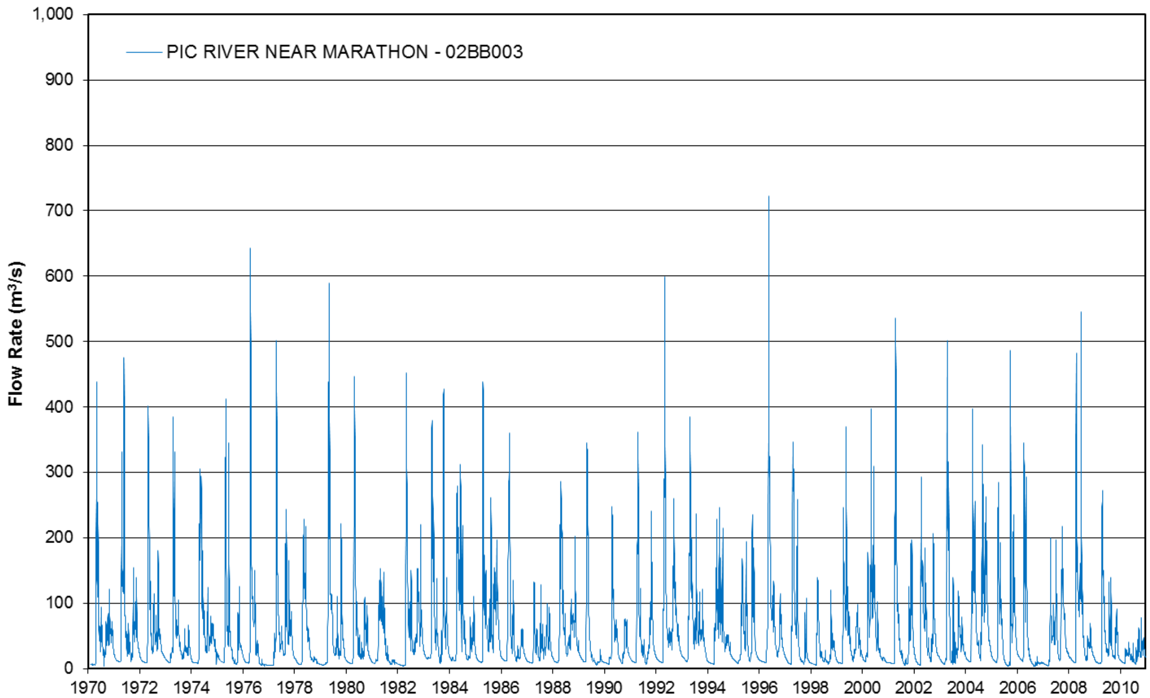


Figure 3-18: Annual Average Flows – Pic River near the Project Site

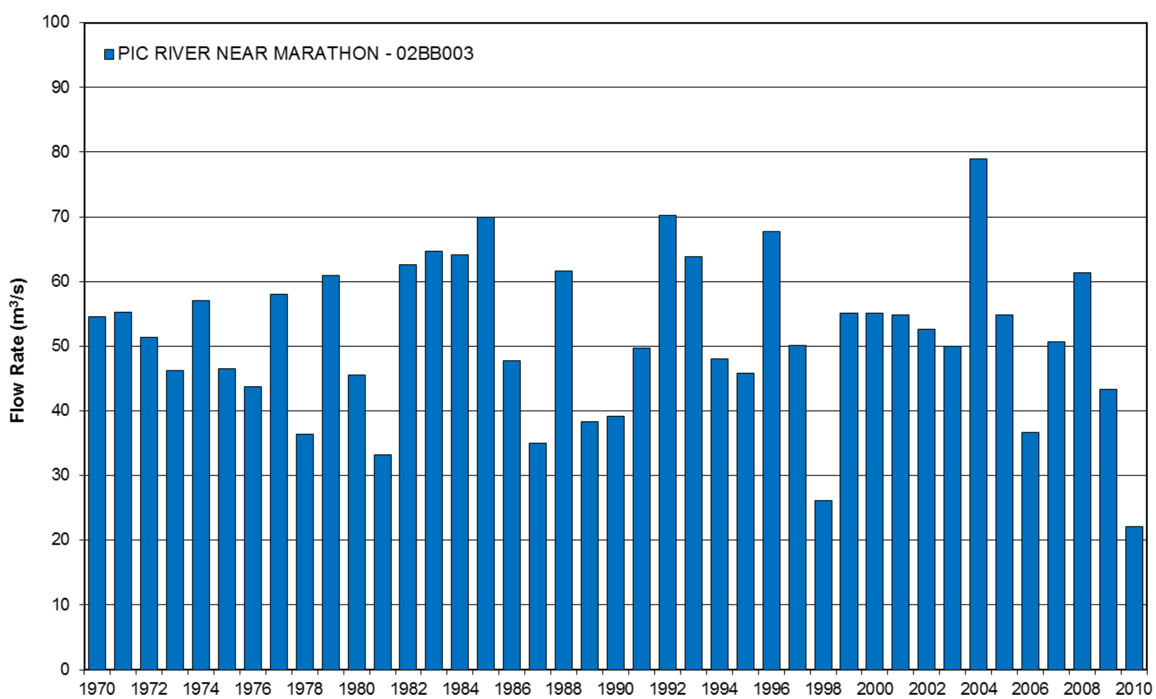


Figure 3-19: Monthly Average Flows – Pic River near the Project Site

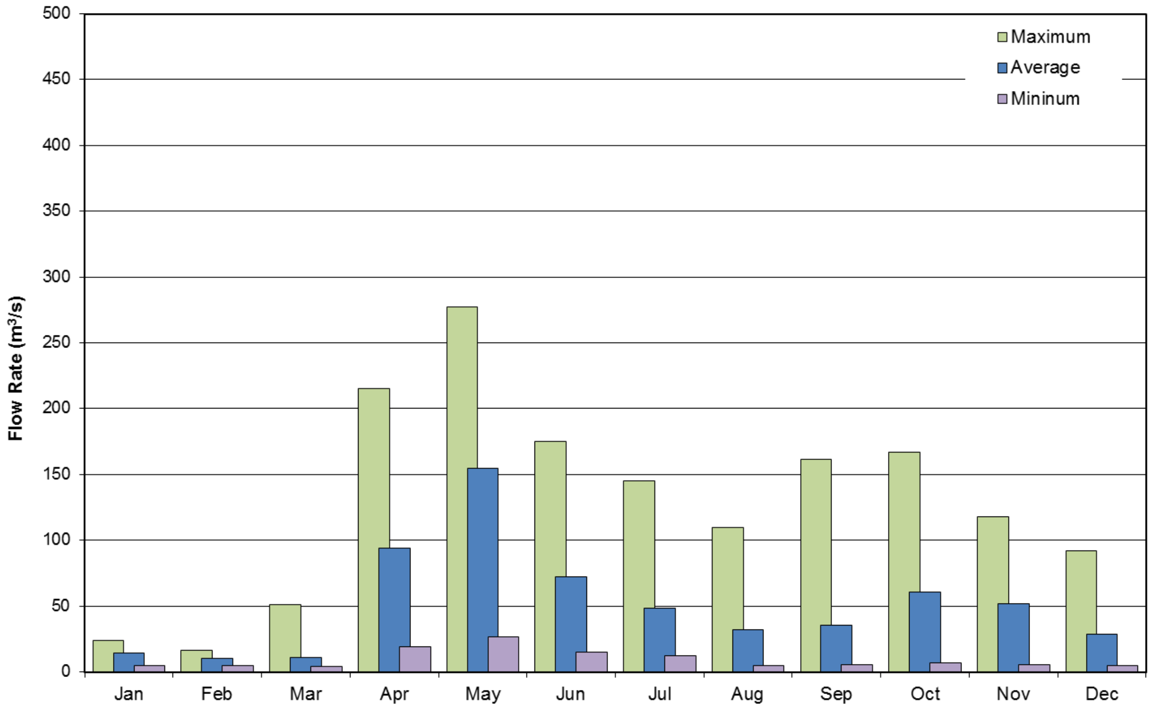


Figure 3-20: Flow Frequency Distribution – Pic River near Project Site

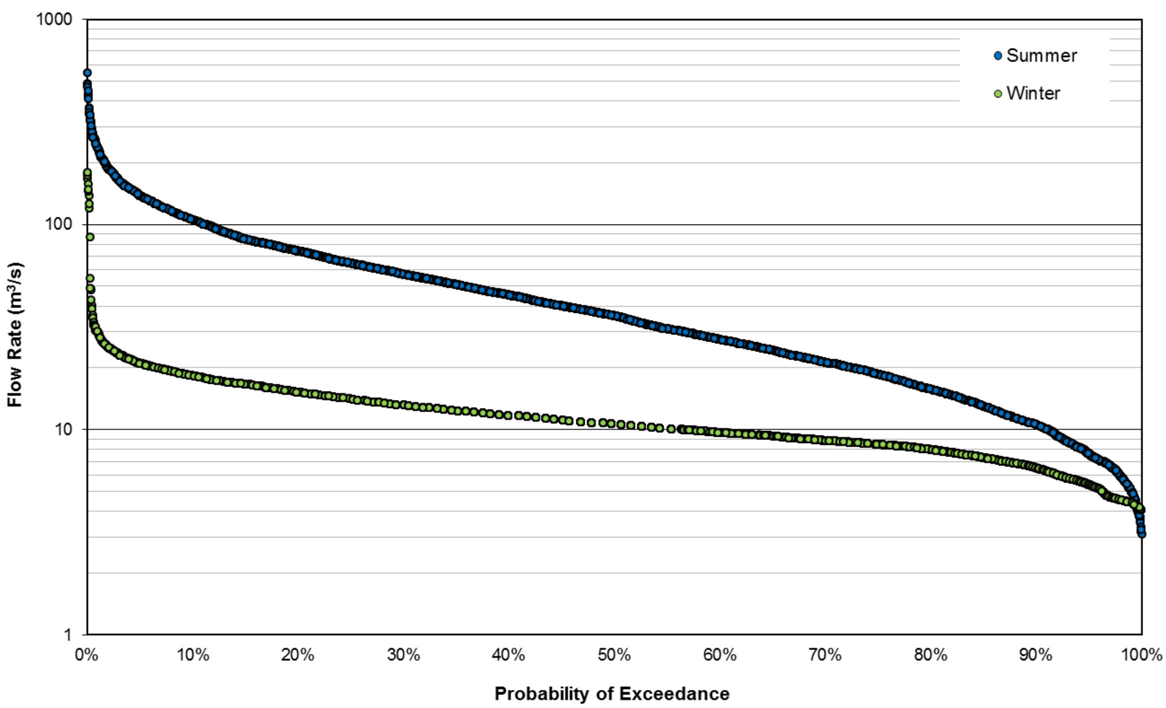
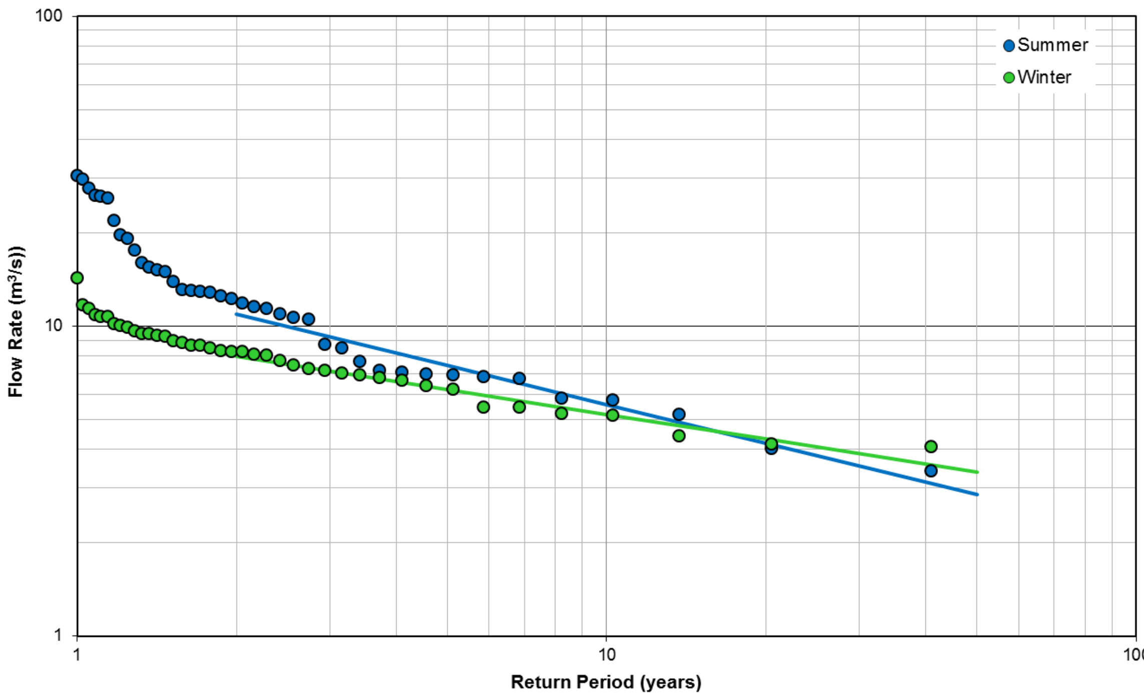


Figure 3-21: 7-Day Average Low-Flow Frequency – Pic River near Project Site



3.4.3 Background Surface Water Quality for the Pic River

The aquatic resources assessment (EcoMetrix, 2012a) presents the background surface water quality data for the watersheds within and near the Project site, including the Pic River. The following section summarizes the main information as it pertains to the assessment of surface water quality effects.

The network of water quality monitoring stations included four stations on the Pic River—a station upstream of the Project site, two stations adjacent to the Project site, and one station downstream of the Project site. Monitoring has extended from 2009 to 2011.

Table 3-6 presents a summary of the surface water quality data for the Pic River. The table includes a comprehensive list of water quality parameters, and summarizes the data collected from the four monitoring stations over the three year period. The table presents the number of samples, the minimum, median, 75th percentile and maximum concentration. Values shown as a less than (“<”) indicate a non-detectable concentration. In such cases, the concentration is assumed to be the analytical detection limit.

Background water quality is characterized by the 75th percentile value. This definition follows MOE’s Procedure B-1-5 (MOEE, 1994b).

Table 3-6: Summary of Surface Water Quality in Pic River

Parameter	Units	Count	Minimum	Median	75th Percentile	Maximum
Alkalinity	mg/L	70	57	112	125	151
Ammonia Total	mg/L	137	<0.021	0.021	0.024	0.055
Ammonia un-ionized	mg/L	137	<0.00032	0.00032	0.00037	0.00086
Chloride	mg/L	70	0.21	0.40	0.60	2.0
Conductivity	µS/cm	31	107	194	221	260
Fluoride	mg/L	70	<0.030	0.047	0.07	0.10
Hardness	mg/L	70	62	118	135	316
Nitrite as N	mg/L	0	-	-	-	-
Nitrate as N	mg/L	70	<0.030	0.030	0.07	0.18
pH	units	30	6.7	8.2	8.2	9
Sulphate	mg/L	70	<1.4	2.3	2.6	3.5
TDS	mg/L	70	72	155	167	250
TKN	mg/L	70	0.25	0.40	0.52	0.66
DOC	mg/L	70	6.0	9.0	11	17
TSS	mg/L	70	2.1	46	162	389
Aluminum (dissolved)	mg/L	37	<0.010	0.022	0.040	0.12
Aluminum	mg/L	70	0.012	0.36	0.94	4.9
Arsenic	mg/L	70	<0.0010	<0.0010	<0.0010	0.010
Barium	mg/L	70	0.010	0.020	0.025	0.10
Boron	mg/L	70	<0.050	<0.050	<0.050	0.50
Calcium	mg/L	51	19	37	41	88
Cadmium	mg/L	70	<0.000090	<0.000090	<0.000090	0.00090
Cobalt	mg/L	70	<0.00050	<0.00050	0.00123	0.0050
Chromium	mg/L	70	<0.0010	0.0020	0.0051	0.011
Copper	mg/L	70	<0.0010	0.0020	0.0040	0.010
Iron	mg/L	70	0.28	1.1	2.7	5.8
Lead	mg/L	70	<0.0010	<0.0010	0.0014	0.010
Magnesium	mg/L	51	3.8	7.3	8.9	24
Manganese	mg/L	70	0.018	0.048	0.088	0.20
Mercury	mg/L	31	<0.00010	<0.00010	<0.00010	<0.00010
Molybdenum	mg/L	70	<0.0010	<0.0010	<0.0010	<0.010
Nickel	mg/L	70	<0.0020	0.0030	0.0050	0.0200
Phosphorus (total)	mg/L	66	<0.0059	0.033	0.090	0.25
Potassium	mg/L	51	<0.40	1.0	1.0	2.1
Selenium	mg/L	70	<0.00040	<0.00040	<0.00040	<0.0050
Sodium	mg/L	47	0.37	1.0	1.3	1.8
Uranium	mg/L	70	<0.0050	<0.0050	<0.0050	<0.050
Vanadium	mg/L	70	<0.0010	0.0020	0.0050	0.010
Zinc	mg/L	70	<0.0030	0.0050	0.011	0.13

3.4.4 Surface Water Quality Benchmarks for the Pic River

Table 3-7 presents the surface water quality benchmarks for the Pic River, and the basis for the selection.

The surface water quality benchmarks for the Pic River are similar to those defined in Section 3.3.4 for Hare Lake with a few exceptions relating to differences in background water quality.

For Hare Lake, the surface water quality benchmarks are based on background water quality for nitrite, aluminum (dissolved), cadmium and iron since the natural background concentrations exceeded the PWQO and/or CWQG for these parameters.

For the Pic River, the surface water quality benchmarks are based on background water quality for cadmium, cobalt, copper, iron, lead and phosphorus (total) since the natural background concentrations exceed the PWQO and/or CWQG for these parameters.

The hardness of the natural background also differs between Hare Lake and the Pic River—Hare Lake has a hardness of 25 mg/L, whereas the Pic River has a hardness of 135 mg/L. The CWQG varies with hardness for cadmium, copper, lead and nickel.

Surface water quality benchmarks were applied to only those parameters having a defined PWQO and/or CWQG.

Table 3-7: Surface Water Quality Benchmarks for the Pic River

	Units	Background	PWQO	CWQG	Benchmark	Comment
Alkalinity	mg/L	125	94 as min	-	94 as min	PWQO
Ammonia Total	mg/L	0.024	1.3	1.2	1.2	CWQG
Ammonia-Un-ionized	mg/L	0.00037	0.020	0.019	0.019	CWQG
Chloride	mg/L	0.60	-	120	120	CWQG
Conductivity	µS/cm	221	-	-	-	N/A
Fluoride	mg/L	0.072	-	0.12	0.12	CWQG
Hardness	mg/L	135	-	-	-	N/A
Nitrite as N	mg/L	-	-	0.060	0.060	CWQG
Nitrate as N	mg/L	0.070	-	2.9	2.9	CWQG
pH	units	8.2	6.5 to 8.5	6.5 to 9	6.5 to 8.5	PWQO
Sulphate	mg/L	2.6	-	-	-	N/A
TDS	mg/L	167	-	-	-	N/A
TKN	mg/L	0.52	-	-	-	N/A
DOC	mg/L	11	-	-	-	N/A
TSS	mg/L	162	-	-	-	N/A
Aluminum (dissolved)	mg/L	0.040	0.075	0.10	0.075	PWQO
Aluminum	mg/L	0.94	-	-	-	N/A
Arsenic	mg/L	<0.0010	0.0050	0.0050	0.0050	PWQO
Barium	mg/L	0.025	-	-	-	N/A
Boron	mg/L	<0.050	0.20	1.5	0.20	PWQO
Calcium	mg/L	41	-	-	-	N/A
Cadmium	mg/L	<0.00009	0.00010	0.00004	0.00009	Background
Cobalt	mg/L	0.0012	0.00090	-	0.0012	Background
Chromium	mg/L	0.0051	See Note 2	See Note 2	-	PWQO
Copper	mg/L	0.0040	0.0050	0.0029	0.004	Background
Iron	mg/L	2.7	0.30	0.30	2.7	Background
Lead	mg/L	0.0014	0.0010	0.0043	0.0014	Background
Magnesium	mg/L	8.9	-	-	-	N/A
Manganese	mg/L	0.088	-	-	-	N/A
Mercury	mg/L	<0.00010	0.00020	0.00026	0.00020	PWQO
Molybdenum	mg/L	<0.0010	0.040	0.073	0.040	PWQO
Nickel	mg/L	0.0050	0.025	0.11	0.025	PWQO
Phosphorus (total)	mg/L	0.090	0.030	0.100	0.090	Background
Potassium	mg/L	1.0	-	-	-	N/A
Selenium	mg/L	<0.00040	0.10	0.0010	0.0010	CWQG
Sodium	mg/L	1.3	-	-	-	N/A
Uranium	mg/L	<0.0050	0.0050	0.015	0.0050	PWQO
Vanadium	mg/L	0.0050	0.0060	-	0.0060	PWQO
Zinc	mg/L	0.011	0.020	0.030	0.020	PWQO

3.5 Receiving Environment – Stream 6

Stream 6 is identified as a receiving environment for the Project since it will receive runoff from the decommissioned PSMF post-closure. The sections below provide greater detail regarding the morphology, hydrology and water quality of Stream 6 to support the assessment of surface water quality effects.

Plate 3-5, Plate 3-6 and Plate 3-7 show photographs of Stream 6 taken in the upper-reach, mid-reach and lower-reach.

Plate 3-5: Stream 6—within the upper-reach

Plate 3-6: Stream 6—within the mid-reach

Plate 3-7: Stream 6—within the lower-reach

3.5.1 Morphometry

Stream 6 flows in a general westward direction, draining the southwestern portion of the Project site and discharging to Lake Superior at Sturdee Cove. The Stream 6 watershed drains a total area of approximately 1,098 hectares, including Stream 6 itself and Lakes 24 and 26. The surface flow regime of Stream 6 will be altered due to construction of the PSMF in the upper areas of the watershed during Project operations. The upper reach of Stream 6 will be diverted away from its natural path to the Hare Lake drainage during operations. There will be no direct releases to the lower reach of Stream 6 watershed during operations. At mine closure and decommissioning, surface runoff from the PSMF will be directed back to the natural Stream 6 drainage route.

The upper reach and headwater lakes of Stream 6 (Plate 3-5) are characterized by low flows and barriers to fish migration such as beaver dams and cascades (EcoMetrix 2012a). The substrate within the mid-reach (Plate 3-6) and lower-reach (Plate 3-7) are comprised of bedrock, boulders, cobble and coarse sand.

Stream morphology consists of pool-riffle sequences with a mostly moderate gradient and some high gradient sections. In areas with low gradients, the stream meanders, and its morphology consists of pools with areas of flat and run, and with a few cascades created by log jams. A large bedrock cascade is located within the lower reach of Stream 6 near its discharge to Lake Superior.

3.5.2 Hydrology

The streamflow rate in Stream 6 is not routinely monitored, so it is necessary to estimate the streamflow from measured flows in other nearby watersheds. Section 3.3.2 describes the methodology used to calculate flows for Stream 6, following a consistent approach as used for Hare Creek.

The mid-reach of Stream 6 at Highway 17 bridge is used to represent Stream 6 flows for the water quality assessment. This point in the watershed drains approximately 489 hectares (Golder, 2012).

The points below summarize the main characteristics of the flows in the mid-reach of Stream 6 downstream of Highway 17 bridge:

- Figure 3-22 presents the estimated daily flows for the mid-reach of Stream 6. As illustrated, the flows vary over the period of record from a minimum daily flow of 0.001 m^3/s to a maximum daily flow of 0.89 m^3/s.

- Figure 3-23 summarizes the estimated annual average flows for the mid-reach of Stream 6. The annual average flow is approximately 0.056 m^3/s, ranging from a minimum of approximately 0.023 m^3/s in 2010 to a maximum of approximately 0.097 m^3/s in 1997.

- Figure 3-24 summarizes the estimated monthly average flows for the mid-reach of Stream 6. High flows typically occur in spring (May), with a monthly average of approximately 0.166 m^3/s. Low flows typically occur in winter (January through March), with a monthly average of approximately 0.013 m^3/s, and in summer (August and September), with a monthly average of 0.024 m^3/s.

- Figure 3-25 presents the flow frequency distribution of daily average flows for the February and August low flow periods. During winter, the daily average flow exceeds 0.013 m^3/s approximately 50% of the time on average, and exceeds 0.007 m^3/s approximately 95% of the time on average. During summer, the daily average flow exceeds 0.027 m^3/s approximately 50% of the time on average, and exceeds 0.007 m^3/s approximately 95% of the time on average.

- The 7Q20 low flow is often used for the assessment of assimilative capacity. Figure 3-26 summarizes the frequency distribution of the 7-day average low flow for winter and summer. The 7Q20 low flow is approximately 0.005 m^3/s based on winter low flows and approximately 0.003 m^3/s based on summer low flows.

Figure 3-22: Estimated Daily Flows – Mid-Reach of Stream 6

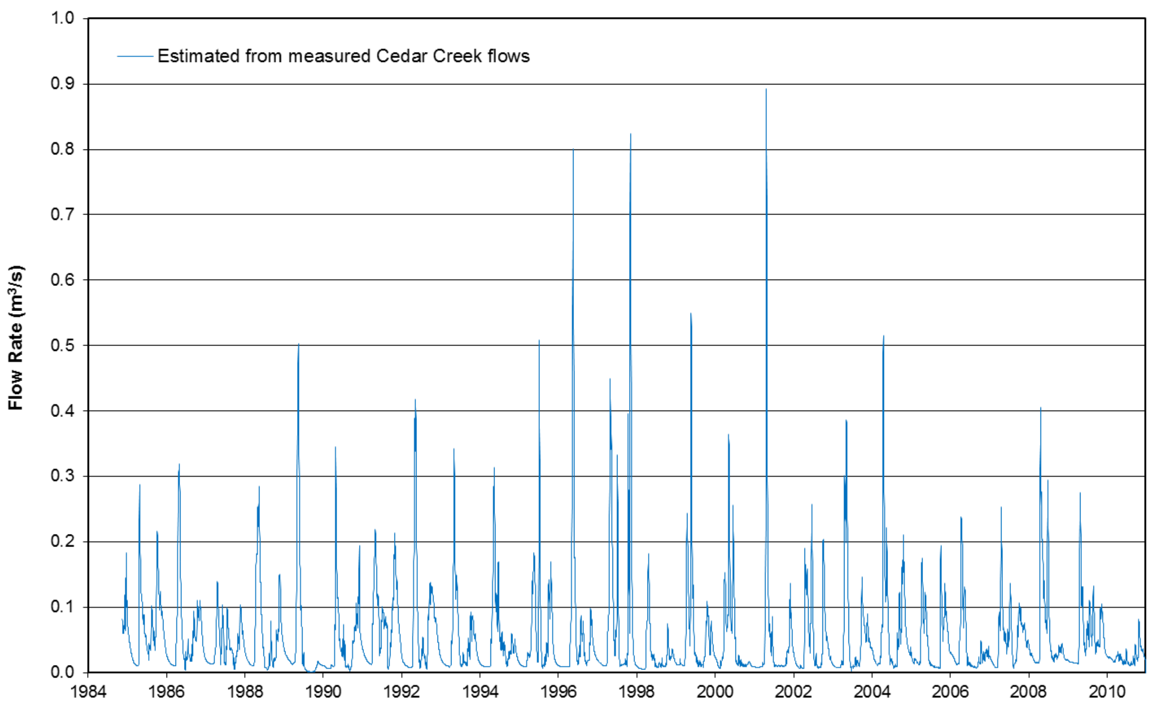


Figure 3-23: Estimated Annual Average – Mid-Reach of Stream 6

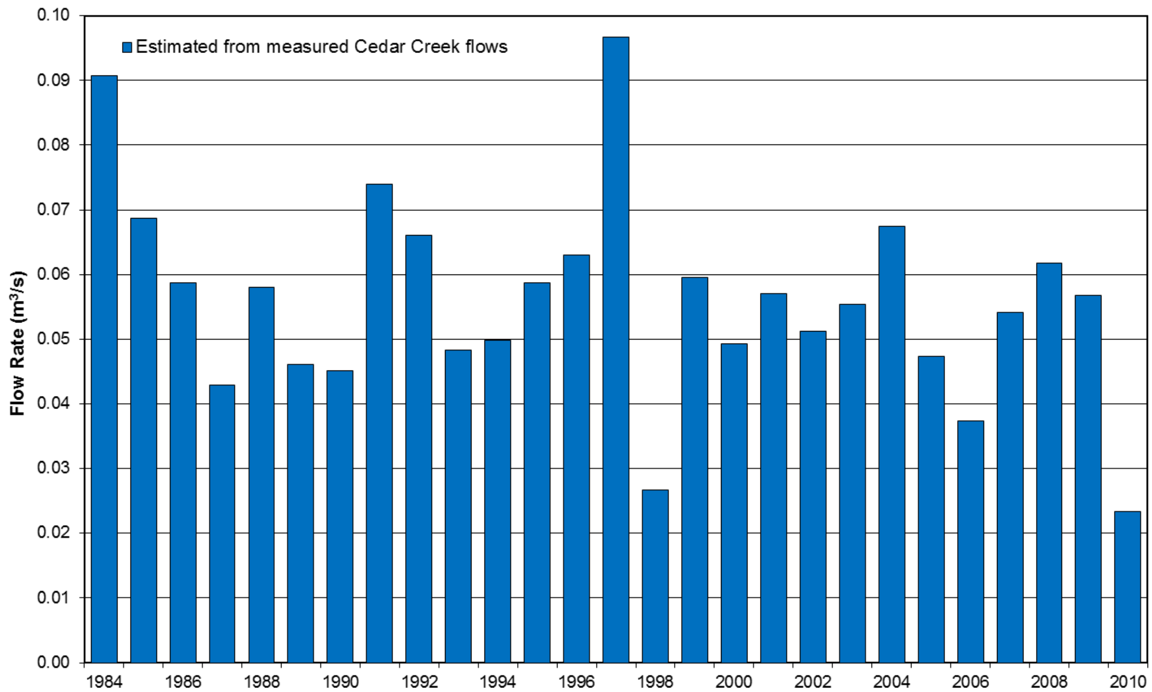


Figure 3-24: Estimated Monthly Average Flows – Mid-Reach of Stream 6

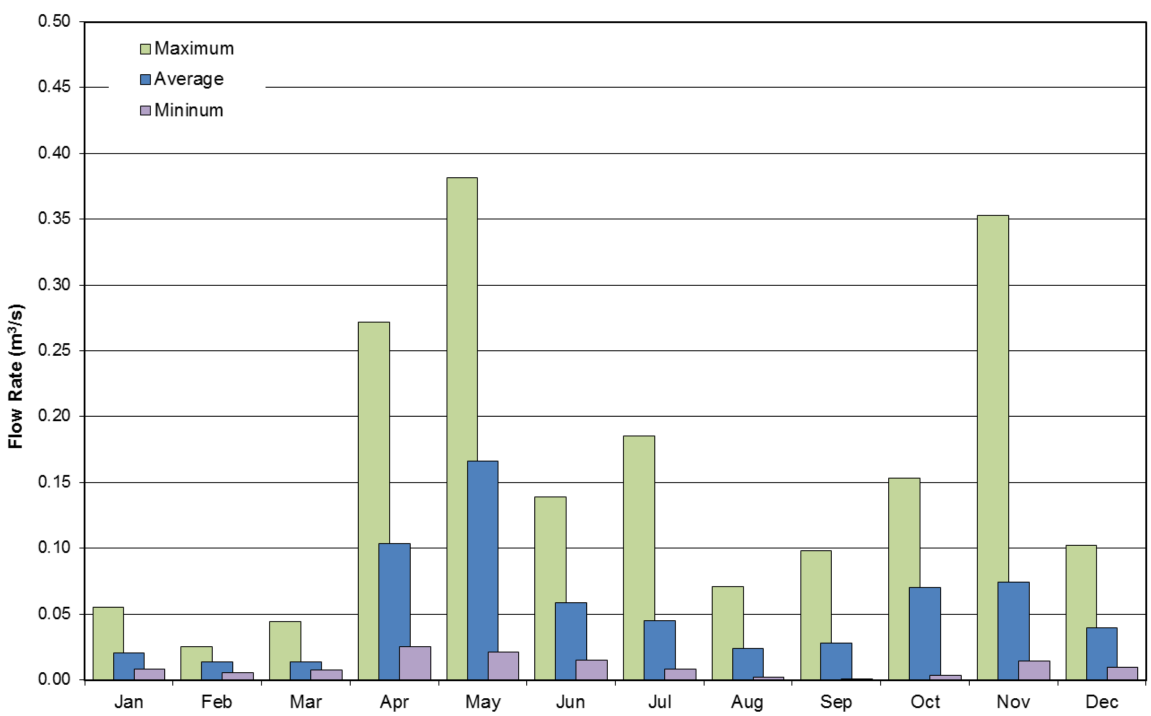


Figure 3-25: Estimated Flow Frequency Distribution – Mid-Reach of Stream 6

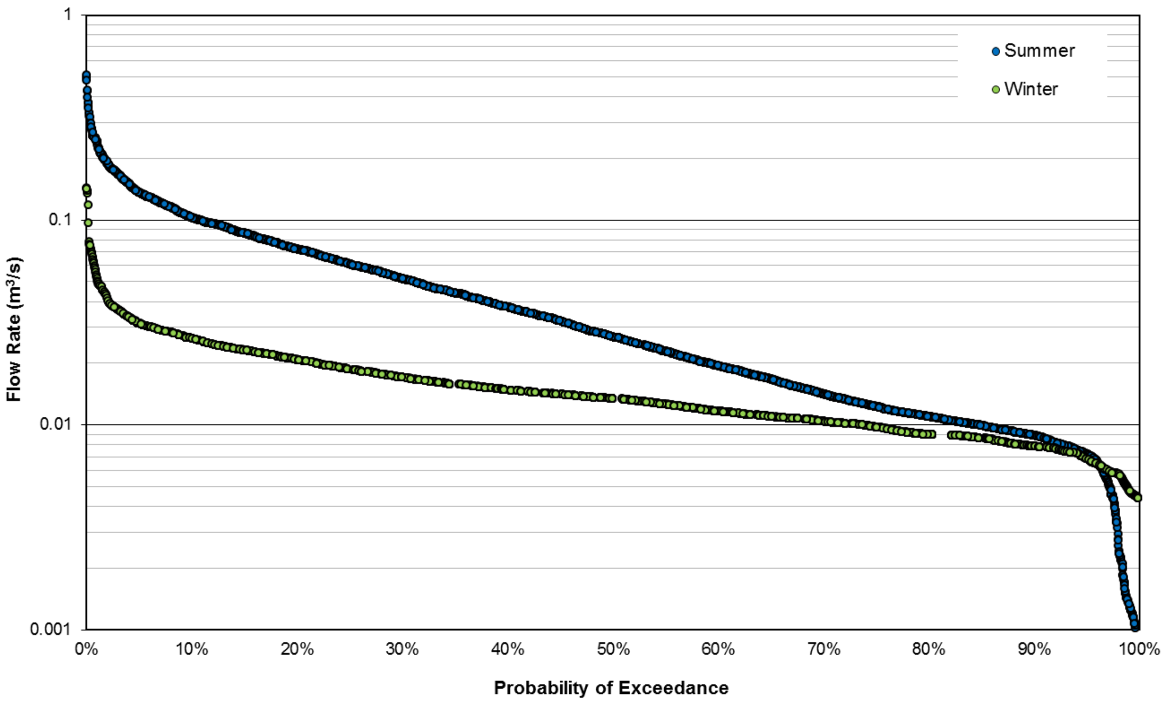
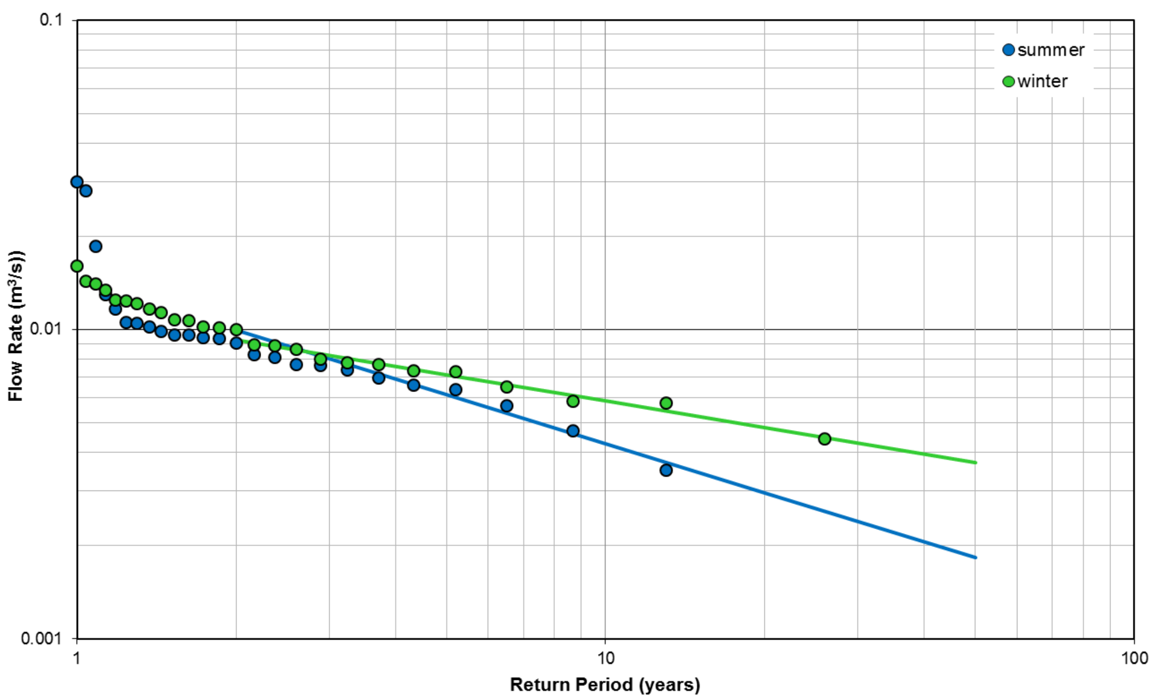


Figure 3-26: Estimated 7-Day Average Low-Flow Frequency – Mid-Reach Stream 6



3.5.3 Background Surface Water Quality for Stream 6

The background surface water quality for Stream 6 is comparable to the background surface water quality for Hare Creek. Table 3-3 from Section 3.3.3 presents the background surface water quality for Stream 6.

3.5.4 Surface Water Quality Benchmarks for Stream 6

The surface water quality benchmarks for Stream 6 are identical to the surface water quality benchmarks for Hare Lake and Hare Creek since the watersheds are comparable. Table 3-4 from Section 3.3.4 presents the surface water quality benchmarks for Stream 6.

4.0 DISCHARGES FROM THE PROJECT SITE

As discussed in Section 2.0, the Project has three identified discharges—the PSMF discharge to Hare Lake during operations; the MRSA discharge to the Pic River during operations and post-closure; and the PSMF discharge to Stream 6 post-closure. The following section presents the characteristics of these discharges based on the following considerations:

- the authorization limits from the Metal Mining Effluent Regulations (MMER);
- the source based discharge quality, derived from the water balance and source loadings for the Project site, represents the expected untreated discharge characteristics based on the Project activities; and
- the receiving-water based discharge quality, derived from the receiving water's assimilative capacity, represents the maximum discharge that ensure protection of the downstream aquatic environment.

The assessment is based on untreated discharge; however, the mine plan provides a contingency for treatment, as necessary. Section 4.1 presents the authorization limits from MMER. Section 4.2, Section 4.3 and Section 4.4 present the source based and receiving-water based discharge qualities for the three identified discharges.

4.1 Authorized Limits from Metal Mining Effluent Regulations

The Metal Mining Effluent Regulations (MMER), registered under the *Fisheries Act*, prescribe authorized concentration limits for COPC in mine effluents that discharge to waters frequented by fish. The regulated parameters include arsenic, copper, cyanide, lead, nickel, zinc, total suspended solids, Radium 226 and pH. They apply to all Canadian metal mines (except placer mines) that exceed an effluent flow rate of 0.00058 m^3/s (50 m^3/day), and apply to effluent from all final discharge points at a mine site.

Schedule 4 of the MMER specifies the maximum prescribed limits under which these substances may be discharged in mine effluent. Table 4-1 presents the maximum allowable concentrations of these substances.

Table 4-1: Authorized Limits Prescribed in the MMER[1]

Deleterious Substance[2]	Units	Maximum Authorized Monthly Mean Concentration	Maximum Authorized Concentration in a Composite Sample	Maximum Authorized Concentration in a Grab Sample
Arsenic	mg/L	0.5	0.75	1.0
Copper	mg/L	0.3	0.45	0.6
Cyanide	mg/L	1.0	1.5	2.0
Lead	mg/L	0.2	0.3	0.4
Nickel	mg/L	0.5	0.75	1.0
Zinc	mg/L	0.5	0.75	1.0
Radium 226	Bq/L	0.37	0.74	1.11
Total suspended solids	mg/L	15	22.5	30
Acutely lethal effluent		100% non-acutely lethal[3]		
pH range		6.0 - 9.5		

1 From http://laws-lois.justice.gc.ca/eng/regulations/SOR-2002-222/page-17.html#h-51
2 All concentrations are total values.
3 For the purposes of the MMER, non-acutely lethal means survival of at least 50% of rainbow trout subjected to 100% concentration effluent for a period of 96 hours.

4.2 Discharge from the PSMF to Hare Lake during Operations

As discussed in Section 2.1.3, all waters collected from the Project site, except for water from the MRSA, will be managed in the PSMF for use in the milling process. Excess water not needed in the mill will be discharged, following treatment as necessary, to Hare Lake via an overland pipeline and offshore diffuser. The quality of the discharge from the PSMF will, as a minimum, comply with the authorized limits prescribed in the MMER.

The following sections present two derivations of discharge quality for the PSMF during operations—the source based discharge quality, and the receiving-water based discharge quality.

4.2.1 Source Based Discharge Quality

The source based discharge quality for the PSMF is derived from the mine schedule, site water balance and source loading estimates described in Section 2.2, Section 2.3 and Section 2.4. It represents the expected discharge characteristics based on the Project activities.

Mathematical models provide the basis to estimate the discharge quality using principles of mass conservation, as represented by Equation 4-1 and Equation 4-2.

$$\frac{dV_{PSMF}}{dt} = \sum Q_{in} - \sum Q_{out} - Q_{PSMF}$$ **Equation 4-1**

$$\frac{dV_{PSMF}C_{PSMF}}{dt} = \sum Q_{in}C_{in} - \sum Q_{out}C_{PSMF} - Q_{PSMF}C_{PSMF}$$ **Equation 4-2**

Where: V_{PSMF} = volume of the PSMF impoundment (m^3);

C_{PSMF} = concentration of COPC in the PSMF impoundment (mg/L);

Q_{in} = flow rate for all inflows to the PSMF impoundment (m^3/s);

C_{in} = concentration for all inflows to the PSMF impoundment (mg/L);

Q_{PSMF} = discharge rate from the PSMF impoundment (m^3/s);

Q_{out} = flow rate for all other outflows from the PSMF impoundment (m^3/s);

t = time (s).

(Standard unit conversions apply)

These partial differential equations are solved numerically as a function of time over the life of the Project. Equation 4-1 represents the change in volume of the impoundment over time, and Equation 4-2 represents the potential change in water quality within the impoundment over time. Separate equations apply to Cell 1 and Cell 2 of the PSMF. Inflows include: pit dewatering; supernatant pond precipitation; runoff from disturbed lands; runoff from the PSMF; and water transfers between Cell 1 and Cell 2. Outflows include: water retained in process solids; evaporation; seepage; water transfers between Cell 1 and Cell 2; water reclaimed in the milling operation; and the discharge of excess waters to Hare Lake.

The models estimates the discharge of excess water from the PSMF on a monthly basis, and account for the natural hydrologic cycles, schedule of mining activities, the recycling of water in the milling operation, and management of on-site waters.

Figure 4-1 presents the predicted discharge rate of excess waters from the PSMF. The discharge rate varies over time due to varying hydrologic inputs, water use requirements, and mine schedule. Zero flow from the PSMF occurs during the winter months due to the limited surface runoff under frozen condition. Peak flow from the PSMF occurs during the spring due to excess water from snow melt and high precipitation. Low flows from the

PSMF occur during the summer months due to limited precipitation, and may approach zero during drought conditions to conserve water for use in the milling process.

The mine schedule also affects the discharge rate for the PSMF. During the first few years, the water management strategy for the PSMF requires storage of water to achieve operational requirements. A discharge is unlikely during this time. A discharge should start in Year 2. The annual average discharge rate is expected to varying during the operations phase as the storage capacity in the PSMF first increases to accommodate the mine production schedule and then decreases with ongoing process solids deposition to the PSMF.

Figure 4-1: Source Based Discharge Flow Rate from the PSMF

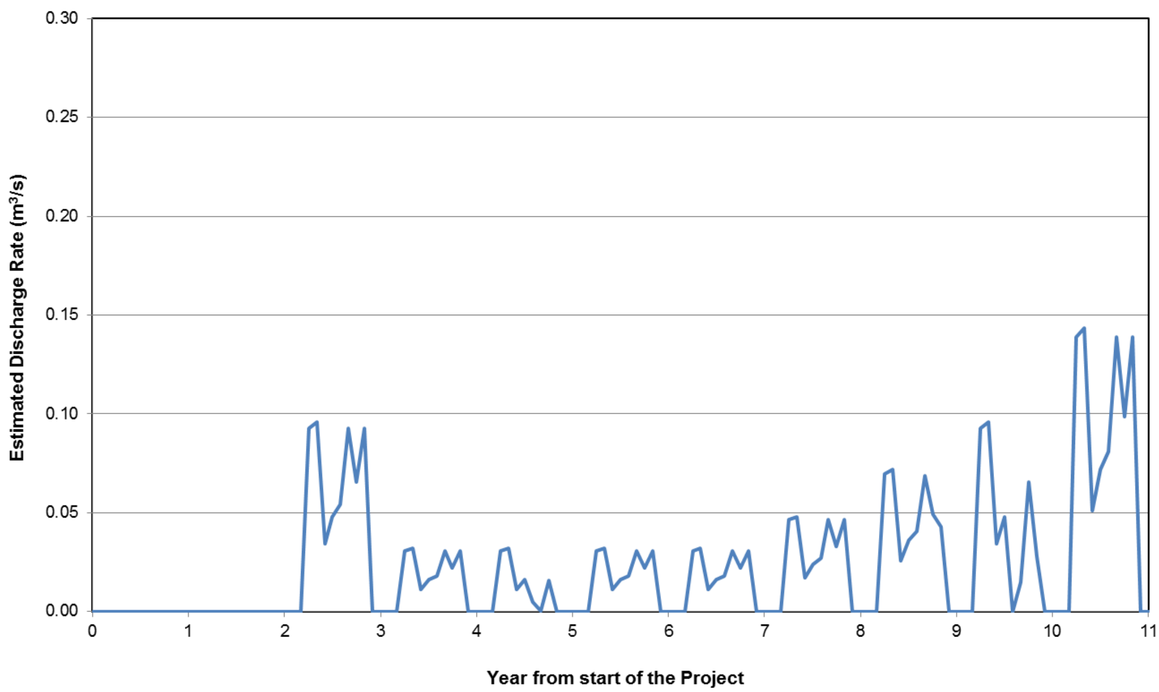


Figure 4-2 presents the predicted quality of the discharge from the PSMF for four COPC—cobalt, copper, molybdenum and selenium. The discharge quality varies over time due to varying source inputs. The concentration of cobalt and copper tends to increase over the life of the Project in response to the development of the pit and PSMF. The concentration of molybdenum and selenium tends to be higher in the early years of the Project prior to the burial of Type 2 materials in the PSMF and prior to their placement in the satellite pits. Concentrations also vary during the year due to the time varying hydrologic inputs to the PSMF.

Figure 4-2: Source Based Discharge Quality from the PSMF

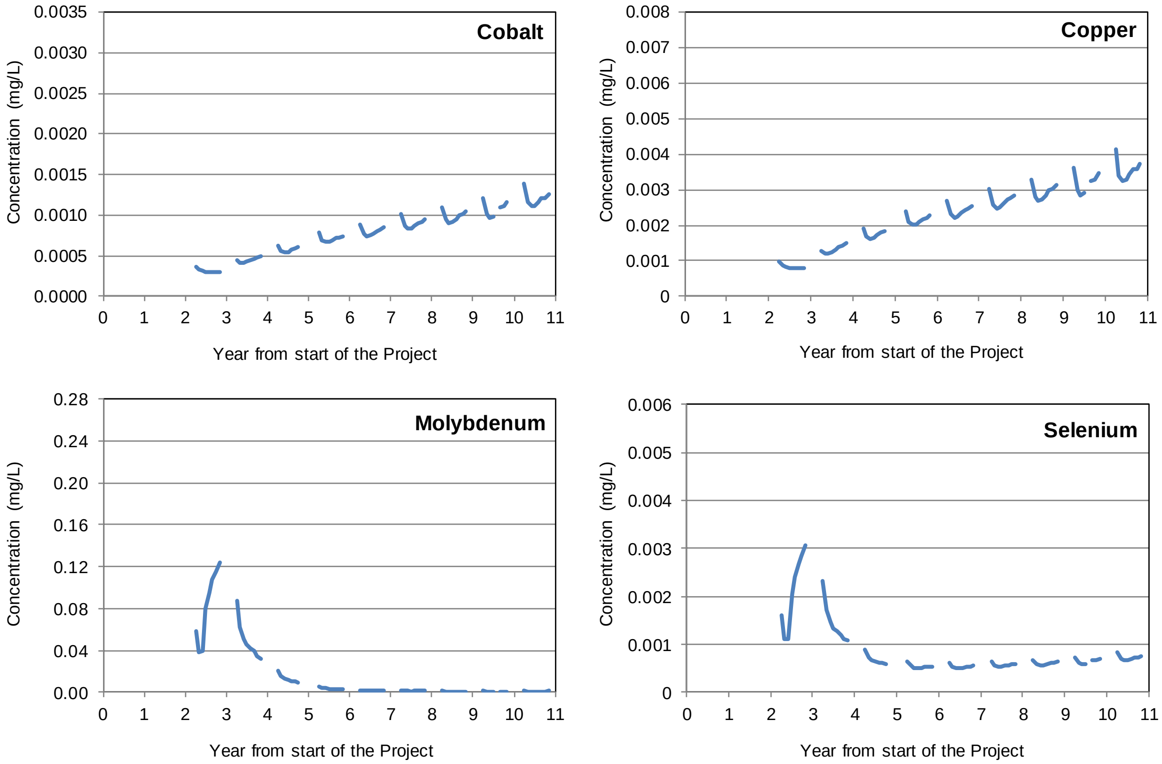


Table 4-2 presents the predicted source based discharge quality for the PSMF for the identified COPC. The predicted discharge quality represents the maximum monthly concentration that may occur during the life of the Project based on anticipated loadings. But, as illustrated in Figure 4-2, the majority of the time, the concentration is expected to be significantly lower than the maximum monthly concentrations. Table 4-2 compares these maximum values to the authorized limits prescribed in the MMER, and demonstrates compliance with these authorized limits.

Table 4-2: Source Based Discharge Quality from the PSMF during Operations

COPC[a]	Source Based Discharge Quality[b] (mg/L)	Authorized Limits Prescribed in the MMER[c] (mg/L)
Aluminum	0.13	-
Arsenic	0.003	0.5
Cadmium	0.00006	-
Cobalt	0.0017	-
Copper	0.005	0.3
Iron	0.54	-
Molybdenum	0.14	-
Nickel	0.006	0.5
Lead	0.0006	0.2
Selenium	0.003	-
Uranium	0.004	-
Vanadium	0.003	-
Zinc	0.02	0.5

[a] COPCs defined through geochemical testing of source materials as described in EcoMetrix (2012c);
[b] Maximum predicted source based discharge quality during the Project life calculated using Equation 4-1 and Equation 4-2;
[c] Maximum authorized monthly mean concentration from Table 4-1.

4.2.2 Receiving-Water Based Discharge Quality

The receiving-water based discharge quality for the PSMF is derived from the assimilative capacity of Hare Lake. It follows MOE's Procedure B-1-5 (1994b). It considers the hydrology of Hare Lake from Section 3.3.2, the background water quality from Section 3.3.3, and the surface water quality benchmark from Section 3.3.4 to derive a discharge quality that ensures protection of the aquatic environment in Hare Lake and Hare Creek.

The assimilative capacity of Hare Lake varies with the natural hydrologic cycles. The receiving-water based discharge quality also varies to best utilize the assimilative capacity. This approach is referred to as a variable allocation.

Equation 4-3 provides a basis to calculate the receiving-water based discharge quality for a variable allocation. It is a steady state form of the mass conservation equation.

$$C_{PSMF} = \left(C_{HL\_benchmark} - C_{HL\_background}\right) \cdot \frac{Q_{HL\_ds}}{Q_{PSMF}} + C_{HL\_background} \qquad \textbf{Equation 4-3}$$

Where: C_{PSMF} = receiving-water based discharge quality for PSMF (mg/L);

$C_{HL\_background}$ = background water quality in Hare Lake (mg/L);

$C_{HL\_benchmark}$ = surface water quality benchmark for Hare Lake (mg/L);

Q_{PSMF} = discharge rate from the PSMF impoundment (mg/L);

Q_{HL_ds} = outflow rate from Hare Lake (L/s).

Table 4-3 presents the receiving-water discharge quality for the PSMF discharge. The discharge quality is presented for three discharge scenarios—a discharge rate of 50% relative to Hare Lake outflow, a discharge rate of 33% relative to Hare Lake outflow, and a discharge rate of 20% relative to Hare Lake outflow. Alternative discharge scenarios can be calculated using Equation 4-3. Baseline and benchmark water qualities for Hare Lake are also presented to show the basis for the derivation.

Table 4-3: Receiving-Water Based Discharge Quality, PSMF during Operations

COPC[a]	Background[b] (mg/L)	Benchmark[c] (mg/L)	Receiving-water Based Discharge Quality[d] (mg/L)		
			Discharge rate relative to Hare Lake Outflow		
			50%	33%	20%
Aluminum	0.14	0.14	0.14	0.14	0.14
Arsenic	<0.001	0.005	0.009	0.013	0.021
Cadmium	<0.00009	<0.00009	0.00009	0.00009	0.00009
Cobalt	<0.0005	0.0009	0.0013	0.0017	0.0025
Copper	<0.001	0.002	0.003	0.004	0.006
Iron	0.97	0.97	0.97	0.97	0.97
Molybdenum	<0.001	0.04	0.079	0.118	0.196
Nickel	<0.002	0.025	0.048	0.071	0.117
Lead	<0.001	0.001	0.001	0.001	0.001
Selenium	<0.0004	0.001	0.0016	0.0022	0.0034
Uranium	<0.005	0.005	0.005	0.005	0.005
Vanadium	<0.001	0.006	0.011	0.016	0.026
Zinc	0.006	0.02	0.034	0.048	0.076
Additional Parameters[e]					
TSS	3	8	13	18[f]	28[f]
NH_3	0.0006	0.019	0.037	0.055	0.093

a COPCs defined through geochemical testing of source materials as described in EcoMetrix (2012c);
b Background water quality for Hare Lake from Table 3-3;
c Surface water quality benchmark for Hare Lake from Table 3-4;

[d] Predicted receiving-water based discharge quality calculated using Equation 4-3 for three different discharge scenarios—a discharge rate of 50% relative to Hare Lake outflow, a discharge rate of 33% relative to Hare Lake outflow, and a discharge rate of 20% relative to Hare Lake outflow.
[e] Additional parameters of potential concern.
[f] The maximum TSS concentration in the discharge will be limited by the authorized limits prescribed in the MMER.

Table 4-3 presents the results for the COPC identified through geochemical testing (EcoMetrix, 2012c), as well as two additional parameters of potential concern—total suspended solids (TSS) and un-ionized ammonia (NH_3). These water quality parameters may be elevated in the discharge from the PSMF and have applicable surface water quality benchmarks for Hare Lake.

4.3 Discharge from the MRSA to Pic River during Operations and Post-closure

Drainage from the MRSA will be collected, stored, tested, treated and discharged as necessary to the Pic River, as discussed in Section 2.1.2. The quality of the discharge from the MRSA will, as a minimum, comply with the authorized limits prescribed in the MMER.

The following sections present two derivations of discharge quality for the MRSA—the source based discharge quality, and the receiving-water based discharge quality.

4.3.1 Source Based Discharge Quality

The source based discharge quality for the MRSA is derived from the mine schedule, site water balance and source loading estimates described in Section 2.2, Section 2.3 and Section 2.4 using Equation 4-4.

$$C_{MRSA} = \frac{M_{MRSA}}{Q_{MRSA}}$$ **Equation 4-4**

Where: C_{PSMF} = concentration of COPC in the MRSA discharge (mg/L);

M_{PSMF} = mass loading from the MRSA (mg/s);

Q_{MRSA} = discharge rate from the MRSA (m^3/s).

(Standard unit conversions apply)

Table 4-4 presents the predicted source based discharge quality for the MRSA for the identified COPC. The predicted discharge quality represents the maximum monthly concentration that may occur during the life of the Project. Table 4-4 compares these values to the authorized limits prescribed in the MMER, and demonstrates compliance with these authorized limits.

Table 4-4: Source Based Discharge Quality from the MRSA

COPC[a]	Maximum Predicted Discharge Quality[b] (mg/L)	Authorized Limits Prescribed in the MMER[c] (mg/L)
Aluminum	0.14	-
Arsenic	0.035	0.5
Cadmium	<0.0001	-
Cobalt	0.0026	-
Copper	0.014	0.3
Iron	0.43	-
Molybdenum	0.01	-
Nickel	0.007	0.5
Lead	0.001	0.2
Selenium	0.013	-
Uranium	0.004	-
Vanadium	0.026	-
Zinc	0.03	0.5

[a] COPCs defined through geochemical testing of source materials as described in EcoMetrix (2012c);
[b] Maximum predicted source based discharge quality during the Project life calculated using Equation 4-4;
[c] Maximum authorized monthly mean concentration from Table 4-1.

4.3.2 Receiving-Water Based Discharge Quality

The receiving-water based discharge quality for the MRSA is derived from the assimilative capacity of the Pic River. It follows MOE's Procedure B-1-5 (1994b).

The Pic River has a significant capacity to assimilate the discharge from the MRSA.

As discussed in Section 3.4.2, the Pic River has an annual flow of approximately 51.4 m^3/s and an extreme low flow of approximately 4.19 m^3/s under the 7Q20 low flow condition. In comparison, the discharge rate from the MRSA is approximately 1,240 times lower than the flow in the Pic River on average and approximately 150 times lower during extreme low flow conditions. These high mixing ratios provide ample capacity to assimilate the discharge from the MRSA.

Drainage from the MRSA discharges to the Pic River through a planned offshore diffuser. The diffuser induces rapid mixing of the discharge waters with the ambient waters in the Pic River.

A mathematical model referred to as CORMIX (Cornell Mixing Zone Expert System) predicts the rate of mixing of the discharge with distance downstream from the diffuser. CORMIX was developed by Cornell University (Jirka and Akar, 1991), is supported by the United States Environmental Protection Agency, and is a widely recognized model for the analysis of mixing characteristics.

Two alternative diffuser configurations are considered—a single port diffuser located 10 m from the bank, and a multi-port diffuser extending from 5 m to 15 m from the bank. Each configuration provides a high degree of initial mixing, as shown in Table 4-5. The derivation of a receiving-water based discharge assumes the use of a multi-port diffuser since it provides somewhat greater mixing potential than a single port diffuser. It also assumes a 50 m mixing zone extending from the diffuser. Such a mixing zone is relatively small, is isolated from sensitive habitat, valued recreational areas and drinking water supplies, and does not pose any risk to valued ecosystem components.

Table 4-5: Estimated Mixing Potential for Alternative Diffuser Configurations

Diffuser Type	**Single Port**		**Multi-Port (5 ports)**	
Scenario	**7Q20 Low Flow**	**Annual Average**	**7Q20 Low Flow**	**Annual Average**
River flow	4.19 m^3/s	51.4 m^3/s	4.19 m^3/s	51.4 m^3/s
MRSA discharge	0.028 m^3/s	0.041 m^3/s	0.028 m^3/s	0.041 m^3/s
Assumed depth	0.5 m	2 m	0.5 m	2 m
Distance from diffuser	**Mixing ratio[a]**		**Mixing ratio[a]**	
50 m	13:1	200:1	36:1	240:1
500 m	35:1	400:1	49:1	400:1
Fully mixed	150:1	1,240:1	150:1	1,240:1

[a] Mixing ratio represents the centerline dilution at the respective distance from the diffuser as calculated from CORMIX. All values are approximate and subject to final design and site selection.

Equation 4-5 uses the results from CORMIX to calculate the receiving-water based discharge quality for the MRSA.

$$C_{MRSA} = D \cdot C_{PR_{benchmark}} - (D-1) \cdot C_{PR\_background} \qquad \textbf{Equation 4-5}$$

Where:

C_{MRSA} = receiving-water based discharge quality for MRSA (mg/L);

$C_{PR\_background}$ = background water quality in the Pic River (mg/L);

$C_{PR\_benchmark}$ = surface water quality benchmark for the Pic River (mg/L);

D = mixing ratio at the edge of the mixing zone (unitless).

Table 4-6 presents the predicted receiving-water discharge quality for the MRSA discharge. The receiving-water based discharge quality is calculated using Equation 4-5, based on a mixing ratio of 36:1 for a multi-port diffuser at 50 m from the diffuser, and under the 7Q20 low flow condition. Baseline and benchmark water qualities for the Pic River are also presented to show the basis for the derivation.

Table 4-6 presents the results for the COPC identified through geochemical testing (EcoMetrix, 2012c), as well as two additional parameters of potential concern—total suspended solids (TSS) and un-ionized ammonia (NH_3). These water quality parameters may be elevated in the discharge from the MRSA and have applicable surface water quality benchmarks for the Pic River.

Table 4-6: Receiving-Water Based Discharge Quality for the MRSA

COPC[a]	Background[b] (mg/L)	Surface Water Quality Benchmark[c] (mg/L)	Receiving-water Based Discharge Quality[d] (mg/L)
Aluminum	0.04	0.075	1.37
Arsenic	<0.001	0.005	0.15
Cadmium	<0.00009	<0.00009	<0.00009
Cobalt	0.0012	0.0012	0.0012
Copper	0.004	0.004	0.004
Iron	2.7	2.7	2.7
Molybdenum	<0.001	0.04	1.48
Nickel	0.005	0.025	0.77
Lead	0.0014	0.0014	0.0014
Selenium	<0.0004	0.001	0.023
Uranium	<0.005	0.005	0.005
Vanadium	0.005	0.006	0.043
Zinc	0.011	0.02	0.35
Additional Parameters[d]			
TSS	3	8 [f]	193 [f]
NH_3	0.00037	0.19	0.71

[a] COPCs defined through geochemical testing of source materials as described in EcoMetrix (2012c);
[b] Background water quality for the Pic River from Table 3-6;
[c] Surface water quality benchmark for the Pic River from Table 3-7;
[d] Predicted receiving-water based discharge quality calculated using Equation 4-5, based on a mixing ratio of 36:1 for a multi-port diffuser, at 50 m from the diffuser, and under the 7Q20 low flow condition.
[e] Additional parameters of potential concern.
[f] The maximum TSS concentration in the discharge will be limited by the authorized limits prescribed in the MMER.

4.4 Discharge from the PSMF to Stream 6 Post-closure

Conceptual closure of the PSMF is described in TGCL (2012d). After mine closure, the PSMF will be revegetated and natural stream channels and ponds will be created to collect surface runoff and direct it to the southwest where an outlet structure will be created to link the upper part of the watershed (which is the PSMF) and the lower part of the Stream 6 watershed.

It is expected that the surface runoff water quality will be similar to existing baseline conditions once the natural flow regime in the Stream 6 subwatershed has been restored.

It is possible that subsurface flows seeping from the PSMF may contain trace levels of COPC from the process solids. The quality of seepage water will be a function of the existing pore water in the process solids in the short to intermediate period, and a function of leaching of the surficial process solids and infiltration rates in the longer term. The pore water in the process solids at the end of the operation will slowly migrate downward to the natural ground and will migrate laterally to appear as seepage near the toes of the PSMF dams. The seepage that appears at the dam toes is expected to have similar quality as the resident pore water. EcoMetrix (2012c) provides an estimate of the quality of the seepage water.

The seepage from the PSMF post-closure will collect in ponds prior to release to the downstream environment. The ponds will be located at the base of the PSMF and along Stream 6 in low lying areas between the PSMF and Highway 17. These ponds will restore the headwaters of Stream 6 to a natural state, similar to that shown in Plate 3-5.

Table 4-7 provides an estimate of the source based discharge quality for the PSMF post closure. The estimate is based on the average seepage rate from the PSMF and average flow in Stream 6 above Highway 17. The table also shows the surface water quality benchmark for Stream 6 for comparison. As shown, the discharge from the PSMF is of similar or better quality then the surface water quality benchmark for the identified COPC. The possible exceptions include copper and selenium, which are slightly above the respective benchmark values, although uncertain due to the detection limit.

The estimated discharge quality is conservative since it does not consider natural attenuation. The ponds increase the hydraulic retention in Stream 6 to several days under average flows and to several months under low flows. This provides attenuation through deposition of particulate matter and biological passive treatment. Deposition alone could reduce the concentration of copper and selenium by over 50%. Biological passive treatment could further reduce these concentrations. These natural attenuation processes will need to be investigated during the operational phase.

Table 4-7: Source Based Discharge Quality from the PSMF Post-Closure

COPC[a]	Maximum Predicted Discharge Quality[b] (mg/L)	Surface Water Quality Benchmark[c] (mg/L)
Aluminum	0.14	0.14
Arsenic	<0.001	0.005
Cadmium	<0.0001	<0.00009
Cobalt	<0.0008	0.0009
Copper	<0.0027	0.002
Iron	0.91	0.97
Molybdenum	<0.002	0.04
Nickel	<0.004	0.025
Lead	<0.0011	0.001
Selenium	<0.0012	0.001
Uranium	<0.005	0.005
Vanadium	<0.004	0.006
Zinc	0.016	0.02

[a] COPCs defined through geochemical testing of source materials as described in EcoMetrix (2012c);
[b] Estimated source based discharge quality for PSMF post-closure at the outlet of the polishing ponds along Stream 6 above Highway 17;
[c] Surface water quality benchmark for Stream 6 from Table 3-4.

5.0 POTENTIAL SURFACE WATER QUALITY EFFECTS

The following section provides the assessment of potential surface water quality effects associated with the identified discharges from the Project site. The assessment addresses the three identified receiving environments—Hare Lake, the Pic River and Stream 6—and the three Project phases—site preparation and construction phase, operations phase, and decommissioning and closure phase.

5.1 Potential Surface Water Quality Effects in Hare Lake

5.1.1 Site Preparation and Construction Phase

During the site preparation and construction phase, Project activities within the Hare Lake watershed are limited to land clearing and construction of the overland pipeline and offshore diffuser. These activities will have limited effect on surface water quality in Hare Lake. They may cause mobilization of suspended solids into natural surface waters, but this can be prevented through the implementation of standard sediment control practices.

5.1.2 Operations Phase

Project Activities

During the operations phase, Project activities within the Hare Lake watershed include the discharge of excess waters from the PSMF to Hare Lake.

As discussed in Section 2.0, the discharge originates from an impoundment located at the base of the PSMF. Waters collected within the impoundment include: runoff from adjacent lands within the Project site; pit dewatering; runoff and seepage from the PSMF; and process water from milling operations. The milling operation recycles the impound water. The pool elevation is maintained within an upper and lower bound to ensure sufficient storage to meet operational requirements during dry periods and to manage waters during wet periods. Excess waters are discharged from the impoundment to Hare Lake following quality confirmation and treatment as necessary.

The discharge flows from the impoundment through an overland pipeline to the south eastern portion of Hare Lake and discharges to the lake through an offshore diffuser. The configuration of the diffuser maximizes the potential mixing of the discharge within the epilimnion, which minimizes the potential effect on surface water quality and aquatic habitats.

Method of Assessment

Mathematical models provide a basis to assess the potential effects of the PSMF discharge on water quality within Hare Lake. The models are based on principles of mass conservation, as represented by Equation 5-1.

$$\frac{dC_{HL}}{dt} = \frac{Q_{PSMF} \cdot C_{PSMF} + Q_{up} \cdot C_{up}}{V_{HL}}$$

Equation 5-1

Where:
- C_{HL} = concentration of COPC in Hare Lake (mg/L);
- C_{PSMF} = concentration of COPC from the PSMF discharge (mg/L);
- Q_{PSMF} = discharge rate from the PSMF (m^3/s);
- Q_{up} = inflow rate from upstream surface waters (m^3/s);
- C_{up} = inflow concentration from upstream surface waters (mg/L);
- V_{HL} = volume of the epilimnion in Hare Lake (m^3);
- t = time (s).

(Standard unit conversions apply)

This partial differential equation is solved numerically as a function of time over the life of the Project. Equation 5-1 represents the potential change in water quality within the epilimnion (surface layer) of Hare Lake. A similar equation represents the potential change in water quality within the hypolimnion (bottom layer) except loadings and flows are replaced with a semi-annual mixing of the epilimnion and hypolimnion.

The models utilize the mine schedule, site water balance and source loading estimates described in Section 2.2, Section 2.3 and Section 2.4, the receiving environment characteristics presented in Section 3.3, and the discharge characteristics presented in Section 4.2.

Section 4.2 presents two discharge scenarios—a source based discharge quality and a receiving-water based discharge quality. The first scenario represents the expected discharge characteristics based on Project activities. The second scenario represents the maximum discharge that ensures protection of the downstream aquatic environment derived from the receiving water's assimilative capacity.

Flow Considerations

MOE Procedure B-1-5 (MOE, 1994b) refers to the 7Q20 low flow condition as a basis for assessment of surface water quality. This condition represents an extreme drought that persists for 7 days and occurs once every 20 years on average.

The 7Q20 low flow condition does not represent a meaningful scenario for assessment of surface water quality effects in Hare Lake.

First, the Project is not expected to discharge to the lake during such an extreme drought condition. The stored water within the impoundment will be recycled in the mill to meet operational requirements.

Second, the 7Q20 low flow condition persists for 7 days in comparison to the residence time within Hare Lake of several years at the 7Q20 flow. The storage capacity of the lake defines the assimilative capacity and not the inflow rate under such extreme conditions.

Instead, the assessment considered the monthly average flows at the outlet of Hare Lake in Hare Creek, as presented in Figure 3-14 of Section 3.3.2.

Predicted Water Quality in Hare Lake

The discharge enters Hare Lake through an offshore multi-port diffuser. The diffuser induces mixing within the vicinity of the discharge and circulation processes within the lake advect and disperse the discharge throughout the lake.

Field investigations completed during the summer of 2011 (EcoMetrix, 2012a), including drogue tracking and vertical profiles of temperature and conductivity, indicate uniform mixing throughout the epilimnion of the lake. Uniform mixing throughout the hypolimnion of the lake and semi-annual turn-over of the lake are assumed limnological processes.

A discharge within the epilimnion will mix throughout the epilimnion during the summer-winter stratified periods, and mix throughout the entire lake twice per year during the spring-fall turnover.

The sections below present the predicted water quality in Hare Lake for the following discharge scenarios:

- Predicted water quality in Hare Lake assuming the source based discharge quality for the PSMF from Section 4.2.1;
- Predicted water quality in Hare Lake assuming the receiving-water based discharge quality for the PSMF from Section 4.2.2.

(a) Water Quality in Hare Lake – Source Based Discharge Scenario

As discussed in Section 4.2.1, the source based discharge quality for the PSMF is derived from the mine schedule, site water balance and source loading estimates. It represents the expected discharge characteristics based on the Project activities.

Table 5-1 presents the predicted water quality in Hare Lake under this discharge scenario. Predictions are provided for the identified COPC for both the epilimnion and hypolimnion. As shown, the discharge is expected to have negligible effect on water quality in Hare Lake. The water quality in Hare Lake remains below the surface water quality benchmark for all identified COPC, and indistinguishable from background water quality for most COPC. Surface water quality benchmarks were defined in Section 3.3.4 and considered the more protective of the PWQO and CWQG. Where natural background exceeded these guidelines, the natural background value was selected as the appropriate surface water quality benchmark.

Table 5-1: Water Quality in Hare Lake – Source Based Discharge Scenario

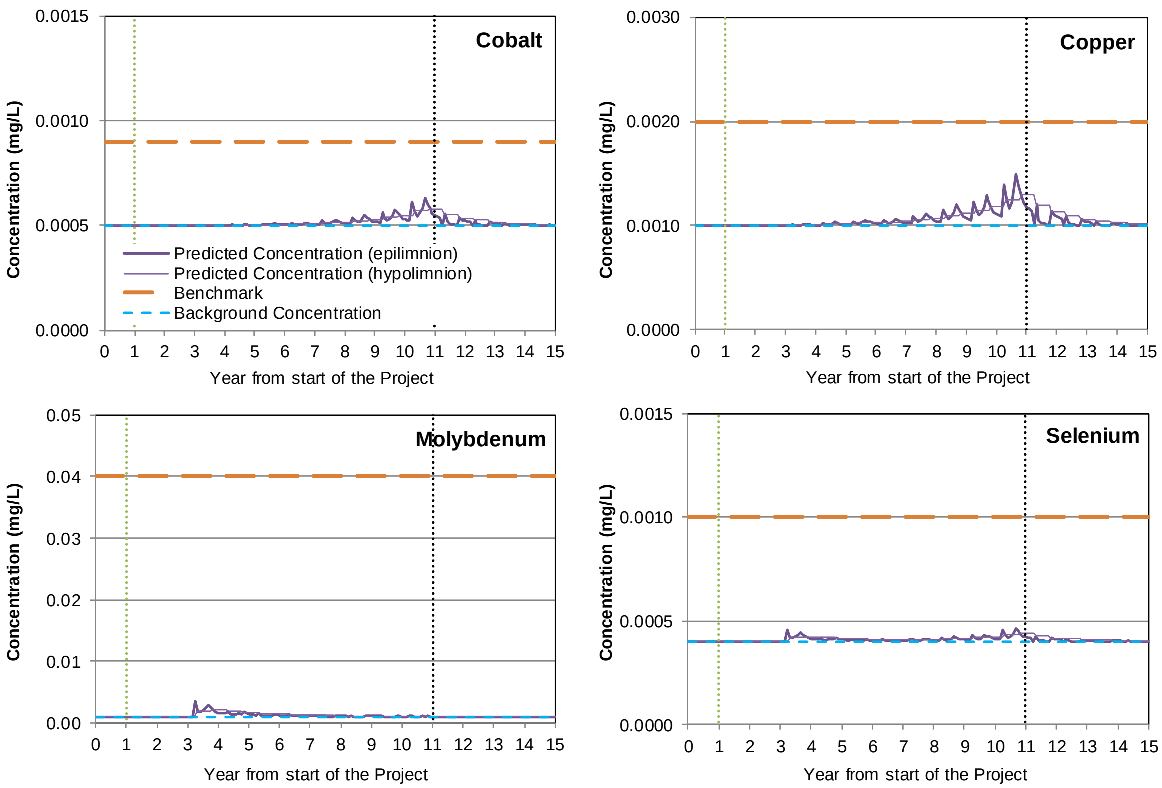
COPC	Baseline[a] (mg/L)	Benchmark[b] (mg/L)	Water Quality in Hare Lake[c] (mg/L)	
			Epilimnion	Hypolimnion
Aluminum	0.14	0.14	0.14	0.14
Arsenic	<0.001	0.005	<0.0012	<0.0011
Cadmium	<0.00009	<0.00009	<0.00009	<0.00009
Cobalt	<0.0005	0.0009	<0.00063	<0.00058
Copper	<0.001	0.002	<0.0015	<0.0013
Iron	0.97	0.97	0.97	0.97
Molybdenum	<0.001	0.04	<0.0035	<0.0020
Nickel	<0.002	0.025	<0.0025	<0.0023
Lead	<0.001	0.001	<0.001	<0.001
Selenium	<0.0004	0.001	<0.00046	<0.00044
Uranium	<0.005	0.005	<0.005	<0.005
Vanadium	<0.001	0.006	<0.001	<0.001
Zinc	0.006	0.02	0.0062	0.0061

[a] Baseline water quality for Hare Lake from Table 3-3;
[b] Surface water quality benchmark for Hare Lake from Table 3-4;
[c] Predicted maximum concentrations during the Project life from Equation 5-1 based on expected flows from Figure 3-14 and source based discharge quality from Table 4-2.

Figure 5-1 presents the potential water quality effects on Hare Lake for cobalt, copper, molybdenum and selenium. As shown, the concentration in Hare Lake remains below the surface water quality benchmark for these four COPCs. The concentrations of these

COPCs remain near background concentrations during the site preparation and construction phase and during most of the operational phase. The concentrations may rise during the latter stage of the operational phase and peak at the end of the operational phase, but the maximum concentrations remain below the surface water quality benchmarks. Through the decommissioning and closure phase, the concentrations return to background concentrations.

Figure 5-1: Expected Water Quality in Hare Lake



The water quality within Hare Lake may vary throughout the year due to natural hydrologic cycles. These cycles affect both the natural inflows to the lake as well as the discharge rate from the Project site. Water quality may also vary through the year due to semi-annual turnover of the lake, which induces mixing of the epilimnion and hypolimnion. Peak concentrations occur during the spring and early fall, coinciding with periods of high precipitation and high discharge. Lower concentrations occur during the summer and winter, coinciding with periods of low rainfall and low discharge.

(b) Water Quality in Hare Lake – Receiving-Water Based Discharge Scenario

As discussed in Section 4.2.2, the receiving-water based discharge quality for the PSMF is derived from the assimilative capacity of Hare Lake. It follows MOE's Procedure B-1-5 (1994b). It considers the hydrology of Hare Lake, the background water quality, and the surface water quality benchmark to derive a discharge quality that ensures protection of the aquatic environment in Hare Lake and Hare Creek. It represents the upper bound water quality in Hare Lake.

Table 5-2 presents the predicted water quality in Hare Lake under this discharge scenario. As shown, the predicted water quality in Hare Lake remains at the surface water quality benchmark for Hare Lake for the identified COPC. This is to be expected since the receiving-water based discharge quality is established to ensure the surface water quality benchmark is not exceeded at any time during the Project life.

Table 5-2: Water Quality in Hare Lake – Receiving-Water Based Discharge Scenario

COPC	Background[a] (mg/L)	Benchmark[b] (mg/L)	Water Quality in Hare Lake[c] (mg/L)	
			Epilimnion	Hypolimnion
Aluminum	0.14	0.14	0.14	0.14
Arsenic	<0.001	0.005	0.005	0.005
Cadmium	<0.00009	<0.00009	0.00009	0.00009
Cobalt	<0.0005	0.0009	0.0009	0.0009
Copper	<0.001	0.002	0.002	0.002
Iron	0.97	0.97	0.97	0.97
Molybdenum	<0.001	0.04	0.04	0.04
Nickel	<0.002	0.025	0.025	0.025
Lead	<0.001	0.001	0.001	0.001
Selenium	<0.0004	0.001	0.001	0.001
Uranium	<0.005	0.005	0.005	0.005
Vanadium	<0.001	0.006	0.006	0.006
Zinc	0.006	0.02	0.02	0.02
TSS	3	8	8	8
Ammonia (NH_3)	0.0006	0.019	0.019	0.019

[a] Baseline water quality for Hare Lake from Table 3-3;
[b] Surface water quality benchmark for Hare Lake from Table 3-4;
[c] Predicted maximum concentrations during the Project life from Equation 5-1 based on expected flows from Figure 3-14 and receiving-water based discharge quality from Table 4-3.

Consideration of Valued Ecosystem Components (VEC)

The assessment above considers the potential effects of the discharge on water quality in Hare Lake based on a comparison to the surface water quality benchmarks. As discussed in Section 3.3.4, these surface water quality objectives consider PWQO and CWQG values and serve as chemical and physical indicators representing a satisfactory level for surface waters. They are set at a level of water quality which is protective of all forms of aquatic life and all aspects of the aquatic life cycles during indefinite exposure to the water.

The assessment also considers the potential effects of the discharge on other valued ecosystem components (VEC), including northern pike, mallard duck, mink and moose. These VEC reside within Hare Lake and/or its watershed and are integrally connected with the aquatic food chain.

Northern pike are piscivores that reside in the shallow waters of Hare Lake and feed on insects and small bodied fish. Mallard ducks are omnivores that may spend a portion of the time in Hare Lake feeding on aquatic plants and insects. Mink are carnivores that may reside along the banks of Hare Lake or Hare Creek feeding on insects, small mammals and small bodied fish. Moose are herbivores that may spend a portion of the time feeding on aquatic plants in Hare Lake. For the purpose of this assessment, it is assumed that these animals reside exclusively in Hare Lake and feed exclusively on aquatic plants and/or aquatic animals from Hare Lake. This assumption is highly conservative and unrealistic for animals that occupy a larger home range.

A mathematical model developed by EcoMetrix referred to as IMPACT ™ was used to provide a screening evaluation of the potential risk to these animals. The risk assessment follows methods described in Beak (2002), Suter (2000) and Sample (1996).

Table 5-3: Predicted Hazard Quotient for Selected Valued Ecosystem Components

COPC	Maximum Calculated Hazard Quotient (unit less)			
	Northern Pike	Mallard Duck	Mink	Moose
Aluminum	-	-	-	-
Arsenic	<0.01	0.34	0.19	<0.01
Cadmium	0.27	<0.01	<0.01	<0.01
Cobalt	<0.01	<0.01	<0.01	<0.01
Copper	0.67	<0.01	<0.01	<0.01
Iron	-	-	-	-
Molybdenum	<0.01	0.05	0.08	<0.01
Nickel	0.76	0.09	<0.01	<0.01
Lead	0.10	0.02	<0.01	<0.01
Selenium	0.91	0.18	0.82	0.30
Uranium	<0.01	0.03	0.03	<0.01
Vanadium	-	-	-	-
Zinc	0.62	0.06	0.23	<0.01

[a] Hazard quotient calculated using IMPACT™. A value greater than or equal to 1.0 indicates a potential risk to the animal. All calculated values are less than 1.0 indicating no potential risk.

Table 5-3 presents the results of the screening level risk assessment. The table presents the calculated hazard quotient for various COPC and VEC. The hazard quotient represents the ratio of contaminant exposure level to a reference dose for that contaminant. A value greater than or equal to 1.0 indicates a potential risk to the animal, and a value less than 1.0 indicates no potential risk to the animal. As shown, the hazard quotients are less than 1.0 for all COPC and all animals included in the assessment. Aluminum, iron and vanadium were not included since reference doses were unavailable.

For conservatism, this assessment considered upper bound water quality effects in Hare Lake from Table 5-2 based on the receiving-water based discharge quality for the PSMF from Section 4.2.2.

5.1.3 Decommissioning and Closure Phase

During the decommissioning and closure phase, Project activities within the Hare Lake watershed are limited to trace seepage from the PSMF. The discharge from the PSMF to Hare Lake will be discontinued, overland pipeline and offshore diffuser decommissioned, and natural watercourse restored within the Stream 6 watershed.

5.2 Potential Surface Water Quality Effects in the Pic River

5.2.1 Site Preparation and Construction Phase

During the site preparation and construction phase, Project activities within the Pic River watershed are limited to land clearing, preparation of the pits and MRSA, construction of the four catch basins, and construction of the offshore diffuser. These activities will have limited effect on surface water quality in the Pic River. They may cause mobilization of suspended solids into natural surface waters, but this can be prevented through the implementation of standard sediment control practices.

Storm water and subsequent seepage from the MRSA will be collected in four catch basins at the drainages east of the mine rock stockpile. These catch basins will be constructed prior to mine rock placement. The discharge from these catch basins is addressed in the operations phase.

5.2.2 Operations Phase

Project Activities

During the operations phase, Project activities within the Pic River watershed include the discharge of surface runoff and seepage from the MRSA. Four catch basins located in the drainages east of the mine rock stockpile collect the runoff and seepage waters to allow settling of suspended solids, to provide treatment if required, and to facilitate monitoring of discharge quality.

The discharge from the four catch basins enters the Pic River through an offshore diffuser. The configuration of the diffuser maximizes the potential mixing of discharge within the river, which minimizes the potential effect on surface water quality and aquatic habitats.

Method of Assessment

The discharge from the MRSA enters the Pic River through an offshore diffuser. The diffuser induces mixing of the discharge with the ambient waters in the Pic River. A mathematical model referred to as CORMIX (Cornell Mixing Zone Expert System) predicts the potential water quality effects of the discharge with distance downstream from the diffuser. The results of the CORMIX model are presented in Table 4-5 from Section 4.3.1.

Equation 5-2 uses the results from CORMIX to calculate the concentration of the COPC within the Pic River at 50 m and 500 m downstream from the diffuser.

$$C_{PR} = \frac{C_{MRSA} + (D-1)C_{PR\_up}}{D}$$ **Equation 5-2**

Where: C_{PR} = concentration of COPC in the Pic River (mg/L);

C_{MRSA} = concentration of COPC from the MRSA discharge (mg/L);

C_{PR_up} = concentration from upstream surface waters (mg/L);

D = mixing ratio at the edge of mixing zone (unitless).

The models utilize the mine schedule, site water balance and source loading estimates described in Section 2.2, Section 2.3 and Section 2.4, the receiving environment characteristics presented in Section 3.4, and the discharge characteristics described in Section 4.3.

Two alternative diffuser configurations are considered—a single port diffuser located 10 m from the bank, and a multi-port diffuser extending from 5 m to 15 m from the bank. Each configuration provides a high degree of initial mixing as shown in Table 4-5 from Section 4.3.1. The assessment of water quality assumes the use of a multi-port diffuser since it provides somewhat greater initial mixing.

Flow Considerations

MOE Procedure B-1-5 (MOE, 1994b) refers to the 7Q20 low flow condition as a basis for assessment of surface water quality. As discussed in Section 3.4.2, the 7Q20 low flow for the Pic River is estimated to be 4.19 m^3/s. In comparison, the discharge rate from the MRSA is estimated to be 0.028 m^3/s—approximately 150 times lower than the 7Q20 low flow in the Pic River.

The 7Q20 low flow provides a conservative basis to assess potential water quality effects on the Pic River. Such an extreme low flow condition occurs once every 20 years on average. Whereas, flows in the Pic River are typically much higher—averaging 10.6 m^3/s in winter, 35.8 m^3/s in summer and 51.4 m^3/s year-around.

Predicted Water Quality in the Pic River

As discussed in Section 4.3.2, the Pic River has a significant capacity to assimilate the discharge from the MRSA since the discharge represents a small fraction of the total flow in the river—1,240 times smaller under the annual average flow and 150 times small under extreme low flow.

The discharge enters the Pic River through an offshore diffuser. The diffuser induces rapid mixing within its immediate vicinity. At 50 m from the discharge and over a width of approximately 10 m, the discharge mixes with ambient river water at a ratio of approximately 240:1 under the annual average river flow and approximately 36:1 under the extreme low river flow. These high mixing ratios provide ample capacity to assimilate the discharge from the MRSA.

The sections below present the predicted water quality in the Pic River for the extreme low flow condition consistent with MOE's Procedure B-1-5 (MOE, 1994b). These predictions are conservative and may only occur once in 20 years on average. All other less extreme flow conditions will achieve improved water quality from that described below.

The discharge scenarios considered include:

- Predicted water quality in the Pic River assuming the source based discharge quality for the MRSA from Section 4.3.1 under an extreme low river flow;
- Predicted water quality in the Pic River the receiving-water based discharge quality for the MRSA from Section 4.3.2 under an extreme low river flow.

(a) Water Quality in the Pic River – Source Based Discharge Scenario under Extreme Low River Flow

As discussed in Section 4.3.1, the source based discharge quality for the MRSA is derived from the mine schedule, site water balance and source loading estimates. It represents the expected discharge characteristics based on the Project activities.

Table 5-4 presents the predicted water quality in the Pic River under this discharge scenario and for the conservative case of the 7Q20 low flow. As shown, the concentrations of all COPC comply with the surface water quality benchmarks for the Pic River within 50 m from the diffuser. The water quality remains indistinguishable from background for most COPC. Under more typical flows, the water quality remains indistinguishable from background for all COPC.

Table 5-4: Water Quality in the Pic River – Source Based Discharge Scenario under Extreme Low Flow

COPC	Background[a] (mg/L)	Benchmark[b] (mg/L)	Water Quality in Pic River[c] (mg/L)	
			at 50 m[d]	at 500 m[e]
Aluminum	0.04	0.075	0.04	0.04
Arsenic	<0.001	0.005	<0.0019	<0.0017
Cadmium	<0.00009	<0.00009	<0.00009	<0.00009
Cobalt	0.0012	0.0012	0.0012	0.0012
Copper	0.004	0.004	0.004	0.004
Iron	2.7	2.7	2.6	2.7
Molybdenum	<0.001	0.04	<0.001	<0.001
Nickel	0.005	0.025	0.005	0.005
Lead	0.0014	0.0014	0.0014	0.0014
Selenium	<0.0004	0.001	<0.0007	<0.0007
Uranium	<0.005	0.005	<0.005	<0.005
Vanadium	0.005	0.006	0.006	0.006
Zinc	0.011	0.02	0.012	0.011

[a] Baseline water quality for Pic River from Table 3-6;
[b] Surface water quality benchmark for Pic River from Table 3-7;
[c] Predicted maximum concentrations during the Project life from Equation 5-2 based on 7Q20 low flows from Figure 3-21, source based discharge quality from Table 4-4,and assuming a multi-port diffuser.
[d] Predicted concentration at 50 m from the diffuser based on a mixing ratio of 36:1 from Table 4-5.
[e] Predicted concentration at 500 m from the diffuser based on a mixing ratio of 49:1 from Table 4-5.

(b) Water Quality in the Pic River – Receiving-Water Based Discharge Scenario under Extreme Low River Flow

The receiving-water based discharge quality for the MRSA is derived from the assimilative capacity of the Pic River following MOE's Procedure B-1-5 (1994b), as discussed in Section 4.3.2. It represents the worst case condition of extreme low flow combined with a MRSA discharge based on the receiving-water based discharge quality. It ensures protection of aquatic resources.

Table 5-5 presents the predicted water quality in the Pic River under this discharge scenario. As shown, the predicted water quality in the Pic River remains at or below the surface water quality benchmark for the Pic River within 50 m. This prediction of water quality is highly conservative since it is based on the 7Q20 low flow condition. Under more typical flows, the water quality downstream from the diffuser will remain indistinguishable from background.

Table 5-5: Water Quality in the Pic River – Receiving-Water Based Discharge Scenario under Extreme Low River Flow

COPC	Background[a] (mg/L)	Benchmark[b] (mg/L)	Water Quality in Pic River[c] (mg/L)	
			at 50 m[d]	at 500 m[e]
Aluminum	0.04	0.075	0.073	0.066
Arsenic	<0.001	0.005	<0.005	<0.004
Cadmium	<0.00009	<0.00009	<0.00009	<0.00009
Cobalt	0.001	0.001	0.001	0.001
Copper	0.004	0.004	0.004	0.004
Iron	2.7	2.7	2.7	2.7
Molybdenum	<0.001	0.04	<0.040	<0.032
Nickel	0.005	0.025	0.025	0.020
Lead	0.0014	0.0014	0.0014	0.0014
Selenium	<0.0004	0.001	<0.0010	<0.0009
Uranium	<0.005	0.005	<0.005	<0.005
Vanadium	0.005	0.006	0.006	0.006
Zinc	0.011	0.02	0.020	0.018
TSS	3	8	4	4
Ammonia (NH_3)	0.0004	0.019	0.019	0.015

[a] Baseline water quality for Pic River from Table 3-6;
[b] Surface water quality benchmark for Pic River from Table 3-7;
[c] Predicted maximum concentrations during the Project life from Equation 5-2 based on 7Q20 low flows from Figure 3-21, receiving-water based discharge quality from Table 4-6, and assuming a multi-port diffuser.
[d] Predicted concentration at 50 m from the diffuser based on a mixing ratio of 36:1 from Table 4-5.
[e] Predicted concentration at 500 m from the diffuser based on a mixing ratio of 49:1 from Table 4-5.

Consideration of Valued Ecosystem Components (VEC)

The assessment above considers the potential effects of the discharge on water quality in the Pic River based on a comparison to surface water quality benchmarks. The assessment also considers the potential effects of the discharge on other VEC, including northern pike, mallard duck, mink and moose.

The assessment follows the same approach as described in Section 5.1.2 for Hare Lake. For the assessment of Pic River, the screening level risk assessment assumes the animals reside and feed exclusively within 50 m from the diffuser, which is a highly conservative and unrealistic assumption.

Table 5-6 presents the results of the screening level risk assessment. The table presents the calculated hazard quotient for various COPC and VEC. The hazard quotient represents the ratio of contaminant exposure level to a reference dose for that contaminant. As shown, the hazard quotients are less than 1.0 for all COPC and all animals included in the assessment. Aluminum, iron and vanadium were not included since reference doses were unavailable.

For conservatism, this assessment considers water quality effects in Pic River from Table 5-5 based on the receiving-water based discharge quality from Table 4-6 and the 7Q20 low flow conditions. The results are unrealistically conservative as discussed above.

Table 5-6: Predicted Hazard Quotient for Selected Valued Ecosystem Components

COPC	Maximum Calculated Hazard Quotient (unit less)			
	Northern Pike	Mallard Duck	Mink	Moose
Aluminum	-	-	-	-
Arsenic	<0.01	0.34	0.19	<0.01
Cadmium	0.27	<0.01	<0.01	<0.01
Cobalt	0.01	<0.01	<0.01	<0.01
Copper	0.41	<0.01	<0.01	<0.01
Iron	-	-	-	-
Molybdenum	<0.01	0.05	0.08	<0.01
Nickel	0.76	0.09	<0.01	<0.01
Lead	0.14	0.02	<0.01	<0.01
Selenium	0.91	0.18	0.82	<0.01
Uranium	<0.01	0.03	0.03	<0.01
Vanadium	-	-	-	-
Zinc	0.62	0.06	0.23	<0.01

[a] Hazard quotient calculated using IMPACT™. A value greater than or equal to 1.0 indicates a potential risk to the animal. All calculated values are less than 1.0 indicating no potential risk.

5.2.3 Decommissioning and Closure Phase

Stormwater and seepage from the MRSA will continue to collect in the catch basins until the discharge quality meets the applicable criteria. Until such time, the discharge will release to the Pic River through the offshore diffuser with the same water quality as described for the operational phase. Water quality in the Pic River will continue to comply with the surface water quality benchmark.

When stormwater and seepage quality from the MRSA have been shown to meet applicable criteria, the catch basins will be dewatered and removed. Accumulated sediment in the catch basins will be excavated and transferred to the PSMF or a Satellite Pit for storage. The catch basin embankments will be breached and contoured to suit the surrounding topography. The basin and embankment areas will be re-graded and seeded and the existing stream beds will be restored. No exceedances of water quality benchmarks in the Pic River are expected during decommissioning and closure.

5.3 Potential Surface Water Quality Effects in Stream 6

5.3.1 Site Preparation and Construction Phase

During the site preparation and construction phase, Project activities within the Stream 6 watershed are limited to land clearing and construction of the PSMF. These activities will have limited effect on surface water quality in Stream 6. They may cause mobilization of suspended solids into natural surface waters, but this can be prevented through the implementation of standard sediment control practices.

5.3.2 Operations Phase

During the operations phase, Project activities within the Stream 6 watershed are limited to surface runoff from undisturbed lands within the Project site. All other waters will be collected within the PSMF and discharged to Hare Lake as described in Section 5.1.2. The Project will have limited effect on surface water quality in Stream 6 during the operations phase.

5.3.3 Decommissioning and Closure Phase

After mine closure the natural flow regime of the Stream 6 subwatershed will be restored. The PSMF will be revegetated and natural stream channels and ponds will be created to collect surface runoff and direct it to the southwest where an outlet structure will be created to link the upper part of the watershed—which is the PSMF—and the lower part of the watershed.

It is expected that the runoff water quality will be similar to existing baseline conditions once the natural flow regime in the Stream 6 subwatershed has been restored.

As discussed in Section 4.4, it is possible that subsurface flows seeping from the PSMF may contain trace levels of COPC from the process solids. The seepage from the PSMF will collect in ponds prior to release to the downstream environment.

Table 5-7 provides an estimate of the source based discharge quality for the PSMF post closure. The estimate is based on average flow above Highway 17, as presented in Section 3.5.2. Table 5-7 also provides an estimate of the water quality above the cascade, which is located approximately 1 km upstream from the outlet to Lake Superior. The cascade impedes the passage of fish to the upstream reaches of Stream 6 and limits the fishery to the lower segment of the river.

The water quality in Stream 6 complies with the surface water quality benchmarks for all COPC within fish bearing waters. The concentration of copper may slightly exceed the surface water quality benchmark within the upper, non-fish bearing portion of the stream but the detection limit on background water quality limits the resolution of this estimate.

These results are conservative since they do not consider the natural attenuation processes that will occur in the constructed ponds downstream from the PSMF. As discussed in Section 4.4, deposition alone could reduce the concentration of copper and selenium by over 50%, and biological passive treatment could further reduce these concentrations. These natural attenuation processes will need to be investigated during the operational phase.

Table 5-7: Predicted Water Quality in Stream 6

COPC	Background[a] (mg/L)	Benchmark[b] (mg/L)	Water Quality in Stream 6[c] (mg/L)	
			Above Hwy 17	Above Cascade
Aluminum	0.14	0.14	0.14	0.14
Arsenic	<0.001	0.005	<0.001	<0.001
Cadmium	<0.00009	<0.00009	<0.0001	<0.0001
Cobalt	<0.0005	0.0009	<0.0008	<0.0007
Copper	<0.001	0.002	<0.0027	<0.0018
Iron	0.97	0.97	0.91	0.94
Molybdenum	<0.001	0.04	<0.002	<0.001
Nickel	<0.002	0.025	<0.004	<0.003
Lead	<0.001	0.001	<0.0011	<0.0011
Selenium	<0.0004	0.001	<0.0012	<0.0008
Uranium	<0.005	0.005	<0.005	<0.005
Vanadium	<0.001	0.006	<0.004	<0.003
Zinc	0.006	0.02	0.016	0.011

a Baseline water quality for Stream 6 from Table 3-3;
b Surface water quality benchmark for Stream 6 from Table 3-4;
c Predicted maximum concentrations post-closure, based on expected flows from Figure 3-24 and source based discharge quality from Table 4-7.

6.0 REFERENCES

Beak, 2002. Guidance for Calculation of Derived Release Limits for Radionuclides in Airborne and Liquid Effluents from Ontario Power Generation Nuclear Facilities. A report prepared for Ontario Power Generation. OPG Ref. N-REP-03482-10000, R00; Beak Ref. 22155.1; October 2002.

Calder Engineering Ltd. 2012a. Baseline Hydrologic Conditions at the Marathon PGM-Cu Project Site.

Calder Engineering Ltd. 2012b. Marathon PGM-Cu Project – Surface Water Hydrologic Impact Assessment.

CCME, 2003. Canadian Environmental Quality Guidelines Summary Table for Suspended Sediments. http://st-ts.ccme.ca/?lang=en&factsheet=218

EcoMetrix Incorporated. 2012a. Marathon PGM-Cu Project Site - Aquatic Resources Baseline Report.

EcoMetrix Incorporated. 2012c. Baseline Water Quality Report for the Marathon PGM-Cu Project Site.

EcoMetrix Incorporated. 2012d. Geological Conditions at the Marathon PGM-Cu Project Site.

EcoMetrix Incorporated. 2012e. Geochemical Assessment of Mine Components at the Marathon PGM-Cu Project Site.

Golder Associates Ltd. (Golder) 2009. Final report on Marathon Platinum Group Metals–Copper (PGM-Cu) Mining Project. Baseline assessment of the aquatic and terrestrial environments. Report prepared for Marathon PGM Corporation. January 2009. 07-1118-0012.

Jirka, G.H. and P.J. Akar, 1991. Hydrodynamic Classification of Submerged Multiport Diffusers Discharges, Journal of Hydraulic Engineering, ASCE, 117, No.9, 1113-1128, 1991.

MOE, 1994a. Water Management, Policies, Guidelines. The Provincial Water Quality Objectives. Ministry of Environment and Energy. July, 1994.

MOE, 1994b. Procedure B-1-5. Deriving Receiving Water Based, Point Source Effluent Requirements for Ontario Waters. Ministry of Environment and Energy. July, 1994.

Sample, B.M., 1996. Toxicological Benchmarks for Wildlife. ES/ER/TM-86/R3. Oak Ridge National Laboratory. Oak Ridge.

Suter, G.W., 2000. Ecological Risk Assessment for Contaminated Sites. Taylor and Francis. Boca Raton.